



## Water Resources Potential of Kirklareli Province in Turkey

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**ABSTRACT:** Water, which is an indispensable element for the continuation of human and other biological life, is a natural and scarce resource. So, it is important not only for human beings, but also for the survival of all living beings and the habitable environment on Earth, and also for many industries. However, it can be contaminated in different ways from water sources to its users. Water basins, which are used as a source of drinking and utility water especially for big cities, are under the threat of heavy pollution or other environmental problems. In Kirklareli, which is growing and developing, water resources are under threat of pollution.

In this study, current, planned, and future water resources potential of Kirklareli province has been examined. The water resources, catchment basins, water wells and water treatment facilities located around the province of Kirklareli were investigated. The current and planned water resources potential of Kirklareli province has been defined and the total water requirement of Kirklareli province is  $368\,577\,000\text{ m}^3$  / year as of 2020 and the total capacity of the compliant water resources ( $375\,482\,000\text{ m}^3$  / year) in providing the required water was safely. Results of the study showed that present water resources could be cover drinkable water supply at the province. In this paper, the simulations of a double pendulum with numerical solutions are discussed. The double pendulums are arranged in such a way that in the static equilibrium, one of the pendulum takes the vertical position, while the second pendulum is in a horizontal position and rests on the pad. Characteristic positions and angular velocities of both pendulums, as well as their energies at each instant of time are presented. Obtained results proved to be in accordance with the motion of the real physical system. The differentiations of the double pendulum result in four first order equations mapping the movement of the system.

**KEYWORDS:** Kirklareli, water resources, water potential

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### I. INTRODUCTION

Water is one of the basic elements of all biological sustainability and many industries in the world. Throughout history, people have lived their life with water and wanted to realize their settlements around water resources. Problems in water resources, which are vital for all living things, often arise when water resources are exposed to environmental influences. Today, the water sources polluted and decreased due to the negative effects arising from both natural and artificial environment are in a higher priority than ever [1], and also in increasing in the populations of the world.

Today, the number of people who cannot reach the desired quality and amount of water on earth reaches billions. These people, most of whom are children and the elderly, suffer from water related diseases due to the lack of safe and secure water [2]. If these current trends persist, it is assumed that approximately two thirds of the world's population will face severe water shortages or lack of water by 2025 [3].

Especially in recent years, many factors have played important roles in the reduction of world water resources. Increasing population and related larger industrialization, excessive and unconscious use of natural resources, wrong land use, reduction of forest areas, global warming, different chemicals used in agricultural lands, and disposal of domestic and industrial wastes into water resources pollute clean water resources and thus reduce the total available water potential. For these reasons, as well as water resources sustainable use in Turkey in the world has reached the limit, or is history [4].

In line with the rapid urbanization and industrialization in our country, there are some problems in the protection of water resources. Conservation of existing natural resources and development, if possible, is not

just a phenomenon that will affect our day; it is a phenomenon that will affect the quality of life of future generations with the increasing young population. On the other hand, the use of natural geology and water resources (eg surface waters, catchment and groundwater) are also the items that should be used by giving importance to the protection and economic environment quality [5].

Economic, technical, social and environmental problems arise in drinkable water resources in Kırklareli Province, which is the material of this study. Thus, almost all drinking water basins have irregular construction and urbanization mistakes. In addition, quantity and quality deteriorations occur in water resources. In this study, it has been tried to make a situation determination with the available data for the protection, development and arrangement of drinking water basins in Kırklareli province of Turkey, by revealing the importance of the water basins where drinking water, which is an indispensable element for living creatures, to survive, and contribute water management practices.

## **II. MATERIAL AND METHOD**

### **2.1. Material**

The material of the study was the condition of existing and planned water resources in Kırklareli province of Turkey located at between the latitudes 41°13' 34" and 42° 05' 03" north and 26° 54' 14" and 28° 06' 15" east longitudes. The province had an area of 6,550 km<sup>2</sup> in the Thrace Region, which was one of the most important towns and tourist forefront of the industry. 3.25% by the existing surface water resources in Turkey, at 1.41% of underground water resources located in the province. For this reason, Kırklareli province was a province with a high annual available water potential.

### **2.2. Method**

The research was carried out in three stages: bureau, land and evaluation studies. In addition, related documents were collected from different institutions together with data of Kırklareli Municipality. Firstly, the condition of the existing water resources of the province was determined. In addition, it has been tried to reveal how much water demand for years. And also, what were the water resources that meet the water supply and the features and problems of these resources were tried to reveal. In line with these determined situations, plans for water resources suggested for future water management.

## **III. RESULTS AND DISCUSSIONS**

Water resources in the province; It could be grouped in three groups as water wells, dam and spring waters. The water needs of Kırklareli province were met from underground and surface water resources inside and outside the municipality and drinkable water; additional resources were distributed to Edirne provinces and districts in Kırklareli Dam, Bademlik water well, Karacaibrahim Neighborhood water well, Gerdanlı spring water and Sazara resources.

Water resources of Kırklareli province could be listed as:

- Kırklareli Dam (dam water), annual amount of water drawn from the spring 5,200,000 m<sup>3</sup>/year (purified),
- Almond Water Well (well water), amount of water withdrawn from the source 150,000 m<sup>3</sup>/year (not purified),
- Karacaibrahim Neighborhood Water Well (well water), amount of water withdrawn from the source 150,000 m<sup>3</sup>/year (not purified),
- Gerdanlı Spring Water (spring water), annual amount of water withdrawn from the source 150,000 m<sup>3</sup>/year (not purified)

In addition, other water resources used in the city were:

- Spring water coming from Kocakasaplar location to historical fountains (4 liters per second)
- Taken from the diving well of Bademlik District (20 liters per second)
- Karacaibrahim Neighborhood was taken from the submersible well (7 liters per second) [8].

However, the existing drinking water transmission lines were:

- Promotion Station; (promoted), pipe type steel (AC), diameter 600 m, length 2600 m, project flow 300 l / s, year of construction 1995
- Drinking Water Treatment Tank; (attractive), built in 1995, the organization Rıza Akkaya
- Balabanbaba Warehouse; (attractive), pipe type (AÇB, diameter 600m, length 1600 m,
- Sazara Depo; (promoted), pipe type steel, 400 m in diameter, 2000 m in length, project flow rate 120 l / s, year of construction 1999.
- Kırklareli Municipality drinkable water treatment plant; The water coming from Kırklareli Dam is stored here and distributed to the treatment process and public institutions and private residence. Conventional treatment plant (physical + chemical) had an existing capacity of 8250000 m<sup>3</sup>/year, the amount of treated drinking and utility water was 5200000 m<sup>3</sup> / year and the facility operates every day of the year. Units available at Kırklareli Municipality Drinking Water Treatment Plant; sand trap, ventilation, coagulation, flocculation, rapid sand filter, disinfection unit, contact tank [6].

The status of the water resources that were in Kırklareli; According to the values the dam occupancy rates on the basis of provinces in 2017, the occupancy rate in the water storage facilities was 30.20% in Kırklareli dam, 43.80% in Kayalıköy Dam and 55.80% in Armağan Dam. Drinkable and potable water resources in the province consist of surface and groundwater. Among the reasons for the deterioration of the quality of water resources in the city were industrialization and urbanization uncontrolled and irregular, agricultural activities. Discharge of urban sewage water to surface waters without being treated or partially purified, leakage from sewage systems and exposed solid waste piles polluting underground waters, excessive and unconscious used of pesticides and fertilizers caused by agricultural activities, especially the water pollution in rivers, caused by industrial activities. The most important pressures were the wastes polluting the groundwater, as well as the negative effects of secondary houses on surface water resources [7].

### 3.1. Water Resources of the Province

It seemed that 3.25% by the existing surface water resources in Turkey, at 1.41% of underground water resources located in the province (Table 1).

**Table 1. Distribution of Turkey and Kırklareli water resource [8]**

Water Resources	Turkey (hm <sup>3</sup> )	Kırklareli (hm <sup>3</sup> )	Kırklareli / Turkey (%)
Surface water resources	98.000 hm <sup>3</sup>	1.137 hm <sup>3</sup>	1.16
Underground water resources	14.000 hm <sup>3</sup>	125 hm <sup>3</sup>	0.89
Total	112.000 hm <sup>3</sup>	1.262 hm <sup>3</sup>	1.13

90% of the total water resources were covered by surface water resources and 10% from underground water resources. The province has a total water potential of 1,262 hm<sup>3</sup>/ year. Considering the use of groundwater potential of Kırklareli province, 19.6% of 125 hm<sup>3</sup>/ yearly underground reserve have been established for irrigation and 48.32% for drinking, using and industry [8].

### Streams

The main streams in the province were presented in Table 2 [9]. The basin of all Kırklareli rivers was open to seas. Streams showed different characteristics in terms of basin, flow and regime. Yıldız Mountains divides the river basins into two because it was the "water section line". Of these, the Aegean Basin; the streams was born on the southern slopes of the Yıldız Mountains follow a direction from north to south to reach the Ergene axis by following the slope of the ground parallel to each other. These rivers before the river Ergene, the Maritza River then flows into the Aegean Sea and finally the Turkey-Greece border. The water collection area of the Aegean Basin was approximately 14,500 km. With this aspect, it was one of the most important basins of the country in terms of agricultural activities. The average annual water volume of the basin was around 1 billion m<sup>2</sup>.

**Table 2. Streams of Kırklareli province [11]**

Stream Name	Total Length (km)	Length Within Province Boundaries (Km)	Ratio to Total Length (%)	Flow rate (m <sup>3</sup> / sec)	Streams as a Lever
Teke Creek	119.25	119.25	100	3.804	Ergene
Devil's Creek	83.3	83.3	100	2.648	Ergene
Great Creek	62.8	62.8	100	0.426	Ergene
Vize Creek	78.2	41.4	53	1.412	Ergene
Ergene River	283	90	32	-	Ergene

### Lakes

The lakes as water resources in the province were divided into natural and artificial lakes in terms of their formations.

**Natural Lakes:** Lakes within the borders of Kırklareli were gathered in the east of Yıldız Mountains, around Demirköy-İğneada. Erikli Lake, located in the north of İğneada, lined parallel to the Black Sea at a distance of 15-20 meters. The surroundings of this lake, which was almost at sea level, are reeds and marshes. Its waters were connected to the Black Sea with an opening in the north direction during the winter months. In summer, the connection with the sea was closed again with piles of sand. Geyik Dere and Mavroça Stream were the streams that feed the lake, especially Efendi stream.

Mert Lake, also known as Kocagöl, was located in the flat area south of Igneada. Mert Lake, which had a connection from the north to the Black Sea in winter, was cut off from the sea in summer, but Deringeçit Stream feeds Mert Lake. The area around the lake was marshy and reed and forest areas begin immediately after this section. Saka Lake was located to the south of Mert Lake. There were also two more lakes named Hamam and Pedina in the region, both of which were in forest land. Apart from these, there were lagoon lakes, which were formed by the closure of the river front in summer months, in the coves located in the south and north of Kıyıköy, near Panayır Pier, and in Kastfos and Çilingöz [8].

**Artificial Lakes:** The landforms and geological structure of Ergene Basin were extremely suitable for pond construction. In order to protect the soil and water resources, to reduce the damage of floods and use them for irrigation, ponds were built by the Soil-Water Directorate in the province. These are Ataköy pond near Pınarhisar, Bayramdere of Kırklareli, Deveçatağı ponds and Ceylanköy ponds near Lüleburgaz [10].

The ponds in Kırklareli province are the central Skopje pond and the central Dolhan pond. Dam reservoirs were also located in the province.

**Central Üsküp Pond:** It was located 3 km northeast of the Skopje District of Kırklareli central district (Figure 1). Its source is Skopje stream. It was built between 1987-1990 for demanding of irrigation and drinking water supply. Zoned soil filling, storage volume  $1.24 \text{ hm}^3$  active volumes  $1.06 \text{ hm}^3$ , dead volume  $0.18 \text{ hm}^3$  height 22 m from the river bed. The lake provided 166 hectares of irrigation area and  $0.05 \text{ hm}^3$  / year drinking water [10].

**Central Dolhan Pond:** It was located in the north of Dolhan village in the central district of Kırklareli province (Figure 1). Cihanlar Stream was fed by the stream. It was built between 1999-2005 for irrigation purposes. Zoned soil filling, storage volume  $1.09 \text{ hm}^3$  active volumes  $0.93 \text{ hm}^3$ , dead volume  $0.16 \text{ hm}^3$  height 22.5 m from the stream bed. The lake provided 172 hectares of irrigation area [10].



Figure 1. Central Üsküp (left) and Central Dolhan (right) Ponds [7]

**Dam Lakes:** They were formed the most important and largest lakes of Kırklareli. It was built to supply irrigation and drinking water. Of these, Kırklareli Dam Lake was used for drinking water and Armağan and Kayalı Dam lakes for irrigation [10].

### Dams

Kırklareli province had four dams given below:

**Kayalıköy Dam:** It was built between 1975 and 1986 for the purpose of irrigation, flood control and drinking water, 14 km northwest of Kırklareli province (Figure 2). The body volume of the dam, which was the soil and rock body filling type, was 68.7 m in height from the river bed of  $1.53 \text{ hm}^3$ , the lake volume in the normal water level was  $149.86 \text{ hm}^3$  and the lake in the normal water level was  $101.86 \text{ km}^2$ . While the dam provided irrigation purpose in agricultural land an area of 15,957 hectares, it supplied  $5,96 \text{ hm}^3$  / year drinking water annually to Edirne province and  $0,49 \text{ hm}^3$ /year drinkable water to Kırklareli province [6].

**Kırklareli Dam:** It was constructed in Kırklareli on Şeytandere for the purpose of irrigation, flood control, drinking water and industrial water between 1985-1997 (Figure 2). The body volume of the dam, which was the soil and rock body filling type, was 67.5 m in height from the river bed of  $1.46 \text{ hm}^3$ , the lake volume in normal water level was  $113.31 \text{ hm}^3$ , and the lake area in normal water level was  $5.98 \text{ km}^2$ . The dam provided irrigation services to an area of 13,679 hectares, while it provided  $10,70 \text{ hm}^3$  / year of potable water annually [10].





Figure 2. Kayalıköy (left) and Kırklareli (right) Dams [7]

Armağan Dam: The dam was built between 1986 and 1998 for irrigation purposes in the northeast of Armağan Village of Kırklareli province (Figure 3). The body volume of the dam, which was the clay core and rock filling type, was 57.5 m in height from the river bed of 1.50 hm<sup>3</sup>, the lake volume in the normal water level was 51.50 hm<sup>3</sup> and the lake in the normal water level was 3.05 km<sup>2</sup>. The dam provided irrigation services to an area of 590 hectares [10].

Çayırdere Dam: Feeding from Kocadere stream 2.5 km northeast of Çayırdere village of Pınarhisar district of Kırklareli province, construction started in 2011 for irrigation and was completed at the end of 2015 (Figure 3). The front was covered with concrete, the rock volume was 0,609 hm<sup>3</sup> and its height was 58,50 m from the stream bed, the lake volume was 28,25 hm<sup>3</sup> in normal water level and its lake in the normal water level was 2,02 km<sup>2</sup>. The dam would supply irrigation demand to an area of 2,583 hectares. Body filling had reached the level of +320,00 [10].



Figure 3. Armağan (left) and Çayırdere (right) Dams [7]

### 3.2. Wastewater Treatment Plants

#### Kırklareli Merkez Municipality domestic wastewater treatment plant:

It was located in the city center of Kırklareli. Domestic waste water of Kırklareli Municipality would be discharged after advanced biological treatment. Its construction was completed between 2013 and 2014 (Figure 4). The normal capacity of the facility was 1<sup>st</sup> Floor: 13.398 m<sup>3</sup>/day, Second Level: 17.268 m<sup>3</sup>/day. It had two coarse and fine grills, 2 aerated sand and oil traps, 3 anaerobic pools, 6 aeration pools, 3 sedimentation pools. The flow rate of Kırklareli (central) potable water Treatment Plant was given as 25,920 m<sup>3</sup> / day (300 l/s) by the provincial bank. The purified water quality in this facility complies with WHO and EEC standards [10].



**Figure 4. Kırklareli Municipality domestic wastewater treatment plant [6]**

Vize Municipality domestic wastewater treatment plant

It was located in Vize district of Kırklareli province. It was built between 2013 and 2014 in order to ensure the discharge of domestic waste water of Kırklareli Vize Municipality after advanced biological treatment (Figure 5). The normal capacity of the facility was 1<sup>st</sup> floor: 2,690 m<sup>3</sup>/day, second level: 3,802 m<sup>3</sup> / day. It had two coarse and fine grills, 2 aerated sand and oil traps, 3 anaerobic pools, 2 aeration pools, 2 sedimentation pools. Board acceptance was completed on 30.05.2014 and it is at the commissioning stage [6].



**Figure 5. Vize Municipality domestic wastewater treatment plant [6]**

Babaeski Municipality waste water treatment plant

The plant was located in Babaeski district of Kırklareli province. It was built between 2013 and 2014 in order to ensure the discharge of domestic waste water of Kırklareli Babaeski Municipality after advanced biological treatment (Figure 6). The normal capacity of the facility is 1<sup>st</sup> floor: 5,266 m<sup>3</sup>/day, second level: 6,651 m<sup>3</sup>/day. It had two coarse and fine grills, 2 aerated sand and oil traps, 3 anaerobic pools, 4 aeration pools, 2 sedimentation pools. Reinforced concrete construction of the ventilation pool and other buildings was ongoing [6].



Figure 6. Babaeski Municipality waste water treatment plant [6]

#### Pınarhisar Municipality waste water treatment plant

The plant built between 2013 and 2014 was located in Pınarhisar district of Kırklareli province in order to discharge the domestic waste water of Kırklareli Pınarhisar Municipality after advanced biological treatment (Figure 7). The normal capacity of the facility was 1<sup>st</sup> floor: 2,050 m<sup>3</sup>/day, second level: 2,789 m<sup>3</sup>/day. It had two coarse and fine grills, 2 aerated sand and oil traps, 3 anaerobic pools, 2 aeration pools, 2 sedimentation pools. Reinforced concrete construction of the ventilation pool and other buildings was ongoing [6].



Figure 7. Pınarhisar Municipality waste water treatment plant [6]

### **3.3. Planned Studies for Water Resources Management of Kırklareli Province**

In parallel with the development of Kırklareli Province, it was stated that various water supply projects have been prepared since 1975 to supply the water needed. However, the projects prepared in the old years did not make much sense today as they served narrow regions and small populations. The most important project related to the city was the 'Meriç-Ergene and Northern Marmara (Thrace Section) Basin Master Plan Report' which covered the future until 2060 and TRAGEP (Thrace Development Project) covering the years 2013-2017. In addition, this project had an Ergene Basin Protection Action Plan [8].

According to Meriç-Ergene and North Marmara Basins Master Plan Report; the current water source of Kırklareli was Kırklareli Dam. In the planning of the Kırklareli dam, which was put into operation in 1995, the projected volume for drinking water was 3.78 hm<sup>3</sup>. Due to the increased need, 14.20 hm<sup>3</sup> of drinking water, which was actually drawn per year, has been increased.

Armağan Dam was put into operation in 1997 and it was connected to Kırklareli Dam with a 2050 m deviation tunnel and the two dams were operated together for irrigation-drinking water purposes. As a result of this report, water needs, evaluation of available resources and supply-demand balances, water consumption, supply would be determined according to projection populations determined until 2060.

In TRAGEP, irrigation and wastewater treatment plants come to the fore for Kırklareli Province. Kırklareli Merkez, Pınarhisar, Babaeski, Vize, Lüleburgaz wastewater treatment plants were opened. The establishment of a solid waste treatment, recycling and disposal facility is ongoing.

In order to carry out the infrastructure services of the dispersed industries better, 2 of the joint advanced wastewater treatment plant was located in Kırklareli OSB. Stream improvement projects were being



carried out to reduce flood risks, 25 of which have been completed in Kırklareli and 32 of them were still under construction. 16 of these facilities were located in the center [6].

In line with this project, the same waste water treatment facilities and stream improvement works were included in the Ergene Basin Protection Action Plan, small treatment plants and sewerage networks collector lines were built by governmental Bank, and the water quality of Meriç-Ergene River was monitored in real time from 5 stations. Waste water of industrial facilities were monitored in real time. To prevent agricultural pollution, farmers were trained, agricultural and fertilizer dealers were inspected and pesticide using was reduced up to 50%. Flood early warning system has been established for the Ergene basin, 21 river stream rehabilitations have been completed by cleaning the Ergene River and its tributaries and 7 of them were in the construction phase. In total 67,985 hectares of area, reforestation and erosion control improvement studies have been conducted [6].

#### **IV. CONCLUSION**

As the province of Kırklareli continues to develop rapidly and the industry increases day by day, problems related to water resources increase for a long time. Many problems and problems on the water resources related to Kırklareli province have been identified.

Problems encountered in the field;

- Problems arising from rapid industrialization and industry fields,
- Problems arising from the discharge of urban sewage waters into surface waters without being treated or partially purified and leaks in exposed solid waste piles,
- Problems arising from excessive and unconscious use of pesticides and fertilizers in agricultural activities,
- Problems arising from wrong land use and unplanned urbanization,
- We can summarize as problems arising from legal and administrative failures.

In addition to improving the current situation in the areas of drinking water supply and waste water removal in the settlements within the borders of Kırklareli Municipality, future investments that need to be made should be made quickly and put into practice. As a result of the rapid industrialization and urbanization in the province, industrial and domestic wastes and agricultural fertilizers and drugs that are used unconsciously create pollution in groundwater. In Kırklareli, because of sewerage, infrastructure and solid waste problems, it mixes with irrigation water and groundwater. Therefore, it should be resolved by making legal arrangements. The fact that illegal housing, which is encouraged by law, houses the water basins should be seen as the main reason for the thirst in cities. In front of the water being a renewable resource, all kinds of intervention to the natural environment (planned / unplanned) in the basins, especially in the forest areas (polluted / unplanned), as a result, the pollution experienced in the lake, river, dam, well or these resources / facilities appear as the problem of thirst.

Consequently, in planning of human development, decision-makers need to be forced together with a rational water and physical planning that takes into account the amount of water demanded by the increasing population and economic development as well as land use and investment decisions that do not cause pollution of water resources. It is a fact that the sources are contaminated. Contamination should be followed carefully.

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