Future Water Demand of Gaziantep Province Using Population Forecasting Method

Yunus Öztürk*, Hüseyin Çağan Kılınç**

*Kilis 7 Aralık University, Faculty of Engineering and Architecture, Department of Civil Engineering Kilis/ TURKEY
**Kilis 7 Aralık University, Faculty of Engineering and Architecture, Department of Civil Engineering Kilis/ TURKEY

ABSTRACT
Population projections are necessary to estimate the future population by following the trend (increase) line. Population projections are significant for managing and planning the research area. This study aims to examine the water need and water consumption of Gaziantep province. In order to determine the future population of Gaziantep city, İlbank method was utilized in the calculations. Düzbağ Dam which is considered to supply drinking water to Gaziantep is not sufficient for close future and in order to supply water to city it is estimated that there will be need for new water resources. Therefore, state corporation should take required precautions.

Keywords: Gaziantep, water need, population, İlbank method

I. INTRODUCTION
One of the fundamental requirements of economic development depends on clean and sufficient water supply. Even if “75% of the Earth’s surface is covered with water”, this statement is misleading about water abundance in the world, only 1% of it is drinkable[1]. The reasons such as the rapid increase in world population, the overdevelopment of industry and technology and also not embracing or expanding environmental consciousness decently, cause to gradual decrease in drinking water quantity in the world [2]. Although Turkey is surrounded by water on three sides, it is located in an insufficient region in terms of drinking water resources. Besides, within climate change, groundwater resources and surface water resources have been decreasing [3]. In order to determine the situation of water system and zoning, the study has started to conduct by Gaziantep Water and Sewerage Administration (GASKİ) and Gaziantep Province Zoning Report has been prepared [4]. Gaziantep province has meet water need from Kartalkaya Dam, Mizmilli water-wells and twenty deep-wells in different location of the city.

II. MATERIAL AND METHOD
Material
In Figure 1, Şehitkamil, Şahinbey and Oğuzeli districts under the responsibility of Gaziantep General Directorate of Water and Sewerage Administration (GASKİ) has shown [5].

---

**Figure 1.** Districts of Gaziantep Province
In Figure 1, population results of three districts of Gaziantep province showed. Şahinbey, Oğuzeli, Şehitkamil are the main towns of Gaziantep province which are also responsibility area of GASKI (General Directorate of Water and Sewerage Administration).

**Table 2. Population Census Results of Gaziantep city center**

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>187756</td>
</tr>
<tr>
<td>1970</td>
<td>253981</td>
</tr>
<tr>
<td>1975</td>
<td>327104</td>
</tr>
<tr>
<td>1980</td>
<td>402743</td>
</tr>
<tr>
<td>1985</td>
<td>509047</td>
</tr>
<tr>
<td>1990</td>
<td>636842</td>
</tr>
</tbody>
</table>

According to records of GASKI (2011-2015), water accrual values, water loss and water consumption rate have been shown in Table 4. These values were given in two groups as household and public.

**Table 4. Water consumption of subscribers and values of water supply to city (2011-2015)**

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water consumption of consumer (m³)</td>
<td>29,908.787</td>
<td>32,198.304</td>
<td>34,540.124</td>
<td>37,630.857</td>
<td>42,550.220</td>
</tr>
<tr>
<td>Total amount of water consumption (m³)</td>
<td>44,994.815</td>
<td>48,821.905</td>
<td>52,408.230</td>
<td>59,780.985</td>
<td>70,070.540</td>
</tr>
<tr>
<td>Total amount of water supply (m³)</td>
<td>90,993.582</td>
<td>95,601.294</td>
<td>99,003.815</td>
<td>110,398.552</td>
<td>123,184.090</td>
</tr>
<tr>
<td>Water Loss (%)</td>
<td>49.4</td>
<td>51.06</td>
<td>52.9</td>
<td>54.1</td>
<td>56.8</td>
</tr>
</tbody>
</table>

**III. METHOD**

In order to determine household and drink water need of Gaziantep province, population census results of the city were compiled at first and then population projections belong to target years in future were showed, then water need has been estimated [6]. By means of these population census results and methods of population estimation as shown below, population growth rate coefficients and population projections for target years in the future were estimated. İlbank method was utilized in the calculations.

İlbank Method

\[
C = \left( \frac{N_y}{N_0} \right)^{\frac{y}{a}} - 1 \times 100 \tag{1}
\]

In this formula, C symbolizes population growth rate (growth/increase) coefficient; a, period between two population year; Ny, population of city in current population year and N0, population of the city in previous population year.

\[
N_g = N_y \left(1 + \frac{C}{100}\right)^x \tag{2}
\]

In this formula, N₀ is population of the province in the future; x is period from last year in 2014 to the target year. And also, calculations have been made in accordance with arithmetic interest rate and compound interest rate methods.

**Population of Gaziantep According to İlbank Method**

When the datas were calculated in accordance with İlbank method, the values were derived from calculations as shown in Table 7. R² was calculated as 0.9834; value of RMSE was found 41.169 people.
Table 7. Population forecasting according to Ilbank method

<table>
<thead>
<tr>
<th>Year</th>
<th>TURKSTAT Population</th>
<th>In reference to 1960, (Ç) values</th>
<th>(Ç)max</th>
<th>Population in accordance with Ilbank method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>124097</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1965</td>
<td>160012</td>
<td>5.21</td>
<td>3</td>
<td>206270</td>
</tr>
<tr>
<td>1970</td>
<td>227652</td>
<td>6.25</td>
<td>3</td>
<td>308259</td>
</tr>
<tr>
<td>1975</td>
<td>300882</td>
<td>6.08</td>
<td>3</td>
<td>404210</td>
</tr>
<tr>
<td>1980</td>
<td>374290</td>
<td>5.67</td>
<td>3</td>
<td>493253</td>
</tr>
<tr>
<td>1985</td>
<td>473635</td>
<td>5.50</td>
<td>3</td>
<td>619127</td>
</tr>
<tr>
<td>1990</td>
<td>689848</td>
<td>5.88</td>
<td>3</td>
<td>917958</td>
</tr>
<tr>
<td>1995</td>
<td>832703</td>
<td>5.59</td>
<td>3</td>
<td>1092959</td>
</tr>
<tr>
<td>2000</td>
<td>949559</td>
<td>5.21</td>
<td>3</td>
<td>1355751</td>
</tr>
<tr>
<td>2007</td>
<td>1190963</td>
<td>4.93</td>
<td>3</td>
<td>1249668</td>
</tr>
<tr>
<td>2008</td>
<td>1256384</td>
<td>4.94</td>
<td>3</td>
<td>1318461</td>
</tr>
<tr>
<td>2009</td>
<td>1299143</td>
<td>4.90</td>
<td>3</td>
<td>1362922</td>
</tr>
<tr>
<td>2010</td>
<td>1370598</td>
<td>4.92</td>
<td>3</td>
<td>1438046</td>
</tr>
<tr>
<td>2011</td>
<td>1397313</td>
<td>4.86</td>
<td>3</td>
<td>1465250</td>
</tr>
<tr>
<td>2012</td>
<td>1442059</td>
<td>4.83</td>
<td>3</td>
<td>1511708</td>
</tr>
<tr>
<td>2013</td>
<td>1501556</td>
<td>4.81</td>
<td>3</td>
<td>1573879</td>
</tr>
<tr>
<td>2014</td>
<td>1556381</td>
<td>4.79</td>
<td>3</td>
<td>1631006</td>
</tr>
<tr>
<td>2015</td>
<td>1626985</td>
<td>4.79</td>
<td>3</td>
<td>1631006</td>
</tr>
</tbody>
</table>

Population Projection and Water Need of Gaziantep city center

For population forecasting, it has been seen that the most appropriate method for population forecasting is Ilbank method and population forecasting for the future has been made via this method. In calculations for Gaziantep province in 2015, it has been seen that water consumption per person is 105 lt/capi/day \((70.070.540(\text{total water consumption})/1.842.368(\text{population of city center})/365(\text{days})=105\ \text{lt/capi/day})\). It has been utilized in calculations 225 liters water which is the daily water consumption value per person according to Ilbank estimation and population forecasting and water need until 2050 have shown in Table 9.

Table 9. For Gaziantep city center, population projection and estimated water need according to population of Gaziantep city center

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated population according to Ilbank method</th>
<th>Estimated water need (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>1.326.775</td>
<td>108.961.437</td>
</tr>
<tr>
<td>2017</td>
<td>1.384.240</td>
<td>113.680.744</td>
</tr>
<tr>
<td>2018</td>
<td>1.444.194</td>
<td>118.604.543</td>
</tr>
<tr>
<td>2019</td>
<td>1.506.744</td>
<td>123.741.416</td>
</tr>
<tr>
<td>2020</td>
<td>1.572.004</td>
<td>129.100.869</td>
</tr>
<tr>
<td>2021</td>
<td>1.640.090</td>
<td>134.692.450</td>
</tr>
<tr>
<td>2022</td>
<td>1.711.125</td>
<td>140.526.212</td>
</tr>
<tr>
<td>2023</td>
<td>1.785.237</td>
<td>146.612.644</td>
</tr>
<tr>
<td>2024</td>
<td>1.862.559</td>
<td>152.962.690</td>
</tr>
<tr>
<td>2025</td>
<td>1.943.230</td>
<td>159.587.767</td>
</tr>
<tr>
<td>2026</td>
<td>2.027.394</td>
<td>166.499.788</td>
</tr>
<tr>
<td>2027</td>
<td>2.115.204</td>
<td>173.711.180</td>
</tr>
<tr>
<td>2028</td>
<td>2.206.817</td>
<td>181.234.910</td>
</tr>
<tr>
<td>2029</td>
<td>2.302.398</td>
<td>189.084.505</td>
</tr>
<tr>
<td>2030</td>
<td>2.402.119</td>
<td>197.274.081</td>
</tr>
<tr>
<td>2031</td>
<td>2.506.159</td>
<td>205.818.360</td>
</tr>
<tr>
<td>2032</td>
<td>2.614.705</td>
<td>214.732.708</td>
</tr>
<tr>
<td>2033</td>
<td>2.727.953</td>
<td>224.033.150</td>
</tr>
<tr>
<td>2034</td>
<td>2.846.105</td>
<td>233.736.412</td>
</tr>
<tr>
<td>2035</td>
<td>2.969.375</td>
<td>243.859.938</td>
</tr>
<tr>
<td>2036</td>
<td>3.097.983</td>
<td>254.421.931</td>
</tr>
<tr>
<td>2037</td>
<td>3.232.162</td>
<td>265.441.382</td>
</tr>
</tbody>
</table>
Düzbağ Dam Water Capacity

It has planned that the Düzbağ Dam, which is considered to meet drinking and utility water needs of the city center of Gaziantep for the long term, is located 4 km away from the Kahramanmaraş - Helete (Düzbağ) town, on the Göksu River which is the tributary of the Euphrates River by DSİ. Estimated water need according to population forecasting has been taken into account in order to determine the water quantity which will be taken from the dam.

Even if the current total water supply flow rate is 6 m³/s (189 million m³), the actual water need of the city is 125 million m³. Pumping efficiency and working times have been adjusted in accordance with this efficiency. The water loss is also another important parameter for water demand projection. It has been accepted that water loss rate is approximately 55% in the current situation, until 2050 it will be reduced to about 30%, thanks to improvements and zoning in the system. The 30% as water loss rate will be a significant standard in international norms for Gaziantep province.

When Kartalkaya Dam’s flow rate which equals to 4 m³/s is considered, the flow rate of water conveyance is on the safe side. When the Düzbağ dam is started to using, the flow rate of water flow is 7.50 m³/s and 245.520.000 m³ water will be able to supply per year. The amount of water consideed to be taken from the dam is given in Table 12. When Table 11 is examined, according to the current situation, it is necessary to operate the dam in 2020 and the dam will be sufficient until 2044.

Table 11. The water quantity from Düzbağ Dam according to population forecasting

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated Water Need (m³)</th>
<th>Water quantity from current water resources (m³)</th>
<th>Estimated water quantity from dam (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>108.961.437</td>
<td>125.000.000</td>
<td>-</td>
</tr>
<tr>
<td>2017</td>
<td>113.680.744</td>
<td>125.000.000</td>
<td>-</td>
</tr>
<tr>
<td>2018</td>
<td>118.604.453</td>
<td>125.000.000</td>
<td>-</td>
</tr>
<tr>
<td>2019</td>
<td>123.741.416</td>
<td>125.000.000</td>
<td>4.100.869</td>
</tr>
<tr>
<td>2020</td>
<td>129.100.869</td>
<td>125.000.000</td>
<td>9.692.450</td>
</tr>
<tr>
<td>2021</td>
<td>134.692.450</td>
<td>125.000.000</td>
<td>15.526.212</td>
</tr>
<tr>
<td>2022</td>
<td>140.526.212</td>
<td>125.000.000</td>
<td>21.612.644</td>
</tr>
<tr>
<td>2023</td>
<td>146.612.644</td>
<td>125.000.000</td>
<td>27.962.690</td>
</tr>
<tr>
<td>2024</td>
<td>152.962.690</td>
<td>125.000.000</td>
<td>34.587.767</td>
</tr>
<tr>
<td>2025</td>
<td>159.587.767</td>
<td>125.000.000</td>
<td>41.499.788</td>
</tr>
<tr>
<td>2026</td>
<td>166.499.788</td>
<td>125.000.000</td>
<td>48.711.180</td>
</tr>
<tr>
<td>2027</td>
<td>173.711.180</td>
<td>125.000.000</td>
<td>56.234.910</td>
</tr>
<tr>
<td>2028</td>
<td>181.234.910</td>
<td>125.000.000</td>
<td>64.045.005</td>
</tr>
<tr>
<td>2029</td>
<td>189.084.505</td>
<td>125.000.000</td>
<td>72.274.081</td>
</tr>
<tr>
<td>2030</td>
<td>197.274.081</td>
<td>125.000.000</td>
<td>80.818.360</td>
</tr>
<tr>
<td>2031</td>
<td>205.818.360</td>
<td>125.000.000</td>
<td>89.732.708</td>
</tr>
<tr>
<td>2032</td>
<td>214.732.708</td>
<td>125.000.000</td>
<td>99.033.150</td>
</tr>
<tr>
<td>2033</td>
<td>224.033.150</td>
<td>125.000.000</td>
<td>108.736.412</td>
</tr>
<tr>
<td>2034</td>
<td>233.736.412</td>
<td>125.000.000</td>
<td>118.859.938</td>
</tr>
<tr>
<td>2035</td>
<td>243.859.938</td>
<td>125.000.000</td>
<td>129.421.931</td>
</tr>
</tbody>
</table>
IV. CONCLUSION
For Gaziantep province, the method in which the trend of population is best observed was investigated and Ilbank method has been applied, and this analysis method has been used in the population estimation. Estimated water demand in the target year of projection has been calculated as 460,629,501 m$^3$ according to the population of 2050 and the water consumption per capita of Ilbank (225 lt / person). The water loss in distribution line rate 30% was added to water consumption which has been calculated for the upcoming years and the consumption-based water need has been calculated. The water need of Gaziantep has been met from Kartalkaya Dam, Mizmilli water-wells and water-wells in inner city and approximately 125,000,000 m$^3$ water has been supplied to city from these resources per year. It can be said that the current resources and Düzbağ Dam will be insufficient in long term. The Düzbağ dam, which will be built in Helete town of Çağlayancıret district in Kahramanmaraş province, makes it possible to supply water with gravity flow and zero energy cost makes this project positive. But, this water supply will no longer meet the growing population need in the future. It will be inevitable that as a safe recourse will be considered to meet water need and similar needs of increasing population. This situation should be examined by notably by companies related to development of city sources.

REFERENCES
[5]. Gaziantep General Directorate of Water and Sewerage Administration (GASKİ), Gaziantep Strategic Planning, Gaziantep, 2013.