Analyzation of water demand projection for Johor River Basin

F Yani[1], N Hussien[1], Z Z Noor[2], C Hafizan[2]

[1] Department of Water and Environmental Engineering, School of Civil Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia
[2] Centre of Sustainable Environmental and Water Security (IPASA), Research Institute of Sustainable Environment (RISE), Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

Corresponding author: fitryyanii478.fy@gmail.com

Abstract. This paper presents the projecting or forecasting of water demand for the Johor River Basin (JRB) from the year 2020 up to 2050. The aim for this research is to quantify and analyse the demand for water in the future from each sector which is most crucial around JRB such as domestic/residential, industrial, agriculture, livestock and non-revenue water; it is a key element for water demand quantification for JRB. Recent work for this quantification is more generalizing in terms of water demand as a whole in Johor state. Meanwhile, this research are using composite approaches which involve secondary data from various local authorities and involved four different districts only around JRB. This research also covers the scope of water consumption baseline data and information of JRB with the recent report. It appears that quality of data in terms of availability and reliability is very important and must be dealt with carefully, with good judgement and good engagement with local stakeholders or authorities when it comes to decision making, therefore must be able to get a rapid and simple understanding of water demand for JRB. It is significant to this research which to accommodate with United Nations Development Program and also promote greater awareness of the Sustainable Development Goal (SDG-6) which to ensure availability and sustainable management of water and sanitation for all.

1. Introduction

Johor River Basin (JRB) also known as *Sungai Johor* is one of our important and the essence for drinking water sources in the state of Johor. Johor River Basin constitutes about 40% of the state of Johor area with a size estimation of 2636 km^2. The river is spread across the basin with 122.7 km in length which covers four different districts in total which are Kluang, Kulai, Kota Tinggi and Pasir Gudang. It is home to many villages and communities and also several townships within the basin. Johor River Basin is supplied both to the Southern part of Johor and also to the neighbouring country, Singapore. There is a standing agreement between Malaysia and Singapore on *Sungai Johor* called the 1962 Water Agreement, where it stated that Singapore is given provision to draw up to 250 million gallons per day of raw water from *Sungai Johor*.

Johor River Basin suffers frequent drought occurrences during the Southwest Monsoon which limits the water availability to be consumed by the consumer. Furthermore, the rapid urbanisation, industrial activities, agriculture development and population growth also contribute to the demand for

water consumption. Water management is crucial to managing the resources effectively and efficiently to accommodate the demand and expectations of all consumers.

In order to assist the government with way better water demand management plan, this research is going to quantify and analyse the water demand of Johor River Basin and also forecast the total water demand from the year 2020 up to 2050 which involve several sectors which is domestic/residential, industrial, agriculture, livestock and non-revenue water. Composite approaches which all the baseline data from relevant agencies need to be collected, gathered and analysed compared from the previous study which more generalize the quantification of water demand.

Water is used by the consumer and also through water infrastructure. Future developments in the river basin areas directly increase the water demand course. The research methodology starts with the determination of suitable methods and sectors for the Johor River Basin. Water demand estimations will include total water demand from all sectors involved within the river basin area. The second phase is the collection of quantitative secondary data from local authorities. Water demand estimation involves four main sectors namely 1) domestic/residential, 2) livestock, 3) industrial and 4) agriculture. Many factors influence water demand including socioeconomic variables such as population density, water price and area development [1]. The availability and reliability of secondary data need to be collected through engagement with relevant agencies. The next stage is data analysis and demand projection. Data analysis includes the estimation of total water demand from all sectors in the water river basin. The projection will be based on the national plan, policy or target; or climate forecasting.

2. Study Site

The JRB (Figure 1.) accommodates four districts – Johor Bahru, Kulai, Kluang, and Kota Tinggi. The fundamental urbanised towns of the JRB are Layang-Layang, Ulu Tiram, and Kota Tinggi, and they may be placed close to Sayong River, Tiram River, and Johor River respectively.

There are four tributaries along the JRB which particularly, Linggiu River which dammed up to make the Linggiu Reservoir at the north part, Sayong River in the north-west, Tiram River in the south-west and Lebam River in the south-east. According to Tan et. al, 2015 [2], the total length for the JRB itself is around 123 km, originates from the Belut mountain located northwards of the JRB and flows to the southern part into the strait settling apart Johor and Singapore.

In addition, huge clusters of residential areas have excessive population equivalent (PE), that are related to excessive density of wastewater treatment plants (WWTPs) for the treatment of wastes. Hence, excessive density of WWTPs is clustered around main residential areas which includes Kota Tinggi, Ulu Tiram, and Chemangan.

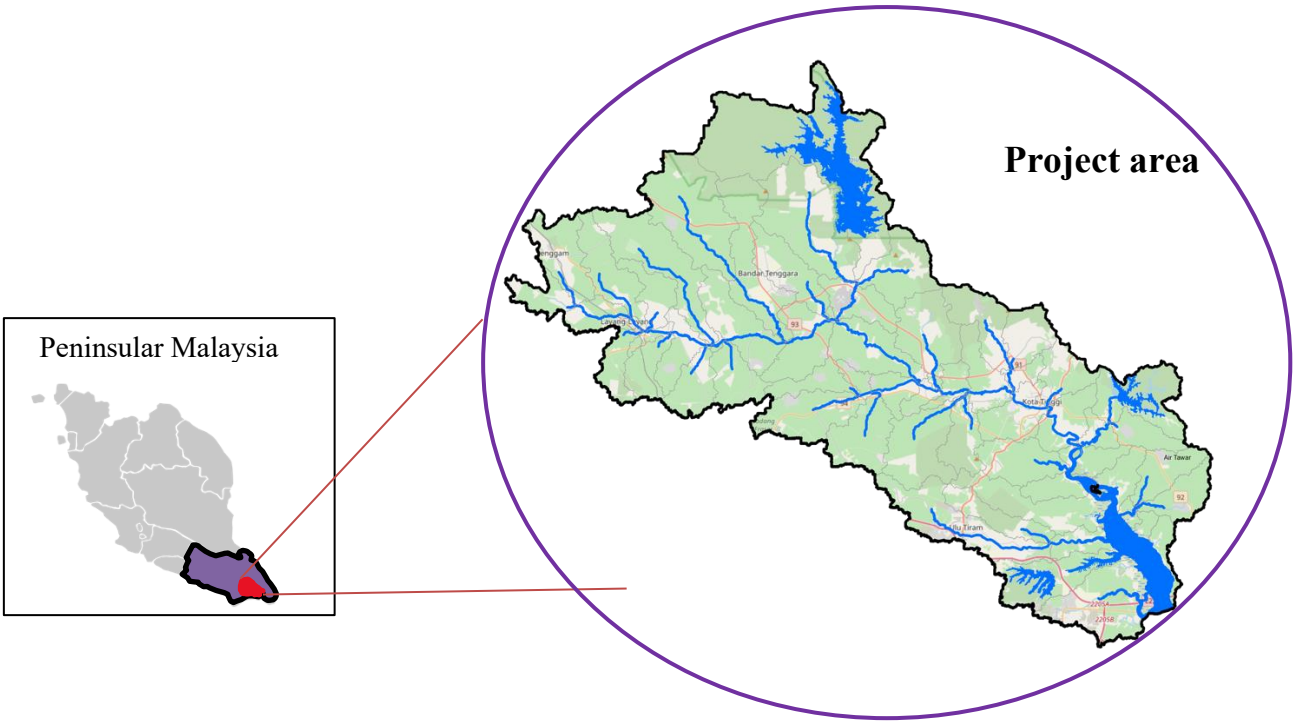

Figure 1. Johor River Basin.

2. Methodology

The calculation of total water demand is based on theoretical water demand modelling framework (Figure 2.) within their contributing catchment area which included domestic/residential, industrial, agriculture, livestock and plus the non-revenue water of all contributing around the catchments area.

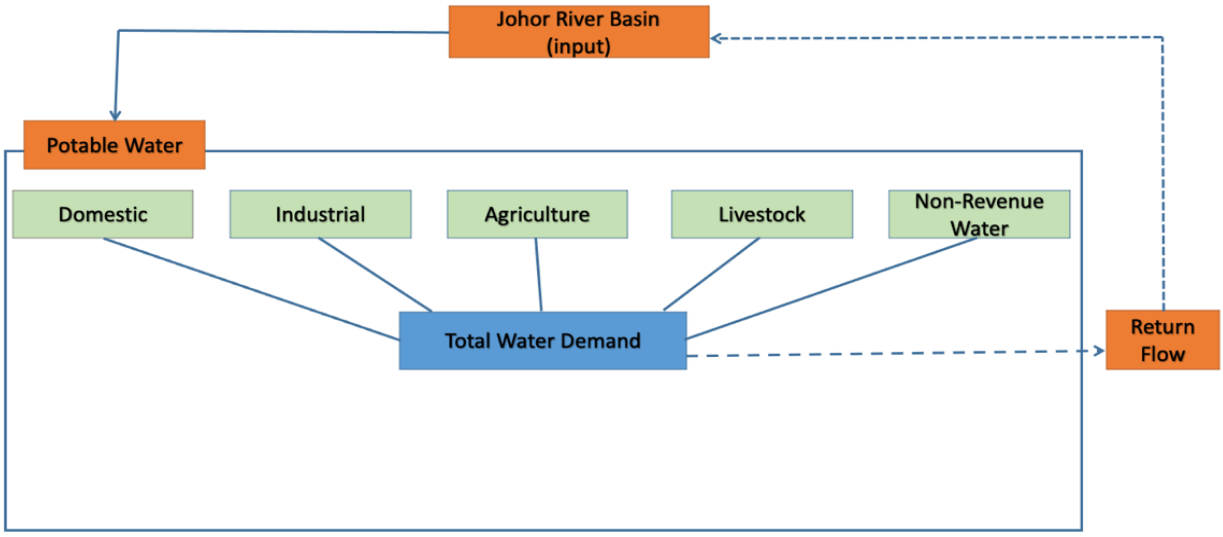

Figure 2. Water Demand Modelling Framework.

2.1 Quantification of Water Demand for each Sectors

Water demand estimations are included total water demand from selected sectors that involves within the river basin area. Water demand estimation involve four main sectors which particularly 1) Domestic/Residential, 2) Industrial, 3) Agriculture, 5) Livestock and plus the non-revenue water. Many

factors influence water demand including socioeconomic variables such as population density, population growth, water price and area development or called land use covered. [1].

The secondary data are collected through engagement with relevant agencies or local authorities. The next stage is data analysis and water demand forecasting which includes estimation of total water demand from all selected sectors in the river basin area. Domestic water demand management is to make water available for all people within the basin area without compromising the sustainability of the system [3]. To calculate domestic water demand (Equation 1.), the capita domestic water use for JRB is multiplied with projected population. As for industrial water demand (Equation 2.), it refers to the level of local water consumption rate, litre per worker per day, (lwd) from the industrial itself and the projected number of workers in manufacturing sector which the degree of industrialization around the JRB [4].

To compute the agriculture water demand (Equation 3.) by multiplying the catchment areas of irrigation projects or namely as irrigated areas with the agriculture annual water use or consumption. As for livestock water demand (Equation 4.), all communes of the considered catchment by multiplying the livestock-specific water needs (L/head/day) with the number of cattle-heads. Last but not least, non-revenue water (NRW) represents the difference between the volume of water supply in water distribution system and the volume that billed to customers or consumers. It is possible that NRW in the water distribution system could be a result of water loss due to theft, leakage, pipe burst, meter inaccuracy and other uncountable losses once it leaves the water treatment plant [5].

Domestic water demand (DWD) = Population projection x lhd (1)

Industrial water demand (IWD) = Projected No. of Workers in Manufacturing x lwd (2)

Agriculture water demand (AWD) = Irrigated areas x Water consumption (3)

Livestock water demand (LWD) = number of cattle-heads x Water consumption (4)

2.2 Total Water Demand for Johor River Basin

The total water demand (Equation 5.) are calculate within their contributing catchment area which included domestic, industrial/institutional/commercial, agriculture, livestock water demands plus the non-revenue water of all contributing around the catchments area. The total water demands are being calculated within the contributing catchment area to the scheme measured at their flow points from all water sectors and Million per Litre per Day (MLD) were finalized as the end value.

$$Total\ Water\ Demand = (DWD + IWD + AWD + LWD) / (100\% - NRW) \quad (5)$$

3. Results

3.1 Population Projection

According to Pak, Chuah, Yong & Snyder, 2021 [6], the Johor River Basin (JRB) are occupied with four different districts in Johor state which was the *Kluang, Kota Tinggi, Kulai* and *Pasir Gudang.* Based on paper from Tan et al., 2021 [7], the JRB are quite important to Malaysia and Singapore for the consumers to consume the water from JRB and it is very crucial when it comes to pollution matters and any other concerns, it might affect the whole entire ecosystem level whether from human being lifestyle, the life for animals and plants or even for the economic values.

It is very fundamental to know the population growth within the river basin that potentially act as a big factor that contribute the water demand from JRB. Based on dataset from Joint Research Centre (2018), *Pasir Gudang* are estimated about 15% from Johor Bahru that occupied within the river basin and it is the gap and recent for calculating the population growth within the river basin itself.

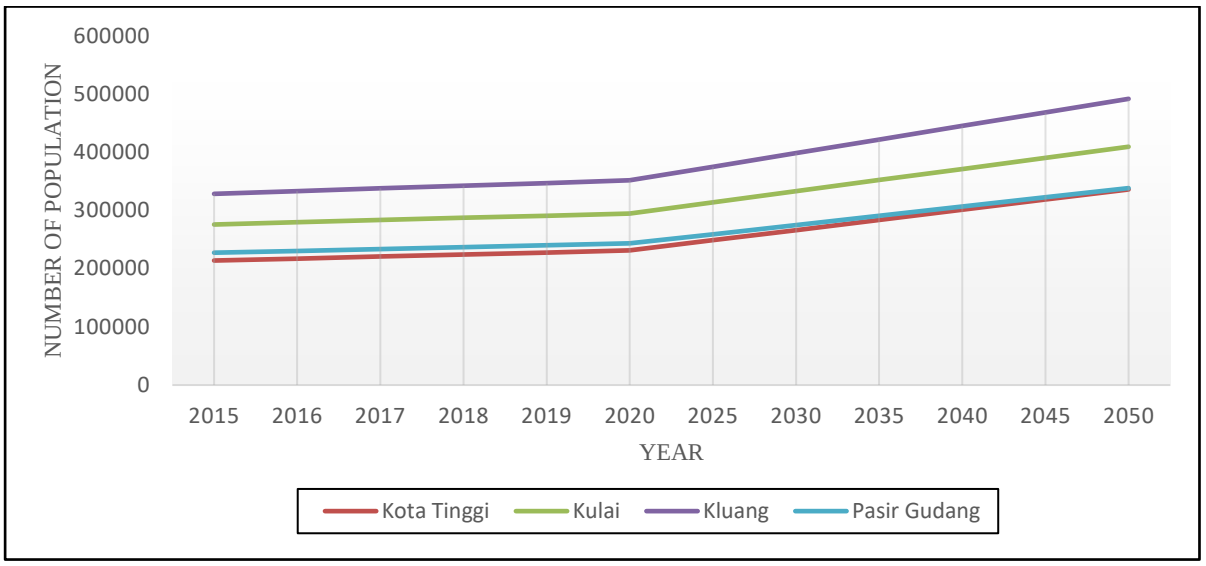

Figure 3. Population projection from 4 different district within Johor River Basin.

By referring Figure 3, Kluang shows the highest value of population growth up to the current data which is 2019 with 347100 population and to be predicted that Kluang will be keep rising up to 2050 with 491717 population compared from other districts. It is forecasted that others district also will keep rising from 2020 up to 2050. From the figure 3, it tells that indeed the consumer are demanding the resources like in this research, water from JRB. But before jumping into conclusions, must be remembered that there are other sectors that involved in utilized the water from JRB.

3.2 Water Demand by Each Sector

3.2.1 Domestic. The figure 4. shows the trend for domestic water demand for Johor River Basin that adopted by total population within the river basin and water consumption (litre per head per day) over period of time and it is forecasted from 2020 (248.88 MLD) up to 2050 (349.76 MLD). Overall, there was linearly climbing up the graph for the domestic water demand with these adoption over period of time even the actual data up to 2020, from 2015 it is slightly increase from time to time in terms of daily water consumption within the JRB since the population growth are forecasted to be increase in a future.

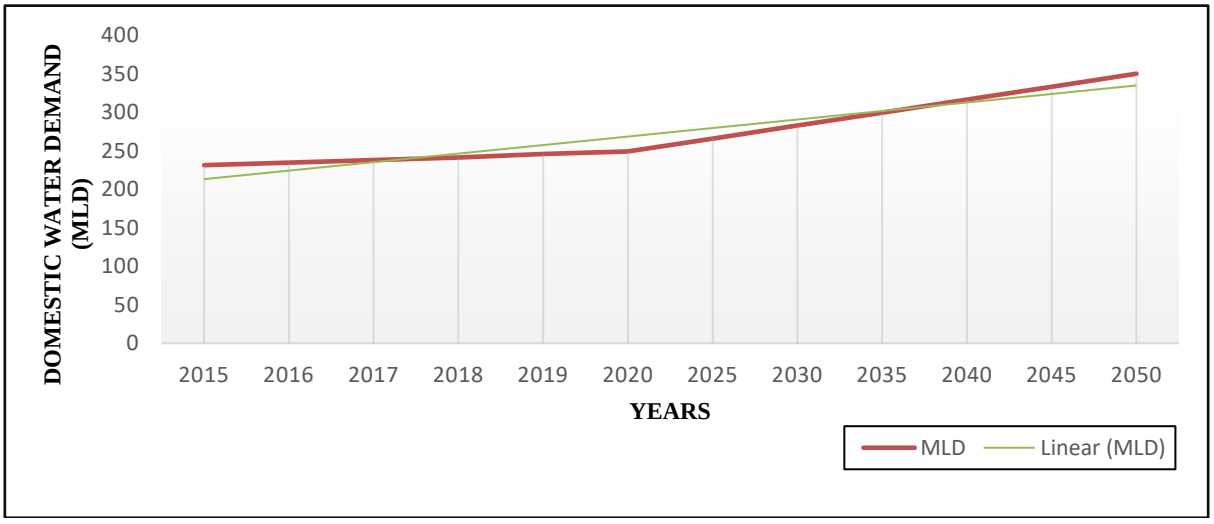

Figure 4. Domestic Water Demand Projections '2020-2050' For Johor River Basin.

3.2.2 Industrial. Since the manufacturing are the main activity for the industrial sector within the Johor River Basin, it is important that to look into the water demand and projection for this sector. According to the figure 5, it shows the gradually predicted to increase over some period of time up to 2050 which is 79.09 MLD and some highlights from the graph, where 2020 (34.65 MLD), the actual data from local authority, it interprets that slightly dropped.

It is believed that the year 2020, where corona virus or Covid-19 virus hit all countries globally and the lockdown enforcement have been implemented through out the entire nation, not just in Malaysia, but across the globe. Therefore, due to this strict operation procedure that have been announced by the government, most the people have to stay and remain at home for quite some time. And also, most of the people have to worked from home and some lost their job. So, this might be one of the factors that the graph shows slightly dropped regarding on water consumption in industrial sector and low production within the river basin since many of the workers lost their job due to pandemic situation

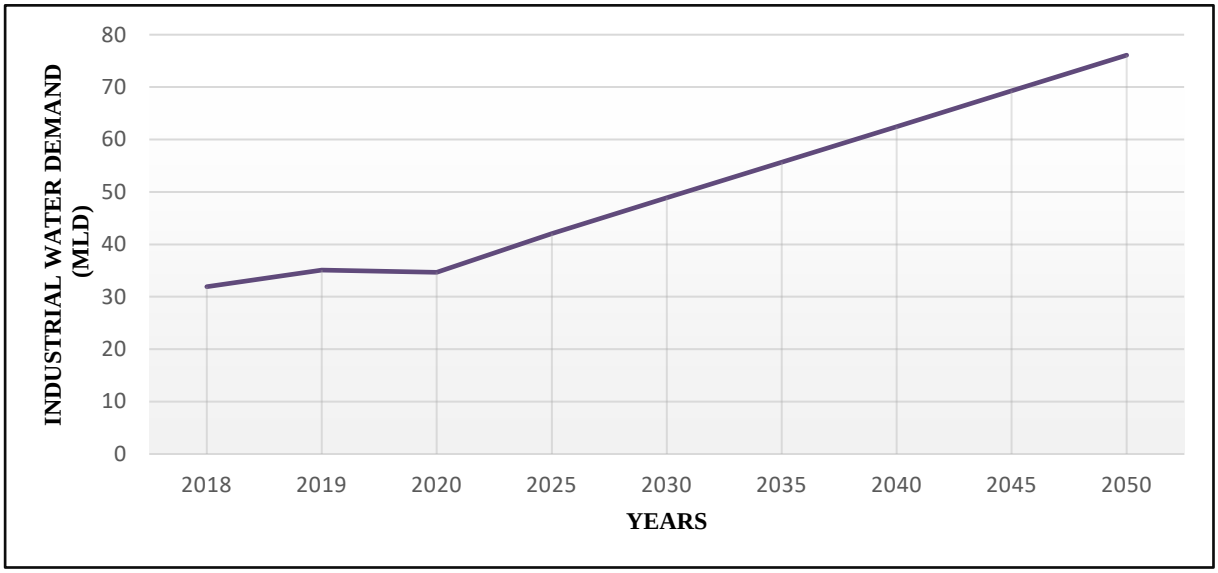

Figure 5. Industrial Water Demand Projections '2020-2050' For Johor River Basin.

3.2.3 Agriculture. It is very interesting when look into the figure 6. regarding on agriculture water demand matters within the Johor River Basin. Based on the figure 6. it can tell that there are few ups and downs over period of time and 2020 gives significantly dropped. But it is predicted up to 2050 it probably only 16893 MLD maybe due existence an advance water technology within the river basin. It is believed that the dropping on 2020 with water demand for agriculture because of first, labour losses in the oil palm field due to pandemic situation happen across entire nation and give consequences poor management on oil palm field and low usage on water from the river basin itself and affect international market value.

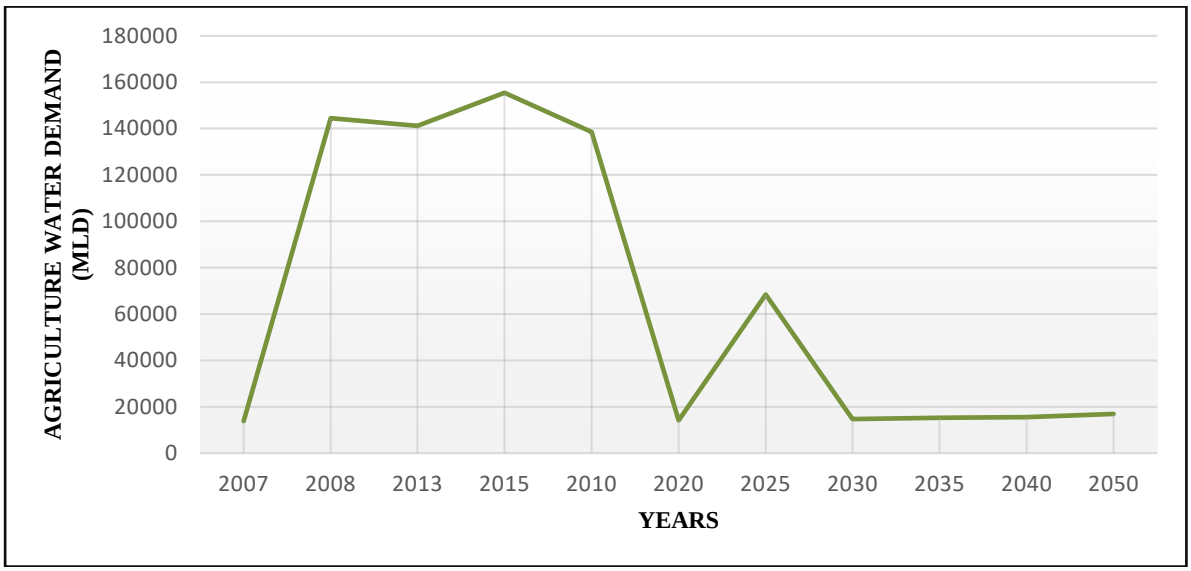

Figure 6. Agriculture Water Demand Projections '2020-2050' For Johor River Basin.

3.2.4 Livestock. The water demand for the animal husbandry or livestock for example, buffalo, beef cattle, pig, local fowl and else are take into consideration on washing, drinking and abattoir water requirements since should be using clean or treated water to prevent contamination and disease carry-over to humans and same goes to the drinking water for the livestock. Based on the graph from 2008 up to 2020, it just shows gradually increase on water requirements and to be predicted that on 2050, the water demand would be 17.48 MLD

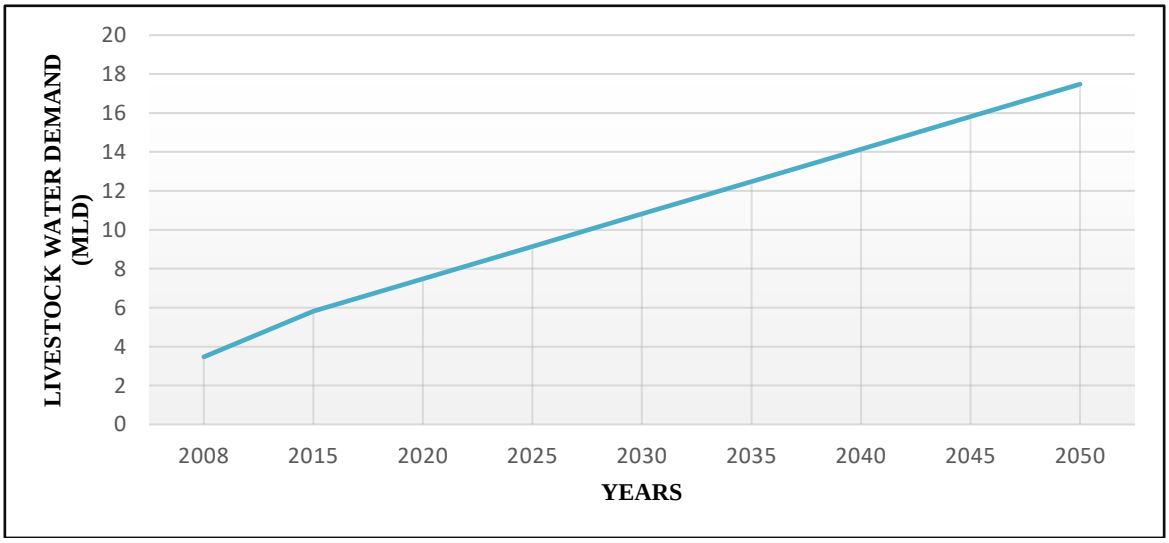

Figure 7. Livestock Water Demand Projections '2020-2050' For Johor River Basin.

3.3 Total Water Demand for Johor River Basin

The total water demand for Johor River Basin is fundamental and important in any water resources study. In this research, the water demand has been computed from all main sectors or activities within the JRB and then the value has been forecasted from 2020 to 2050 since it is the main objective for this research.

Table 1. Total Water Demand Forecast from '2020-2050' for Johor River Basin.

	2020	2030	2040	2050
Water Demand For Johor River Basin (MLD)	193	201	213	232

Based on Table 1, the water demand for Johor River Basin on 2020 and 2050 are 193 MLD and 232 MLD respectively. From the table, the per capita consumption (pcc) is assumed to be increase steadily to 232 MLD and must be work closely with local stakeholder to work with policy-maker to reduce the value into 180 lhd since that in line with Suruhanjaya Perkhidmatan Air Negara (SPAN) or National Water Services Commission's target.

4. Conclusion

The findings in this research help and have significant implications for the water demand framework locally. The assessment framework developed through this research will provide a valuable tool in opening up and introducing the analysis of the proposed water demand framework worldwide. These findings are important to both policy-makers and stakeholders in planning, reviewing and comparing the availability of water resources and the increase in water demand. In the future, research should be conducted to look into the effects of climate change factors for example weather on the prediction of water demand using different scales or parameter.

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