SINGAPORE MANAGEMENT UNIVERSITY

IS602 – Spreadsheet Modelling

Group 7

Project Final Report

Names: Lin Shuyan
Kenneth Low Yan Wei
Peace Tay Jiunn Ching
Widya Tantiya Yutika
Yap Pin Yaw

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1. Background

To ensure adequate water supply, Singapore has signed two (2) Water Agreements in 1961 and 1962 with the State of Johore, Malaysia (MFA, n.d.). Under the agreements, Singapore may draw raw water from Johor at fixed prices, subject to stipulated terms and conditions. The first Water Agreement expired in 2011, and the second Water Agreement will expire in 2061.

Under the second Water Agreement, Singapore may draw and use 250 million gallons of raw water. While imported water is one of Singapore's main sources of water, imported water alone is not enough to meet Singapore's water demand of 430 million gallons per day (PUB, n.d.a). To meet water demand and mitigate the possibility of water shortage, Singapore has diversified water supply sources and supplements her potable water supply with water from desalination plants, NEWater plants, and local water catchments (i.e. rainwater, reservoirs)

However, the second Water Agreement has been a contentious issue between Malaysia and Singapore since Singapore separated from Malaysia in 1965 (Ng, 2018). There have been numerous disputes regarding the fairness of the deal, and price of water per gallon. Malaysia threatened Singapore's survival by threatening to cut the water supply in 1998 and 2002 and attempted to unilaterally change the terms of the agreement on other occasions (Ng, 2018).

2. Problem statement

It is imperative that Singapore achieve water self-sufficiency before the second Water Agreement expires in 2061. It is expected that total water demand will double by 2060. The project will consider supply side measures of how to increase supply from the other 3 water sources, while also considering demand factors affecting potable and non-potable water demand in Singapore.

This study will explore Singapore water needs, namely:

- What is the increase of local water supply needed, to achieve 100% self-sufficiency in water supply by 2060?
- Which source of local water supply should Singapore increase?
- How will water demand change by 2060?

3. Data Sources

Variable	Description	Data Source
Imported Water	Water imported by Malaysia	mfa.gov.sg
Local Water Production (Desalination and NEWater)	Water supply from existing desalination and NEWater plants	authors.library.caltech.edu/78271 straitstimes.com pub.gov.sg
Population Size	Historical population size	singstat.gov.sg
Water Sales	Historical water sales, by Potable Water, NEWater, and Industrial Water	singstat.gov.sg data.gov.sg
Projected Population Growth Scenarios	Different scenarios of population growth of Singapore	lkyspp.nus.edu.sg/ips worldpopulationreview.com
Rainfall	Historical total annual rainfall in Singapore	data.gov.sg
Land Area	Historical Singapore land area	data.gov.sg

Table 1: List of Data Sources

4. Blackbox model and Influence Diagram

4.1 Influence Diagram

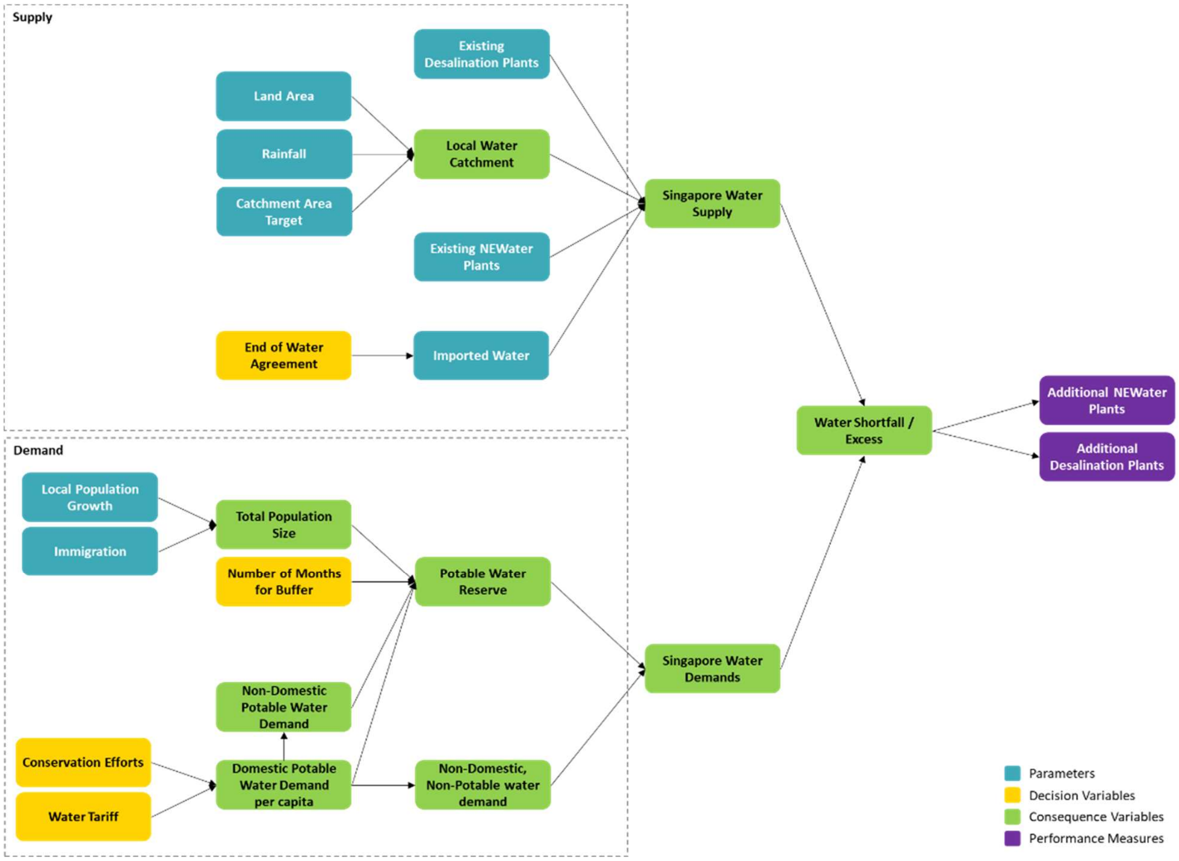


Figure 1: Influence Diagram for Singapore's Water Self-Sufficiency

4.2 Black Box Model

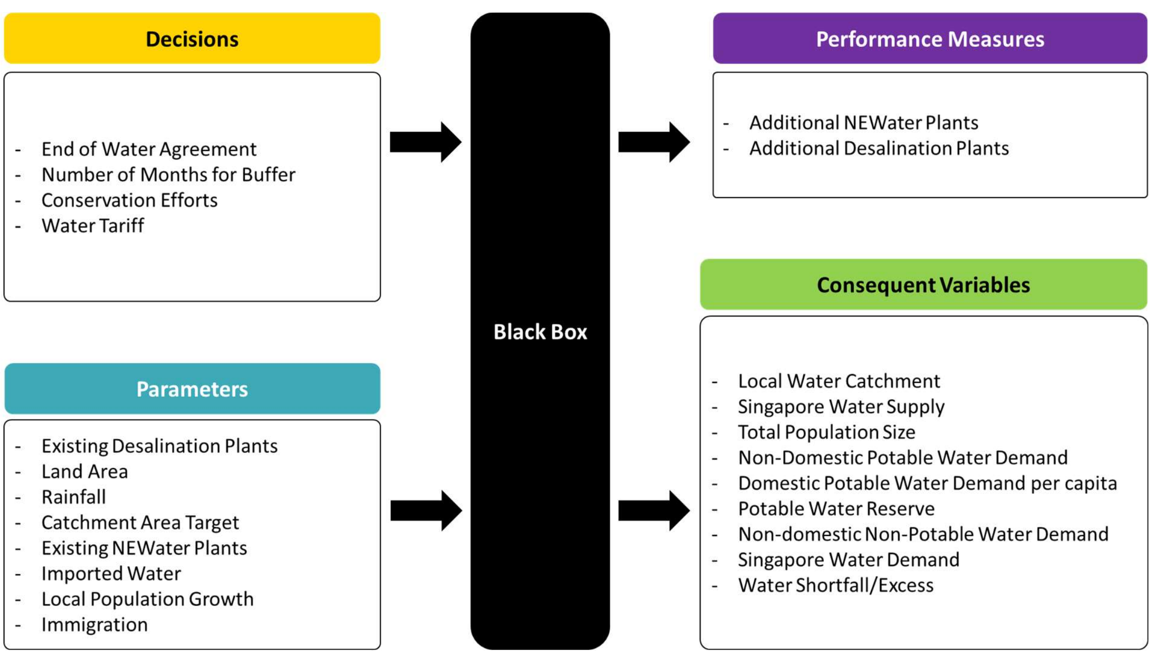


Figure 2: Black Box Model for Singapore's Water Self-Sufficiency

5. Model Computation & Assumptions

5.1 Planning Scenarios

Three pre-set scenarios were used in the model to forecast the results: Low, Expected and High, where the decision variables are used to determine the demand for water. The "Main" tab also allows users to vary individual decision variables to explore further.

The variables were determined to simulate the following situations:

- **Low Scenario** – Low demand, and high supply of water
- **Expected Scenario** – Expected demand, and expected supply of water
- **High Scenario** – High demand, and low supply of water

Demand Factors:

	Low Scenario	Expected Scenario	High Scenario
Population	**Low:** 6,100,000 in 2060 *World Population Review (2022)*	**Medium:** 9,600,000 in 2060 *Appendix A - Equation 1*	**High:** 11,200,000 in 2060 *Appendix A - Equation 1*
Water tariff (% Increase)	**High:** 6%	**Medium:** 3%	**Low:** 0%
Conservation efforts	**High Effect:** 110 litres per day per capita in 2060	**Medium Effect:** 120 litres per day per capita in 2060	**Low Effect:** 130 litres per day per capita in 2060

Table 2: List of Demand Factors and the Parameters under Pre-set Scenarios

Supply Factors:

	Low Scenario	Expected Scenario	High Scenario
Rainfall intensity (percentile of historical data)	**High:** 75th Percentile	**Medium:** 50th Percentile	**Low:** 25% Percentile
Water agreement end date	2061	2040	2022

Table 3: List of Supply Factors and the Parameters under Pre-set Scenarios

5.2 Water Demand

The R^2 value of the linear relationship between population and the total water demand is 69%. Therefore, the model uses the total population as the main driver of water demand to predict both domestic and non-domestic water demand in the coming years.

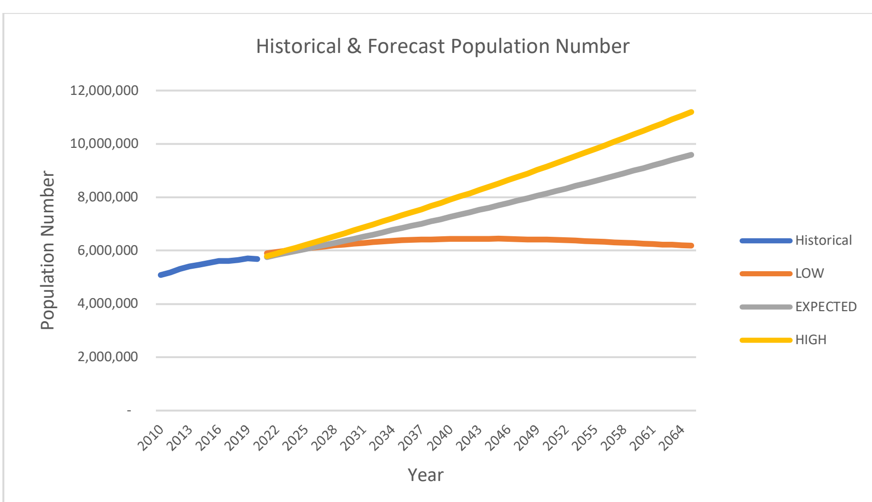


Figure 3: Existing Population Size (2010-2020), with Forecasted Population Size (2021-2064)

5.2.1 Potable Water Demand

5.2.1.1 Domestic Potable Water Demand

Domestic potable water demand is dependent on population growth, water conservation efforts and water tariff. This is computed in the "DD Pot_Water" sheet. Historical daily domestic water demand per capita is found using Appendix A – Equation 2a.

Conversation efforts:

- In the pre-set scenarios, it was taken that the Singapore government's target to reduce daily domestic water consumption per capita to 130 litres by 2030 (PUB, n.d.a) is met. The 2060 target consumption rates for the three pre-set scenarios are arbitrary. Water consumption is assumed to decrease linearly.

Increase in Water Tariff:

- Historically, water tariff increases about every 20 years with last two increases in 2018 and 2000. Hence, it is assumed that the next price hike will occur in 2040, with the percentage increase varied for the three pre-set scenarios. The effect of price change is applied on top of conservation efforts. The adjusted daily, per capita potable water demand is calculated using Appendix A – Equation 3.
- The project assumes price elasticity of demand of water is -0.4 based on a study on US residential water conservation programs (Olmstead and Stavins, 2007); this means that for a 10% increase in price, the demand for potable water will decrease by 4%.

Total annual domestic potable water demand is then computed using Appendix A – Equation 2b.

5.2.1.2 Non- Domestic Potable Water Demand

With reference to historical domestic and non-domestic potable water demand, an average ratio of 59% (domestic potable water demand) and 41% (non-domestic potable water demand) is used. It is assumed economic and population growth are positively correlated; hence this ratio is unchanged till 2060. The daily per capita non-domestic potable water demand is calculated using Appendix A – Equation 4a. Total annual non-domestic potable water demand is calculated using Appendix A – Equation 4b.

5.2.1.3 Water Reserve

As potable water is a basic survival need, we assume that a reserve is kept as a buffer in the event of sudden termination of imported water supply. For all three pre-set scenarios, the water reserve is set at 2 months of total potable demand.

5.2.2 Non-Potable Water Demand

For computation of non-potable water demand, refer to the sheet "DD Water_Total".

In 2020, non-domestic water demand (potable water, industrial water, NEWater) comprised of 51% of the total water demand. According to PUB (n.d.a), the non-domestic sector will consume 70% of total water demand by 2060. The model adopts this ratio for 2060 and assumes a uniform increase until 2060. The projection of the total water demand as well as the respective domestic and non-domestic water demand uses Appendix A – Equations 5 and 6.

As non-potable water demand is derived from the potable water demand, water conservation efforts will also result in reduction of non-potable water demand. PUB also implements water conservation efforts for the non-domestic sector.

5.2.2.1 Industrial and NEWater Demand

It is assumed that the proportion of industrial and NEWater out of non-domestic non-potable water demand will remain at 16% & 84%. This ratio is derived from the average of proportions from 2010 to 2020. This ratio will be used in Appendix A - Equation 7 and 8 to calculate the Industrial Water Demand and NEWater Demand.

5.3 Singapore Water Supply

To estimate the total water supply in Singapore, we consider the "Four National Taps" (PUB, n.d.a):- (1) imported waters from Malaysia, (2) desalinated water, (3) NEWater and (4) water from local catchment areas.

5.3.1 Imported Water Supply

According to the second Water Agreement, the volume of imported raw water is 1.137 * 10^6 m^3/day. It is assumed that Singapore always draws this maximum amount all the time as long as the Water Agreement is active.

Each of the three pre-set scenarios assumes a different year of termination of imported water supply. In the LOW pre-set scenario, Malaysia continues to export water to Singapore until 2061 as per the Water Agreement. The EXPECTED and HIGH pre-set scenarios assume early termination of imported water supply in 2040 and 2022 respectively.

5.3.2 Desalination plants

Plant Name	Year Built	Capacity (10^6 m^3/year)
SingSpring Desalination Plant	2005	49.8
Tuas South Desalination Plant	2013	116.25
Tuas Desalination Plant	2018	49.8
Marina East Desalination Plant	2020	49.8
Jurong Island Desalination Plant	2021	49.8

Source: (pub.gov.sg, straitstimes.com, authors.library.caltech.edu/78271)

Table 4: Table of Desalination Plants, their Year Built, and Production Capacity

Capacity of new desalination plants is estimated to be the average of the three latest plants. It is also assumed that all plants operate at maximum capacity all the time.

5.3.3 NEWater

Plant Name	Year Built	Capacity (10^6 m^3/year)
Bedok NEWater Factory	2002	14.6
Kranji NEWater Factory	2002	12.4
Seletar NEWater Plant	2004	*Decommissioned*
Keppel Seghers NEWater Plant	2007	54
Sembcorp NEWater Plant	2010	83.2
BEWG-UESH NEWater Plant	2017	83.2

Source: (pub.gov.sg, straitstimes.com, authors.library.caltech.edu/78271)

Table 5: Table of NEWater Plants, their Year Built, and Production Capacity

Capacity of new NEWater plants is estimated to be the average of the three latest plants. It is also assumed that all plants operate at maximum capacity all the time.

5.3.4 Local Water Catchment Areas

Water from the local catchment is computed in the “SS Water_CM” sheet. Water from the local water catchment refers to the amount of rainfall that can be captured and used. The maximum water supply from local catchment is computed considering the total rainfall and catchment land area, using Appendix A – Equation 9. The rainfall intensity is set at the 75^{th}, 50^{th} and 25^{th} percentiles of historical annual rainfall (1982-2021).

Catchment coverage:

- Current local catchment area covers 67% of Singapore’s land area, and it is planned to be increased to 90% by 2060 (PUB, 2015; Centre for Liveable Cities, 2019). Catchment coverage is assumed to increase linearly.
- We have also assumed that total land area is constant until 2060 (i.e. no land reclamation).

Water loss:

- 70% due to evapotranspiration (Friedrich et al., 2018) and an additional of 10 % due to seepage (Cotton Catchment Communities, 2011).

5.4 Supply & Demand Computation

According to the water loop diagram in Figure 4, the demand for domestic and non-domestic potable water are fulfilled by water catchment, imported water and desalination plants. While the demand for non-potable water (i.e. industrial and NEWater demand) are to be fulfilled by NEWater plants.

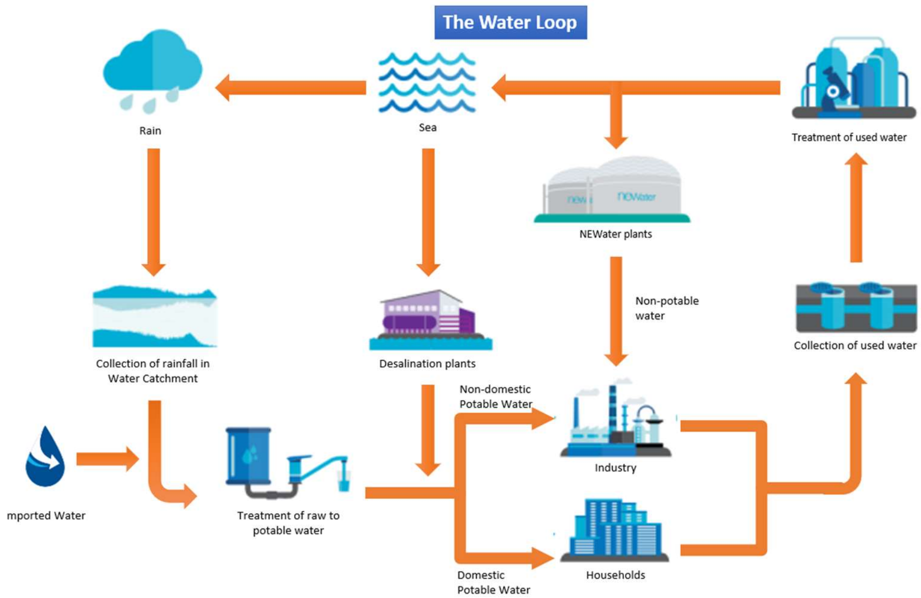


Figure 4: Water Loop Diagram on the Sources of Both Potable and Non-Potable Water

To determine the number of desalination and NEWater plants to be built by 2060 for Singapore to be self-sufficient, there are several computations as follows:

- **Excess/Shortfall**

Excess or shortfall refers to the amount of water left after subtracting water demand from water supply. Excess of water supply is reflected by a positive value, and shortfall a negative value. This is calculated using Appendix A – Equation 10.

- **Number of Additional Plants**

The supply and demand are divided into potable and non-potable water. When there is a shortfall in water supply as compared to demand, additional desalination and NEWater plants are required to be built to fulfil the demand for potable and non-potable water respectively.

6. Analysis & Results

6.1 Overall Results

Based on the historical record and the forecasted values, both potable and non-potable water demand increases steadily across the years. With this demand, Singapore would need to increase the source of the supply for both potable and non-potable water so that Singapore can be self-sufficient by year 2060.

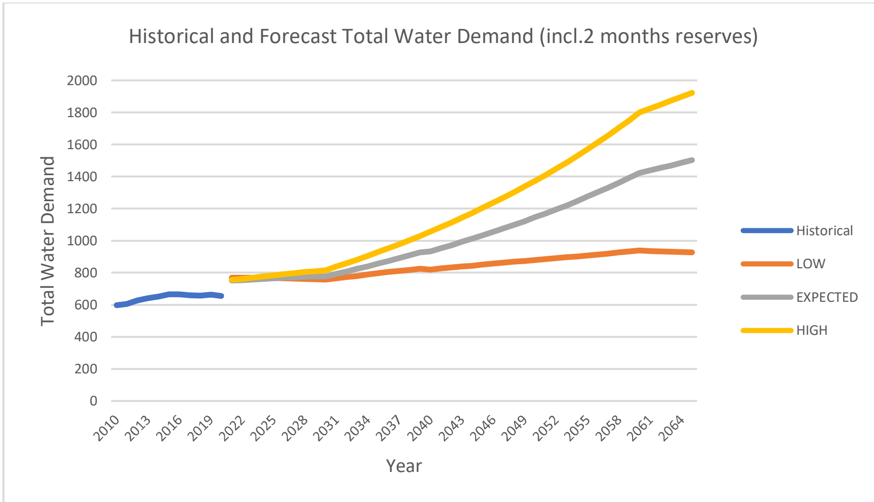


Figure 5: Forecasted Total Water Demand with 2 months of Buffer for Reserve

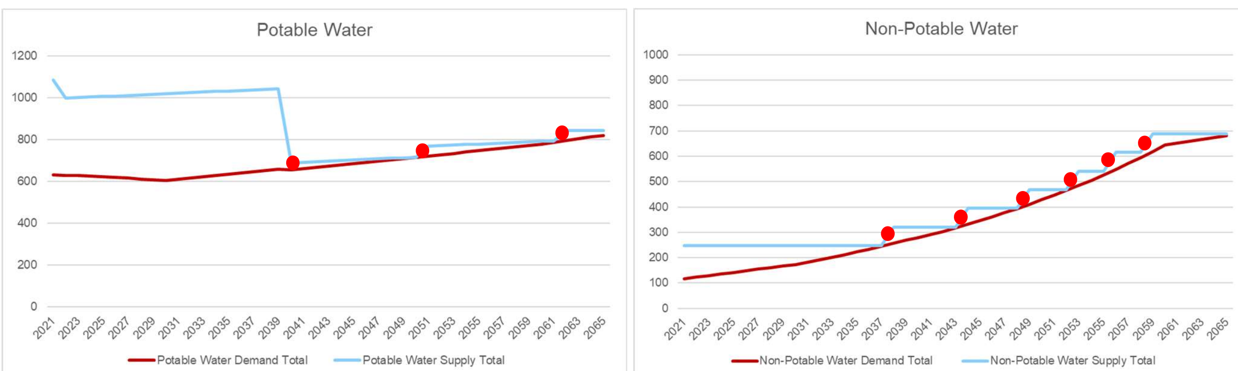


Figure 6: Potable and Non-Potable Water Demand/Supply (Expected Pre-Set Scenario)

Figure 6 describes the supply and demand for potable water (left) and non-potable water (right) after building additional desalination and NEWater plants respectively. The red dot in supply indicates the year by which desalination/NEWater plants are required to be built. The number of additional desalination and NEWater plants that are required for Singapore to be self-sufficient in 2060 for the various pre-set scenarios are summarised as follows.

Pre-set Scenario	Number of Additional Desalination Plants	Desalination Plants Required by year:	Number of Additional NEWater Plants	NEWater Plants Required by year:
Low Scenario	0	-	3	2042,2051,2060
Expected Scenario	3	2040, 2051, 2062	6	2038, 2044, 2049, 2053, 2056, 2059
High Scenario	9	2022, 2022, 2036 2042, 2047, 2052, 2057, 2061, 2065	9	2036, 2041, 2045, 2049, 2052, 2054, 2057, 2059, 2062

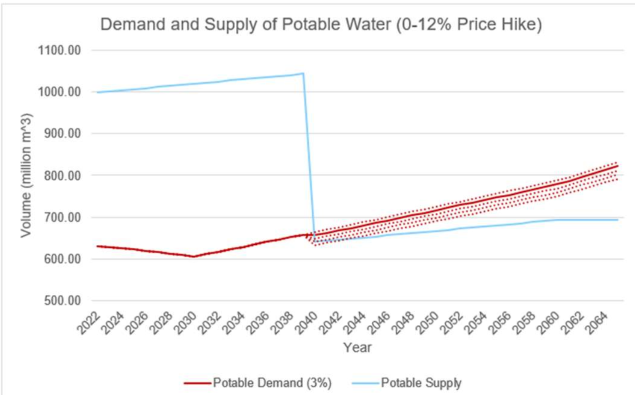
Table 6: Table of Desalination & NEWater Plants, with Required Year under Pre-Set Scenarios

In the LOW and EXPECTED pre-set scenarios, more NEWater plants are required than desalination plants because non-domestic demand exceeds domestic demand and non-domestic non-potable water demand is fulfilled by NEWater plants.

According to Tan and Rawat (2018), NEWater is more energy-efficient and cost-efficient to produce as compared to desalination, meaning that it is more costly to increase potable supply than non-potable supply. As such, to reduce the cost of ensuring sufficient water supply, more focus should be placed on securing natural potable water sources from the local catchment and reducing potable water consumption.

The following trade-off and sensitivity analyses use the EXPECTED pre-set scenario as a base.

6.2 Price Hike Trade-off Analysis



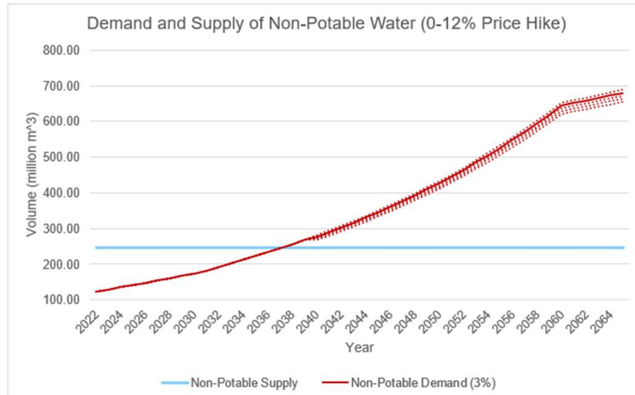


Figure 7: Total potable and non-potable water demand with different rate of price hike (0%, 3%, 6%, 9%, and 12%)

The price hike trade-off analysis examines how demand changes with different rates of water tariff increase. Figure 7 shows the effect of a price hike of 0%, 3%, 6%, 9%, 12% in the EXPECTED pre-set scenario. Increasing the water tariff does not significantly affect both potable and non-potable water demand. This is because water is a necessity, and its demand is price inelastic.

6.3 Rainfall Sensitivity Analysis

The rainfall sensitivity analysis studies the impact of different rainfall intensities on the total supply of potable water. Three cases based on historical annual rainfall are shown: low rainfall at 25th percentile, medium rainfall at 50th percentile, and high rainfall at 75th percentile.

Figure 8 shows the demand and supply of potable water with the three rainfall intensity cases under the EXPECTED pre-set scenario where Malaysia's water agreement ends in 2040. The intersection between the demand and supply lines indicates the year by which the addition of desalination plant is required. In the case where there is low and medium rainfall, the first desalination plant must be built by 2040 to prevent shortage. This means that if Malaysia terminates imported water supply suddenly, there is a 50% chance Singapore will face potable water shortage. With high rainfall, new plants are only needed by 2048, giving Singapore more time to prepare and build the required first desalination plant.

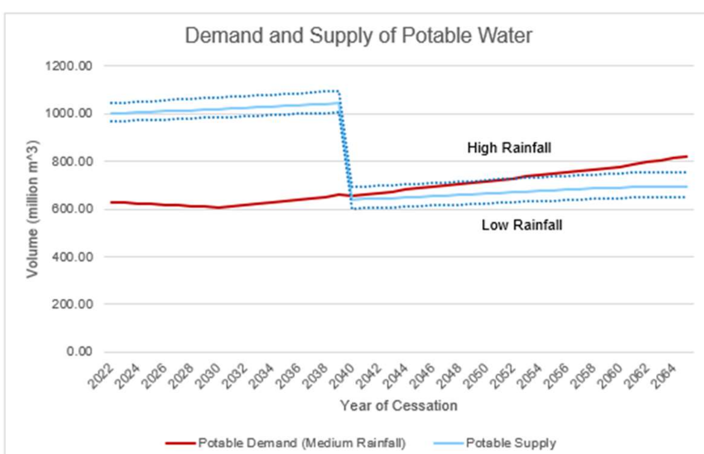


Figure 8: Total potable water demand and supply with different rainfall volume

The amount of rainfall is a crucial deciding factor in the sufficiency of potable water supply in the event of sudden termination of imported water supply. As such, expansion of catchment area should be one of the key areas of focus.

6.4 Water Conservation Efforts Sensitivity Analysis

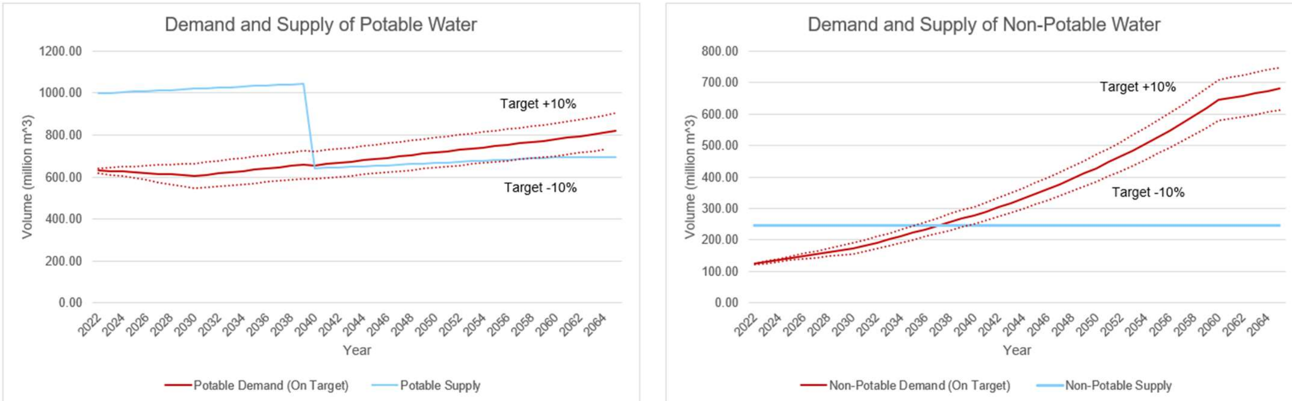


Figure 9: Total potable and non-potable water demand with +/-10% from the conservation effort target

The water conservations sensitivity examines how demand changes depending on whether the water conservation targets are not met (target +10%), met (on target) or exceeded (target -10%). In the EXPECTED pre-set scenario, 10% difference from the target significantly affects potable water demand by around 80 million m^3 and non-potable water demand for around 65 million m^3 in 2060. In total, about 145 million m^3 can be saved annually if the conservation target is lowered by 10%. Therefore, it is important for PUB to initiate wide range of conservation efforts plan to encourage prudent water usage and ensure that the targets are met.

7. Model Limitation and Future Work

The model has some limitations due to lack of data and some assumptions made to build the model. For a more accurate estimation of additional plants needed to ensure water self-sufficiency, the future work should focus on addressing these limitations:

- The model does not account for fact that potable water can be used for non-potable uses which could result in wastage of excess supply of potable water in some years. However, we note that this is rarely done because the cost of processing non-potable water is less than potable water.
- The model does not account for seasonal fluctuations in rainfall because it uses annual total rainfall. During periods of low rainfall, there may be shortage if there is insufficient water reserve buffer. During high rainfall months, not all rainfall can be collected as there is flooding risk. Seasonal rainfall fluctuations may become more pronounced in the future due to climate change and increase short term uncertainty of supply (NCCS, n.d.).
- The model does not account for capital and operating costs of plants and water processing. In considering when and which plants to build, the Government would also need to account for these cost factors.
- The model also does not account for the possibility of new technologies that can be more efficient (i.e. higher capacity processed per day) and cost-effective in processing water in the future (e.g. nuclear desalination).

8. Conclusion

This model allows policy makers to easily test different scenarios and to plan relevant demand-side and supply-sides measures to achieve water self-sufficiency before the termination of Singapore-Malaysia's imported water agreement.

Based on the analysis above, we can conclude that the most direct impact from the termination of Malaysia's imported water agreement would be on the potable water supply as it contributes 37% of it. To ensure Singapore is self-sufficient on potable water, Singapore must boost supply of the two other sources of potable water. As the current water catchment area is only at 66%, Singapore would need to focus on the expansion of the catchment area to 90% to fully utilize the natural rainfall supply of water. In addition, as the rate of climate change is unpredictable, it is recommended that Singapore expect the worst situation of low rainfall and add on more desalination plants to substantiate the potable water supply. Furthermore, the addition of NEWater plants would ensure that non-domestic water demand does not need to draw from potable water sources as the non-domestic water demand outstrips domestic water demand.

This study highlights that Singapore's ability to self-sufficient in water hinges on the growth of water demand. Therefore, the key to allow Singapore being self-sufficient is to focus on conservation efforts plan to ensure prudent water usage by households and businesses.

9. References

Boh, S. (2017, January 18). Singapore launches fifth NEWater plant at Changi, boosting water supply. *The Straits Times*. https://www.straitstimes.com/singapore/singapore-launches-fifth-newater-plant-at-changi-boosting-treated-used-water-supply-by-10

Centre for Liveable Cities. (2019). *Four national taps*. https://eresources.nlb.gov.sg/infopedia/articles/SIP_2019-05-24_170025.html#:~:text=The%20Four%20National%20Taps%2C%20a,as%20NEWater%2C%20and%20desalinated%20water.

Cotton Catchment Communities. (2011). Storage seepage and evaporation. https://eprints.usq.edu.au/23245/1/87551_NCEA-Storage_Seepage_%26_Evaporation_8pp_Bklet_PRF.pdf

Friedrich, K., Grossman, R. L., Huntington, J., Blanken, P. D., Lenters, J., Holman, K. D., Gochis, D., Livneh, B., Prairie, J., Skeie, E., Healey, N. C., Dahm, K., Pearson, C., Finnessey, T., Hook, S. J., and Kowalski, T. (2018). Reservoir evaporation in the Western United States: Current science, challenges, and future needs. *Bulletin of the American Meteorological Society, 99*(1), 167-187. https://journals.ametsoc.org/view/journals/bams/99/1/bams-d-15-00224.1.xml

Hong, J. (2018, June 28). Singapore opens third desalination plant in Tuas. *The Straits Times*. https://www.straitstimes.com/singapore/environment/singapore-opens-third-desalination-plant-in-tuas

Lim, V. (2020, August 29). Construction of new S$230m NEWater factory in Changi expected to start in 2022. *CNA*. https://www.channelnewsasia.com/singapore/pub-new-newater-plant-water-supply-singapore-changi-634876

Ministry of Foreign Affairs (MFA). (n.d.). *Water agreements*. https://www.mfa.gov.sg/SINGAPORES-FOREIGN-POLICY/Key-Issues/Water-Agreements#:~:text=Under%20the%201962%20Water%20Agreement%2C%20we%20continue%20to%20draw%20250,the%20water%20supplied%20to%20Singapore

National Climate Change Secretariat (NCCS). (n.d.). *Impact of climate change in Singapore*. https://www.nccs.gov.sg/singapores-climate-action/impact-of-climate-change-in-singapore/

Ng, K. (2018, June 25). Mahathir revives water dispute with Singapore, calls 1962 deal 'ridiculous'. *Today*. https://www.todayonline.com/world/mahathir-revives-water-dispute-singapore-says-1962-deal-too-costly

Olmstead, S. and Stavins, R. N. (2007). Managing water demand: Price vs. non-price conservation programs. https://www.researchgate.net/publication/242276472_Managing_Water_Demand_Price_vs_Non-Price_Conservation_Programs

Public Utilities Board (PUB). (n.d.a.). *Singapore water story*. https://www.pub.gov.sg/watersupply/singaporewaterstory

PUB. (n.d.b.). *Desalinated water*. https://www.pub.gov.sg/watersupply/fournationaltaps/desalinatedwater

PUB. (2015). *Our water: The flow of progress. Annual report 2014/2015*. https://www.pub.gov.sg/annualreports/annualreport2015.pdf

Tan, H. H. (2016, September 29). PUB to award contract for $400-500m desalination plant next month. *AsiaOne*. https://www.asiaone.com/singapore/pub-award-contract-400-500m-desalination-plant-next-month

Tan, P. T. and Rawat, S. (2018). *NEWater in Singapore*. Global Water Forum. https://globalwaterforum.org/2018/01/15/newater-in-singapore/

Tang, L. (2018, July 4). PUB aims to double water supply by 2060 without using more energy or producing more waste. *Today*. https://www.todayonline.com/singapore/pub-aims-double-water-supply-2060-without-using-more-energy-producing-more-waste

World Population Review. (2022). *Singapore population*. https://worldpopulationreview.com/countries/singapore-population

World Resources Institute (WRI). (2015). *Ranking the world's most water stressed countries in 2040*. https://www.wri.org/insights/ranking-worlds-most-water-stressed-countries-2040

Xi, X. and Poh, K.L. (2015). A novel integrated decision support tool for sustainable water resources management in Singapore: Synergies between system dynamics and analytic hierarchy process. *Water Resource Management, 29*, 1329–1350. https://doi.org/10.1007/s11269-014-0876-8

APPENDIX A Equations

Equation 1 – Expected Scenario

Variables 1) Annual Birth Rate: 1.24%, (2) Net Annual Migration: 30,000, (3) Total Death Rate: 0.48%

$$\text{Population Number}_{(n)^{\text{th}}\text{year}}\ \text{Population Number}_{(n-1)^{\text{th}}\text{year}} * (\,1 + \text{Annual Birth Rate} - \text{Total Death Rate}) + \text{Net Annual Migration}$$

Equation 1 – High Scenario

Variables (1) Annual Birth Rate: 1.24%, (2) Net Annual Migration: 60,000, (3) Total Death Rate: 0.48%,

$$\text{Population Number}_{(n)^{\text{th}}\text{year}}\ \text{Population Number}_{(n-1)^{\text{th}}\text{year}} * (\,1 + \text{Annual Birth Rate} - \text{Total Death Rate}) + \text{Net Annual Migration}$$

Equation 2a – Daily domestic potable water demand, per capita

$$\text{Daily, per capita domestic water demand} = \frac{\text{Annual Domestic Water Demand}}{\text{Population Number}_{(n)^{\text{th}}\text{year}} * \ 365\ days}$$

Equation 2b – Annual total domestic potable water demand

$$\text{Annual, total domestic water demand} = \text{Daily, per capita domestic water demand} * \text{Population Number}_{(n)^{\text{th}}\text{year}} * \ 365\ days$$

Equation 3 – Daily domestic potable water demand, per capita (Price Hike)

$$\text{Daily, per capita water demand(new)} = \text{Daily, per capita water demand} * (1 - \text{Price Hike\%} * \text{Price Sensitivity})$$

Equation 4a – Daily non-domestic potable water demand, per capita

$$\text{Daily, per capita nondomestic water demand} = \frac{\text{Daily, Per Capita Domestic Water Demand}}{\text{Domestic Potable Water Demand Percentage}} * \text{Nondomestic Potable Water Demand Percentage}$$

Equation 4b – Annual non-domestic potable water demand

$$\text{Annual nondomestic potable water demand} = \text{Daily, per capita nondomestic water demand} * \text{Population Number}_{(n)^{\text{th}}\text{year}} * \ 365\ days$$

Equation 5 – Total Water Demand

$$\text{Total Water Demand} = \frac{\text{Domestic Potable Water Demand}}{\text{Domestic Potable Water Demand Percentage}}$$

Equation 6 – Non-Domestic Water Demand

$$\text{NonDomestic Water Demand} = \text{Total Water Demand} - \text{Domestic Water Demand}$$

Equation 7 – Industrial Water Demand

$$\text{Industrial Water Demand} = (\text{NonDomestic Water Demand} - \text{NonDomestic Potable Water Demand}) * 16\%$$

Equation 8 – NEWater Water Demand

$$\text{NEWater Demand} = (\text{NonDomestic Water Demand} - \text{NonDomestic Potable Water Demand}) * 84\%$$

Equation 9 – Rainfall water supply

$$\text{Maximum water supply (annual)} = \text{Total rainfall} * \text{Total land area} * \text{Catchment coverage} * (1 - \text{Evapotranspiration Loss}) * (1 - \text{Seepage Loss})$$

Equation 10 – Excess/Shortfall

$$\text{Excess/Shortfall} = \text{Water Supply} - \text{Water Demand}$$