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Overview of Sustainable Water Management Policies in Cities in Terms of Preventing Climate Change Impacts: Center/Bilecik-Türkiye Case

Sevgi AKKOY[1], Edip AVŞAR[2]

[1]*Bilecik Seyh Edebali University, Graduate School Institute, Industrial Sustainability Department, 11230 Bilecik, Türkiye*

[2]*Bilecik Seyh Edebali University Vocational School, Environmental Protection Technologies Department, 11230 Bilecik, Türkiye*

Abstract: Water is a vital resource for the world and humanity and is an essential issue for sustainable development. According to sustainable development goals, access to water in the required quantity and quality is everyone's most fundamental right. While the water resources in the world cover two-thirds of the globe, the distribution of water resources on the globe varies; due to the climate crisis and pollution, clean water resources are decreasing day by day. The pressure on water resources is increasing day by day with the increase in competition in agriculture, industry and domestic use.

The main goal of the study is to ensure sustainable water resources management in Bilecik city center. Within the scope of the study, it aims to determine how the resources will be used more efficiently to meet the rapidly increasing water demand, how the water resources in the city center will be affected by the population growth, how the need for alternative resources and management will be done, and strategies for water recovery and reuse. According to the research conducted, the average daily amount of water drawn per person was calculated as 228 liters. In three major cities, the average amount of water drawn per capita was determined to be 190 liters for Istanbul, 246 liters for Ankara, and 221 liters for Izmir. In this context, the strategies developed and implemented for cities were evaluated specifically for Bilecik (Center). All the city's drinking water is provided by the Karasu Stream. Drinking and utility water network service is provided to 99% of Bilecik's population. (Bilecik Municipality Performance Program, 2023). It was obtained from the interview with Bilecik Municipality officials that the instantaneous water flow rate according to the population in Bilecik (Center) in 2023 was 181 liters. According to the obtained data, Bilecik (Center) remains below the average amount of water drawn per capita. Considering that the population will increase regularly with the increase in industry in the coming years in Bilecik province, there may be a water supply problem in the city soon.

Strategic development targets should be determined in order to increase the efficient use of water resources in urban areas and projects that will support them should be implemented. Another important issue in increasing the quality of water resources and reducing water losses is that the water and wastewater infrastructure should be well designed. Therefore, it is envisaged that General Directorate of State Hydraulic Works (GDSH), governorships and local governments urgently develop a B plan to prevent a water crisis.

Keywords: Water Efficiency, Water Resources, Sustainable Development, Bilecik

I. INTRODUCTİON

One of the factors underlying environmental problems is the inevitable population growth. Studies show that the world population will exceed 11 billion in the coming years for a habitable universe. It is thought that this situation will bring along problems such as deterioration of ecological balance, increase in unplanned urbanization and disappearance of hunger, shelter and poverty [1] Increasing pollution worldwide and its negative effects on water resources have led to the concept of "sustainable water management", which was first used at the International Water Conference in 1992. Water Management is based on 4 principles. These are; efficient use of freshwater resources to ensure environmental sustainability, ensuring the participation of all relevant stakeholders to ensure successful water management, the role of women in water supply and management, and the economic value of water are important in this context [2]. In the 20th century, sustainable development is a development model that addresses social and environmental factors as well as economic developments. The sustainable development model, which has been in every field of industry in the last century and emphasizes equal participation of the public, is an approach model that advocates openness and equality. In short, the model is to bring the needs of the society to the most favorable level [3]. Cities are a complex system in which numerous economic, social, cultural, institutional and natural structures and a wide range of risks are

intertwined. 56% of the world's population, which will reach 8 billion in November 2022, lives in cities. The population living in cities is increasing [4].

Water efficiency in cities covers drinking and potable water, individual water efficiency, wastewater treatment and pricing that incentivizes the efficient use of water. The main point in water supply is to deliver the desired quantity and quality of water to the user. At this point, it is important to prevent water losses. It is especially important for local governments to control the loss and leakage rates in water networks for the efficient use of water [5].

According to the researches, the average amount of water withdrawn per person per day is calculated as 228 liters. In the three big cities, the average amount of water withdrawn per capita is 190 liters for Istanbul, 246 liters for Ankara and 221 liters for Izmir [6]. In this context, the strategies that have been developed and should be implemented for cities are evaluated for Bilecik (Center). All of the city's drinking water is supplied from Karasu Stream (Bilecik Municipality Performance Program, 2023). In 2023, it was obtained from the interview with Bilecik Municipality officials that the instantaneous water flow rate according to the population in Bilecik (Merkez) is 181 liters. In line with the data obtained, Bilecik (Center) is below the average amount of water withdrawn per capita. Considering that there will be a regular population increase in Bilecik with the increase in industry in the coming years, there may be a water supply problem in the city in the near future. In this study, strategies developed for cities based on water efficiency in cities and strategies that should be implemented are evaluated. In line with the data obtained, it is thought that the city of Bilecik will face a water crisis in the coming years.

II. CLIMATE CHANGE AND CITIES

Cities are an indicator of human adaptation and change in the natural environment and have the capacity to drive environmental systems [7]. Urban ecology combines natural and social sciences to understand ecosystems and the urbanization of societies and the environment [8]. For the first time in history, more than half of the world's population of 3.5 billion people live in urban areas. This urban share will increase to almost 60% by 2030 and 70% by 2050 [9]. Large-scale urbanization requires huge amounts of resources to build, feed and fuel cities [10].

Cities are complex systems in a constant dynamic state. They evolve in complex ways through their size, social structure, economic systems, geopolitical location and the development of technology [11]. They require a large amount of resources to maintain their dynamic state, and compete intensely for space through diverse patterns, clustering and other land uses [12]. In the past, the depletion of the nearest and most accessible resources has become a constraint on the growth of cities [13]. However, technological and infrastructural innovations have driven increases in urban inputs and outputs [14]. From the past to the present, the need for water has increased the most with the increase in population, urbanization and the development of technology.

Water plays an important role in urban development. As water availability is increasingly constrained by deficiencies in quality and quantity, water management in cities is at the center of sustainability planning. The water cycle in cities is diverging from past methods and techniques with the increasing impact of water services, defined as drinking and domestic water supply, municipal, commercial and industrial resources and raw materials, virtual water products and irrigation, and wastewater volume [15]. Certain regions of the world face major challenges in water management. The World Economic Forum has completed its Global Risk Report on water crises. According to the report, it is thought that there will be large-scale catastrophic floods on a global scale in the coming years.

In cities, there is an environment that depends on the processes, benefits and products provided by the ecosystem for human survival, that is, ecosystem services. Water has a privileged place among these resources. The existence of water is a prerequisite for ensuring climate, food, energy and ecosystem security. Sustainable management of water, especially in cities, should be ensured in order to achieve a climate resilient city. One of the most important features of a city resilient to climate change is to ensure effective water management and to provide quality water to its citizens. There are many different approaches and measures that can be taken for sustainable, healthy drinking water supply in an urban settlement [16].

III. CLIMATE CHANGE AND WATER MANAGEMENT

Climate is a systematic or long-term statistical description of the long-term effects of all weather conditions experienced or observed in any region of the earth [17]. Human impact on climate has been a dominant cause of observed warming since the mid-20^{th} century.

According to the IPCC, the global average surface temperature increased by 0.85 ^{0}C between 1881 and 2012. Many regions of the world are already experiencing more regional warming. 20-40% of the global population experiences warming above 1.5^{0}C in at least one season. To date, increases in temperature, droughts,

floods and extreme weather events have been caused by humans and human activities [18]. According to the United Nations Framework Convention on Climate Change, climate change is all human activities that directly or indirectly disrupt the composition of the atmosphere observed over a comparable period of time [19].

Low- and middle-income countries are the most affected by climate change and its impacts. This is partly due to increased migration and poverty [20]. Sustainable development and poverty eradication are supported by international legal instruments to be a supportive and successful agreement in terms of climate action [21]. For the last 30 years, in order to find a solution to the climate crisis, the world states have been aiming to restrain the global average temperature below 2^0C and, if possible, at 1.5^0C in order to provide adequate adaptation against the effects of climate change within the scope of the Framework Convention on Combating Climate Change (UNFCCC), which entered into force in 1994 under the roof of the United Nations, the Kyoto Protocol, which entered into force in 2004, and finally the Paris Climate Agreement, which entered into force in 2016, and each party country determines the method to be followed in achieving this goal with its national contributions (NDC).

The Paris Climate Agreement contributes to global efforts to increase climate resilience in cities by strengthening resilience in society in order to ensure adequate adaptation to the effects of climate change, increasing adaptive capacity and paving the way for societies to realize the United Nations Sustainable Development goals adopted in 2015 in line with these goals [22].

Efficient use of water in cities contributes to the reduction of negative impacts such as drought. In addition, efficient water use reduces infrastructure costs leading to less wastewater services. The resources offered to us by the natural environment are decreasing day by day as a result of human activities. In order for the environment to renew itself, people need to provide it with opportunities to renew itself. Therefore, sustainable development has a very important place. Water efficiency is at the center of societies' realization of sustainable development [23]. The sustainability of water distribution and exchange relations encompasses a lot of data that are directly or indirectly exchanged between the public and private sectors. Without this cooperation, world water demand is expected to exceed 40% in 2030. (24].

According to the World Water Development Report published by the United Nations in 2020, it is estimated that the possibility of periodic water scarcity will increase worldwide due to climate change. In addition, water temperature will increase, dissolved oxygen levels will decrease and the assimilation capacity of freshwater ecosystems will decrease due to climate change. Therefore, climate change also has negative impacts on water quality.

In addition, climate change can also cause increased pollutant problems during drought periods through pollutant transport of water as a result of floods. Climate change also affects forest and wetland ecosystems. Damage to ecosystems will not only reduce biodiversity but also affect the maintenance of water-related ecosystem services such as water purification, carbon capture and storage, natural flood protection and water supply for agriculture, aquaculture and recreation [25].

IV. SUSTAINABLE WATER MANAGEMENT IN TÜRKİYE

Although temperature increases and the increase in global temperature are primarily considered in the fight against climate change, one of the most important reasons for climate change is the change in precipitation regime. The universe is directly or indirectly affected by climatic conditions. Changes in precipitation, flood and drought events, as well as flood and drought events directly affect the amount of water seeping into the ground, plant pattern and growth rate of plants [26]. Since 2000s, public, private sector and NGOs have started to work on “Water Management” in Türkiye [27]. Table 2 shows the Water Action Plans realized since 2000s until today. It is seen that mostly the Ministry of Agriculture and Forestry (MAF) and the Ministry of Environment, Urbanization and Climate Change (MEUCC) have prepared various action plans.

Table 1: Water Action Plans Realized in Türkiye

Institution/Organization	**Plan**
MAF	River Basin Management Plan
MAF	Basin Protection Action Plans
MAF	Water Quality Action Plan
MAF	Potable Water Basin Protection Plan
MAF	Flood Management Plan
MAF	Drought Management Action Plan
MAF	Basin Water Allocation Action Plan
MAF	National Action Plan for Combating Desertification
MAF	Action Plan for Combating Erosion
MAF	Dam Basins Green Belt Action Plan
MAF	Rural Development Action Plan
MAF	Wetland Management Plan
MEUCC	European Union Integrated Environmental Approximation Strategy
MEUCC	Climate Change Action Plan
MEUCC	Waste Water Action Plan
MEUCC	Türkiye's Climate Change and Adaptation Strategy Action Plan
MEUCC	Water Resources Management Plan in Special Environmental Protection Areas
MEUCC	Action Plan for Accession to the European Union

Source[28]

Table 2: Türkiye's Water Potential and Uses

Potential/Uses	Unit	Amount
Annual Rainfall	billion m^3	450
Available Surface Water		96
Total Available Water		112
Amount of Water Used in Irrigatioillion		44
Amount of Water Used in Industry and Drinking Water		13
Total Water Used		57

Source: [29]

According to the 2014 Official Gazette, there are currently 25 main water basins, 1,848 sub-basins and 14,608 micro-basins in Türkiye [30]. According to 2015 data, Türkiye's available water potential was 112 billion m^3, while its population was approximately 78.75 million. As a result of these values, Türkiye's Falkenmark Indicator was realized as 1,422.23 m^3 per person per year in 2015. In 2017, this value decreased to 1,385.92 m^3 due to population growth. In 2020, the total population is 83,614,362 and it is concluded that the annual amount of water per capita is 1,339 m^3. According to the Falkenmark Water Stress Index, Türkiye is a water-stressed country.

Table 3: Population and Drinking Water Data for Türkiye between 2014-2018

Year	**Total Municipality Population**	**Total Water Withdrawn (1000 m^3 /year)**	**Amount of Water Distributed (m^3 /year)**
2010	61,571,332	4,784,734	2,579,676
2014	63,743,047	5,237,407	3,394,545
2016	72,505,107	5,838,561	3,732,875
2018	74,911,343	6,193,158	4,045,486

Source: [31]

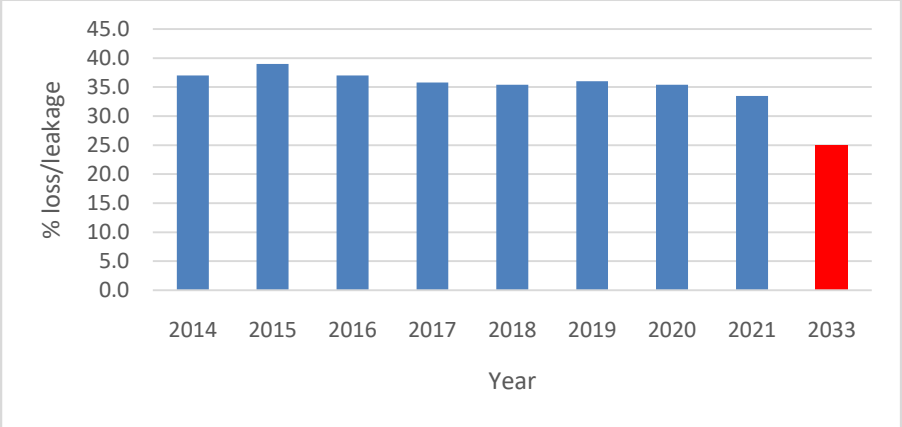
As seen in Table 3, the population rate in 2010 has shown a continuous increase until 2016. Again, looking at the data in 2010, it is among the information obtained that the total amount of water withdrawn and the amount of water distributed have increased over the years. Thus, the amount of water withdrawn and the amount of water distributed in water systems in Türkiye were determined at 2 years interval.

According to the studies conducted in 2017, it was determined that the rate of lost and illegal water in Türkiye was 46% [32]. Within the framework of the 11th Development Plan in Türkiye, the Regulation on the Control of Water Losses in Drinking Water Supply and Distribution System was prepared in relation to the efficient use of water. According to the Regulation, water losses in metropolitan and provincial municipalities should be maximum 30% by 2023 and 25% by 2028 [33].

According to TÜİK data, 56.8% of the water withdrawn in Türkiye in 2022 was from the sea, 22.1% from groundwater and 21.1% from surface water, totaling 43.2% of freshwater resources.

The average annual precipitation in Türkiye is approximately 574 mm, which corresponds to 450 billion m^3 of water per year. The surface water potential that can be consumed today is 94 billion m^3 per year on average. Together with 18 billion m^3 of groundwater potential, Türkiye's consumable surface and groundwater potential is 112 billion m^3 per year on average, of which 57 billion m^3 is used. The annual amount of water available per capita in Türkiye was 1,652 m^3 in 2000, 1,544 m^3 in 2009, 1,323 m^3 in 2021 and 1,322 m^3 in 2022 [34].

Figure 1: Water Loss-Leakage Rates (2014-2023)



Source: [35]

Water consumption in Türkiye has been increasing at certain rates in recent years. Metropolitan municipalities and provincial municipalities are obliged to reduce water consumption to a maximum of 30% by 2023, 25% by 2028 and 25% by 2033 [36].

Table 4: Türkiye Water Consumption in Future Years

Year	Population	Water Consumption Calculation (L/s)
2020	83,614,362	189
2038	88,417,000	114
2053	93,475,000	142

Source: [37].

According to Table 4, water consumption in Türkiye in 2020 is calculated as 189 L/s in proportion to the population. The instantaneous water consumption rate is estimated to be 114 L/s in 2038 and 142 L/s in 2053 in parallel with the population.

Table 5: Türkiye 2003 and 2030 Water Utilization Rates

Sector	2003 (m^3)	2030 (m^3)
Irrigation	29.6	72.0
Drinking water	6.2	18.0
Industry	4.3	22.0

Source:[38].

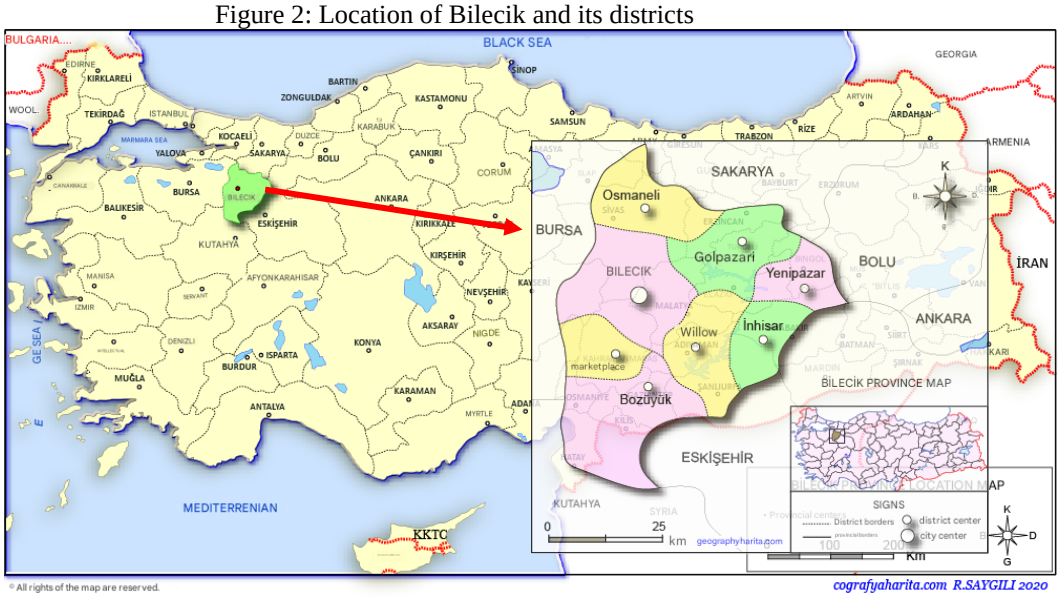
Türkiye uses 1/3 of its water potential today. In 2030, it is thought that it will use all of its water potential. This means that Türkiye is expected to experience water stress after 2030 [38].

Utilization Availability Ratio was calculated for each municipality in Türkiye. The data were used from TÜİK Municipal Water Statistics. Total water withdrawn is defined as water distributed to end-users through the municipal water network. Supplied water is defined as water extracted from sources for distribution by networks. The Falkenmark Indicator calculates the per capital water potential of a region, while the Availability Ratio provides information on how efficiently water is used in each municipality.

V. MATERIAL/METHOD

Bilecik (Center), which was selected as the research area, is located at the intersection of Marmara, Central Anatolia and Aegean Regions. The province is neighboring Kütahya, Eskişehir, Bursa, Sakarya and Bolu provinces. The city consists of 8 districts, 3 towns and 61 neighborhoods [39]. The location of Bilecik and the distribution of its districts are given in Figure 2.

Figure 2: Location of Bilecik and its districts



Source: [41]

In Bilecik city center, water is supplied from Karasu Water Source through Karasu Drinking and Potable Water Union. This situation is monitored 365 days a year. However, as a result of the malfunction in the line, water is supplied to Bilecik province from local water wells. This rate varies between 30-40% per year [40]. Therefore, the amount of water per capita in Türkiye is 1400m^3 based on potential, but only 500m^3 based on usable water. While this figure is 873m^3 for Bilecik province based on total potential, it drops to 232m^3 when we emphasize usable water [42]. This situation causes irregular development of the city.

VI. BİLECİK WATER MANAGEMENT

The not very large plains along the Sakarya River in Bilecik cover 7% of the city's territory. One of the most important water sources of the city is the Sakarya River. Another water source of the city is the Karasu drinking line. The line originates from Bozüyük. Within the provincial borders, the water source passes through the Karasu Strait [43]. There are water production farms in the region and there are 5 water production facilities.

Table 6. Amount of Water Resources in Bilecik Province

Water source	Amount (hm^3 /year)
Surface Water	320.0
Underground Water	54.7
Total	**374.7**

Source:[44].

The largest water source of the province is surface water. Groundwater constitutes 14.6% of the total water resource. In addition, the urban sewerage system serves 98% of the total population in the province, including the center and districts.

Table 7: Occupancy Rates of Dams in Bilecik Province by Years

Point in Bilecik /Year	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Darıdere(Dodurga)	43,50	25,60	3,60	51,60	45,50	22,0	13,80	7,30	3,20
Kızıldamlar	59,50	44,20	33,60	72,10	57,10	61,0	46,20	49,50	55,70
Günyurdu Mustafa Beydemir	49,30	43,30	35,30	76,40	66,50	63,90	72,70	68,80	57,80

Table 8: Waste Water Treatment Plants in Bilecik Province

OIZ No	The Current Situation	Tons/Day	WWT Types	Discharge Point
OIZ 1	Active	5,500	Physical Chemical Biological	Pelitözü Pond
OIZ 2	Active	2,200	Physical Biological	Karasu Stream

Source: [45].

After the wastewater is treated at certain intervals, it is discharged into Karasu Stream according to the appropriate parameter values. The construction of Bilecik Central Waste Water Treatment Plant for the treatment of wastewater was started to serve in 2018 [46]

Studies on Water Management in Bilecik Province

In Bilecik Central District, water supply to factories within Organized Industrial Zone 1 (OIZ 1) is distributed by the GDSH by drawing water from permitted wells. In general, water supply is carried out by collecting wastewater in the facility and treating it in the treatment facility within the Organized Industrial Zone. Rainwater and industrial water waste are also collected separately in the system and discharged to Pelitözü in the wastewater facility in accordance with the Water Pollution Control Regulation (ÇED, 2016). When water usage of the city is investigated in terms of sectors, all of the drinking water is provided by Karasu Creek. Drinking and utility water network service is provided to 99% of Bilecik's population.

According to the 2023 performance status report of Bilecik Municipality, there is also a wastewater treatment plant and a Brigade Command wastewater system in the city. However, these treatment facilities located in the city are not operational. These facilities are planned to be activated in the performance program in 2023. In addition, making the necessary project applications to minimize the amount of drinking water and wastewater loss and leakage is among the desired targets (Bilecik Municipality Performance Program, 2023). Bilecik Municipality Environmental Protection and Control Directorate Water and Waste Management Strategies are as follows;

Treating and analyzing wastewater delivered to wastewater treatment plants in accordance with regulation standards,

- Issuing wastewater connection permits,
- Taking samples of water supplied to the city network at certain periods up to the farthest point of the city network,
- Conducting water analysis studies with water field control analysis equipment,
- Conducting hygiene and cleanliness control of water tanks,
- Within the scope of Environmental Development and Management Activities; making necessary plans and projects within the scope of minimizing the amount of drinking water loss and leakage [47]

Bilecik Municipality Directorate of Technical Affairs lists its strategies within the scope of Infrastructure and Manufacturing Studies as follows;

- Making drinking water and sewage connections,
- Conducting studies on water pipes falling into the line and water bursts [48].

When the amount of water withdrawn in the province since 2010 is examined, while 91% of the water withdrawn in 2010 was withdrawn from resources, this rate decreased to 13% in 2014. In 2016, this rate decreased to 66%. [49].

VII. RESULT

In Türkiye, many plans have been made to prevent water pollution in the last 20 years. However, the plans are still in the early stages. It is very important for GDSH, governorships and local governments to care about water efficiency policies both in the world and in Türkiye. This study aims to examine water management studies through the example of Bilecik province. First of all, studies in the field of water management were examined globally in the study. Then, the subject of water efficiency in Türkiye was introduced and the studies in Bilecik province were examined in depth. Studies on water pollution in Türkiye require investment, quality personnel and technical equipment. Strategic plans should be developed and projects should be implemented in order to increase the efficient use of water resources in local municipalities. In the field of water efficiency, water losses should be reduced, water monitoring and infrastructure studies should be planned well. For this, local municipalities should minimize water pollution on the environment, health and economy. Considering the increasing water demand in the last century and the importance of cities in water management, existing water resources, water production and consumption rates based on population were examined in order to evaluate the current situation in the field of water efficiency in Bilecik province. Between 2010 and 2020, it is seen that the current water withdrawal rates have been continuously decreasing, the city's water consumption has increased and water resources have started to become insufficient.

As a result of the research conducted, the main reasons for water pollution within the provincial borders are wastewater, domestic and industrial waste. It is also seen that studies are carried out in the university of the city in 2023 within the scope of water saving. The studies conducted by the Zero Waste Coordination are as follows; 50% more water saving has been achieved by using aerator systems in university buildings [50]. In this context, it is recommended that the aerator system be used in all administrative buildings in the center of Bilecik. In addition, it is recommended that provincial administrators prepare a local water plan for the future of the city together with the university. When the necessary activity and performance reports of GDSH, the governor's office and local governments are examined, it is seen that there are no emergency plans.

It is very important for local governments to set an example for citizens by using water efficiently in their own services on a provincial basis. In this context, brochures on water efficiency, preparation of necessary documents, joint studies with other local government units should be examples for other stakeholders from studies on the efficient use of water in the city. Municipalities should also contribute to the measurement of the studies carried out by providing their data on water usage to TÜİK. Especially in the last 20 years, the fact that the loss-leakage water rates have not been regularly entered into the system in Bilecik center is a very important deficiency in the field of water management.

As a result of the personal interview, it was seen that the instantaneous flow rate remained below the personal water consumption rate. In this case, it is thought that a water crisis will be experienced within the provincial borders in the coming years. Therefore, it is foreseen that GDSH, the governorship and local governments urgently make a B plan in order to prevent the water crisis. In addition, it is thought that it is necessary to establish a Water and Sewerage Directorate within the municipality and to open a Water Loss-Leakage Unit within the directorate.

Finally, studies on water efficiency in cities can also be applied technologically, where engineering and economic solutions dominate. Thus, the administrative management mechanisms of the city need to make an institutional change and invest in social capital. Although the suggestions recommended in the short term may seem difficult, it will be very valuable in the future for the institutions that have a say in the management of the city to invest in the field of water management.

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