DETERMINING FUTURE WATER DEMAND NEEDS FOR DOMESTIC USERS IN PAHANG

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Thesis submitted in fulfillment of the requirement
for the award of the
Bachelor Degree in Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2017

In the name of Allah, the most merciful and most gracious

To my beloved family;

Sazali bin Sayuti

Zaharah binti Ali

Muhammad Firdaus bin Sazali

Muhammad Azwan bin Sazali

Nor Asyiqin bin Sazali

To my supportive and encouraging friends;

Muhammad Hanif bin Rafiee

Siti Nurfarah Aqilah binti Shiekh Anuar

Zulaikha binti Zuremi

Amirah binti Mohamad

Noor Balqish binti Mohd Din

Nurul Haziqah binti Jabar

Nurhidayatul Akhma binti Mat Rokha

ACKNOWLEDGEMENT

In the name of Allah SWT, The most Merciful and The Most Beneficient. Praise to Allah SWT because of His blessing and His willingness for my final year, I completely finished my thesis of Projek Sarjana Muda (PSM) which the name of project is Determining Future Water Demand Needs for Domestic Users in Pahang. I would like to thank all the people who contributed in some way to work described in this thesis.

First of all, a million thanks and appreciation to my supervisor of Projek Sarjana Muda, Dr. Mohamad Idris bin Ali for the continuous support of my final year project, for his patience, motivation, enthusiasm and immense knowledge. His guidance helped me in all the time of research and writing this thesis. I also sincerely thanks for the time spent proofreading and correcting my many mistakes. I could not have imagined having a better supervisor for my final year project.

I am higly indebted to Faculty of Civil Engineering and Earth Resources, University Malaysia Pahang (UMP) especially to my Final Year Project Coordinator, Dr. Nurul Nadrah Aqilah binti Tukimat and my others lecturer for all guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in completing my final year project.

I would like to thankfulness to the most precious person in my life, my mother and my father for providing me with unfailing support and continuous encourgament throughout my years of study and through the process of researching and writing this thesis. I cannot find approriate words that could properly describe my appreciation for their devotion, support and faith in my ability to achieve my goals. This accomplishement would not have been possible without them.

Lastly, my thanks and appreciations also to my coursemate in developing the project and people who have wilingly helped me out with their abilities. I very much appreciate for their entire kindness helping during I was copleting my final year project.

ABSTRACT

Water demand is to determine the water supply capacity needed for a particular population. As population is constantly growing, the domestic water demand also increasing. To fulfil the water demands needs, the projected water demand planning have been developed by local authorities. However, there is still have insufficient water supply occur in the some areas. The main objective of this study is to determine future water demand needs for domestic users in Pahang. To achieve the main objective of study, the specific study were performed as follow; develop forecast population growth and compare domestic water demands trends and water supply by district level in Pahang. The statistical analysis of population data and domestic water demands will be made based on the research. Therefore, the several methods will be applied to get information in order to achieve the objectives of study. For this study, the method of data collecting are based on researched from various state report from government agencies, journals, articles and website. An analysis data are developed to forecast population growth and water demand by equation of study. All data analysis were tabulate and presented in graphical chart. The period of study was conducted in 10-years interval from 2020 to 2050. The result of the study shows the forecast population is growing constantly, the domestic water demand will be increased. The comparison between domestic water demand and water supply have been analysed to identify the problem that will occur in the future. In conclusion, the research objective of this study are achieved when the forecast of population growth and domestic water demand trends have developed by district level in Pahang. If the water supply does not meet the demand caused by population growth, this might be a problem for domestic users someday.

ABSTRAK

Permintaan bekalan air adalah air yang diperlukan untuk kegunaan penduduk di setiap kawasan. Peningkatan populasi penduduk telah menyebabkan peningkatan bekalan air. Untuk memenuhi permintaan bekalan air, kajian terhadap unjuran permintaan air akan datang telah dikaji oleh pihak kerajaan. Namun begitu, masih juga terdapat permasalahan gangguan bekalan air bersih yang berlaku di beberapa kawasan. Objektif utama kajian ini adalah untuk menentukan masa depan keperluan permintaan air untuk pengguna domestik di Pahang. Untuk mencapai objektif utama kajian, kajian khusus telah dijalankan seperti berikut; membangunkan pertumbuhan penduduk ramalan membandingkan permintaan bekalan air domestik dan air dibekalkan oleh peringkat daerah di Pahang. Analisis statistik data populasi penduduk dan permintaan air domestik akan dibuat berdasarkan penyelidikan. Oleh itu, beberapa kaedah akan digunakan untuk mendapatkan maklumat bagi mencapai objektif kajian. Untuk kajian ini, kaedah pengumpulan data adalah berdasarkan kajian dari pelbagai laporan negeri daripada agensi-agensi kerajaan, jurnal, artikel dan laman web. Data analisis dibangunkan untuk unjuran pertumbuhan penduduk dan air permintaan baru oleh persamaan pengajian. Semua analisis data adalah jadualkan dan dibentangkan dalam carta grafik. Tempoh pengajian dijalankan pada 10-tahun selang dari 2020 untuk 2050. Hasil kajian menunjukkan penduduk ramalan berkembang sentiasa, permintaan air domestik akan meningkat. Perbandingan antara permintaan air domestik dan bekalan air telah dianalisis untuk mengenal pasti masalah yang akan berlaku pada masa akan datang. Dari hasil, peningkatan pertumbuhan penduduk boleh menyebabkan kekurangan air. Kesimpulannya, objektif kajian kajian ini tercapai apabila ramalan pertumbuhan penduduk dan trend permintaan air domestik telah dibangunkan oleh peringkat daerah di Pahang. Jika bekalan air bersih tidak dapat memenuhi permintaan yang disebabkan oleh peningkatan penduduk, ini mungkin menjadi masalah kepada pengguna domestik suatu hari nanti.

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W	Average daily water demand
N	Number of type of house
C	Per unit consumption
F	Service factor
D_a	Additional water demand
P_n	Population after ‘n’ decades
P	Present population
c	Rate of change of population with respect to time is constant
I_G	Geometric mean (%)
X	Average increase
Y	Incremental increase
C	Water use per capita
WD_n	Water supply demand in year ‘n’
q	Water supply demand per capita
F_1	Factor of service
F_2	Factor of design
P_t	Population at time, t
T	Time period in years

LIST OF ABBREVIATIONS

WTP	Water Treatment Plant
NWRS	National Water Resources Strategy
PAIP	Pengurusan Air Pahang
JBA	Jabatan Bekalan Air
MPK	Majlis Perbandaran Kuantan
SPAN	Suruhanjaya Perkhidmatan Air Negara
WEPA	Water Environment Partnership in Asia

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Water demand is to determine the water supply capacity needed for a particular population. Water demand could be categorized into domestic, commercial, institutional and industrial. Domestic demand covers usage of water houses and public standpipes for indoor use such as drinking, cooking, personal hygiene, house cleaning, laundry and outdoor use such as gardening, car washing and etc.

Insufficient and adequate supply of water is the greatest single barrier to a healthy population and a productive community (Oguntoyinbo et al., 1983; Ezekiel, 2014). The need for water is constantly increasing because of high rate population growth and urbanization, which have not been accompanied with corresponding growth in water-producing sector. (Musa et al., 2009; Ezekiel, 2014)

From the National Water Resources Study, domestic and industrial water demand for Peninsular Malaysia will increase 3-fold from 9543 Mld (3483 million m 3/yr) in 2000 to 31,628 Mld (11,543 million m3/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. (Faezah, 2012)

According to Haliza (2015), total water demand is divided into 17% for domestic, 21% for industry and 62% for agriculture in Malaysia. However, almost more than quarter of treated water is used by domestic sector. This is because many agriculture and industries use water directly from nature for their use. During 2020, the overall water demand increase annually at the rate of 4% and is anticipated to be around 20 billion m^3. The annual domestic and industrial water demand will increase to almost half of the total by that time while irrigation water demand will remain steady at just over 10 billion m^3. For both time and space, this is only 3.5% of total annual runoff but due to the variation of rainfall. Some regions of high water demand are moving towards the limits of readily available water and water stress has become more prevalent over the past few years. Some parts of the country are affected by culminating in the water crisis. Combined with growing demand, unmatched water supply, decrease of river basin management and from a growing population, the nation is heading towards a water crisis.

As population is growing constantly, the water demand will be increased each and every day. The activities of domestic water uses have become important to people for their household activities. During the last few decades, Malaysia is experiencing rapid economic growth. The demand for water is rising as the population is expanding and the country is developing. (Ahmed et al., 2014)

1.2 PROBLEM STATEMENT

To fulfil the water demands needs, the projected water demand planning have been developed by local authorities. However, there is still have insufficient water supply occur in the some areas such as water shortage and clean water supply. In Malaysia, supply of water faces a lot of challenges such as prolonged drought, water rationing, seasonal floods, water pollution, non-revenue water and impacts of climate change which require some authorities to better manage our country consumption of water.

According to article SPAN (2016), the water supply problem in Pahang still occur because the water level has not reached the normal level. In Pahang, due to a reduce in the level of Sungai Pahang, withdrawal of water supply in the Water Treatment Plant (WTP) Lubok Kawah reduced from 99.6 Mld to 92.2 Mld with reduction of 7%. The district in Pahang such as Mentakab, Temerloh and Lancang also have face water supply problem with 460 account number affected. Furthermore, two water treatment plants which are WTP Jelai and WTP Batu 9 also affected with the reduced water level from river. The water supply in WTP Jelai also reduced from 16 Mld to 13 Mld and affected the water supply to several areas in Lipis total of 6029 accounts. WTP Batu 9 also has decrease from 290,000 litres per day to 190,000 litres per day with reduction of 33%. WTP Chini that supply water to Felda Chini is also facing a water shortage. Their water supply decrease from 16.3 Mld to 12.5 Mld

Besides that, domestic water demand is increasing due to an increase in per capita consumption. The main cause of scarcity of water is population growth. Besides that, water supply for domestic user were seriously interrupted. If the population growth is increasing so the water demand increase. If the clean water supply could not satisfy the demand due to increase of population growth, this might be problem to the domestic user someday. Therefore, a study is to overcome this problem should be done in order to avoid this situation happen in the future.

1.3 OBJECTIVES

There are objectives need to be achieved for this study. In order to achieve a successful study, there are two objective as a guideline of outcomes have been determined. The objective are;

(i) To develop forecast population growth and domestic water demand trends in State of Pahang
(ii) To compare domestic water demand and water supply in State of Pahang

1.3 SCOPE OF STUDY

There are several scopes of study that should be followed in order to achieve the goals of study. Thus, the scope of this study includes the area of study, the period of this study and the data that need to be obtained.

The area of this study located in Pahang Darul Makmur. There is consists of eleven (11) districts namely, Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Pekan, Maran, Raub, Rompin, and Temerloh. Pahang was choose as study area to know population growth on water demand trends for domestic user. Kuantan is the state capital of Pahang, Malaysia. It is near the mouth of the Kuantan River and faces the South China Sea. Kuantan is the ninth largest city in Malaysia. The total area of Kuantan City is 2,065 square kilometers. The city has a high area in the west, low land in the central section and swampy area in the coastal region facing the South China Sea.

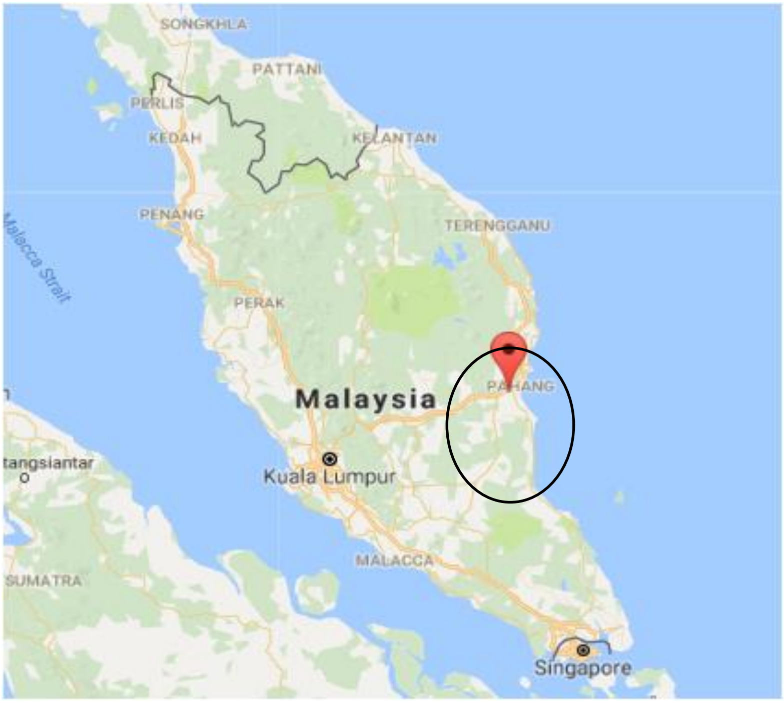

Figure 1.1: Peninsular Malaysia Map

Source: Google Map

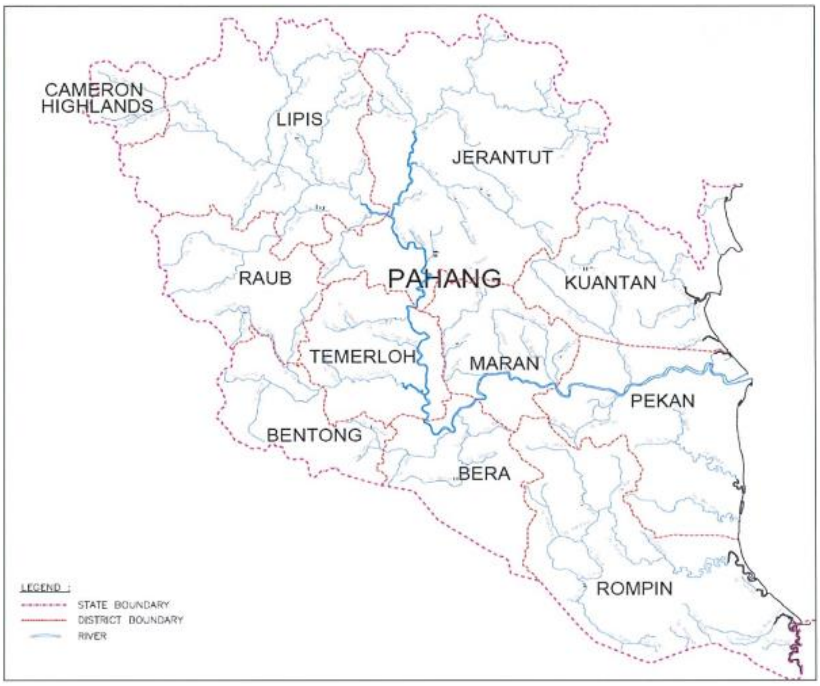

Figure 1.2: Map by districts in Pahang

Source: NWRS (2011)

The period of study will obtain by 10-years intervals from 2020 to 2050. State/ Federal Government agencies and local authorities is where an analysis of study will be made based on the data and interview gained from the state/federal government agencies and local authorities such as Jabatan Bekalan Air (JBA), Pengurusan Air Pahang (PAIP) Majlis Perbandaran Kuantan (MPK) and others in order to establish the model forecasting for population growth and water demand in each district of Pahang.

1.4 SIGNIFICANCE OF STUDY

This important of this study can be interpreted population growth and domestic water demand. Developed of population growth at district level in Pahang is increase year by year. So it indicates that domestic water demand will increase. With the increase of demand, it also will face the high chances to meet water crisis at Pahang. It also show how water demand is directly proportional to the water supply at Pahang.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research related to water demand. A review of other relevant research studies is also provided. Substantial literature has been studied on definition water demand, type of water demand, technique estimation of water demand and forecasting population growth and also issues of water demand. The review is detailed so that the present research effort can be properly tailored to add to the present body of literature as well as to justify the scope and direction of the present research effort.

2.2 TYPE OF WATER DEMAND

In the review of the National Water Resources Study, the water demand is made up of five components which is domestic, industrial, commercial, institutional. There are many data relating to water production and consumption have been collected for this purpose from relevant parties especially the state water service providers. This includes information on dams, WTPs, non –revenue water and project under implementation.

According to the research by World Committee for Water (2003), population at all cities will increase into three fold in every years. Hence, by approaching year 2040 about 2.5 million population at about 29 countries will face sufficient of water supply. Besides that, according to Dato' Ir. Lim Chow Hock, Department of Irrigation and Drainage Malaysia was said in the dialogue on Water Environment Partnership in Asia

(WEPA), rivers provide main water sources for 97% of water supply for domestic, industrial and agriculture.

Table 2.1: Total domestic, industrial and irrigation demand for Peninsular Malaysia

Type of water demand		**1998**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Domestic	Million m3/yr	1833	2029	2987	3862	4606	5251	5904
	Mld	5022	5558	8184	10582	12622	14388	16176
Industrial	Million m3/yr	1260	1454	2592	3561	4330	5016	5639
	Mld	3453	3985	7101	9756	11863	13743	15452
Domestic and Industrial	Million m3/yr	3093	3483	5578	7423	8936	10267	11543
	Mld	8475	9543	15285	20338	24485	28131	31628
Irrigation	Million m3/yr	7350	7350	6517	6517	6132	6132	6132
	Mld	20139	20139	17857	17857	16802	16802	16802
Total Demand	Million m3/yr	10443	10833	12095	13940	15068	16399	17675
	Mld	28614	29682	33142	38195	41287	44933	48430

Source: WEPA (2008)

In Iran, mountains and deserts with low availability of suitable water account for 52% of the total 1.65 million km^2. Although the long-term average precipitation is about 250 mm/yr, most of the territory receives less than 100 mm/yr of rainfall and the annual withdrawal of water has already exceeded the renewable water resources. From the total water consumption in Iran, 95% is used in agriculture, 4% for domestic water supply and 1% in industry. In rural areas, especially in arid and semi-arid regions access to a sustainable and adequate supply of clean water is critical. Therefore, determining the number of people who will be served, their per capita use, and the factors that affect the water consumption is very important in management of water resources appropriate as potable water. (Keshavarzi et al., 2006)

2.2.1 Domestic Water Demand

Domestic water use is water used for indoor and outdoor household purposes. According to Villarreal and Dixon (2005), the sources of drinking water supply in Sweden are groundwater and surface water from rivers, stream and lakes. About 75% of the Swedish municipal water works depend on lakes and streams for supplying drinking water and about 25% uses natural groundwater. Water in Sweden is as yet a rich regular asset, where just 0.5% per year of the available resources is utilized. However, widespread urbanization and the consequent production of large-scale centralized system local drinking water supply frameworks vulnerable o shortages and water quality deterioration.

Domestic water demand forecast are needed for a wide of arranging study, frequently by different water benefits companies and other water planning organizations. During past 30 years, considerable effort has been made on the change of water demand forecasting procedures. The fundamental consideration has been centered around disaggregation of interest into different companies, improving forecasting methods, reducing forecasting uncertainty, integration of demand management effect and realizing the benefits of computer management. Since demand forecast and demand management are interrelated and involve many numerous factors which may complicate the analysis methodology, emphasis must be made on building up a robust system that can make the forecasting and management process integral, flexible and reliable as much as possible.

According to the National Water Resources (2011), the domestic water demand is determined by the population and the consumption per person. The domestic water demand to each community can be classified according to its ultimate use such as domestic, commercial. Industrial, public, loss and waste. Domestic water consumption with significant component of the total water use varies according to living standards of the consumers in urban and rural areas. However, rural households use water for both indoor and outdoor purposes. Indoor water use includes consumption for drinking, cooking, hygiene and others purpose such as air conditioner. Outdoor activities include car washing, livestock watering, garden and small-scale greenhouse watering and yard cleaning (Keshavarzi et al., 2006).

HJ Van Zyl (2008) have highlighted the extension of urban areas, increased infrastructural development and steady requirement for potable water services, have conveyed to light the significant of accurate water demand estimates in municipal water services planning and design in South Africa. Water demand estimates are used to calculate peak water demand and sewer flows and hence determine municipal water and sewer infrastructure requirements. Inaccurate estimates result in a lack in fundamental plan data that could prompt insufficient service due to over-, or under-outline of water supply framework. A key input therefore in municipal water services planning and design is the estimation of present demand, and the prediction of future water demand. Likewise, South Africa is a water-scarce country that continually strives to apply its accessible water resources in the most proficient and equitable manner. Different users including industry, domestic, agriculture and the nature, compete for the assessible resources and must be granted an equitable and adequate share. Inaccurate estimates of the water needs of different user may well result in inequitable distribution.

2.2.2 Industrial Water Demand

Water in industry is very important nowadays especially for cooling, transportation and washing and the completed product needed. The list of users have been leaded by thermal and atomic power generation. It requires an incredible measure of water to cool assemblies. The volume of water for industrial are distinctive between branches of industry. It also include different type of production, based on the technology of the process of manufacturing.

The industries that deliver metal, wood and paper items, chemicals, fuel and oils, and those priceless grabber utensils you use to get your ring out of the refuse transfer are significant clients of water. Most likely every fabricated items utilizes water used for such as purposes as fabricating, processing, washing, diluting, cooling or transporting an items, fusing water into an items or for sanitation needs inside the assembling office. Some industries that use a lot of water deliver such items a food, paper, chemicals, refined oil or essential metals.

The combination of water demand management and cleaner production concepts have brought about economical and ecological benefits. The biggest challenge for developing countries is how to retrofit the industrial procedures, which at times are based on outdated technology, within financial, institutional and legal constraints. Processes in closed circuits can decrease water intake substantially and minimize resources input and the subsequent waste thereby reducing pollution of finite fresh water resources. These three industries were study in Bulwayo, Zimbawe to recognize potential opportunities for decreasing water intake and material usage and minimising waste. The industries included of a wire galvanizing company, soft drink manufacturing and sugar refining industry. The outcomes demonstrate that the wire galvanized industry could save up to 17% of water by recycling hot extinguish water through a cooling system (Gumbo, Mlilo, Broome, & Lumbroso, 2003)

Observing of water use in industries in ventures is picking up significance due to increasing competition and stringent condition standards. Water is at no time in the future seen as a free items. Further, inventive innovations, along with modification of existing technologies are commercially available to decrease process water consumption. In generally, decrease in industrial wastewater can be accomplished through one or a combination of the following measures such as process modification or change in raw materials to reduce water consumption, coordinate reuse of wastewater, in-plant reuse of reclaimed wastewater and use of treated wastewater for non-industrial purposes (Saha, Balakrishnan, & Batra, 2005)

According the National Water Resources, the projected number of workers in the manufacturing sector was obtained from demography projection. The unit for the water consumption per worker per day is litre per worker per day (lwd). By using the forecast number of workers in the manufacturing factor, the industrial water demand was estimated and estimated daily water consumption per worker as follow:

Industrial consumption per day = projected number of workers in the manufacturing sector x water consumption per worker per day

The table shows the water consumption per worker per day applied in the projection at State of Pahang. The projection assumes that the consumption per worker per day increase drastically in the period of projection.

Table 2.2: Summary of industrial consumption per worker per day (l/w/d)

District	2010	2015	2020	2030	2040	2050
Bentong	400	420	440	510	610	760
Cameron Highlands	100	105	110	130	155	190
Jerantut	400	420	440	510	610	760
Kuantan	900	945	990	1140	1350	1750
Lipis	100	105	110	130	155	190
Pekan	900	945	990	1140	1350	1750
Raub	400	420	440	510	610	760
Temerloh	900	945	990	1140	1350	1750
Rompin	400	420	440	510	610	760
Maran	900	945	990	1140	1350	1750
Bera	400	420	440	510	610	760

Source: National Water Resources (2011)

2.2.3 Institutional and Commercial Water Demands

National Water Resources stated that commercial demand includes by shophouses, shopping complexes, offices, hotels, commercial seaport and airports. As commercial activities are very much dependent n the size of the population, it is therefore, not surprising that commercial demand is closely related to domestic demand. For institutional demand includes demand by government offices, schools, institution of higher learning, army camps, naval bases, hospitals. Schools also dependent on the population. Therefore, its demand will be closely related to the domestic demand.

The table below shows the percentages used in the projection. Both commercial demand and institutional demand are projected as a percentage of the domestic demand.

Table 2.3: Commercial demand and institutional demand

Commercial Demand		**Institutional Demand**	
Urban	Rural	Urban	Rural
20	15	15	10

Source: National Resources Water (2011)

2.2.4 Agriculture Water Demand

Agriculture is the main consumptive user of water resources management in Malaysia. It is estimated nearly 70% of consumptive user of water resources in Malaysia. Water will channel from agriculture or ecological reserves, aquifers to achieve the enlargement of water supply. Review a large number of cities in the world and increase the water supply. There is a long tradition in several places urban agriculture. Usually, people need larger amounts of water for irrigated agriculture than domestic and industrial uses. For example, paddy rice and dry area. Water is redirected for human uses and effects of environmental rarely occur.

According to Gunther (1998), urban agriculture is as old as human settlements and cities. During the last decade, the urban population of the world has increased 2.5 times. 80% of those situated in creating nations, the same period increase to 23 of megacities. Individuals have constantly attempted to enhance their living conditions by development of yields in the region of their houses. Urban areas in Africa develop fastest, more than 10% every year and the development is going ahead with no control generally in slum and squatter areas without access to safe potable water and sanitation facilities, without work and probability to get enough food. Urban agriculture may convey an option for those individuals.

Water consumption for agriculture was 9 billion m^3, accounting for over 75% of the total water use in country in 1990. There is no plan to expand the paddy irrigation area further, but it is imagined that whole area will be double-cropped. The crop diversification program from paddy to non-paddy crops in marginal paddy lands is anticipated that would decrease the expansion in the overall demand for water system supply. By 2020, the irrigation of water demand is expected to increase to 13.2 billion m^3 but its national share is expected to decrease to 66%. This is because of the streamlining of agriculture activities, particularly paddy irrigation and the greater demand for water from the extending industrial and domestic sectors. (Azhar, 2000)

By directing the river water in the vicinity of the areas from upstream for agriculture plots, the water for agriculture areas in Cameron Highlands is obtained through self-constructed piping using high density polyethylene tubes. The local authority with a minimal annual fee of RM10 payable to the District Land Office have approved the type of irrigation used in agriculture area in the District. For the moderately larger agriculture plots a impermanent pond would be made upstream and the gathered water be directed to a impermanent distribution pond in the agriculture plot from which water will be appropriated for activity of agricultures. Some of the farmers in Cameron Highlands use modern drip-irrigation system inclusive of fertigation and overhead sprinkler irrigation systems in the open field. During the growth fruit, irrigation is important after sowing until the seedlings grow. There are periods in the enlargement cycle where water will reduce can fundamentally affect yield and quality for most vegetables. (Barzani et al., 2009)

The worldwide interest for water in agriculture will increase over time with expanding population, rising earnings and changes in dietary inclinations. Expanding water demands by industrial and urban users and water for the environment will heighten the competition. In the meantime, water shortage is increasing in a few essential agriculture areas. Furthermore, the challenges confronting agriculture water management today are unique in relation what they were a few decades ago. The worldwide population has develop and they demand more agriculture commodities. Additionally the sort of food they consume is moving towards more meat, fish, dairy, and sugar. The product is normally require more water than customary staple foods such as grains and tuber crops. (Fraiture & Wichelns, 2010)

2.3 ISSUE OF WATER DEMAND

According to Mr. Alias, Director Planning and Development Department Kuantan Municipal, the water supply department is under the state government. Water supply is the most pressing issue facing Kuantan City, followed by traffic congestion and pollution. The water reservoir is undersized and cannot meet the demand. Many public developments are rejected because of this, and we receive many complaints from the public. Domestic waste water is often discharged directly into drains, increasing the risk of river pollution and creating a threat to marine life. Solid waste management is limited to a dumping ground mainly for domestic waste. Industrial waste is being dumped in many places.

There are four primary rivers in Kuantan City. The Kuantan River is the major source of the water supply, providing 350,000 cubic meters per day. About 78 percent is for domestic use, 18.7 percent for industrial use, and 3.3 percent for agriculture. Water is supplied to a population of 454,422, with 100 percent coverage. In 2000 the water system supplied 85 million cubic meters of water per year. By 2010 this figure is expected to rise to 195 million.

The Kuantan Water Supply Department is headed by the District Engineer. The department faces many challenges, including deteriorating pipes, pipes not able to handle high pressures, plants running at maximum capacity, lack of finances, low water pressure, lack of ability to reach new development areas, and maintaining pipes that are located under roads. The department is currently upgrading three reservoirs to increase their capacity, and constructing a new reservoir. There is also a number of new piping and water tanks projects under way. This work is all funded by loans from the Malaysian federal government. Domestic water users pay an increasing charge as water consumption increase. This is to encourage and expedite the growth of industry in Pahang State and especially Kuantan City.

Reviewing the star online (2014), 28 of the 80 water treatment plants throughout Pahang recorded low levels due to the drought. The Public Relations of Pengurusan Air Pahang Berhad (PAIP) Datuk Jafar Abdullah said the affected plants were located in eight districts, which obtained seven of the plants were in the district of Lipis, Jerantut, Temerloh, Maran, Pekan, Bentong and one each in Rompin and Bera. He said if the drought prolonged further, it will lead to the plants that record low water levels to be closed down.

Moreover, in Raub about RM2 million allocation is provided to overcome the water shortage are common in this area. Manager Corporation Air Pahang Berhad (Pipe) Raub District, Azeri Abdul Aziz said the installation of Mild Steel pipe double the size of 300 millimeters are being made to overcome burst pipe resulting in residents without water. He said, the existing pipe to channel water from the Loji Sungai Bilut to the main water treatment where is Abestos Cement aged over 50 years due to the use of old pipes, pipe bursts often occur to make it difficult for consumers. (Sinar, 2013)

2.4 ESTIMATION OF WATER DEMANDS

Water demand is the total amount of water needed by the consumer in the area of their needs and activities in a specified period time. The amount of water demand varies from season to season, day to day and hour to hour, depending on climate, topographic, characteristic of the environmental concern, population, industrialization and other factors.

Based on Malaysian JKR Standards, the water demand formula for housing estate is as follows:

$$W = \Sigma(N \, x \, C) \, X f + D_n \qquad (2.1)$$

Where,

W = Average daily water demand

N = Number of type of house

C = Per unit consumption

F = Service factor

D_a = Additional water demand

There are many methods for calculating expected water demands. One of the method is to calculate a design parameter called the Population Equivalent (PE) of a catchement and convert is to a flow rate. The PE is an estimate of the usage made of sewage facilities. It is not measure population.

For residential areas the population equivalent is calculated as five per dwelling and is direct measurement of the population in an area. However, for commercial areas it is calculated from the floor area, which is considered to be proportional to the number of people using a premises during the day. In this case it does not reflect the population living in an area.

The following table shows how the PE is calculated:

Table 2.4: Estimation of population equivalent

Type of Establishment	Population Equivalent
Residential	5 per house
Commercial: Includes offices, shopping complex, entertainment / recreational centres, restaurants, cafeteria and theatres	3 per 100m2 gross area
School / educational Institutions	
- Day schools / Institutions	0.2 per student
- Fully residential	1 per student
- Partial residential	0.2 per non- residential student 1 per residential student
Hospitals	4 per bed

Hotel with dining and laundry facilities	4 per room
Factories, excluding process water	0.3 per staff
Market (Wet Type)	3 per stall
Market (Dry Type)	1 per stall
Petrol kiosks / Service stations	15 per toilet
Bus Terminal	4 per bus bay
Taxi Terminal	4 per taxi bay
Mosque / Church / Temple	0.2 per person
Stadium	0.2 per person
Swimming Pool or Sport Complex	0.5 per person
Public Toilet	15 per toilet
Airport	0.2 per passenger / day 0.3 per employee
Laundry	10 per machine
Prison	1 per person
Golf Course	20 per hole

Source: Indah Water Konsortium

2.5 TECHNIQUE FORECASTING FUTURE OF POPULATION GROWTH

Design of water supply and sanitation scheme is based on the projected population of a particular city, estimated for the design period. Any underestimated value will make system inadequate for the purpose intended; similarly overestimated value will make it costly. Changes in the population of the city over the years occur, and the system should be designed taking into account of the population at the end of the design period. Factors affecting changes in population are increase due to births, decrease due to deaths, increase/ decrease due to migration and increase due to annexation. The present and past population record for the city can be obtained from the census population records. After collecting these population figures, the population at the end of design period is predicted using various methods as suitable for that city considering the growth pattern followed by the city.

Table 2.5: Water supply state of Pahang 2014/2015

Year	Account Holder	Population received water supply	Pahang average population	Population received water supply (%)
2014	388278	1553112	1592045	98
2015	393425	1581569	1615926	98

Source: Buku Data Asas Pahang 2014/2015

2.5.1 Service Factor

National Water Resources stated the service factor is the potential percentage of the population served by the public water supply system. A service factor of 90% means that the water distribution system can satisfactorily covers 90% of the area and the population located in that area can get easy access to a public water supply. However, it does not IMPLY that 90% of the population has service connection.

The population served by the water supply system is thus calculated as follows:

$$\textit{Population served} = \textit{service factor x total population} \qquad (2.2)$$

The service factors for Pahang abstracted from Malaysia Water Industry Guide are summarized in Table 2.7. It is assumed in the projection that 100% service factor will be achieved by the state by 2010.

Table 2.6: Summary of service factor

Year	Service Factor	
	Urban (%)	Rural (%)
2008	98	89
2009	100	96

Source: National Water Resources Study (2011)

2.5.2 Arithmetical Increase Method

This method is suitable for large and old city with considerable development. If it is used for small, average or comparatively new cities, it will give lower population estimate than actual value. In this method the average increase in population per decade is calculated from the past census reports. This increase is added to the present population to find out the population of the next decade. Thus, it is assumed that the population is increasing at constant rate.

$$P_n = P + nc \tag{2.3}$$

Where,

P_n = Population after ‘n’ decades
P = Present population
c = rate of change of population with respect to time is constant

2.5.3 Geometrical Increase Method

In this method the percentage increase in population from decade to decade is assumed to remain constant. Geometric mean increase is used to find out the future increment in population. Since this method gives higher values and hence should be applied for a new industrial town at the beginning of development for only few decades. The population at the end of nth decade ‘P_n’ can be estimated as:

$$P_n = P\ (1 + I_G/100)^n \qquad (2.4)$$

Where,

I_G = Geometric mean (%)

P = Present population

N = no. of decades.

2.5.4 Incremental Increase Method

This method is modification of arithmetical increase method and it is suitable for an average size town under normal condition where the growth rate is found to be in increasing order. While adopting this method the increase in increment is considered for calculating future population. The incremental increase is determined for each decade from the past population and the average value is added to the present population along with the average rate of increase. Hence, population after nth decade is;

$$P_n = P + n.X + \{n\ (n+1)/2\}.Y \qquad (2.5)$$

Where,

P_n = Population after nth decade

X = Average increase

Y = Incremental increase

CHAPTER 3

RESEARCH AND METHODOLOGY

3.1 INTRODUCTION

The purpose of this chapter is to describe the methods of this study to fulfill the objectives based on literature review and previous study that related to the water demand. This study will focus to domestic water demand. An organized methodology is needed to ensure the effectiveness of the study. All needed information and data can be collected through a well-organized procedures which outlined various step in collecting data and information.

The aim of the study is to determine the future water demands trends for domestic users by district level in State of Pahang. In order to achieve of the objective of study, the statistical analysis of population growth and water demands will be made based on the research. Therefore, several methods and procedures will be applied to get the required information in order to achieve the objectives of study. The preliminary study and identifying problem statement due to the study have been carried out at the beginning. The flow chart of methodology begins with the data collecting, pre-processing data, processing data, result and discussion.

3.2 FLOW CHART OF THE METHODOLOGY

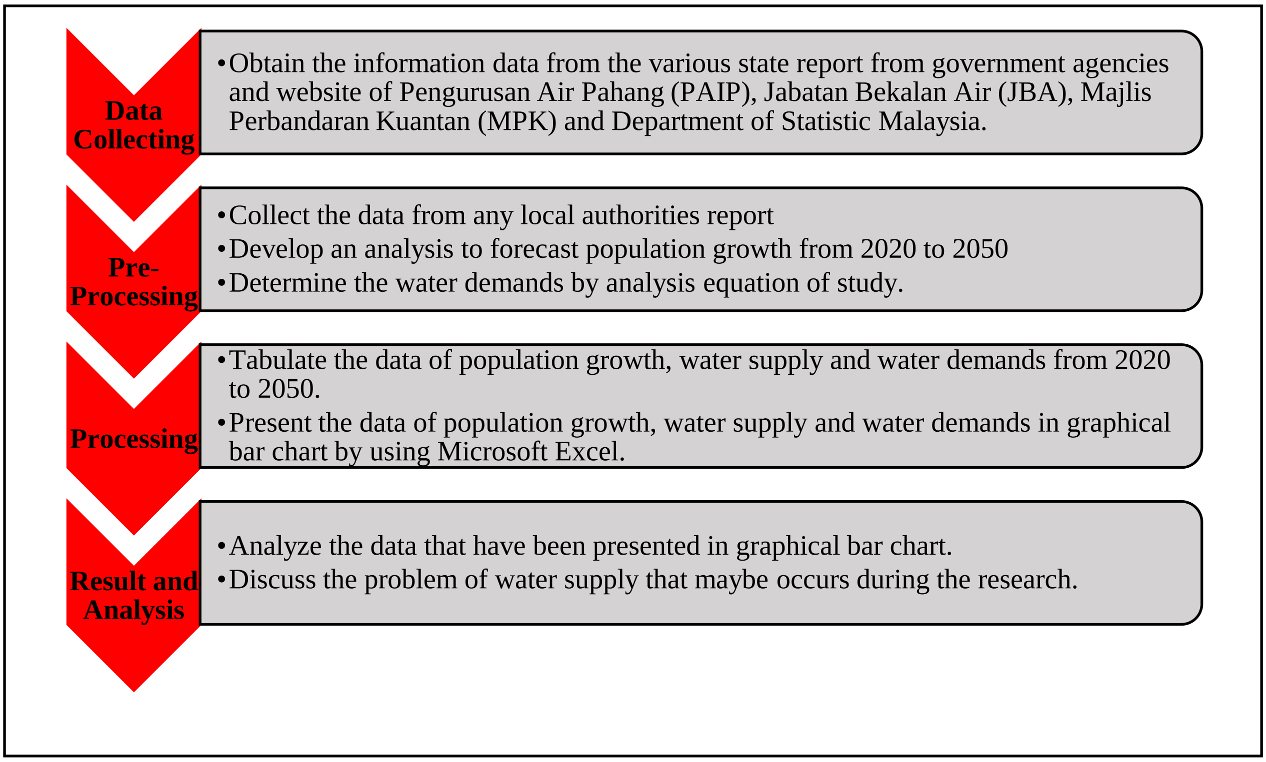

Figure 3.1: Flow chart of methodology

3.3 DATA COLLECTING

Data collecting is the systematic approach to gathering and measuring information from a variety of sources to get a complete and accurate picture of an area of interest. Data collecting enables a person or organization to answer relevant questions, evaluate outcomes and make predictions about future probabilities and patterns.

For the study, the methods of the data collection are literature review and interview the government agencies such Pengurusan Air Pahang (PAIP), Jabatan Bekalan air (JBA) and Majlis Perbandaran Kuantan (MPK). The purpose of the interview the related government agencies is to get the some data of population growth year by year, the water supply and domestic water demand trends for State of Pahang. For the literature review, the data information of the study will be get from the various state report from government agencies, journals, articles and website that related to this study.

3.4 PRE – PROCESSING

Pre-processing describes any type of processing performed on raw data to prepare it for another processing procedure. Normally used as a preliminary data mining practice, data pre – processing changes the data into a format that will be more easily and effectively processed for the purpose of the user. For example in a neural network. There are a number of different tools and methods used for pre-processing including sampling, which selects a representative subset from a large population of data which manipulates raw data to produce a single input which removes noise from data which organizes data for more efficient access and feature extraction, which pulls out specified data that is significant in some particular context.

3.4.1 Water Demand Estimation

The estimation of water supply demand can be made by analyze through total population that being supplied with water, water use per capita, factor of services, factor of design and factor of additional demand.

The estimation of water use usually is planning for the vertical years less than 20 years with water supply scheme for every 5 years. Plan that exceeds more than 20 years normally will cause problem because the estimation of demand is not accurate. However, the age limit for components of main structure such dams and reservoirs normally will not exceed more than 50 years.

3.4.1.1 Basic estimation water supply for domestic use

$$D_D = P \times F \times C \qquad (3.1)$$

Where,

D_D = domestic demand
P = population supplied with water
F = percentage population supplied with water
C = water use per capita

3.4.1.2 Water Supply Demand

The formula to estimate the water supply demand in the following:

$$WD_n = P_n \ x \ q \ x \ F_1 \ x \ F_2 \ \ldots\ldots + D_m \qquad (3.2)$$

Where,

WD_n = water supply demand in year 'n'
P_n = numbers of population projection in year 'n'
q = water supply demand per capita
F_1 = factor of service
F_2 = factor of design
D_m = additional demand

3.4.1.3 Water Supply Demand Per Capita

$$Water\ demand\ per\ capita, q = \frac{Total\ of\ water\ needs\ in\ a\ year\ (liter)}{365\ \text{x number of person}-\text{day}} \qquad (3.3)$$

Certain authorities have their own per capita value. As a guide, normally the demand per capita can be dividing into few categories such:

Urban (town) – 230 - 300 liter/person/day
Semi-urban – 180 - 280 liter/person/day
Area in between the border of urban area which the level of socio-economy and the water use is between the use at urban and rural area
Rural – 135 -180 liter/person/day

However in Malaysia, the value is 225 litre/ person / day.

3.4.1.4 Service Factor

Factor of service pictured the percentage of population which will be supply with water. Because of Malaysia is a developing country, thus the sufficient financial budget will be a barricade to the 100% water supply. Therefore, the authorities' party of water supply will set the goals and policies due to the financial budget to supply enough water to the consumers.

Calculation are based on the following relationship:

$$\text{Service Factor} = \text{Population Served} / \text{Total Population} \tag{3.4}$$

3.4.1.5 Design Factor

Even though demand per capita is already decided accordance to the category of area and use. However, there are still differences on the water use from month to month due to season factors, climates, community behaviour, industrial activities, commercial and agriculture. In order to balance the differences, factor of design is introduced to ensure the continuality of water supply. The values for factor of design which is being use until now are:

Table 3.2: Design factor for water demand

Use	Factor
Domestic	2.5
Commercial/ School	2.5
Light Industry	1.5
Specific Industry	1.0

Source: (Ramzi, 2009)

3.4.2 Projection of Population

The census population record can be used as a basic of forecast in order to forecast the increasing water demand in a design period, statistics of population and industrial development. The data collection could be taken from these following sources such as Malaysia Statistic of Department, Local District Office, Federal and States Economy Planning Unit and related other agencies or recent report.

3.4.2.1 Forecast of Future Population Projection

Future population are estimated using the standard procedure for projecting total population based on rates of growth:

$$P_t = P_0 e^{rt} \qquad (3.5)$$

Where,

P_0 = population in the base year
P_t = population at time, t
R = rate of population growth and
T = time period in years

3.5 PROCESSING

Processing is an operations performed on a given set of data to extract the required information in an appropriate form such as diagrams, reports or tables. Moreover, processing also is manipulation of input data with an application program to obtain desired output as a graphic, numeric or text data file.

After analyze the equation, tabulate the data of population growth, water supply, water demands from 2020 to 2050. Then, present these data into a graphical bar chart by using Microsoft Excel

3.6 RESULT AND ANALYSIS

At this method, several discussions and conclusion will be discussed based on the analysis. The discussion are based on the final analysis and some suggestion and recommendations will be made in order to improve the strategy water resources planning State of Pahang in State Pahang. Hence, there is no insufficient water in the future.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

This chapter will show the analysis of data of population and domestic water demand in this study. The data collecting has been analyzed by using the equation to get the result.

4.2 DATA COLLECTING

Some of collected data were obtained from the local auhorities report. The equation that used is come out from the previous study. Therefore, the data that have got were presented in the tables and graphical bar chart.

4.3 ANALYSIS OF POPULATION GROWTH

Data analysis of forecast population in Pahang are presented in the various local authorities reports which are published by the States government. In this study, state forecasts population are derived by using the equations in Chapter 3.

Table 4.1 shows the forecast population growth in Pahang at 10-year intervals from 1995 to 2050. It shows a population of 1192454 in 1995 and 4492505 in 2050. The populations are increase gradually for every 10-year intervals when Malaysia is expected to achieve the status of developed country. The data of the population were obtained from National Water

Resources Strategy Report.

Table 4.1: Forecast population growth in Pahang from 1995 to 2050

Year	Forecast Population (Person)
1995	1192454
1997	1257885
2000	1408413
2010	1939235
2020	2470056
2030	3144206
2040	3818355
2050	4492505

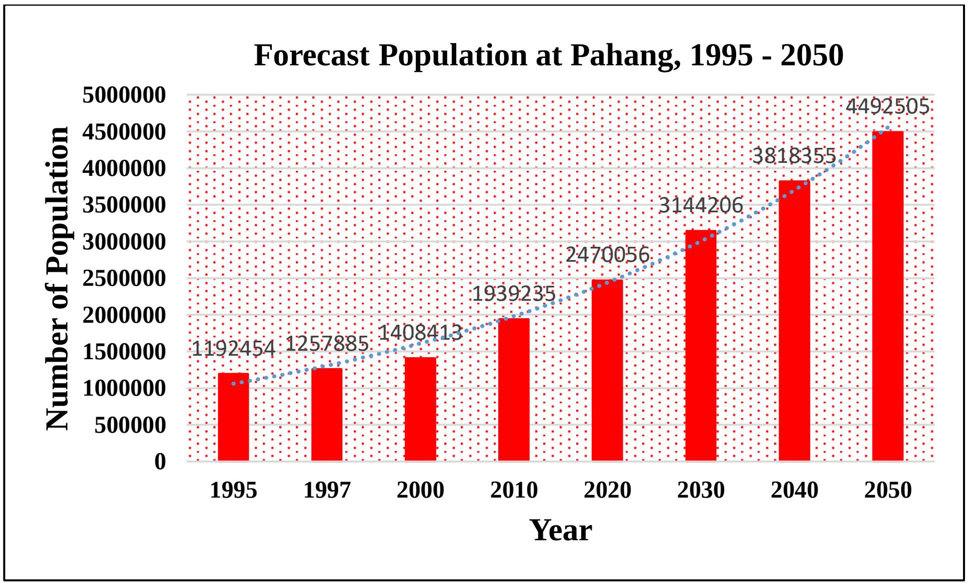

Figure 4.1: Graph of forecast population at Pahang from 1995 to 2050

Above is the graph of forecast population at Pahang by using bar graph analysis. As shown in Figure 4.1, the forecast population growth in Pahang had increase gradually from 2470056 in 2020 to 4492505 in 2050. The state is projected to grow approximately 82%.

The Table 4.2 shows the forecast population in Pahang are projected for 30 years at 10 years interval from 2020 to 2050, using data from 2015 as the baseline. It recorded a population of 1623300 in 2015 according to Buku Data Asas Pahang 2014/2015. The forecast population from 2020 to 2050 have derived by using equation 3.5.

Table 4.2: Forecast population growth in Pahang from 2020 -2050 by using data 2015

Year	Forecast Population , person
2015*	1623300
2020	2084358
2030	3436526
2040	5665872
2050	9341445

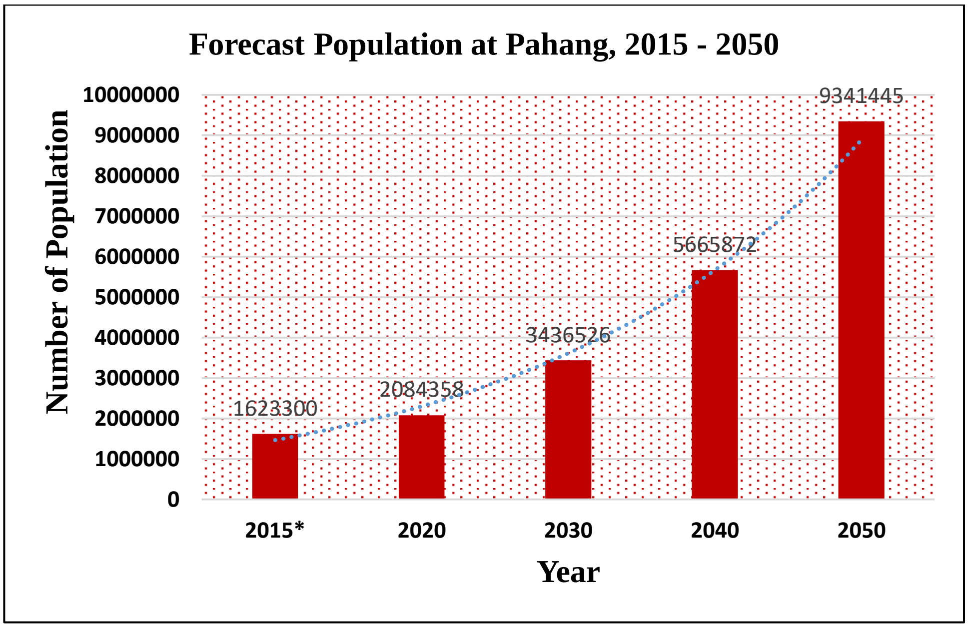

Figure 4.2: Graph of forecast population at Pahang from 2020 to 2050

The graph chart below is plotted based on the Table 4.2 to show the pattern of increasing of the forecast population that have been derived by using equation 3.5 from 2020 to 2050. The forecast population growth in Pahang is expected to increase more than 100 percent between the years 2015 to 2050, projected from 2084358 in 2020 to 9341445 in 2050 with an increase rate population of about 5%. The estimation of population shows the graph increase drastically from 2015 to 2050.

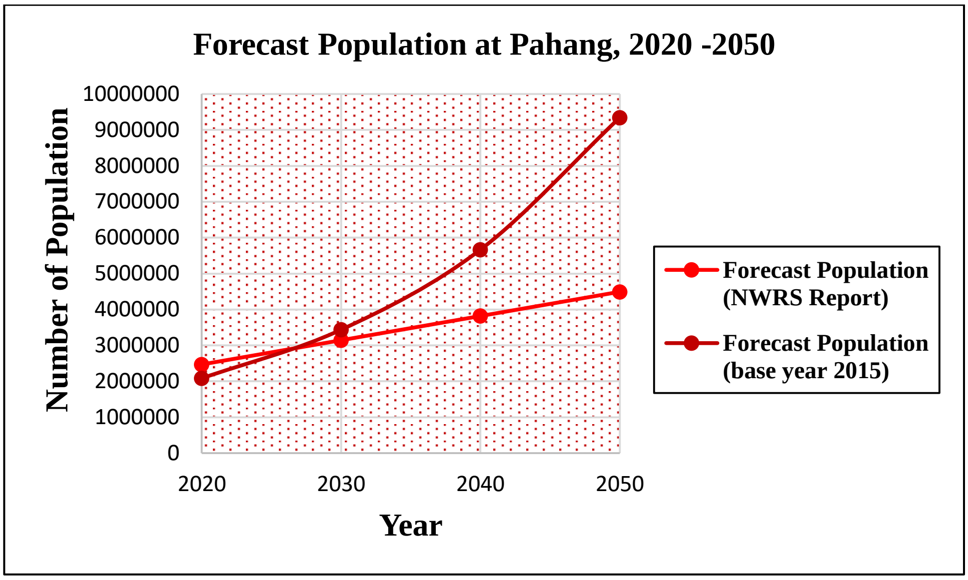

Figure 4.3: The comparison graph of forecast population growth in Pahang from 2020 to 2050

As indicated in Figure 4.3, the forecast population covers the period from 2020 to 2050 with specific projection for the years 2020, 2030, 2040 and 2050. The forecast population from Figure 4.1 is compared to the forecast population in Figure 4.2. From the graph, for 2030, 2040 and 2050 are expected to have more modest growth than previous forecasting. For 2020, the new forecast population that have been derived by equation 3.5 has less than previous projection at about 16%. The highest forecast population shows in 2050. This rapid growth has led to concerns that continued growth will cause an increasing water demands for domestic user in State of Pahang.

Table 4.3 shows the forecast population by district level at Pahang from 1995 to 2050. It consists of ten (10) districts namely, Bentong, Cameron Highlands, Jerantut, Kuantan, Kuala Lipis, Maran, Pekan, Raub, Rompin and Temerloh respectively. However, Daerah Bera was not recorded in this National Water Resources Strategy Report.

Table 4.3: Forecast population by district level at Pahang in 1995 – 2050

District	Year							
	1995	**1997**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Bentong	92334	95370	124214	147859	171504	205382	239259	273137
Bera	-	-	-	-	-	-	-	-
Cameron Highlands	26915	28012	33162	41336	49509	56994	64478	71963
Jerantut	84606	88826	123107	169057	215006	270448	325889	381331
Kuantan	295712	313896	343967	472655	601342	793008	984674	1176340
Lipis	75787	78959	84901	104494	124087	145992	167897	189802
Maran	125207	132189	158889	472655	601342	793008	984674	1176340
Pekan	101112	107893	92414	128069	163724	207012	250301	293589
Raub	82018	84644	89212	109984	130756	152388	174019	195651
Rompin	97349	106425	94682	167495	240308	327258	414208	501158
Temerloh	211414	221673	263865	377117	490369	623561	756752	889944

As mentioned in Chapter 3, the forecast population are made by district level at Pahang by using data 2015 as the baseline year according to Buku Data Asas Pahang 2014/2015. For this study, the forecast population are derived by using equation 3.5 for each districts. It is consists of 11 district including Daerah Bera.

The Table 4.4 presented the estimated population in each district at 10-years interval from 2020 to 2050. The proposed of forecast population using data 2015 is to know the pattern of increasing population growth for each district. From Table 4.4, Daerah Kuantan has highest population and Daerah Bera has lowest population for 2015 at about 517200 and 41700 respectively.

Table 4.4: Forecast Population by district level in Pahang from 2015 to 2050

District	**Year**				
	2015*	**2020**	**2030**	**2040**	**2050**
Bentong	128000	164355	270976	446764	736589
Bera	41700	53544	88279	145547	239967
Cameron Highlands	96500	123908	204291	336818	555319
Jerantut	94800	121726	200692	330885	545536
Kuantan	517200	664098	1094912	1805205	2976280
Lipis	120400	154597	254887	420237	692854
Maran	117600	151001	248959	410464	676741
Pekan	99900	128274	211488	348685	574885
Raub	178700	229455	378308	623724	1028347
Rompin	122900	157807	260179	428963	707241
Temerloh	105600	135593	223555	368580	607686

The comparison of graph forecast population by districts at Pahang have been plotted for 2020, 2030, 2040 and 2050 to estimate future water demands for domestic users. However, there is no recorded at Bera inside NRWS report.

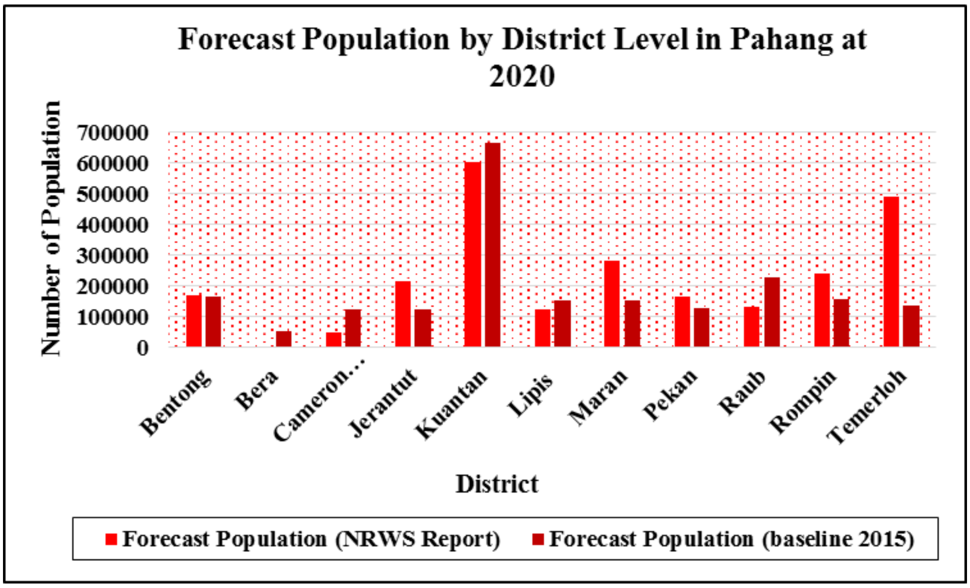

Figure 4.4: The comparison graph of forecast population by district in Pahang for 2020

As shown in Figure 4.4, Cameron Highlands, Kuantan, Lipis and Raub show the highest forecast population growth is projected to be increased than what was projected in NRWS report. The differences between two forecast population growth for Cameron Highlands, Kuantan, Lipis and Raub is about 123908, 350202, 30510 and 98699 respectively. Daerah Lipis has a smaller differences between these two forecast population for 2020 with approximately 24% and Kuantan has a larger different population with approximately 58%. For Daerah Bera, it has estimated about 53544 population. From the Figure 4.4 also can be seen the differences population between Bentong, Jerantut, Maran, Pekan, Rompin and Temerloh is about to 7149, 93280, 450341, 35350, 82501 and 354776 respectively. These differences show the previous forecast population is higher than estimated forecast population by using data 2015. Daerah Bentong has a smaller difference between these two population about approximately 8%. In Temerloh, it has a highest different between two forecast population.

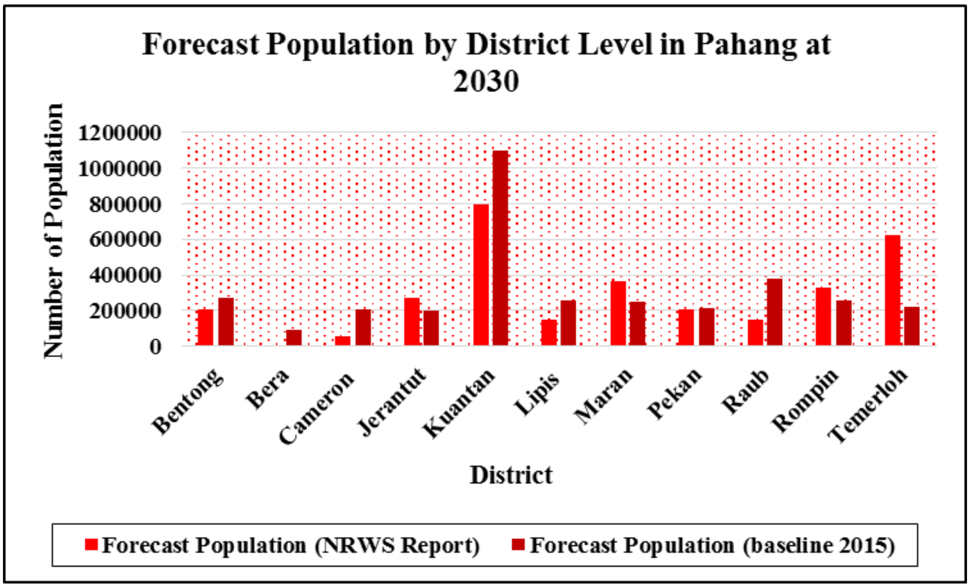

Figure 4.5: The comparison graph of forecast population by district in Pahang for 2030

The Figure 4.5 illustrated the difference of forecast population for 2030. It shows Bentong, Cameron Highlands, Kuantan, Lipis, Pekan and Raub show the highest forecast population growth is projected to be increased than what was previous projected in NWRS report. The differences between two forecast population growth for Bentong, Cameron Highlands, Kuantan, Lipis, Pekan and Raub are about 65594, 147297, 301904, 108895, 4476 and 225920 respectively. Daerah Pekan has a smaller differences between these two forecast population with approximately 2.1% and Daerah Kuantan has a larger different population with approximately 38%. For Daerah Bera, it has estimated about 88279 population. From the Figure 4.5 also can be seen the differences population between Jerantut, Maran, Rompin and Temerloh is about to 69756, 113205, 67079 and 400006 respectively. These differences show the previous forecast population is higher than estimated forecast population by using data 2015. Daerah Rompin has a smaller different between these two population about approximately 26%. In Temerloh, it has a highest different between two forecast population with approximately 64.1%.

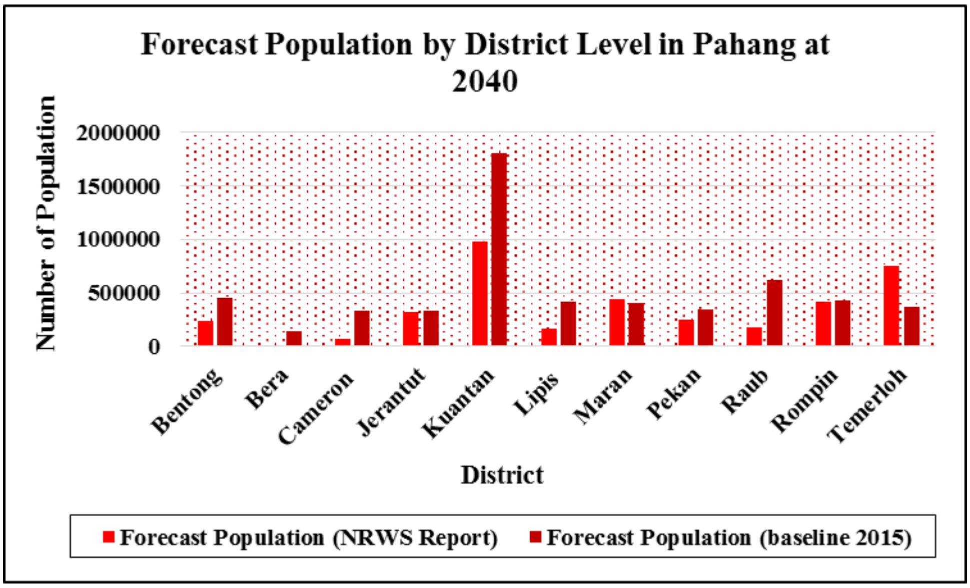

Figure 4.6: The comparison graph of forecast population by district in Pahang at 2040

As shown in Figure 4.6, there is the comparison forecast population by district in Pahang for 2040. Bentong, Cameron Highlands, Jerantut, Kuantan, Lipis, Pekan, Raub and Rompin show the highest forecast population growth is projected to be increased than what was previous projected in NWRS report. The differences between two forecast population growth for Bentong, Cameron Highlands, Jerantut, Kuantan, Lipis, Pekan, Raub and Rompin are about 207505, 272340, 4996, 820531, 252340, 98384, 449705 and 14755 respectively. Daerah Jerantut has a smaller differences between these two forecast population with approximately 1.5% and Kuantan has a larger different population with approximately 83.3%. For Daerah Bera, it has estimated about 145547 population. From the Figure 4.6 also can be seen the differences population between Maran and Temerloh is about to 30413 and 388172 respectively. These differences show the previous forecast population is higher than estimated forecast population by using data 2015. Daerah Maran has a smaller difference between these two population about approximately 6.8% while Daerah Temerloh is the higher difference with approximately 51.3%.

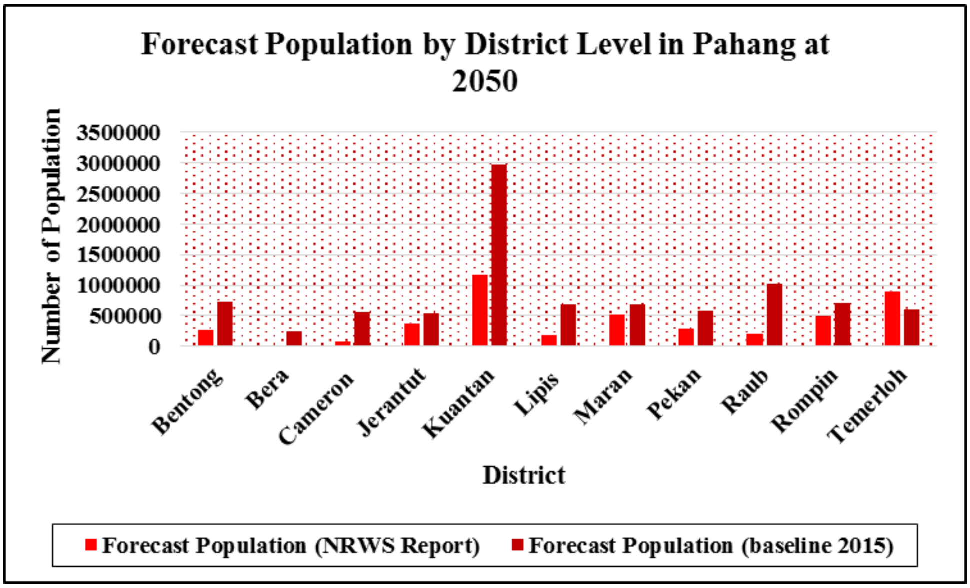

Figure 4.7: The comparison graph of forecast population by district in Pahang at 2050

Figure 4.7 indicated the comparison of forecast population by district in Pahang for 2050. The graph show all the districts except Daerah Temerloh show the highest forecast population growth is projected to be increased than what was projected in NRWS report. The differences between two forecast population growth for Bentong, Cameron Highlands, Jerantut, Lipis, Maran, Pekan, Raub and Rompin is about 463452, 483356, 164205, 1799940, 503052, 157151, 281296, 832696 and 206083 respectively. Daerah Maran has a smaller differences between these two forecast population with approximately 30.2% and Kuantan has a larger different population with approximately 60.5%. For Daerah Bera, it has estimated about 239967 population. From the Figure 4.7 also can be seen the differences population between Temerloh is about to 282258 with approximately 31.7%. These differences show the previous forecast population is higher than estimated forecast population by using data 2015.

4.4 ANALYSIS OF DOMESTIC WATER DEMAND BY FORECAST POPULATION FROM 2020 TO 2050

For this study, the analysis of projection of water demand and water supply for domestic users are derived by using equation 3.1, equation 3.2, equation 3.3 and equation 3.4. The estimation of water demand and water supply for domestic users are generally presented in the form of table after derived by using equation in Chapter 3. The tables that presented consists for each district in Pahang from 2020 to 2050 in 10-years interval.

The Table 4.5 shows the projection of water demand summary by district level in Pahang for 2020. All the estimation that have been derived will be plotted in the form of graphical graph by using Microsoft Excel to identify the pattern of increasing of water demand and water supply for domestic user.

Table 4.5: Projection of Water Demand Summary by district level in Pahang at 2020

District	Projected Population	Domestic Water Demand (Mld)	Total Water Demand (Mld)	Losses (Mld)	Water Demand (Mld)	Water Supply (Mld)
Bentong	164355	48.5	86.3	22.7	109.0	121.2
Bera	53544	15.8	28.1	7.4	35.5	39.5
Cameron Highlands	123908	36.6	65.1	17.1	82.2	91.4
Jerantut	121726	35.9	63.9	16.8	80.7	89.8
Kuantan	664098	195.9	348.7	91.6	440.3	489.8
Lipis	154597	45.6	81.2	21.3	102.5	114.0
Maran	151001	44.5	79.3	20.8	100.1	111.4
Pekan	128274	37.8	67.3	17.7	85.0	94.6
Raub	229455	67.7	120.5	31.7	152.1	169.2
Rompin	157807	46.6	82.8	21.8	104.6	116.4
Temerloh	135593	40.0	71.2	18.7	89.9	100.0

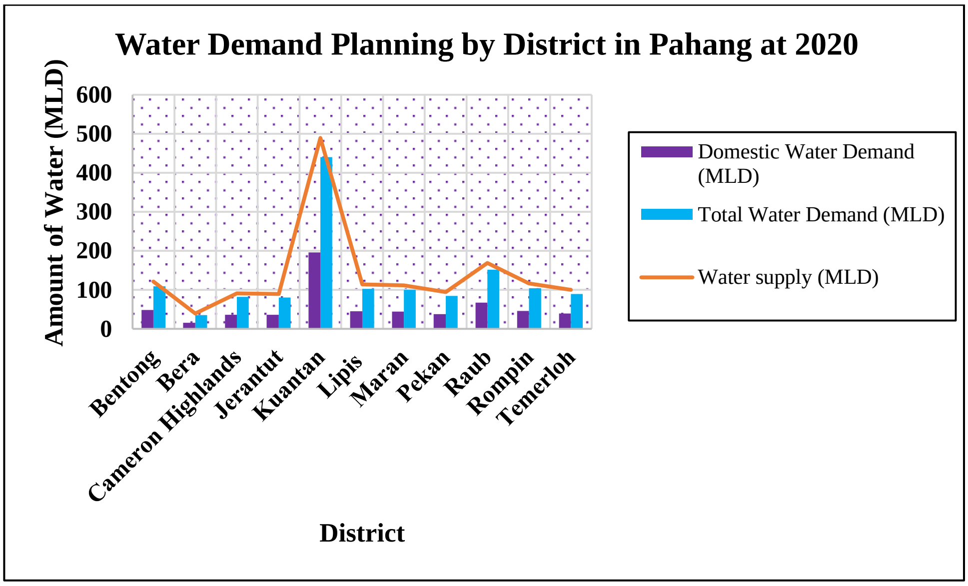

Figure 4.8: Graph of water demand planning by district level in Pahang at 2020

The Figure 4.8 shows the projection of water demand planning based on the forecast population for each district for 2020. The graph shown the comparison of domestic water demand is less than the total water demand. Domestic water demand for Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin and Temerloh are approximately about to 44% from the water demand. The water consumption per person for 2020 takes 295 l/c/d. Daerah Kuantan stated the highest domestic water demand based on the highest population about to 195.9 Mld and the second highest domestic water demand is Daerah Raub about to 67.7 Mld. Besides that, Daerah Bera stated the lowest domestic water demand about to 15.8 Mld and the second lowest domestic water demand is at Daerah Jerantut about to 35.9 Mld.

The Table 4.6 presented the projection of water demand summary by district level in Pahang for 2030. All the estimation for domestic water demand, water demand and water supply are based on the forecast population in 2030 with annual increase rate 5%.

Table 4.6: Projection of Water Demand Planning by district level in Pahang at 2020

District	Projected Population	Domestic Water Demand (Mld)	Total Water Demand (Mld)	Losses (Mld)	Water Demand (Mld)	Water Supply (Mld)
Bentong	270976	81.3	159.3	35.0	194.3	203.2
Bera	88279	26.5	51.9	11.4	63.3	66.2
Cameron Highlands	204291	61.3	120.1	26.4	146.5	153.2
Jerantut	200692	60.2	118.0	25.9	143.9	150.5
Kuantan	1094912	328.5	643.8	141.2	785.1	821.2
Lipis	254887	76.5	149.9	32.9	182.8	191.2
Maran	248959	74.7	146.4	32.1	178.5	186.7
Pekan	211488	63.4	124.4	27.3	151.6	158.6
Raub	378308	113.5	222.4	48.8	271.2	283.7
Rompin	260179	78.1	153.0	33.6	186.5	195.1
Temerloh	223555	67.1	131.5	28.8	160.3	167.7

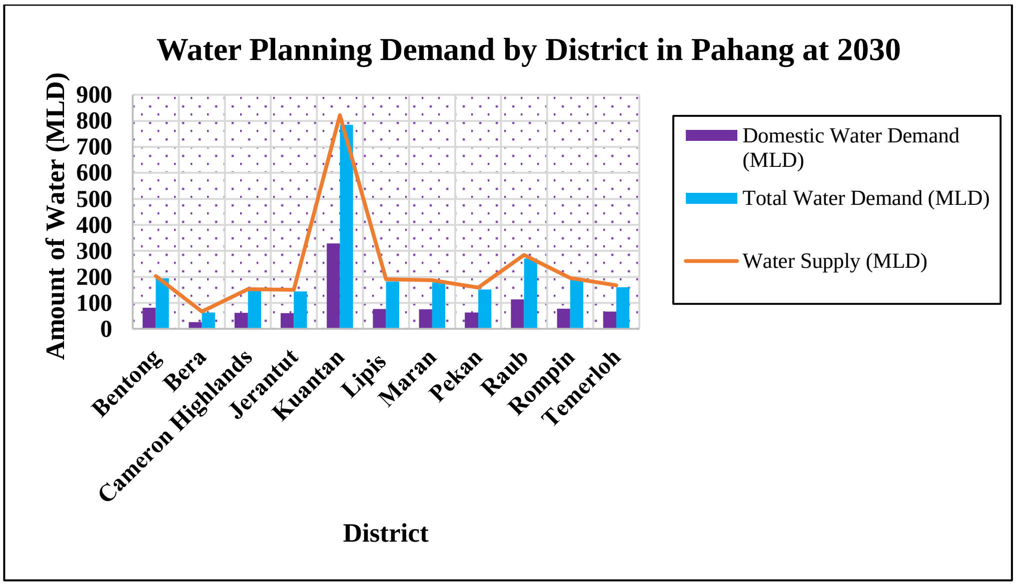

Figure 4.9: Graph of water demand planning by district level in Pahang at 2030

The Figure 4.9 illustrated the projection of water demand planning based on the forecast population for each district for 2030. The graph shown the comparison of domestic water demand is less than the total water demand. Domestic water demand for Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin and Temerloh are approximately about to 44.4% from the water demand. The water consumption per person for 2030 takes 300 l/c/d increase 2% from 2020. Daerah Kuantan still stated the highest domestic water demand based on the highest population about to 328 Mld and the second highest domestic water demand is Daerah Raub about to 113.5 Mld. Besides that, Daerah Bera stated the lowest domestic water demand about to 26.5 Mld and the second lowest domestic water demand is at Daerah Jerantut about to 60.2 Mld.

The Table 4.7 tabulate the projection of water demand summary by district level in Pahang for 2040. All the estimation for domestic water demand, water demand and water supply are based on the forecast population in 2040 with annual increase rate 5%.

Table 4.7: Projection of Water Demand Summary by district level in Pahang at 2040

District	**Projected Population**	**Domestic Water Demand (MLD)**	**Total Water Demand (MLD)**	**Losses (MLD)**	**Water Demand (MLD)**	**Water Supply (MLD)**
Bentong	446764	138.5	288.2	52.3	340.4	346.2
Bera	145547	45.1	93.9	17.0	110.9	112.8
Cameron Highlands	336818	104.4	217.2	39.4	26.7	261.0
Jerantut	330885	102.6	213.4	38.7	252.2	256.4
Kuantan	1805205	559.6	1164.4	211.2	1375.6	1399.0
Lipis	420237	130.3	271.1	49.2	320.3	325.7
Maran	410464	127.2	264.7	48.0	312.8	318.1
Pekan	348685	108.1	224.9	40.8	265.7	270.2
Raub	623724	193.4	402.3	73.0	475.3	483.4

Rompin	428963	133.0	276.6	50.2	326.9	332.4
Temerloh	368580	114.3	237.7	43.1	280.9	285.6

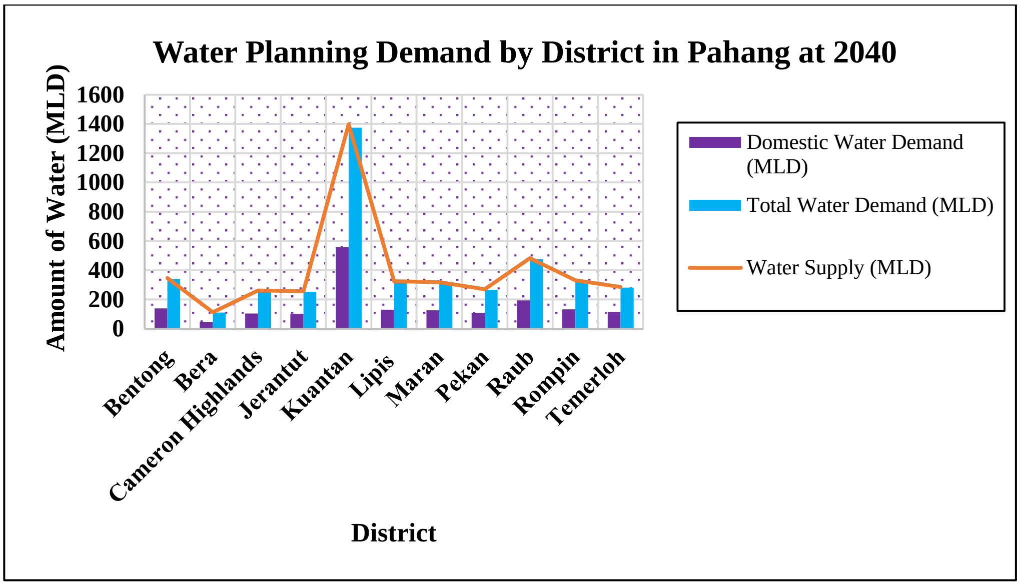

Figure 4.10: Graph of water demand planning by district level in Pahang at 2040

The Figure 4.10 illustrated the projection of water demand planning based on the forecast population for each district for 2040. The graph shown the comparison of domestic water demand is less than the total water demand. Domestic water demand for Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin and Temerloh are approximately about to 40.6% from the water demand. The water consumption per person for 2040 takes 310 l/c/d increase 3.3% from 2030. Daerah Kuantan still stated the highest domestic water demand based on the highest population about to 559.6 Mld and the second highest domestic water demand is Daerah Raub about to 193 Mld. Besides that, Daerah Bera stated the lowest domestic water demand about to 45 Mld and the second lowest domestic water demand is at Daerah Jerantut about to 102.6 Mld.

Table 4.8 presented the projection of water demand summary by district level in Pahang for 2050. All the estimation for domestic water demand, water demand and water supply are based on the forecast population in 2050 with annual increase rate 5%.

Table 4.8: Projection of Water Demand Summary by district level in Pahang at 2050

District	Projected Population	Domestic Water Demand (MLD)	Total Water Demand (MLD)	Losses (MLD)	Water Demand (MLD)	Water Supply (MLD)
Bentong	736589	232.0	497.2	88.4	585.6	580.1
Bera	239967	75.6	162.0	28.8	190.8	189.0
Cameron Highlands	555319	174.9	374.8	66.6	441.5	437.3
Jerantut	545536	171.8	368.2	65.6	433.7	429.6
Kuantan	2976280	937.5	2009	357.2	2366.1	2343.8
Lipis	692854	218.2	467.7	83.1	550.8	545.6
Maran	676741	213.2	456.8	81.2	538.0	532.9
Pekan	574885	181.1	388.0	69.0	457.0	452.7
Raub	1028347	323.9	694.1	123.4	817.5	809.8
Rompin	707241	222.8	477.4	84.9	562.3	557.0
Temerloh	607686	191.4	410.2	72.9	483.1	478.6

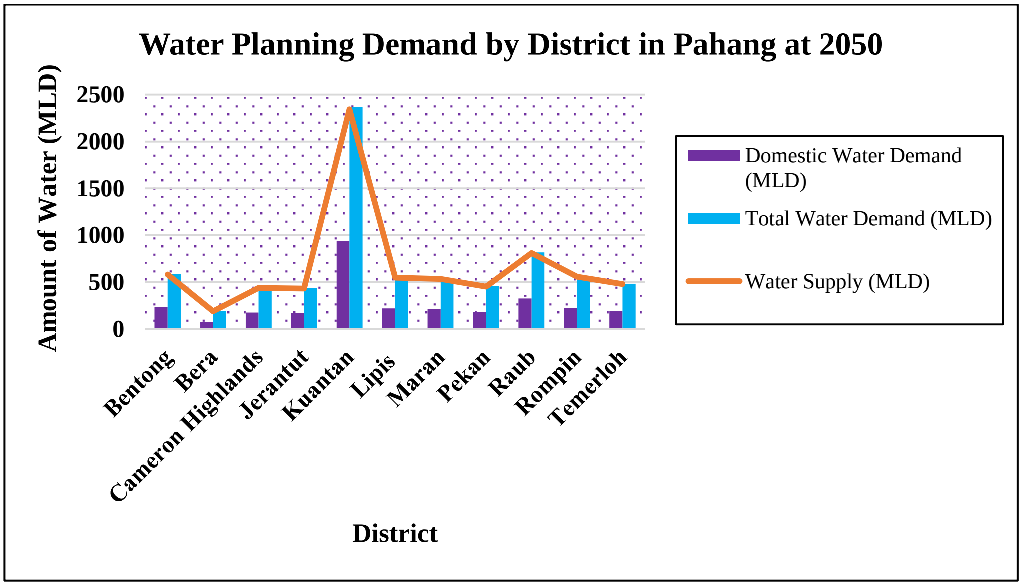

Figure 4.11: Graph of water demand planning by district level in Pahang at 2050

The Figure 4.11 illustrated the projection of water demand planning based on the forecast population for each district for 2050. The graph shown the comparison of domestic water demand is less than the total water demand. Domestic water demand for Bentong, Bera, Cameron Highlands, Jerantut, Kuantan, Lipis, Maran, Pekan, Raub, Rompin and Temerloh are estimated about to 39.6% from the total water demand including losses. The water consumption per person for 2050 takes 315 l/c/d increase 1.6% from 2040. Daerah Kuantan still stated the highest domestic water demand based on the highest population about to 937.5 Mld and the second highest domestic water demand is Daerah Raub about to 323.9 Mld. Besides that, Daerah Bera stated the lowest domestic water demand about to 75 Mld and the second lowest domestic water demand is at Daerah Jerantut about to 171.5 Mld.

4.5 ANALYSIS ON DOMESTIC WATER DEMAND BY DISTRICT LEVEL IN PAHANG

The Table 4.9 presented the domestic water demand by district level in Pahang from 1995 to 2050. This data collection was get from the NWRS Report. The data collection will be compared with the estimation of domestic water demand that have been derived by equation in the Chapter 3 to know the differences between the period of study

Table 4.9: The domestic water demand by district level in Pahang from 1995 to 2050

District	Domestic Water Demand (Mld)							
	1995	**1997**	**2000**	**2010**	**2020**	**2030**	**2040**	**2050**
Bentong	16	22	31	42	51	62	74	86
Bera	-	-	-	-	-	-	-	-
Cameron Highlands	5	7	8	12	15	17	20	23
Jerantut	14	21	31	48	63	81	101	120
Kuantan	54	78	91	75	186	254	333	412
Lipis	13	18	21	30	37	44	52	60
Maran	23	33	42	75	88	254	333	412
Pekan	17	25	23	36	48	62	78	92

Raub	14	20	27	31	39	46	54	62
Rompin	16	25	24	48	71	98	128	158
Temerloh	36	52	66	107	145	187	235	280

Based on data analysis in Table 4.5, Table 4.6, Table 4.7, Table 4.8 and Table 4.9, the domestic water demand for each district is presented in line graph as shown below.

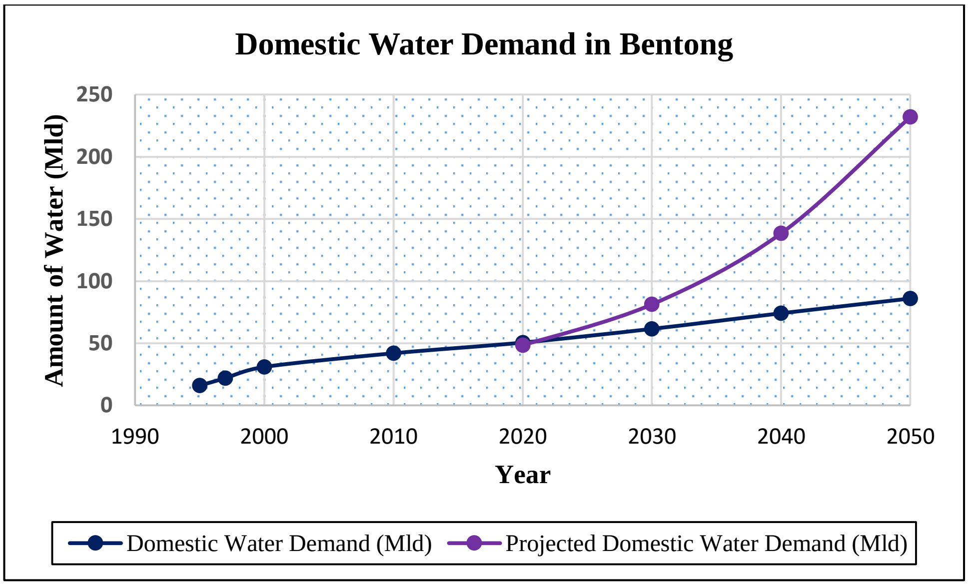

Figure 4.12: Graph of comparison of domestic water demand in Bentong

As indicated in Figure 4.12, the domestic water demand from previous report had increased from 16 Mld in 1995 to 86 Mld in 2050 approximately ratio 5.3. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 48.5 Mld. In 2030, there increased slightly to 81.3 Mld, rising sharply to 138 Mld in 2040. In 2050, rising to 232 Mld. However, the difference between data of year 2020 is very nearly to 2.5 Mld but in 2050 shows the larger difference projected domestic water demand.

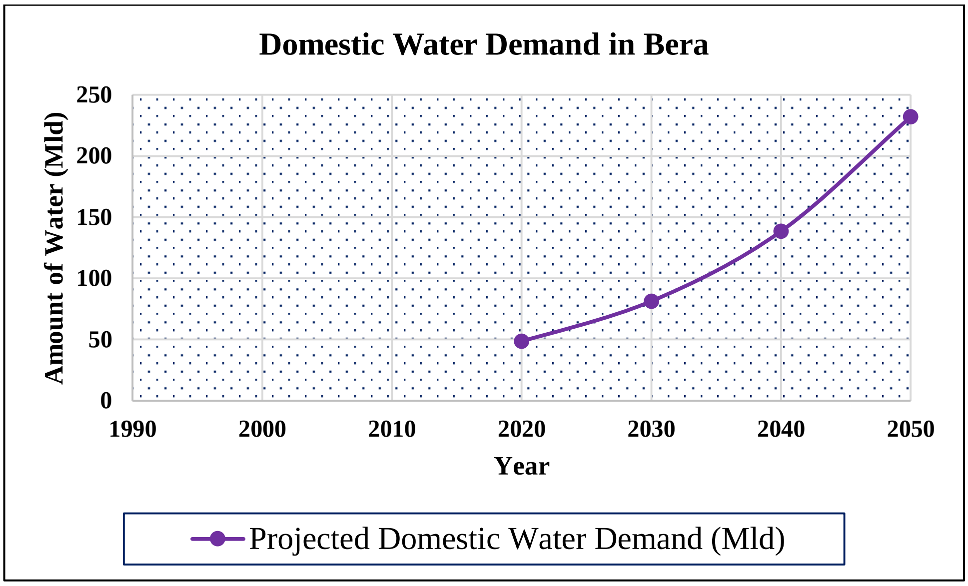

Figure 4.13: Graph of domestic water demand in Bera

As shown in Figure 4.13, the domestic water demand in Bera increased from 45.8 Mld in 2020 to about 232 Mld in 2050. Its domestic water demand increase sharply over period of 2050. However, there was no data for domestic water demand from the previous report for Daerah Bera to compare with new projected domestic water demand.

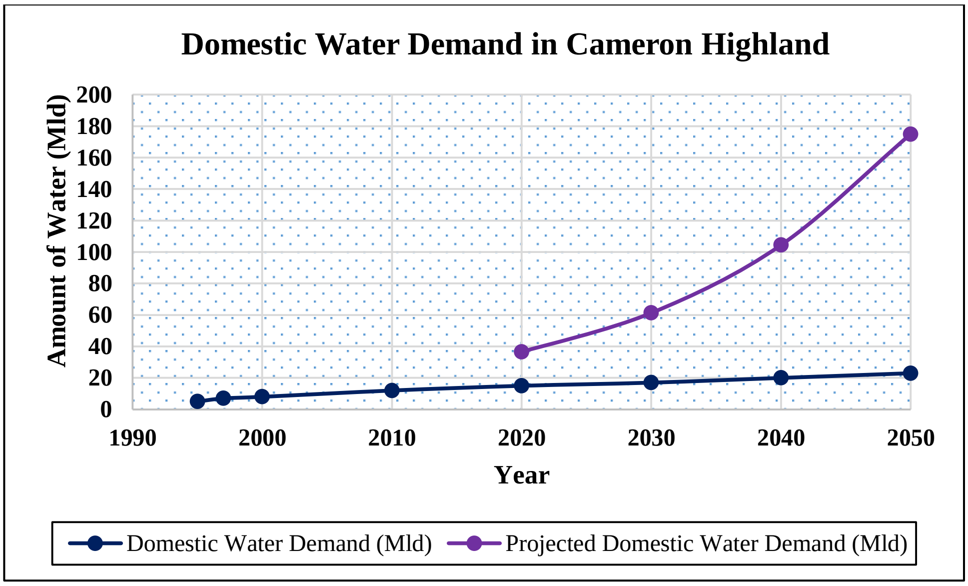

Figure 4.14: Graph of comparison of domestic water demand in Cameron Highland

The Figure 4.14 illustrated the graph of comparison of domestic water demand in Cameron Highland. The domestic water demand from previous report had increased from 5 Mld in 1995 to 23 Mld in 2050 approximately ratio 4.6. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 36.6 Mld. In 2030, there increased gradually to 61.3 Mld, rising sharply to 104.4 Mld in 2040. In 2050, rising to 174.9 Mld. However, the trend of domestic water demand from previous report is increased slightly from 1995 to 2050. For comparison of year 2050, seen very larger difference based on the forecast population.

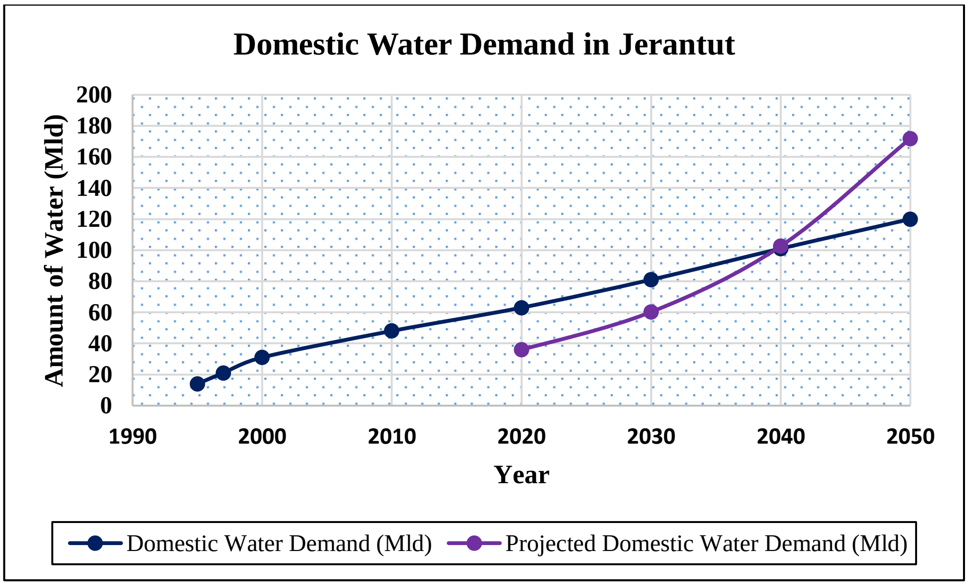

Figure 4.15: Graph of comparison of domestic water demand in Jerantut

The Figure 4.14 illustrated the graph of comparison of domestic water demand in Jerantut. The domestic water demand from previous report had increased from 14 Mld in 1995 to 120 Mld in 2050 approximately ratio 8.6. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 35.9 Mld. In 2030, there increased gradually to 60.2 Mld, increase steadily to 102.6 Mld in 2040. In 2050, going up to 171.8 Mld. However, the trend of domestic water demand from previous report is increased steadily from 1995 to 2050. However, there is lowest comparison data of domestic water demand in 2040. The domestic water demand by using data population 1995 as baseline just increase 1.6% from the previous projection domestic water demand.

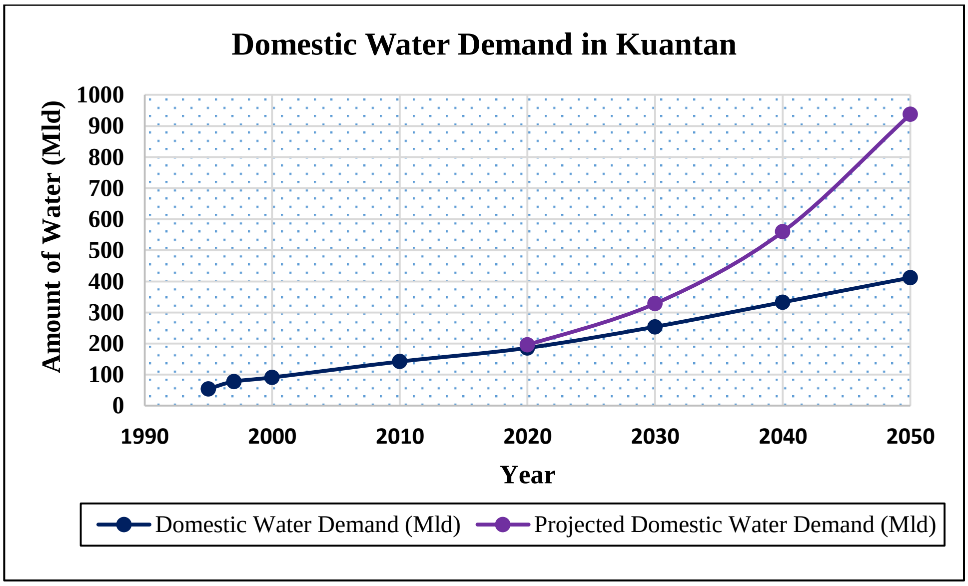

Figure 4.16: Graph of comparison of domestic water demand in Kuantan

The Figure 4.16 illustrated the graph of comparison of domestic water demand in Kuantan. As indicated in Figure 4.16, the domestic water demand from previous report had increased from 54 Mld in 1995 to 412 Mld in 2050 approximately ratio 7.6. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 195.9 Mld. In 2030, there increased slowly to 328.5 Mld, rising sharply to 559.6 Mld in 2040. In 2050, increase gradually to 937.5 Mld. However, the difference between data of year 2020 is very nearly about to 9.9 Mld but in 2050 seems the larger difference projected domestic water demand.

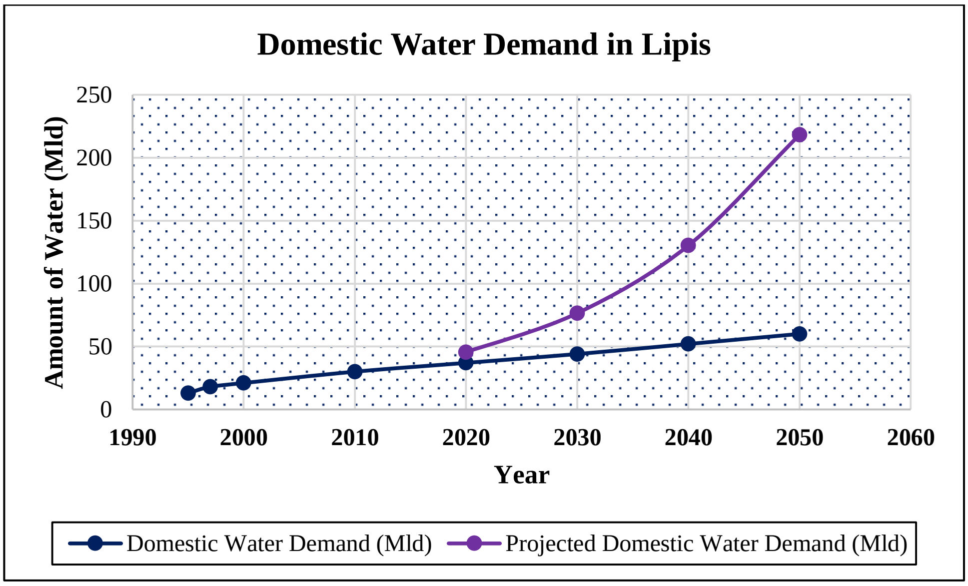

Figure 4.17: Graph of comparison of domestic water demand in Lipis

The Figure 4.17 illustrated the graph of comparison of domestic water demand in Lipis. As indicated in Figure 4.17, the domestic water demand from previous report had increased from 13 Mld in 1995 to 60 Mld in 2050 approximately ratio 4.6. The pattern graph line for previous projection domestic water demand in increase slowly from 1995 to 2050. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 45.6 Mld. In 2030, there increased to 76.5 Mld, rising sharply to 130.3 Mld in 2040. In 2050, increase gradually to 218.2 Mld. However, the difference between data of year 2020 is increased about to 8.6 Mld but in 2050 seems the larger difference projected domestic water demand.

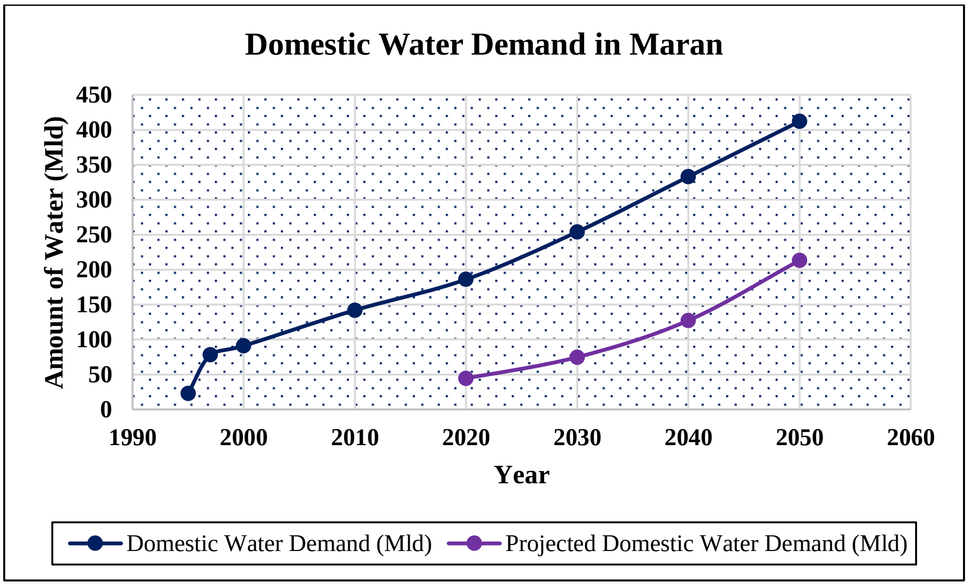

Figure 4.18: Graph of comparison of domestic water demand in Maran

The Figure 4.18 illustrated the graph of comparison of domestic water demand in Maran. As indicated in Figure 4.18, the domestic water demand from previous report had increased from 23 Mld in 1995 to 412 Mld in 2050 approximately ratio 17.9. The pattern graph line for previous projection domestic water demand in increase a lot from 1995 to 2050. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 44.5 Mld. In 2030, there increased to 74.7 Mld, increase to 127.2 Mld in 2040. In 2050, increase gradually to 213.2 Mld. However, the difference between data of year 2020 to 2050 seems the larger difference projected domestic water demand. There is no closed point between year.

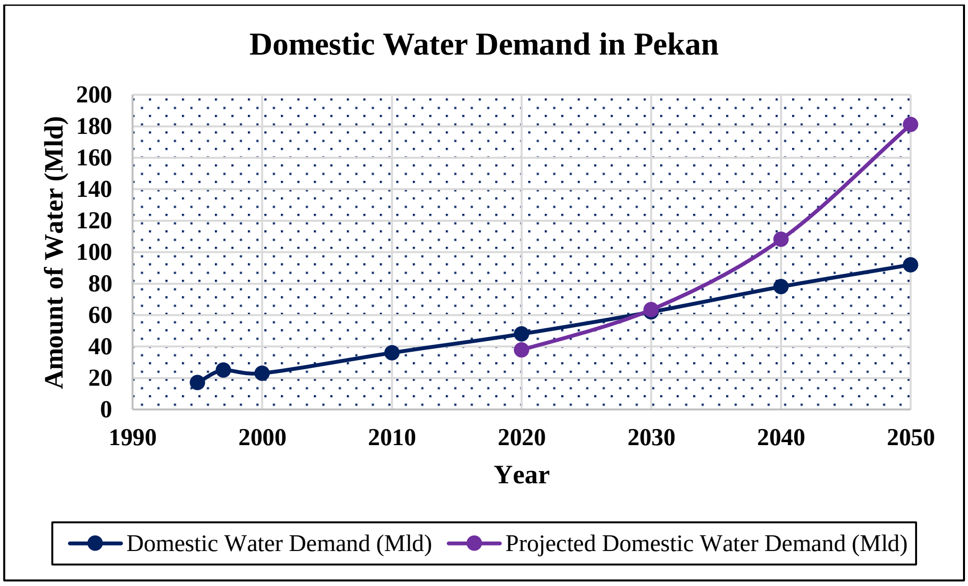

Figure 4.19: Graph of comparison of domestic water demand in Pekan

The Figure 4.19 illustrated the graph of comparison of domestic water demand in Pekan. The domestic water demand from previous report had increased from 17 Mld in 1995 to 92 Mld in 2050 approximately ratio 5.4. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 37.8 Mld. In 2030, there increased slighly to 63.4 Mld, increase steadily to 108.1 Mld in 2040. In 2050, rising up to 181.1 Mld. However, the trend of domestic water demand from previous report is increased steadily from 1995 to 2050. However, there is lowest comparison data of domestic water demand in 2030. The domestic water demand by using data population 1995 as baseline just increase 2.3% from the previous projection domestic water demand.

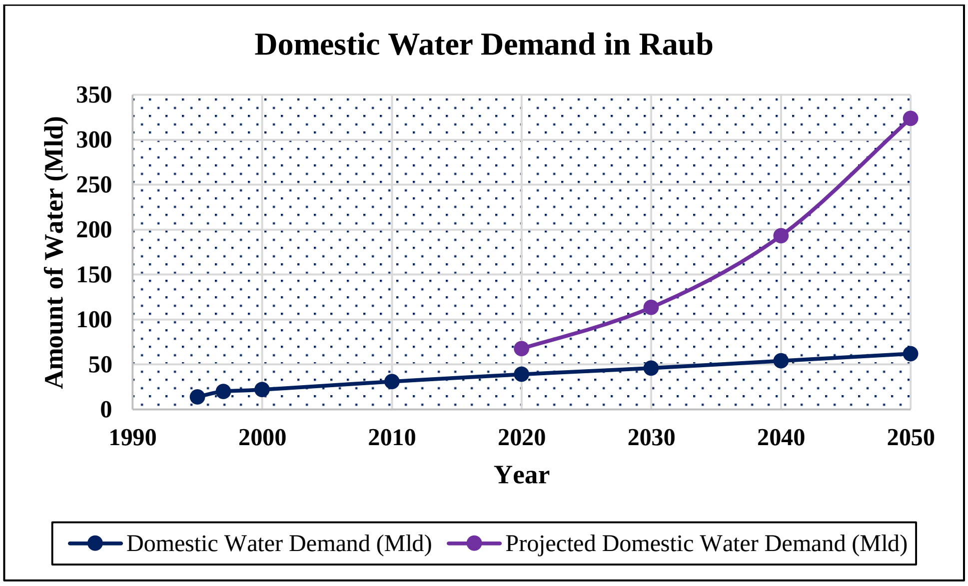

Figure 4.20: Graph of comparison of domestic water demand in Raub

The Figure 4.20 illustrated the graph of comparison of domestic water demand in Raub. As indicated in Figure 4.20, the domestic water demand from previous report had increased from 14 Mld in 1995 to 62 Mld in 2050 approximately ratio 4.4. The pattern graph line for previous projection domestic water demand in increase slowly from 1995 to 2050. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 67.7 Mld. In 2030, there increased to 113.5 Mld, rising sharply to 193.4 Mld in 2040. In 2050, increase gradually to 323.9 Mld. However, the difference between data of year 2020 is increased about to 28.7 Mld but in 2050 seems totally difference projected domestic water demand.

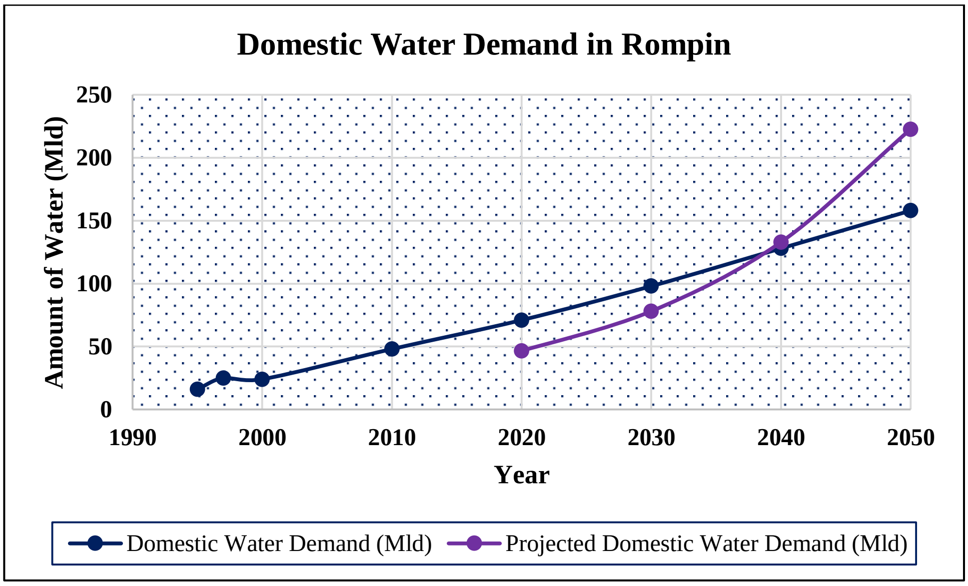

Figure 4.21: Graph of comparison of domestic water demand in Rompin

The Figure 4.21 illustrated the graph of comparison of domestic water demand in Rompin. The domestic water demand from previous report had increased from 16 Mld in 1995 to 158 Mld in 2050 approximately ratio 9.8. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 46.6 Mld. In 2030, there increased gardually to 78.1 Mld, increased to 133 Mld in 2040. In 2050, rising to 222.8 Mld. However, the trend of domestic water demand from previous report is increased steadily from 1995 to 2050. However, there is lowest comparison data of domestic water demand in 2040. The domestic water demand by using data population 1995 as baseline just increase 5% from the previous projection domestic water demand.

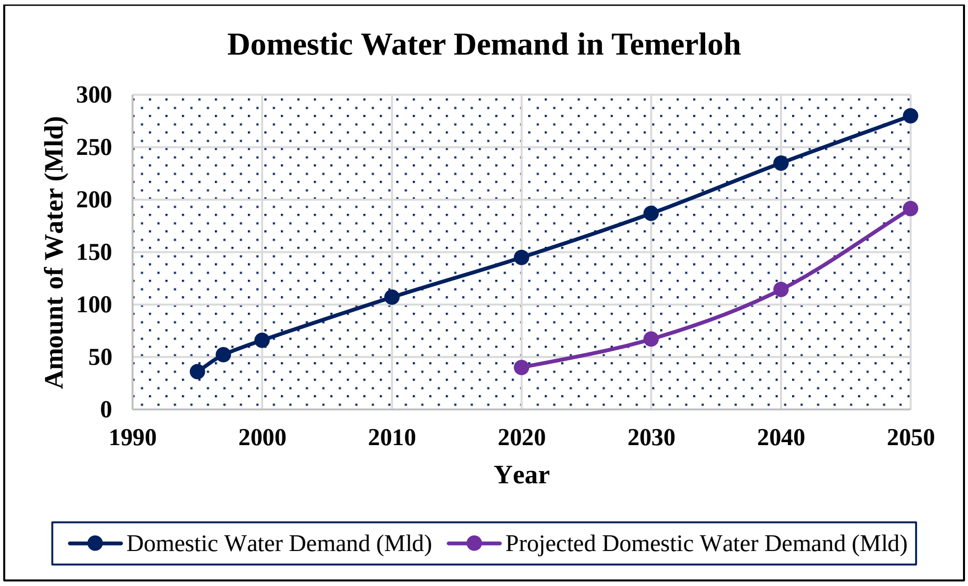

Figure 4.22: Graph of comparison of domestic water demand in Temerloh

The Figure 4.22 illustrated the graph of comparison of domestic water demand in Temerloh. As indicated in Figure 4.18, the domestic water demand from previous report had increased from 36 Mld in 1995 to 280 Mld in 2050 approximately ratio 7.7. The pattern graph line for previous projection domestic water demand in increase a lot from 1995 to 2050. For the forecast population data by using 2015 as baseline, in 2020, the domestic water demand is about 40 Mld. In 2030, there rising to 67.1 Mld, increased steadily to 114.3 Mld in 2040. In 2050, increase gradually to 191.4 Mld. However, the difference between data of year 2020 to 2050 seems the larger difference projected domestic water demand. There is no closed point between year.

CHAPTER 5

CONCLUSION

5.1 INRODUCTION

The purpose of this chapter is to discuss more about the conclusion of the analysis of data that has been done on this study. The conclusion is to show whether this study has been achieved the objective or not. Besides that, there suggestions and recommendation included in this chapter.

5.2 CONCLUSION FOR OBJECTIVE OF STUDY

Referring to the chapter 4, data analysis has been done. Data analysis have been shown in the forms of tables and presented in graphical bar chart by using Microsoft Excel. Therefore, the objective of the study such as to develop forecast of population growth and domestic water demand trend and comparison between domestic water demand and water supply in Kuantan, Pahang has been achieved.

5.2.1 Conclusion for Objective 1: To Develop Forecast of Population Growth and Domestic Water Demand Trends in Kuantan, Pahang

By referring to Table 4.1 and Figure 4.1 for the analysis on forecast the population of Pahang from 1995 to 2050, can be conclude that the population growth in Pahang is having increment 82% from 1995 to 2050. It shows a population of 1192454 in 1995 and 4492595 in 2050. For the Table 4.2 and Figure 4.2, shows a population of 2084358 in 2020 and 9341445 in 2050. The populations are increase gradually for every 10 year intervals. Growth of population due to natural increase has been estimated based on an assumed trend in the rate of natural increase. Pahang is the largest state in Peninsular Malaysia and Kuantan is the capital state. Rapid urbanization has occurred in Kuantan, Pahang. It has been transform and become modernized. From the previous research, many facilities project have been develop such as institution, industrial, tourism places and hospitals under the Kuantan District. Therefore, this rapid urbanization has increased the population rate and expected to be enhanced year by year as more transformation occurs in developing an urbanization of Kuantan, Pahang.

By referring to Table 4.5, Table 4.6, Table 4.7 and Table 4.8 and Figure 4.8, Figure 4.9, Figure 4.10 and Figure 4.11, can be concluded that the total water demand and the domestic water demand increase for every 10 years interval from 2000 to 2050 by projected population. Main factor of the increasing of water demands because of the population growth are gradually increase for every year. Hence, a sustainable water management strategies are needed to supply enough water that satisfies the domestic water demand in Pahang. However, Kuantan and Raub have a highest domestic water demand and Bera and Jerantut have a lowest domestic water demand.

5.2.2 Conclusion for Objective 2: To Compare Domestic Water Demand and Water Supply in Pahang

By referring to Figure 4.8, Figure 4.9, Figure 4.10 and Figure 4.11, for the analysis between total water demand and domestic water demand, its show more than 50% of water demand is for domestic users while the other is for other types of water demands such as industrial, institutional, agriculture and bussiness. The domestic use includes drinking clean water, baths, washes and sanitary. Some of purpose of domestic water demands depends on water quality and quantity, sanitary system, price of water tarrif, climate change and water supply. The number of residential area in Pahang is one of factor increasing domestic water demands. In addittion, there are many house development project are on going in Pahang. It may be increase the number of migration to Pahang year by year.

Futhermore, the analysis between water supply and domestic water demand, can be concluded that both of amount of water supply and total water demand gradually increase year by year. However, in the future can be seen that the water supply could not satisfy the domestic water demands if the water treatment plant not supply water at high design capacity. It will be face the high chances to meet water crisis in certain district at Pahang. The problem that related to water supply may be the cannot reach new development areas. Besides that, the condition of pipes are deteriorating due to 20 years of usage. The capacity of the pipes are not adaptable to high pressure. Therefore, the water supply required is needed to satisfy the domestic water demands.

On the other hand, the analysis of comparison of domestic water demand has been analyzed through the graphical bar for each district. It shown the pattern of increasing water demand for each district increase drastically from 2020 to 2050.

5.3 RECOMMENDATION

For the study, there are several recommendations being made to encourage the analysis of the water demand problem in future. The main sources of potable water are Kuantan River and underground. Consumers in the Kuantan district are supplied by 9 separate water treatment plants located at Bukit Ubi, Pasir Kemudi, Bukit Goh, Kampung Pandan, Paya Bungor, Lepar Hilir, Kampung Penor, Sungai Lembing, and Semambu. The Bukit Ubi and Semambu treatment plants together supply more than 90.0 percent of the water demand in the district of Kuantan.

The department of Water Supply and Government State should planning to ensure that all the piping system in Pahang are in good condition. They have to make routine supervision on piping systems and do technical maintenance at pipes that under their supervision. Besides that, the analysis and planning water supply should be done systematically due to increase of population growth. Therefore, the related agencies with the water supply should take action to overcome the insufficient water supply happen in the future.

Thus, more attention should be given to managing water demand through pricing mechanisms, education, and conservation and reuse programs. There are several general recommendations of a diverse nature concerning improved understanding of the regional hydrology, reuse of reclaimed wastewater, protection of the quality of existing resources, greater efficiency of use, and institutional change, all designed to improve the existing system.

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APPENDIX A

TABLE 1A: PAHANG WATER DEMAND: YEAR 2000-2050 (CAPITAL REGION) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
1995	Kuantan	295712	0.8	236570	230	54	39	12	37	9	36	9	342	83	126	30	468	113
	Maran	125207	0.8	100166	230	23	39	5	37	4	36	4	342	35	127	13	469	48
	Subtotal	420919		336735		77		16		12		12		118		43		161
1997	Kuantan	313896	0.92	288784	270	78	40	13	40	12	45	13	395	115	143	41	538	156
	Maran	132189	0.92	121614	270	33	40	5	40	5	45	5	395	48	143	17	538	66
	Subtotal	446085		410398		111		18		16		18		164		59		222
2000	Kuantan	343967	0.94	323329	280	91	48	17	48	16	48	16	424	138	142	46	566	184
	Maran	158889	0.94	149356	280	42	48	8	48	7	48	7	424	64	142	21	566	85
	Subtotal	502856		472685		132		24		23		23		202		67		269
2010	Kuantan	472656	1	472655	300	142	75	35	55	26	55	26	485	229	134	63	619	293
	Maran	221170	1	221170	300	66	75	17	55	12	55	12	485	107	134	30	619	137
	Subtotal	693825		693825		208		52		38		38		337		93		429

TABLE 2A: PAHANG WATER DEMAND: YEAR 2000-2050 (CAPITAL REGION) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
2020	Kuantan	601342	1	601342	310	186	120	72	58	35	58	35	546	328	120	72	666	400
	Maran	283451	1	283451	310	88	120	34	58	16	58	16	546	155	120	34	666	189
	Subtotal	884793		884793		274		106		51		51		483		106		589
2030	Kuantan	793008	1	793007	320	254	153	121	60	48	60	48	593	470	130	103	723	573
	Maran	362164	1	362164	320	116	153	55	60	22	60	22	593	215	130	47	723	262
	Subtotal	1155172		1155172		370		177		69		69		685		150		835
2040	Kuantan	984674	1	984674	338	333	185	182	65	64	62	61	650	640	118	116	768	756
	Maran	440877	1	440877	338	149	185	82	65	29	62	27	650	287	118	52	768	339
	Subtotal	1425551		1425551		482		264		93		88		927		168		1095
2050	Kuantan	1176340	1	1176340	350	412	200	235	70	82	65	76	685	806	117	138	802	943
	Maran	519590	1	519590	350	182	200	104	70	36	65	34	685	356	118	61	803	417
	Subtotal	1695930		1695930		594		339		119		110		1162		199		1364

APPENDIX B

TABLE 1B: PAHANG WATER DEMAND: YEAR 2000-2050 (OUTER DISTRICTS) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
1995	Bentong	92334	0.75	69251	225	16	35	3	36	2	35	2	331	24	120	8	451	32
	Cameron Highland	26915	0.75	20186	225	5	35	1	36	1	35	1	331	7	120	2	451	9
	Jerantut	84606	0.75	63455	225	14	35	2	36	2	35	2	331	22	120	8	451	29
	Lipis	75787	0.75	56840	225	13	35	2	36	2	35	2	331	19	120	7	451	26
	Pekan	101112	0.75	75834	225	17	35	3	36	3	35	3	331	26	120	9	451	35
	Raub	82018	0.75	61514	225	14	35	2	36	2	35	2	331	21	120	7	451	28
	Rompin	97349	0.75	73012	225	16	35	3	36	3	35	3	331	25	120	9	451	34
	Temerloh	211414	0.75	158561	225	36	35	6	36	6	35	6	331	54	120	19	451	73
	Subtotal	771535		578651		130		27		21		20		198		69		268
1997	Bentong	95370	0.88	83926	265	22	45	4	45	4	46	4	401	34	142	12	543	46
	Cameron Highland	28012	0.88	24650	265	7	45	1	45	1	46	1	401	10	142	4	543	14
	Jerantut	88826	0.88	78167	265	21	45	4	45	4	46	4	401	32	142	11	543	43
	Lipis	78959	0.88	69484	265	18	45	4	45	4	46	3	401	28	142	10	543	38
	Pekan	107893	0.88	94946	265	25	45	5	45	5	46	4	401	39	142	13	543	52
	Raub	84644	0.88	74487	265	20	45	4	45	4	46	3	401	30	142	11	543	41
	Rompin	106425	0.88	93654	265	25	45	5	45	5	46	4	401	38	142	13	543	51
	Temerloh	221673	0.88	195072	265	52	45	10	45	10	46	9	401	79	142	28	543	107
	Subtotal	811800		714384		189		37		37		33		291		101		392

TABLE 2B: PAHANG WATER DEMAND: YEAR 2000-2050 (OUTER DISTRICTS) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
2000	Bentong	124214	0.9	111793	280	31	55	7	50	6	48	5	433	49	133	15	566	64
	Cameron Highland	33162	0.9	29846	280	8	55	2	50	1	48	1	433	13	133	4	566	17
	Jerantut	123167	0.9	110796	280	31	55	7	50	6	48	5	433	49	133	15	566	63
	Lipis	84901	0.9	76411	280	21	55	5	50	4	48	4	433	34	133	10	566	44
	Pekan	92414	0.9	83173	280	23	55	5	50	4	48	4	433	37	133	11	566	48
	Raub	89212	0.9	80291	280	22	55	5	50	4	48	4	433	35	133	11	566	46
	Rompin	94682	0.9	85214	280	24	55	5	50	4	48	4	433	37	133	11	566	49
	Temerloh	263865	0.9	237479	280	66	55	15	50	12	48	11	433	104	133	32	566	136
	Subtotal	905557		815001		228		50		41		39		358		108		466
2010	Bentong	147859	1	147859	285	42	80	12	55	8	54	8	474	70	135	20	609	90
	Cameron Highland	41336	1	41336	285	12	80	3	55	2	54	2	474	20	135	6	609	25
	Jerantut	169057	1	169057	285	48	80	14	55	9	54	9	474	80	135	23	609	103
	Lipis	104494	1	104494	285	30	80	8	55	6	54	6	474	50	135	14	609	64
	Pekan	128069	1	128069	285	36	80	10	55	7	54	7	474	61	135	17	609	78
	Raub	109984	1	109984	285	31	80	9	55	6	54	6	474	52	135	15	609	67
	Rompin	167495	1	167495	285	48	80	13	55	9	54	9	474	79	135	23	609	102
	Temerloh	377117	1	377117	285	107	80	30	55	21	54	20	474	179	135	51	609	239
	Subtotal	1245410		1245410		355		100		68		67		590		168		758

TABLE 3B: PAHANG WATER DEMAND: YEAR 2000-2050 (OUTER DISTRICTS) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
2020	Bentong	171504	1	171504	110	19	60	10	60	10	90	90	525	90	138	24	663	114
	Cameron Highland	49509	1	49509	110	5	60	3	60	3	90	26	525	26	138	7	663	33
	Jerantut	215006	1	215006	110	24	60	13	60	13	90	113	525	113	138	30	663	143
	Lipis	124087	1	124087	110	14	60	7	60	7	90	65	525	65	138	17	663	82
	Pekan	163724	1	163724	110	18	60	10	60	10	90	86	525	86	138	23	663	109
	Raub	130756	1	130756	110	14	60	8	60	8	90	69	525	69	138	18	663	87
	Rompin	240308	1	240308	110	26	60	14	60	14	90	126	525	126	138	33	663	159
	Temerloh	490369	1	490369	110	54	60	29	60	29	90	257	525	257	138	68	663	325
	Subtotal	1585263		1585263		468		174		95		95		832		219		1051
2030	Bentong	205382	1	205382	300	62	160	33	64	13	64	13	588	121	129	26	717	147
	Cameron Highland	56994	1	56994	300	17	160	9	64	4	64	4	588	34	129	7	717	43
	Jerantut	270448	1	270448	300	81	160	43	64	17	64	17	588	159	129	35	717	194
	Lipis	145992	1	152388	300	44	160	23	64	9	64	9	588	86	129	19	717	105
	Pekan	207012	1	327258	300	62	160	33	64	13	64	13	588	122	129	27	717	148
	Raub	152388	1	152388	300	46	160	24	64	10	64	10	588	90	129	20	717	109
	Rompin	327258	1	327258	300	98	160	52	64	21	64	21	588	192	129	42	717	235
	Temerloh	623561	1	623561	300	187	160	100	64	40	64	40	588	367	129	80	717	447
	Subtotal	1989034		1989034		597		318		127		127		1170		257		1426

TABLE 4B: PAHANG WATER DEMAND: YEAR 2000-2050 (OUTER DISTRICTS) PLANNING DEMAND

Year	District	Projected Population	Service Factor	Population Served	Domestic Uses		Industrial Uses		Commercial Uses		Institutional Uses		Total		Losses		Demand	
					l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld	l/c/d	Mld
2040	Bentong	239259	1	239259	310	74	185	44	75	18	75	18	645	154	117	28	762	182
	Cameron Highland	64478	1	64478	310	20	185	12	75	5	75	5	645	42	117	8	762	49
	Jerantut	325889	1	325889	310	101	185	60	75	24	75	24	645	210	117	38	762	248
	Lipis	167897	1	167897	310	52	185	31	75	13	75	13	645	108	117	20	762	128
	Pekan	250301	1	250301	310	78	185	46	75	19	75	19	645	161	117	29	762	192
	Raub	174019	1	174019	310	54	185	32	75	13	75	13	645	112	117	20	762	133
	Rompin	414208	1	414208	310	128	185	77	75	31	75	31	645	267	117	48	762	316
	Temerloh	756752	1	756752	310	235	185	140	75	57	75	57	645	488	117	89	762	577
	Subtotal	2392804		2392804		742		443		179		179		1543		280		1823
2050	Bentong	273137	1	273137	315	86	200	55	80	22	80	22	675	184	120	33	795	217
	Cameron Highland	71963	1	71963	315	23	200	14	80	6	80	6	675	49	120	9	795	57
	Jerantut	381331	1	381331	315	120	200	76	80	31	80	31	675	257	120	46	795	303
	Lipis	189802	1	189802	315	60	200	38	80	15	80	15	675	128	120	23	795	151
	Pekan	293589	1	293589	315	92	200	59	80	23	80	23	675	198	120	35	795	233
	Raub	195651	1	195651	315	62	200	39	80	16	80	16	675	132	120	23	795	156
	Rompin	501158	1	501158	315	158	200	100	80	40	80	40	675	338	120	60	795	398
	Temerloh	889944	1	889944	315	280	200	128	80	71	80	71	675	601	120	107	795	708
	Subtotal	2796575		2796575		881		559		224		224		1888		336		2223

APPENDIX C

TABLE 1C: PAHANG: PROJECTION OF WATER DEMAND SUMMARY (PLANNING DEMAND)

Year	Population Served	Domestic Mld	Industrial Mld	Commercial Mld	Institutional Mld	Total Uses Mld	Losses Mld	Demand Mld
1995	915386	208	43	33	32	317	112	429
1997	1124782	300	54	49	51	454	160	615
2000	1287686	361	74	63	62	560	176	735
2010	1939235	563	152	107	105	927	261	1188
2020	2470056	742	281	146	146	1315	325	1640
2030	3144206	966	495	197	97	1855	407	2261
2040	3818355	1224	706	272	268	2470	448	2918
2050	4492505	1474	899	342	334	3049	535	3584