# Cyprus Water Supply Project: Features and Outcomes

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## Abstract

Cyprus Island has very limited water resources. Recently, this problem has rather been resolved by transferring water from Turkey to the island known as Cyprus Water Supply Project (CWSP). The CWSP is comprised of three phases named, Turkey side, sea crossing, and Cyprus side. From the construction point of view, sea crossing is the most important phase of the project that is the first in the world with its high-density polyethylene pipeline of 80 km crossing the Mediterranean Sea in a suspended position at 250 meters below sea level. Besides, the annual amount of water transferred to the island is more important from socio-environmental perspective. This article aims to introduce the main construction features of CWSP. In addition, outcomes of the project were reviewed regarding the island climate, available water, local and regional development objectives and ambitions, and increasing water demand in the foster island. Since 2015, with the realization of CWSP, 75 million cubic meters of water is supplied to the island per year that is used for potable, irrigation, and industrial needs. The results indicated that the supplied water has significantly increased the annual amount of total accessible water of northern island. But, there is still substantial shortage of water in the entire island to meet its needs. Lessons learnt from this project improved the knowledge of submarine water pipeline construction and could be considered as a real milestone toward transboundary water supply projects in the world.

***Keywords:*** *water shortage, subsea pipelines, Cyprus, Turkey, water supply.*

## 1 Introduction

Cyprus is the 3rd biggest island on Mediterranean Sea with a surface area of 9251 km². The island covers two separated zone of Republic of Southern Cyprus and Turkish Republic of Northern Cyprus. It has typical Mediterranean climate with annual average precipitation about 345 mm on the northern part and about 503 mm on the southern part. On the basis of historical precipitations, several drought periods in the island has been reported (Griggs, 2013). It also suffers from potable water scarcity due to salinization problem in groundwater and limited geomorphological variations for surface detention systems. Under these sever climate and environmental conditions, since the early 1900, Cyprus has started to invest on surface water detention systems. In the meantime, the available dams, water ponds as well as groundwater resources became insufficient to the significant population increase (DPÖ, 2015). To solve the problem, a number of studies have been carried out including the water transportation from Turkey to island but none of them came true because of technological or financial difficulties (Ağıralioğlu 2016). Finally, at 2011, the first step taken toward the realization of Cyprus Water Supply Project (CWSP). Symbolically named Peace Water (Barış Suyu), the project brings 75 million cubic meters of fresh water annually from Anamur River, Turkey to Cyprus. This is the longest subsea water pipeline project in the world that pumps water directly to Northern Cyprus with the help of an 80-kilometre water pipe running under the Mediterranean Sea at a depth of up to 280 meters. This article aims to review the main construction features of CWSP and put forward some comments that may be useful for the future of sustainable water resources management in the island.

## 2 Climate, water potential and water demand of Northern Cyprus

According to the climatological classifications, the island located in a semi-arid region. Temperature can reach up to 40 °C during summer. Long term average of monthly temperature variation in Northern Cyprus was shown

in Figure 1 that indicates the highest monthly temperature is observed in July-August at each year (KKTC, 2018).

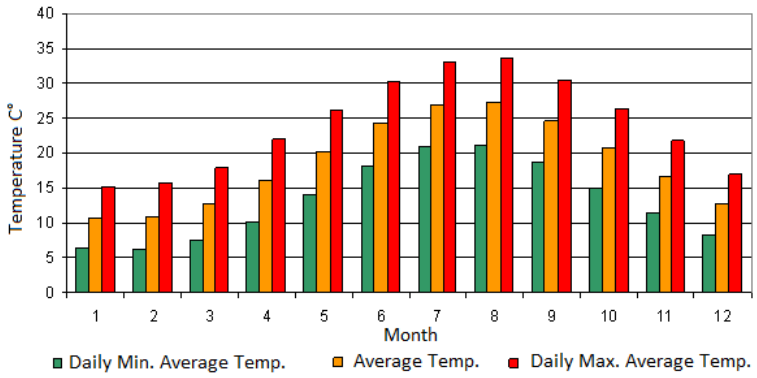


**Figure 1.** the observed minimum. Maximum and Long term mean of monthly temperature at Northern Cyprus

According to the meteorological observations, in 20th century average rate of temperature increase equals to 0.01 degree/year. Urbanization plays an important role on temperature increase in the area. When we compare the 2016 maximum daily temperatures with the normal values considered by Republic of Cyprus which is recorded between (1981-2010), 1.5 C° difference stands out (KKTC 2018). Among the climatological variables, precipitation is of the important components of the water budget calculations in the island. In opposite to the temperature, the precipitation tends to decrease year by year. Figure 2 presents the long term areal average precipitation and evaporation in Northern Cyprus. Precipitations are not evenly distributed, and 80 percent of precipitations is estimated to be evaporated due to high temperature. Long-term mean of total annual precipitation amount is about 500mm. Heavy precipitations are typically observed during December and January.

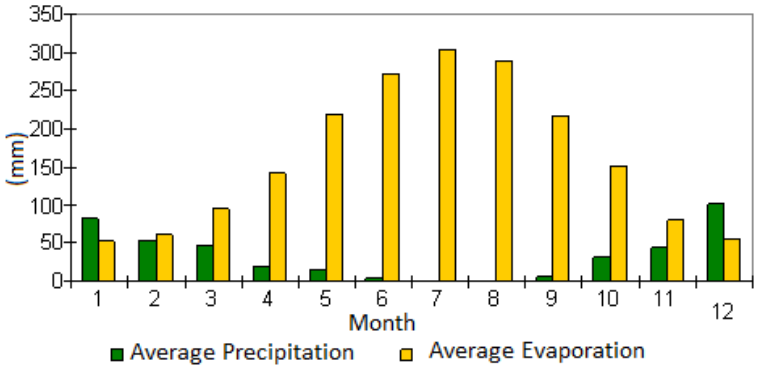


**Figure 2.** Records of N Cyprus Annual Precipitation between 1991-2016

Potable water amount in any catchment mainly depends on the precipitation across the catchment. Meanwhile, precipitation distribution is influenced by the climate of the catchment. Based upon type of a climate, Table 1 (UNESCO 2003) shows mean precipitation and its corresponding evaporation, surface runoff and ground water components at each climate region.

**Table 1.** Precipitation ant its components of different climate types (UNESCO 2003)

| | **Mild climate** | | **Semi-arid climate** | | **Arid climate** | |
|---|---|---|---|---|---|---|
| | % | mm | % | mm | % | mm |
| Total Precipitation | 100 | 500-1500 | 100 | 200-500 | 100 | 0-200 |
| Evaporation/Evapotranspiration | ~ 33 | 160-500 | ~ 50 | 100-250 | ~ 70 | 0-140 |
| Groundwater recharge | ~ 33 | 160-500 | ~ 20 | 40-100 | ~ 1 | 0-2 |
| Surface runoff | ~ 33 | 160-500 | ~ 30 | 60-150 | ~ 29 | 0-60 |

With respect to the historical climatic observations the total annual precipitation in entire island is around 498 mm. As it is located in a semi-arid zone, the corresponding evaporation, groundwater and surface runoff components can be estimated as 250mm, 100mm, and 150mm, respectively. The table also indicates that Norther Cyprus fits to semi–arid climate type and therefore, %20 and %30 of the total precipitation are estimated to run down for groundwater recharge and surface runoff, respectively. From this point, its calculated that total volumetric annual water amount for groundwater and surface water is respectively 925 and 1388 MCM (million cubic meters) (Ağıralioğlu 2016). However, due to the nature of the island as well as the irregularity of river flow regimes most of the surface water directly flows to the sea and only %10 of surface water is accessible for human use. In addition, the main aquifers in Northern Cyprus include Güzelyurt, Gazimağusa and Girne Aquifer. Total estimated capacity is around 52.2 MCM. consequently, total potable water resources in Northern Cyprus is estimated to be around 94 to 173 million cubic meters.

Limited water resources of the island in one hand, and growing demand with the increment on the population of the island from the other hand create a difficult water management problem. Water consumption for the years between 2000 and 2012 was given in Table 2. It points out that through the years while residential water consumption increases, the agricultural water use decrease. Increasing population, decreasing groundwater levels, decreasing agricultural lands and groundwater contaminations are some of the reasons behind the current state. Water consumption in the island is according to 2011 data, about 693 m³/capita/year. This amount can be classified as “scarcity condition” according to Falkenmark water stress index (Falkenmark et al. 1989).

**Table 2.** Annual Water Consumption in Northern Cyprus According to Types of Consumption (MCM)

| Type of Consumption | 2000 | 2001 | 2011 | 2012 |
|---|---|---|---|---|
| Residential | 36 | 37 | 49 | 50 |
| Agricultural | 106 | 89 | 63 | 75 |
| Total | 142 | 126 | 112 | 125 |

## 3 Cyprus Water Supply Project

The CWSP has also known as the Cyprus Peace Water Project, the Cyprus Life Water Project, and the Project of the Century from time to time in Northern Cyprus. The water collected in Alaköprü Dam reservoir built on the Anamur (Dragon) Stream in Turkey is carried to the Mediterranean Sea shore by a 23-km long transmission pipeline. From the sea shore, 75 million m³ water is transported via 80 km suspended sea crossing pipeline to Geçitköy Dam reservoir located at Kyrenia, North Cyprus (sea Figure 3.). Using a transmission line built in the Northern Cyprus territory the water is distributed to the residential and agricultural areas in Northern Cyprus.

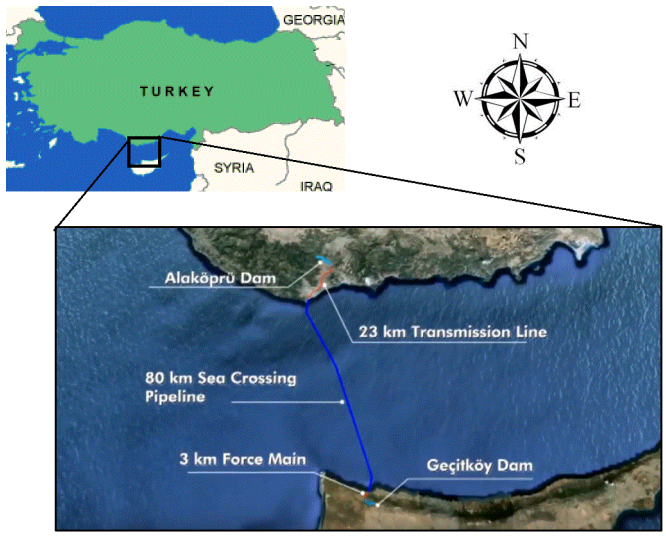


**Figure 3.** Main Parts of CWSP crossing Mediterranean Sea

As illustrated in Figure 3, this project has three major sides named as Turkey side, sea crossing and Northern Cyprus side. On the Turkey side, project includes; Alaköprü Dam with total storage capacity of 130.5 MCM. A hydroelectric power plant with installed capacity of 26 MW is also take a part on outskirts of Alaköprü Dam. The second portion of Turkey side of the project includes a 23 km long ductile cast iron pipe transmission line with 1500 mm diameter, Anamuryum Balancing Tank of 10,000 m³ volume and sea entrance valve rooms. Figure 4 shows some of construction phases of Turkey side of the project.


**Figure 4.** Some of construction features of Turkish side of CWSP project a) Alaköprü Dam, b) construction of new residencies in Anamur, c) and d) pipe manufacturing in Mersin (Ağıralioğlu 2016).

Sea crossing side (please see Figure 5) of CWSP is the first in the world with its high-density polyethylene pipeline of 80 km length and 1600 mm diameter crossing the sea in a suspended position at 280 meters below sea level. In Turkey and Northern Cyprus, sea crossing pipeline was constructed to buried under sea bed until a water depth of 20 m and laid under sea bed between 20 and 280 m water depth with its stability provided by means of concrete weight blocks. After 280m water depth is reached, 500 meters long single-piece pipes are connected mechanically to each other by Y shape connections. Total of 134 Y connections (see Figure 6a), each of which 16000 kg, were located 280 meters below the sea level. These are connected to buoyancy modules and, in turn, to anchor blocks (see Figure 6b) that provide stable suspended pipeline system. Subsea construction at this phase of the project accomplished by high tech methods whereby remotely operated robot technology (see Figure 6c) was used to install anchors.

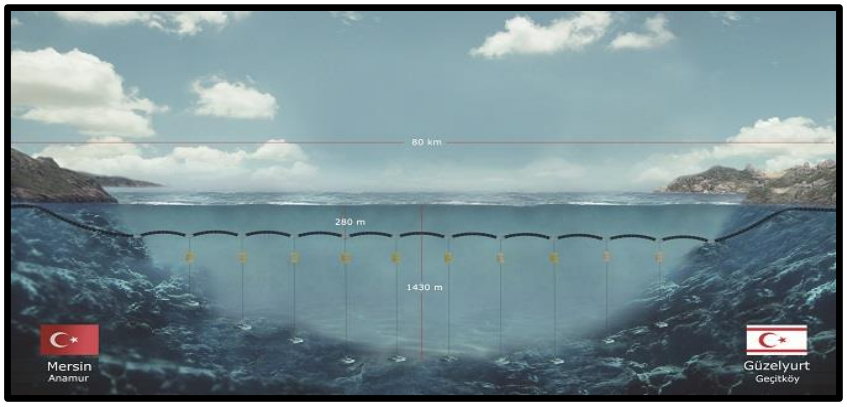


**Figure 5.** Sea crossing side of CWSP (taken from Kalyon website, 2018)


**Figure 6.** Some of construction features of sea crossing side of CWSP project; a) Y connection, b) anchor blocks having 220-ton weight, c) remotely operated vehicle, and d) ship carrying high capacity winch to install Y connections (Ağıralioğlu 2016).

On Northern Cyprus side, the project includes Güzelyalı pumping station with installed capacity of 5 MW, 3 kilometers long ductile cast iron pipe with 1400 mm diameter, Geçitköy dam (Figure 7) with storage capacity of 26.5 MCM and Geçitköy pumping station with installed capacity of 16.4 MW.


**Figure 7.** Geçitköy dam at Northern Cyprus side of CWSP project

## 4 Evaluation of the project on the island's current and future development/water demand

The water transformed from Turkey to Cyprus has greatly improved the quality and quantity of the fresh and tap water of the Northern Cyprus. This resulted in a significant increase in the living standards in the island. The

CWSP caries water from Anatolia to the island that is important for developing both Southern and Northern regions. It has positive impact on the potable, irrigation and industrial needs of Cyprus. Based upon the quality of the water delivered to the island, it can be used for municipal, agricultural and industrial developments. To evaluate future water demand, population census of the Northern Cyprus was given in Table 3.

**Table 3.** Population by census in Northern Cyprus (DPÖ 2015).

| Year | Population | Annual Population Growth Rate (%) |
|---|---|---|
| 2011 | 286,257 | 1,95 |
| 2006 | 256,644 | 2,6 |
| 1996 | 200,587 | 1,7 |
| 1978 | 146,740 | 1,9 |
| 1960 | 104,942 | 1,9 |
| 1946 | 80,548 | 1,5 |
| 1931 | 64,245 | 0,5 |
| 1921 | 61,339 | 0,8 |
| 1911 | 56,428 | 1,0 |
| 1901 | 51,309 | 0,7 |

The table revealed that the population of Northern Cyprus is increasing continuously. The population has been predicted to reach 464,000 – 485,000 by 2031 (KKTC 2014). The Alaköprü and Geçitköy Dams have the capacity to take advantage of 450 million tons of water annually. The drinking and tap water usage of Northern Cyprus in 2015 was 34-35 million tons. The capacity of the installed system is roughly 12 times larger. The water capacity of the systems indicates that it is proper for extra pipes to be added in the future. An important amount of the population in Northern Cyprus is a result of the higher education institutions. Water will have a large effect on the education sector in Cyprus. The estimated 74 thousand university students in 2015 will be able to reach 100,000 within 10 years thanks to the water supply project. It is expected that the income of higher education increases from 400 million dollars to 1 billion dollars within 10 years.

The Northern Cyprus covers 3355 $km^2$ out of the total 9251 $km^2$ area of the entire island. 1870 $km^2$ of this area is proper for vegetable and fruit cultivation. Due to the climate characteristics of the island and the land productivity, irrigation with the water supplied will enable 2 or 3 times the crop to be harvested per year. Through the project, a total of 167 $km^2$ of land will be irrigated with 96 $km^2$ at Mesarya plain and 71 $km^2$ at Güzelyurt with the help of the transboundary water, and the dry farming activities that have been going on for thousands of years will be reduced and vegetables and fruit grown with irrigated agriculture will be implemented. The income from 1000 $m^2$ of irrigated agriculture is equal to at least 10, at most 40000 $m^2$ of dry farming. Taking this into consideration, it is obvious that the contribution of the transboundary water only to farming in the agricultural sector will be 25 times more on average in terms of income (Atun 2015). Most importantly, the Northern Cyprus land will recover from its years of drought.

As the Northern Cyprus is a sea and sun state, the water demand of accommodation facilities is far over average numbers. The accommodation and lodging facilities by years shown in Table 4. The expense of one $m^3$ of treated water is 4 TL or higher while the expense of water in its source is lower than 1 TL, which is proof of how beneficial this project will be to the tourism sector (Atun 2015). It has become possible for the tourism sector of the Northern Cyprus which can currently accommodate 20.000, to reach 100.000 within the next 10 years. If 100.000 accommodation capacity is reached, the unemployment problem of the Northern Cyprus could be solved.

**Table 4.** Accommodation and Lodging Facilities (2009 - 2013)

| Year | Number of Facilities | Number of Accommodates |
|---|---|---|
| 2013 | 132 | 18,443 |
| 2012 | 159 | 20,397 |
| 2011 | 150 | 19,740 |
| 2010 | 142 | 17,358 |
| 2009 | 134 | 16,177 |

## 4 Conclusion

This article reviewed CWSP futures and its effects on the future of the Cyprus Island. Based upon the results the following suggestions are recommended.

- The project only considers 10% storage capacity of Alaköprü Dam (i.e., Anamur River inflow). Using the obtained experiences/results of the project, the second and the third pipeline may be added to the project in the near future.
- Using the available pipeline system, a power supply network may be added to the project which will be beneficial to solve the electricity shortage in Northern Cyprus.
- It is well-known that all the islands on Mediterranean Sea suffer from water scarcity. This is a successful transboundary water transmission solution/project in the region. Similar projects may be considered to solve water scarcity problem of the other islands.
- Undoubtedly, the CWSP increased welfare condition in the island. Inasmuch as one of the main reason behind the socio-economic problems and immigration of Cypriots was extreme droughts in the history of the island, the CWSP not only will change this unwilling history, but also will be a milestone in the history of the island.
- In order to sustainable use of transmitted water for the upcoming 50 years, a comprehensive water management plan which considers both domestic and transmitted water resources is needed.

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