WEAP Analysis of Water Supply and Demand in Langat Catchment of Malaysia

***Khan M.M.H[1] and Kundai T. C.[1]**
[1] INTI International University, Persiaran Perdana, Putra Nilai, Negeri Sembilan, Malaysia.

***Email:** munir.hayetkhan@newinti.edu.my

Received: *1 June 2022;* ***Accepted:*** *13 June 2022;* ***Published:*** *20 June 2022*

Abstract: Recently, there have been water shortages in the state of Selangor of Peninsular Malaysia due to pollution from surrounding river tributaries, increase in destruction and degradation of water catchments. This study serves to look into the water demand and supply issues by analyzing the trend and relationship between demand and supply of water in Langat catchment, evaluating the current water availability and water demand for different sectors, such as agriculture, industry, and domestic using and analyzing the status of future scenarios of the water supply system. Water Resource Modelling tool called Water Evaluation and Planning (WEAP) obtain meteorological, population and climate data from relevant authorities and entering the data into WEAP which will simulate results based on the data entered and scenarios suggested by the users. The results obtained from the simulation show that an increase in population growth rate will result in increased demand for water, as found that in 2009 the demand for water is 370 million cubic meters and in 2040 it is 560 million in cubic meters, low population growth rate however shows that as population growth rate decreases demand and unmet demand for water decreases which shows that demand for water in 2009 the demand for water is 370 million cubic meters and in it is 280 million cubic meters. Hence this will help water management authorities to plan and allocate available resources accordingly so that it does not affect water availability for future generations.
.

Keywords

WEAP; Water demand; Langat; Hydrological data

1. Introduction

Malaysia is a country located in South-East Asia and has been experiencing extensive economic development since after 1980. This has caused an upscale of water demand in the residential, industrial, and commercial aspects of the country, it was predicted that by 2020 if it had not been for the COVID-19 pandemic, Malaysia could have fully industrialized hence the government had to conserve, manage, utilize, and develop water sources through sustainable and environmentally conscious schemes (Anang et al.,2019). Also, Malaysian Water Sector noted that there was a decrease in water resources in Selangor and Negeri Sembilan states. An article on The Edge Malaysia Weekly noted that Suruhanjaya Perkhidmatan Air Negara or the National Water Services Commission's (SPAN) publication, Water and Sewerage Statistics 2019, indicated that Selangor had a water treatment capacity of 4,706 million liters a day however the demand in Selangor was

4,856 million liters a day in 2018. Another major concern for Suruhanjaya Perkhidmatan Air Negara or the National Water Services Commission is that in 2019 its publication showed that Selangor's water services operating expenditure was RM2.78 billion and the revenue received was RM2.11 billion bringing a large deficit of RM668.23 million. The major issue of concern is whether the available water resources in the catchment will be able to sustain the people, industries and agricultural sectors that lie within the catchment. After taking note of all the problems mentioned above, this research serves to use the Water Evaluation And Planning (WEAP) software to analyze the trend of water supply and demand and the water resources at hand in the Langat catchment. Hence the objectives of this study are to: 1. To analyze the trend and relationship between demand and supply of water in Langat catchment, evaluate the current water availability and water demand for different sectors, such as agriculture, industry, and domestic using WEAP. 2 To analyze the status of future scenarios of the water supply system and then evaluate them to make recommendations for these different future scenarios.

2. Methodology

2.1 Study Location

The Langat River catchment is in the south-eastern parts of the Selangor state of Malaysia. Figure 2.1 indicates the boundaries of Langat River catchment and its major tributaries which are Langat River, Semenyih river and Labu river. The catchment has an estimated area of 2350 km^2, Langat River, the main tributary, having a length of 182 km. This catchment has a tropical climate, having annual rainfall of 2145mm and annual evapotranspiration of 1500mm. The catchment has been chosen as the study area due to its importance to the country. The catchment has an important role of providing water for both domestic use and commercial use to approximately 2.5 million people that live inside and outside of the basin, comprising of Kuala Lumpur, which is the capital city of Malaysia and it contains highest population density in Malaysia and Federal Territories of Putrajaya and Cyberjaya.

Figure 2.1 Langat basin

2.2 Data collection and Utilization

The data used in this research (from 2009 to 2019) was attained from different government ministries by emailing them and filling out application forms to confirm the exact information required and for which years. The following is the data needed for the study and where it will be obtained:

- Catchment map in shapefile format from the Drainage and Irrigation Department (DID) and Lembanga Urus Air Selangor (LUAS)
- Land use map in shapefile format and land use data (catchment area) from Federal Department of Town and Country Planning Malaysia and also from Department of Statistics Malaysia
- Hydrological data such as rainfall station data, data, evaporation, streamflow data and data about dams and reservoirs in the catchment from the Drainage and Irrigation Department (DID)
- Meteorological and population data from Department of Statistics Malaysia
- Water demand data including water consumption in the industry sector, domestic and water use rates from Lembanga Urus Air Selangor (LUAS)

2.3 WEAP modelling tool

In developing a WEAP model, the study boundary, the study period, and components of the study system were required to be defined as an independent set of data and assumptions. Figure 2.2 shows the overall hydrologic modeling framework. To develop the model structure, the whole Langat area was observed as a single catchment in WEAP, according to available hydrological data from respective government departments and ministries, and three sub-districts which were domestic, industrial and agricultural demands. The detail step by step methodlogy could be read in SEI, 2011.

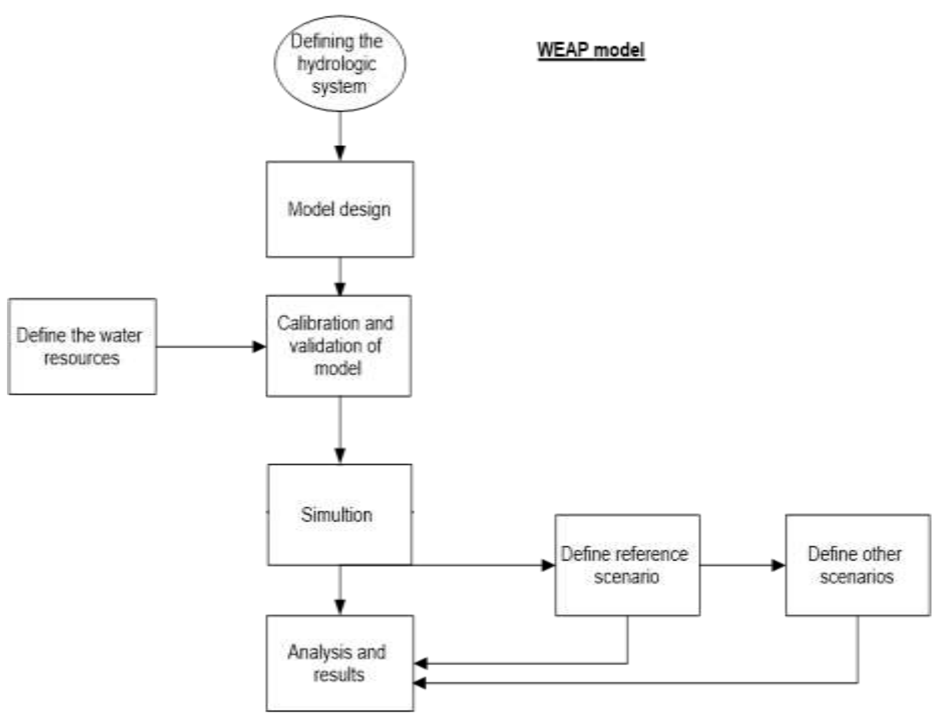

Figure 2.2: modelling framework of WEAP

To notify WEAP on how the demand is met, the user needs to connect the supply system which has been identified previously to each demand site. This was completed in the schematic view where transmission link is added from the water supply source. The link was first positioned on the river, then pointing to the demand node. This was done for the three demand sites represented in this study (industrial urban and agricultural). After transmission links were added the return flow links, were then incorporated into the model to inform WEAP on how the demand is satisfied, this was done by connecting the return flows from the demand sites. The return flow links were connected back to the rivers.

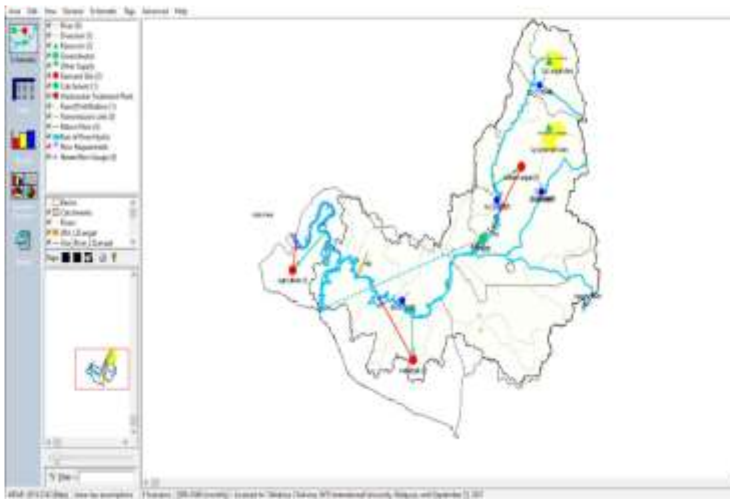

Figure 2.3: Schematic representation of Langat in WEAP.

3. Results and Discussion

3.1 Calibration and Validation

The six years of observed discharge data, from 2009 to 2014 were selected for the model parameters adjustment. After the calibration, the quality of the model was evaluated according to the study by Moriasi et.al. (2007) who recommend three quantitative approaches to quantify how well the WEAP model fits the observed data in watershed simulations. These methods are: (1) Nash-Sutcliffe efficiency (NSE) is a normalized statistic that determines the relative magnitude of the residual variance compared to the measured data variance, it indicates how well the plot of observed versus simulated data fits the 1:1 line. The NSE ranges between $-\infty$ and 1.0 with NSE = 1 being the optimal value. Values between 0.0 and 1.0 are generally viewed as acceptable levels of performance, whereas values <0.0 indicates that the mean observed value is a better predictor than the simulated value, which indicates unacceptable performance. (2) Percent bias (PBIAS) measures the average tendency of the simulated data to be larger or smaller than their observed counter parts. The optimal value of PBIAS is 0.0, with low-magnitude values indicating accurate model simulation. Positive values indicate model underestimation bias, and negative values indicate model overestimation bias. (3) Ratio of the root mean square error to the standard deviation of measured data (RSR). RSR incorporates the benefits of error index statistics and includes a scaling/normalization factor, so that the resulting statistic and reported values can apply to various constituents. RSR varies from the optimal value of 0, which indicates zero RMSE (root mean square error) or residual variation and therefore perfect model simulation, to a large positive value. The lower RSR, the lower the RMSE, and the better the model simulation performance.

Table 3.1: Accuracy of model through quantitative analysis by calibration and validation

Simulations	NSE	PBIAS	RSR
Calibration (2009-2014)	0.95	9.82	0.21
Validation (2015-2019)	0.89	11.09	0.34

3.2 Reference scenario

The reference scenario for this study was set using information from current accounts as well as census information from the Department of statistics Malaysia. To set the reference scenario the date, population and growth rate of population were entered in WEAP as key assumptions. The growth from function in WEAP was used to process the data. The last census before current account year was done in 2000, yielding a population growth rate of 1.3% and the population in the Langat catchment was 663293 people. According to the graphical results simulated by WEAP in the reference scenario the water demand increases steadily from 2009 to 2016 where the demand is 330 MCM (million cubic meters) in 2009 to 400MCM in 2016, thereafter there is a steep rise in the water demand for all demand sites in the catchment, that is urban, industrial and agriculture. In 2040 the demand for water in the reference scenario for all demand sites is 450MCM as shown in Figure 3.1.

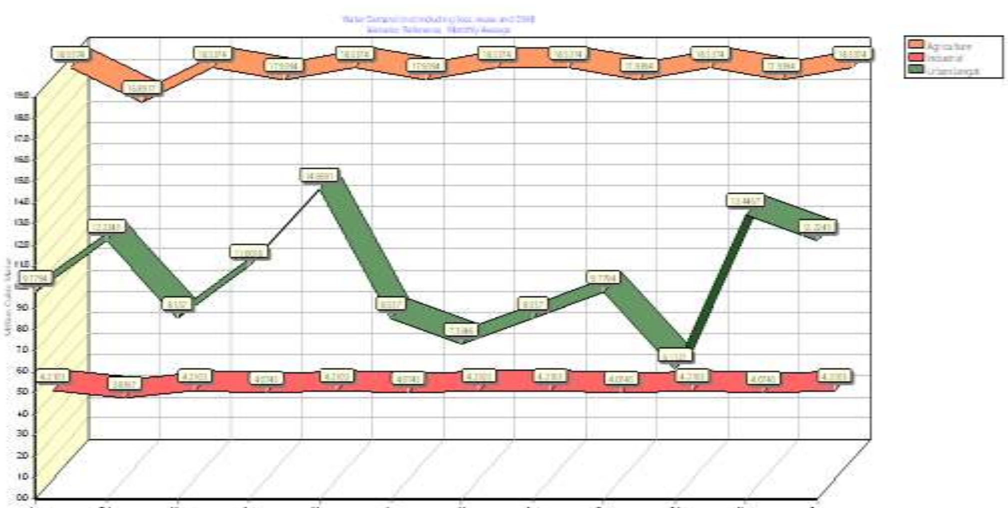

Figure 3.1: Graphic representation of reference scenario water demand in WEAP

3.3 High population growth rate

In this scenario WEAP is used to project results for a rise in population growth at a rate of 3% instead of the 1.3% in the current account within the Langat catchment. This scenario is based on the data that is provided by Department of statistics annually, the data shows a gradual rise in the population of people in the catchment annually. The results in WEAP were simulated by assuming this scenario and results are analyzed accordingly.

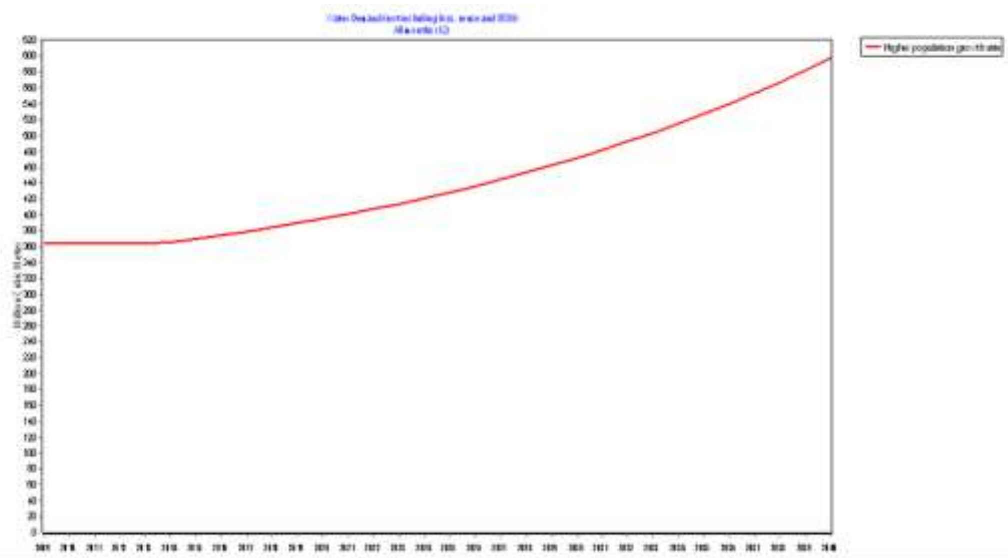

Figure 3.4: Water demand analysis for high population growth rate in Langat

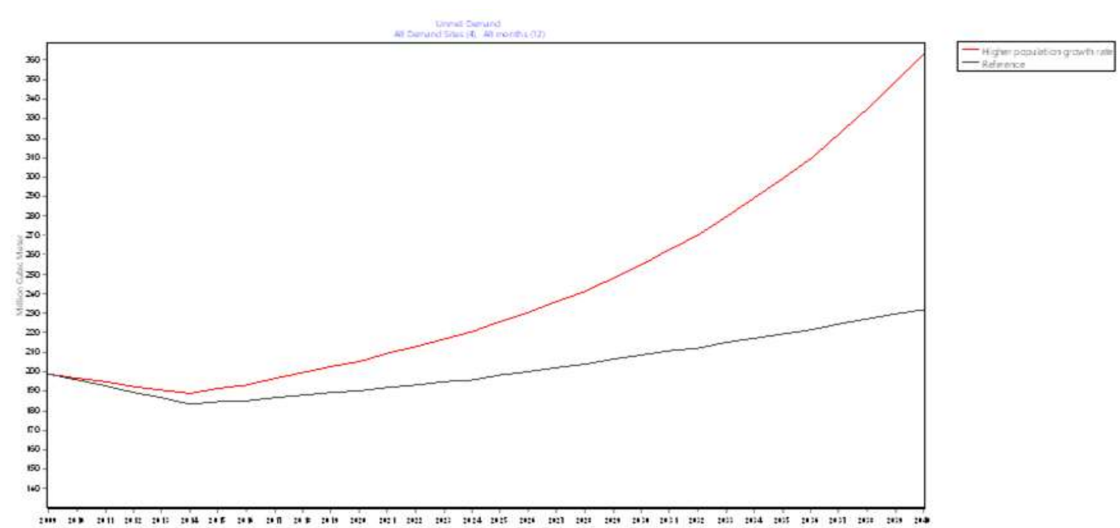

Figure 3.5: Unmet water demand comparison between reference scenario and high population growth rate scenario

Langat is a largely urbanized area in Malaysia because of being in the capital state of Selangor. This area is close to the capital Kuala Lumpur, where most people work. The population in the area is increasing annually as shown by the population data in Appendix A. People migrate from other areas to Selangor to ensure ease of mobility when travelling to work. Also, students both international and local flock into Selangor especially for tertiary education, this also results in increase of population gradually. Figure 3.4 shows the water demand of water for the increased population growth rate in the whole catchment for all demand sites. Water demand in this scenario increases from 300MCM in 2009 to 600MCM in 2040, this shows that the demand for water doubles over the 31 years. This means that increase in population is directly proportional to increase in demand for water for all demand sites (urban, agricultural, and industrial). Figure 3.5 outlines the comparison between unmet water demand for the reference scenario and the high population growth rate scenario, in the reference scenario the population growth rate is 1.3% and in the high population growth rate scenario is 3%, this means that there is a higher population in the high population growth rate scenario and a lower population in the reference scenario. The unmet demand for water in 2040, according to the high growth rate scenario, is 360MCM and that of the reference scenario is 210MCM. This factor shows that meeting he demands of water in the catchment is highly dependent on the population increase because increase in population means increase in water demand for both domestic and industries due to increased industrialization.

Previous research Azlinda (2009) was carried out on water demand in the catchment of Langat, for the scenario of high population of 2.2% this scenario gave the Unmet Demand value of 230.5MCM in 2010. This is less than the 360MCM observed in this study because of variation in dates of the data used.

4. Conclusions and Recommendations

The aim of this study was to apply WEAP to Langat catchment by performing scenario analysis of the water management and development in the catchment. For simulation of an analysis in WEAP, accurate data is required to model the hydrology and water management more precisely. The model was able to simulate the catchment water management scenario. The calibration and validation results from the stream flow data showed that the results modelled in WEAP were good and very good as per NSE, PBIAS and RSR values obtained (Table 3.1), therefore the model was well adapted to the Langat catchment. The model would have worked much better if there had been availability of additional data.

.

Acknowledgements

We would like to thank INTI International University, Malaysia for supports in the research.

References

Anang, Zuraini, et al. Factors Affecting Water Demand: Macro Evidence in Malaysia. 2019, Amani, A, “Modelling Water Resource Management in Lake Naivasha.” Msc. Thesis.

Azalinda Saadon,, Ali, M.F.,., Abd Rahman, N.F., Khalid, K. (2014). An Assessment of Water Demand in Malaysia Using Water Evaluation and Planning System. In: Hassan, R., Yusoff, M., Ismail, Z., Amin, N., Fadzil, M. (eds) InCIEC 2013. Springer, Singapore. https://doi.org/10.1007/978-981-4585-02-6_64

Barrock, Jose. “Water Conundrum in Selangor.” The Edge Markets, 24 Nov. 2020, www.theedgemarkets.com/article/water-conundrum-selangor.

Mohammed, S. (2020). *Selangor water crisis: Less talk, more action*. [online] New Strait Times. Available at: https://www.nst.com.my/opinion/letters/2020/10/633839/selangor-water-crisis-less-talk-more-action.

Moriasi, DN, Arnold, JG, Van Liew, MW, Bingner, RL, Harmel, RD & Veith, T 2007, 'Model evaluation guidelines for systematic quantification of accuracy in watershed simulations', Transactions of the ASABE, vol. 50, no. 3, pp. 885-900.

SEI (Stockholm Environment Institute) 2001. WEAP: Water evaluation and planning system – user guide. Boston, USA