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FORECASTING DOMESTIC WATER DEMAND FOR THE NORTHERN MALAYSIA

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ABSTRACT

The objective of this study is to forecast the domestic water needs for the Northern Malaysia until the year 2010. The IWR-MAIN software was used in this study. The Constant Use Rate Model and the Build Forecast Model were explored in this study. The forecast is done based on targets outlined in Kedah Action Plan 2010, which intends to transform the Kedah state to become a developed state by the year 2010. It is assumed that the 'high performance' targets outlined in Kedah Action Plan can be achieved by the year 2010. The forecasted daily demand using the first model is 112.983 million gallons per day by the year 2010. The second model forecasts the daily demand to be 1673 million gallons per day by the year 2010. The forecasted daily demand using the second model has significant difference compared to the forecasted demand using the first model.

1 INTRODUCTION

The study was carried out in the state of Kedah situated in the Northern part of Malaysia. The demand for water supply has amplified due to the increase of housing and industrial areas in State of Kedah with the launching of Kedah Action Plan 2010. There are plans for more housing and industrial areas, thus increase the demand for domestic water. An effective water management plan is necessary to avoid any shortage of water supply. In addition, variables such as weather changes should be taken in account because of its huge effect to water management. However, there is a significant amount of money concerned in treating and distributing clean water which is still borne by the government. The state government has the option to either privatise the water supply management or bear the cost itself, with the federal government giving little financial assistance. In 1999, Kedah State Water Supply Division recorded lost amounting USD 1,654.692.30.

The objectives of this research is to:

- forecast the domestic water need for Kedah State
- determine the cost of domestic water supply
- determine the trend of domestic water demand

2 2 RESEARCH METHODOLOGY

Kedah State Water Supply Division provided information of the whole water management process that was used to determine the main factors for forecasting purposes. Relevant data such as population growth of Kedah State, unemployment rate, household income, land usage and the state's economic growth was sought from The Secretariat Office of Kedah State. Data from 1990 was collected and analyzed using descriptive analysis. Information regarding the mean, variances and data range is analyzed. In addition, an observation is done to confirm that consumers' demand are independent to time but dependent to population growth and other factors. Data for water demand and the distribution cost are plotted to get the curve of water demand and distribution cost. Only one model will be used because 92.3% of water supply in Kedah State is for domestic purposes (Development Statistics of Kedah, 2000). IWR-MAIN is used to model the water demand and distribution cost up to the year 2010. The curves from IWR-MAIN are evaluated to see if there any pattern exists.

As it is nearly impossible to get an accurate data, several estimation has been done such as the population, number of houses, income mean, the average of house density over kilometer square and average household size. There is need for population estimation because this research is a short-term forecast. The estimated number of people for time t, is calculated from equation 1.

$$P_t = P_o e^{rt} \quad (1)$$

Where;

P_t = population at time t
P_o = population at base year
R = population increasing rate
t = time

3 IWR-MAIN SOFTWARE

IWR-MAIN is a software package that is capable of forecasting water needs according to sectors i.e. domestic, business and industry. It needs information on demography, housing, business, population and employment. IWR-MAIN provides four different models for forecasting. In this study, two models have been used to help forecast water demand by consumers, which are the Constant Use Rate Model and the Build Forecasting Model. Both are different in terms of mathematics and assumptions. The Constant Use Rate Model will calculate the average usage of water for the starting year based on information on water usage and number of unit in a sector (every unit is considered to use the same amount of water daily). Thus the quantity of water use in a given subsector, month, and forecast year is calculated as:

$$Q_{s,m,y} = N_{s,m,y} q_{s,m,b} d_m \quad (2)$$

Where;

Q = Gallons of water used in subsector (s) in month (m) in year (y)
N = Number of units in subsector (s) in month (m) in year (y)
q = Average daily use rate per unit in subsector (s) in month (m) in base year (b)
d = Number of days in month (m)

With the constant use rate method, the change in counting units (N) explains the change in the water use forecast from year to year.

The Build Forecasting Model allows the user to adjust the per unit usage rate with information about selected explanatory variables. The base year per unit water use rate (q) is calculated from the base year water use and the number of counting units for the subsector. This calculated rate of use is adjusted by the relationship between subsector water use and explanatory variables selected for the subsector. The variables are specified by the user and the values of the variables may change over time. Thus, the quantity of water use in a given subsector, month, and forecast year is calculated as:

$$Q_{s,m,y} = N_{s,m,y} q_{s,m,b} \left(\frac{X_{j,s,m,y}}{X_{j,s,m,b}} \right)^{B_{j,s,m}} d_m \quad (3)$$

Q = Gallons of water used in subsector (s) in month (m) in year (y)
N = Number of units in subsector (s) in month (m) in year (y)
q = Average daily use rate per unit in subsector (s) in month (m) in base year (b)
X_y = Value of exploratory variable (j) in year (y)
X_b = Value of exploratory variable (j) in base year (b)
b = Elasticity of per unit use for variable (j) in subsector (s) in month (m)
d = Number of days in month (m)

4 4 DATA ANALYSIS

On average, the state of Kedah receive 2,000 mm to 2,500 mm of rain annually and the air temperature ranges between 21ºC to 31ºC. The Kedah State covers an area of 9,426 km square, with most of it is used for agricultural activities. The Kedah State has the population of 1,572,110 (Statistics of Kedah Darul Aman, 2000). Kedah State provides treated water to almost 100% of its people. The demand for water supply also has rise exponentially (Table 1).

Table 1: Water Demand for the Year 1985-2002.

Year	Demand (million of gallons)	Number of users
1985	13,827	115,835
1990	25,920	187,130
1995	43,780	274,149
1996	48,003	292,495
1997	52,269	306,719
1998	58,975	328,416
1999	60,428	342,748
2000	64,587	No record available
2001	67,558	No record available
2002	69,363	353,370

(Source: Economic Indicators and Kedah Social Development Plan 2010).

Until the year 2002, there are 353,370 consumer accounts registered with Kedah Department of Water Supply. Most

of them (92.30%) are domestic users while the rest are for industrial and commercial use.

The trend of water supplied in the Kedah State is examined closely as it helps in estimating the model suitable for forecasting and factors contributing can be identified. In general, the authority provides more water every year to cope with the demand (Table 2).

Table 2: Water Production, 1991-2002.

YEAR	Production (mgd)
1991	88.28
1992	93.88
1993	100.75
1994	116.74
1995	122.00
1996	131.00
1997	146.04
1998	161.58
1999	165.55
2000	176.95
2001	185.09
2002	190.10

(Source: Kedah Public Work Department, 2002)

The increase of water demand is due to several factors. First, the Seventh Malaysian Plan has catalyzed development in some areas, thus increasing the demand for clean water. The Kedah Action Plan 2010 also increased the number of housing units over kilometer square (Figure 1).

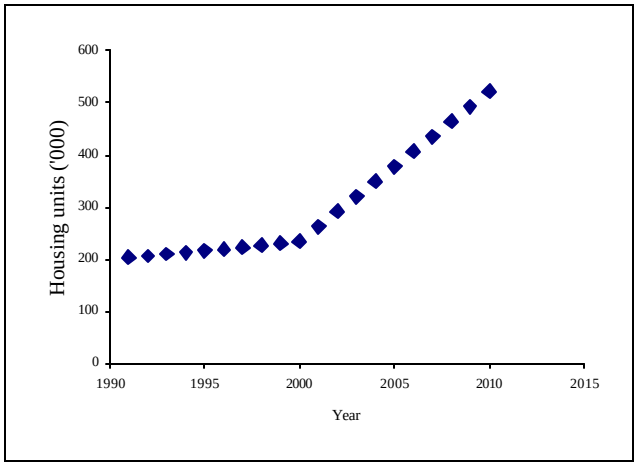

Figure 1: The Estimation of Number of Houses for the State Of Kedah, 1990-2010

The second factor is the increasing in population of Kedah State. The third factor is the increase in average annual income also contributes to more demand for water. According to Kedah Action Plan 2010, the annual income will rise around 11.4%. Other factors include economical influence, weather change and quantity of water supplied. However as Malaysia is a tropical country, constant humidity and small temperature change does not effects very much on the usage of water.

5 DOMESTIC WATER USAGE FORECAST UNTIL YEAR 2010

Population is always used as a variable to estimate water usage. Using estimation of population growth in the pervious chapter, the data applied in the Constant Rate Model. With the 1995 used as the starting year, water usage rate is estimated by equation 2.

It was found that the water usage for Kedah State in the the year 1995-2009 is increasing exponentially with a mediocre rate. There is a twitch between the year 2004 and the year 2005 because it is assumed that by the year 2005, 100% of Kedah State is provided with water supply. (Figure 2).

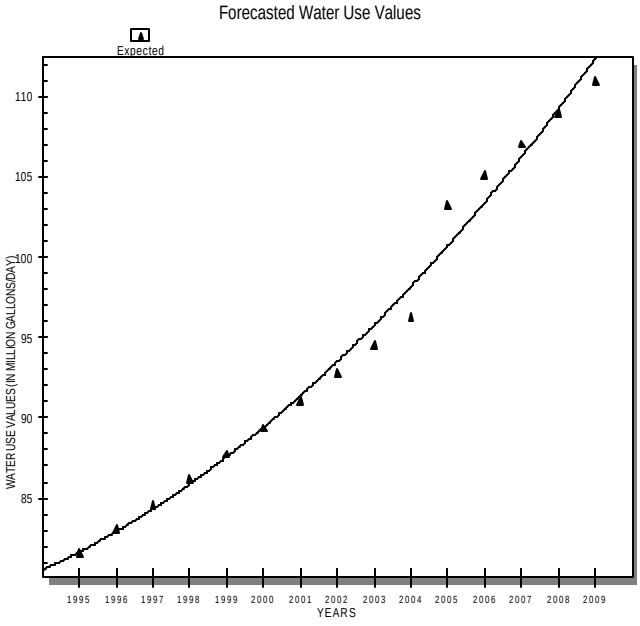

Figure 2: The Forecasted Water Demand State, Equation 2

Another model is developed using the number of housing units. The idea is when there is a new housing area; water demand is proportionate to the number of houses. The model uses equation 3 to estimate water usage.

Figure 3 shows the relation between domestic water usage rate and number of housing units with household income and household size aggregated.

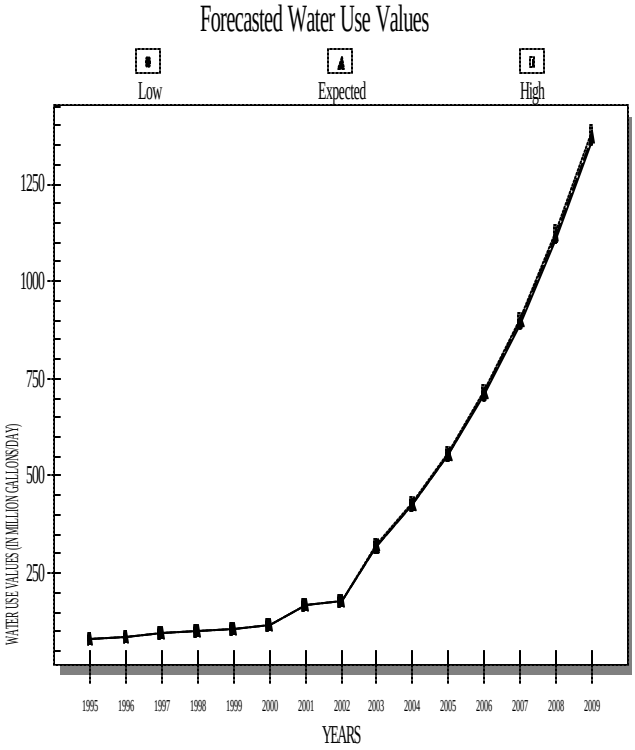

Figure 3: The Forecasted Domestic Water Demand, Equation 3

6 CONCLUSION

An analysis has shown that the Build Forecasting Model gives satisfactory forecasted values compared to the Constant Use Rate Model. IWR-MAIN software requires an accurate data for a better forecast results. Future industrial water demands cannot be done because of lack of information. In the year 2010, the Kedah State will need 1673 million gallons of water per day.

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