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Anthropogenic Impacts on Groundwater Resources and Legal-Administrative Approach in Türkiye

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ABSTRACT

The main anthropogenic impacts on groundwater resources in Türkiye may be divided into four, overexploitation (excessive use), pollution, preventing recharge by covering it with impermeable materials, and destroying the aquifer by excavation. Excessive use of groundwater primarily causes a decrease in water level and quality deterioration. Industrialization, urbanization and agricultural activities are the biggest polluting threats. Most cities in Türkiye are located on valuable alluvial and limestone aquifers. Groundwater recharge is altered and reduced due to the covering with impermeable materials such as roofs, asphalt and concrete roads, parking lots, and pavements in urban areas. Sand-gravel and stone quarries are the other threats to groundwater resources.

There is comprehensive legislation on groundwater in Türkiye that started in 1960 and developed over time. However, significant problems still persist and are even growing. The gaps in the legislation against some anthropogenic impacts on groundwater and sometimes the failure to implement the legislation weaken the sustainable protection of groundwater resources. Groundwaters in Türkiye, which are already under the impact of drought and global climate change, should be evaluated as a strategic resource and protected for future generations. A new paradigm is needed to overcome the problems created by anthropogenic and natural impacts.

Keywords**:** Groundwater, overexploitation, pollution, urbanization, excavation, legislation

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1. Introduction

Alluvial and carbonate formations constitute the most productive aquifers in Türkiye. Carbonates (mostly limestones) cover approximately one-third of the country. In areas where limestones are extensive and thick, they contain considerable groundwater and discharge large springs. Alluvial deposits particularly located in fault-controlled plains and wide valleys are the other valuable groundwater resources for the country. Basalts and tuffs are also aquifers that have local importance (Apaydın, 2018). According to DSI data (DSI, 2020), the total usable groundwater reserve of the country is 18 km3, of which 15 km3 is used. Almost three-quarters of the use is used in the irrigation sector (DSI, 2020; Yılmaz, 2021). As in many regions of the world, groundwater, the main source of which is precipitation, is under the influence of spatial and temporal changes in climate and also in anthropogenic effects in Türkiye. In the country, the annual average precipitation does not exceed 500 mm except in coastal areas and high mountain belts, and it falls below 400 mm in a wide area in the interior regions. In arid and semiarid regions, precipitation generally occurs mostly in winter and

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spring, but water is needed most in summer and early autumn. In Türkiye, where serious droughts have been experienced in the recent past and historical periods (Apaydın and Ocakoğlu 2020; Altındaş, 2018; Karademir, 2014; Uyanık and Sarı 2011; Erler, 1997), droughts have become more frequent, longer and more severe due to climate change, thus affecting life more.

The issue of climate change, global warming and drought has been a frequently discussed issue in Türkiye since the early years of the 21st century. In addition to drought and climate change, anthropogenic impacts are also very effective on water resources. Agricultural activities, urbanization and industrialization, especially due to population growth, threaten groundwater resources in terms of quantity and quality. Overuse and pollution are the two most important problems. In addition, urbanization and the deterioration of the groundwater balance, the threat of sand pits, stone and marble quarries, and unlicensed and uncontrolled use complicate the situation even more. In fact, the fundamental problem is that the public and decision-making authorities accept that the impact on water resources and aquatic environments is solely due to global climate change or highlight this factor. This mentality is actually a result of avoiding responsibility by ignoring anthropogenic impacts.

In this study, the anthropogenic impacts on groundwater in Türkiye are analysed, and related legal and administrative approaches are examined. Firstly, anthropogenic impacts are classified and defined, and then their effects and results are analysed. It is supported with examples from anywhere in the country. In the advanced stage, legal legislation aimed at preventing impacts on groundwater resources and thus protecting groundwater is examined. How legislation is implemented at the institutional level and how the process is managed is also examined. The rationale, purpose and approach in practice of legal provisions are questioned and interpreted.

2. Anthropogenic Impacts on Groundwater Resources in Türkiye

The anthropogenic impacts on groundwater in Türkiye may be divided into four overexploitation (overabstraction), pollution, preventing recharge by covering it, and reducing or destroying the aquifer by excavation. Most people may be familiar with the first two because there are many scientific publications, media and press reports on this subject. The other two, which are less frequently discussed, are more dangerous (Fig. 1).

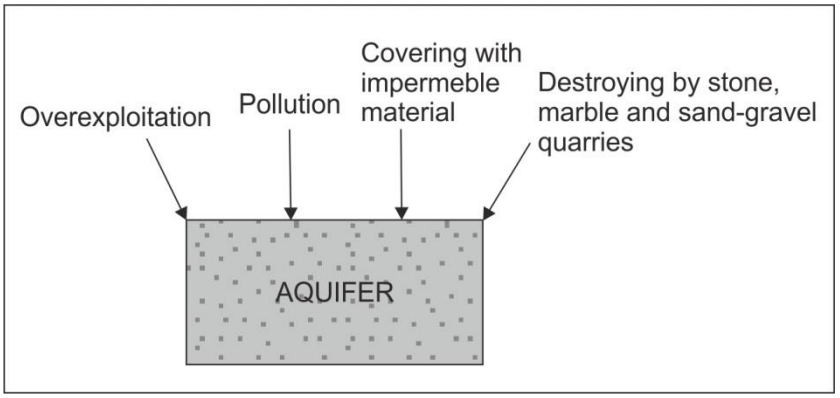

Fig. 1. Schematic presentation of the main anthropogenic impacts on groundwater resources in Türkiye (The damage increases to the right)

2.1. Groundwater Overexploitation

Excessive use of groundwater primarily causes a decrease in water level, sometimes quality deterioration, negative effects on the ecosystem related to the aquifer, and subsidence (sinkhole formation in carbonate aquifers) (Fig. 2). The situation becomes more complicated when several of these negative factors are present in a region. If there is also a withdrawal due to drought and climate change, the situation becomes even more complicated.

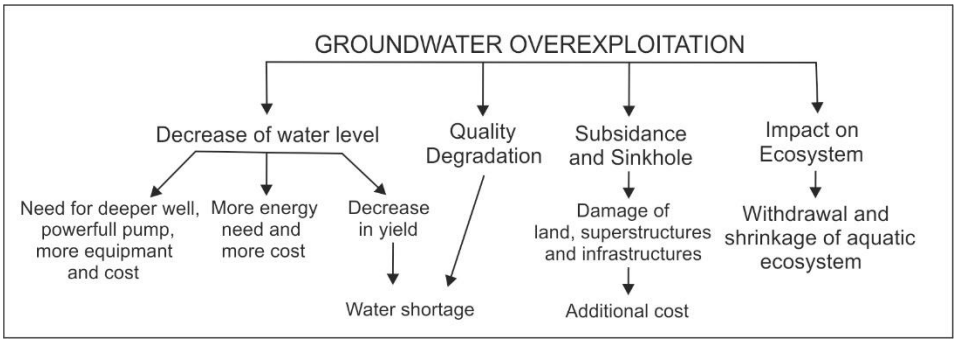

Fig. 2. Hierarchical expression of undesired consequences of excessive groundwater use in Türkiye

The most common negative effect of excessive extraction in Türkiye is the decrease in the groundwater level. This means that it is necessary to drill deeper wells and draw water from deeper depths compared to the past. In other words, it means an increase in construction and operating costs. Moreover, as the water level drops and the saturated thickness of the aquifer decreases, well yields also decrease. As the level and yield decrease, neighbouring wells affect each other more, which causes disagreements among water users.

In various regions of Türkiye, the groundwater level has fallen in a way that it cannot easily rise again due to excessive withdrawal, and the most famous site in this regard is the Konya Closed Basin (Fig. 3). This basin has semi-arid climate characteristics in the central region of Türkiye, and irrigated agriculture, especially sugar beet, is widespread. Irrigated agriculture is carried out on one-third of the 18.5 million decares agricultural area in the Konya Plain, known as the 'granary of Türkiye'. It supplies approximately 10 percent of Türkiye's total agricultural production (URL-1). Irrigation has mostly been done by withdrawal from wells since the 1960s. Excessive withdrawal and falling water levels have been on the country's agenda for at least 30 years. Many scientific papers, books and reports have been published on this subject. It also remains on the agenda with frequent news in the media and press (URL-1, URL-2, URL-3, URL-4). As of 2021, the number of licensed wells in the basin is around 20 thousand (Gedik, 2021). The number of unlicensed wells is at least four times this number. More than twice the annual recharge is used (SYGM 2018a). 60% of the groundwater used is illegal. Borehole depth varies between 70-250 m (SYGM 2018b). In some parts of the region, new sinkholes are formed due to the decrease in groundwater level (Ateş 2003; Yılmaz, 2010). The sinkholes formed in the last 5 years (Fig. 4) are narrower in diameter (45-50 m) and deeper (90-95 m) than the old ones. This is because groundwater has now fallen to very deep levels. In addition to local pollution, there is also pollution caused by agriculture and animal husbandry in the groundwater in the basin (SYGM 2018b). However, no evidence of quality deterioration due to the decrease in water level has been found. The groundwater level has decreased to 170-200 meters (URL-5). Some studies have been carried out in order to control the groundwater level and withdrawals in the region(Tunçok

and Bozkurt 2015; SYGM, 2018b, 2023; Yıldız, 2022). In addition, some water is discharged from the water channel taken from the Mavi Tunnel to the Gökhöyük (Timraş) Sinkhole, one of the large sinkholes in that region, by the State Hydraulic Works (DSİ) and transferred to the Hotamış storage for artificial recharge of the groundwater (Fig. 5).

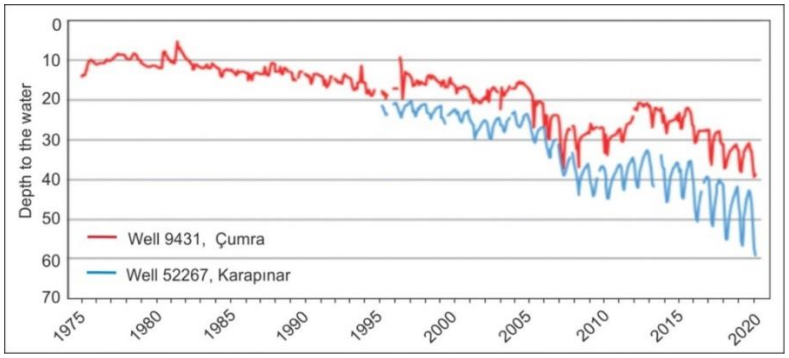

Fig. 3. Long-term permanent groundwater level change in some wells in Konya Closed Basin (URL-6)

Fig. 4. New sinkhole formations in Konya Karapınar region (URL-7, 8, 9)

Fig. 5. Artificial groundwater recharge with water flowing from the channel to the Gökhöyük (Timraş) sinkhole (URL-10, 11)

2.2. Pollution of Groundwaters

Pollution is one of the most important threats to water resources. Although groundwater is slightly more resistant to pollution than surface water, it is exposed to pollutants because it is associated with surface water. The biggest threat to groundwater pollution in Türkiye is industrialization and urbanization. The use of agricultural pesticides and fertilizers is also an important source of pollution (Fig. 6). The Ergene Basin in the northwest, and the Büyük Menderes and Küçük Menderes Basins in the west are the most well-known regions. Due to the industrialization that started in the 1970s in the Ergene basin, streams (Tokatlı, 2015, 2020) and groundwater associated with it have been polluted. Today, industrial facilities discharge their wastes, especially into Çorlu Creek, a tributary of Ergene, without treatment, and therefore the Ergene aquifer, which is in contact with the creek, has been polluted (Arkoç and Erdoğan 2006; Arkoç, 2012; Orta, 2010). Other examples of nitrate pollution from agricultural sources are Ankara (Ataseven, 2011), Antalya (Kaplan and others, 1996), Bursa (Yahşi 1981), Eskişehir (Kaçaroğlu and Günay 1997).

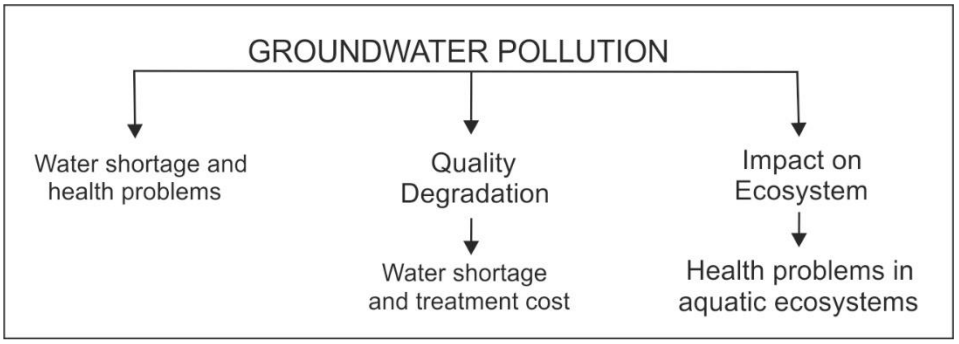

Fig. 6. Undesired consequences of groundwater pollution in Türkiye

2.3. Covering with Impermeable Materials in Urban Areas

Many studies (Craig and Anderson, 1979; Foster and others. 1997, 1998, Lerner, 2002; Morris and others 2003) indicate that urbanization affects the quantity and quality of groundwater (Fig. 7). These effects occur in the form of changes in the amount of recharge and circulation, changes in the withdrawal regime and groundwater level, and negative effects on groundwater quality (Foster and Chilton 1998). Recharge is altered due to the covering with impermeable materials such as roofs, asphalt and concrete roads, parking lots, and pavements. However, water collected from such areas, where groundwater recharge was previously widespread, is collected and drained in pipes or channels with narrower cross-sections (Lerner, 2002) and moves away from the region without infiltrating into the aquifers. As cities expand, impermeable areas also expand, but water infrastructure increasingly depends on surface water or groundwater brought from outside the urban area. In addition to the recharge from leakage from this expanding infrastructure, other sources of recharge are car washes and other cleaning activities, and recharge from irrigation in parks and sports areas (Morris and others, 2003). Thus, natural recharge in urban areas decreases; but new recharge mechanisms are created. As a result, urban development alters the natural hydrological cycle. These alterations disrupt the balance of surface water and groundwater interactions, leading to lowered water tables and diminished recharge rates (URL-12).

Most cities in Türkiye are located on or at the edge of alluvial plains. 52 out of 81 cities in Türkiye are partially or completely located on large and highly productive aquifers (Apaydın, 2018). The development and expansion of some cities located at the foothills of mountains is towards the alluvial plains where there is abundant groundwater. 55% of the country's population lives in large cities (provincial centres) that completely or partially cover aquifers. This ratio reaches 63% when we include large district centres such as Akhisar, Nazilli, Ceyhan and Tarsus. In addition, many smaller cities are located on highly productive aquifers. The potential for groundwater withdrawal in Türkiye has been estimated by the DSI as approximately 18 billion m3/year. Approximately three-quarters of this amount is in aquifers where cities are located or in close contact. In other words, 13.5 million m3 of groundwater is under the impact of urbanization. The aquifers most affected by urbanization in Türkiye are alluviums. Urbanization affects groundwater resources in terms of both quantity and quality. This situation is also the case in other parts of the world. For example, in a study conducted for some megacities in Asia (Haque and others, 2013), groundwater levels in Delhi (India) and Dhaka (Bangladesh) cities decreased due to excessive urban expansion, and groundwater was polluted in Delhi due to the pressure of dense population. In the coastal areas of Karachi and Mumbai, groundwater pollution has increased even more due to seawater intrusion and dense population.

There are few current studies in Türkiye on the impact of urbanization on groundwater resources. Apaydın (2018) examined the impact of urbanization on groundwater recharge in Türkiye, especially in terms of quantity, by addressing the issue of urbanization-groundwater recharge. Baba and Yazdani (2017) concluded in their study on the city of Izmir that the recharge rate from precipitation in the Izmir-Bornova region, which was 25% in 1925, decreased to 13% in 2012, and it was predicted that recharge would decrease to 1% in 2030 as a result of the continuation of the urbanization effect. Baba and Yazdani (2019) concluded that the groundwater dynamics were disrupted by urbanization in the Izmir-Bornova plain and that the construction of high-rise buildings with deep foundations prevented the natural discharge of groundwater towards the sea.

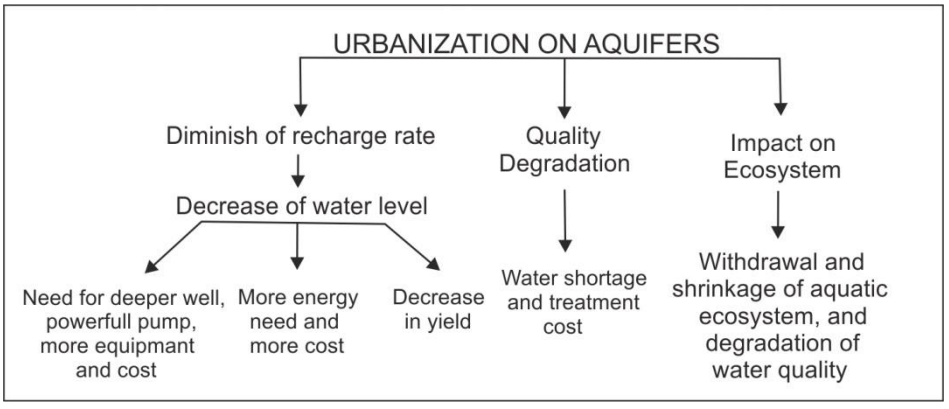

Fig. 7. Undesired results of covering aquifers with impermeable material in urban areas

2.4. Destroying the Aquifer by Excavation

The extraction of sand-gravel (Sonak and others 2006; Kondolf, 1994, 1997) and stone and marble (Marzouk, 2018; Sharma and others 2024) resources has a number of adverse environmental impacts. One of the most important environmental changes caused by sand–gravel pits occurs in groundwater

aquifers. Sand–gravel pits affect groundwater systems in terms of quality and quantity. The potential impacts of sand–gravel pits include lowering groundwater levels due to excavations and mine dewatering, changes in turbidity levels in groundwater due to operation, temperature change (thermal impacts) in groundwater due to cropping out to the surface and contamination (Kondolf 1994, 1997; Sonak and others, 2006; Marquez and others, 2007; Navarro and Carbonel 2007; Peckenham and others, 2009). The most significant environmental impact of sand–gravel pits includes the reduction and destruction of the aquifer volume.

In most regions of Türkiye, Quaternary sand–gravel aquifers are under the threat of sand–gravel pits, and also some aquifers have already been damaged or completely excavated in the last decade. Hundreds of pits continue to destroy productive aquifers. Kazan Plain near the capital Ankara is a striking example of both the effects of sand-gravel mining and overexploitation on fresh groundwater (Apaydin and others, 2021, Apaydin 2012).

Natural stone is an important material used for construction, sculpting and decorative purposes. Thanks to the various geological formations found in various parts of the world, natural stones such as granite, marble, travertine, onyx, basalt and quartzite can be obtained. Türkiye carries out 33% of the world's marble exports and 40% of the world's travertine exports. There are more than two thousand marble and travertine quarries in Türkiye and more than 10,000 facilities processing natural stone. The main countries to which natural stone is exported from Türkiye are China, Italy, the USA, Germany, Japan, Russia, Poland, Spain and the United Arab Emirates (STSO 2023). According to the data of the General Directorate of Mineral Research and Exploration (MTA), Türkiye's natural stone potential is approximately 5 billion cubic meters (Adıgüzel and Şengüler 2019). Almost 40% of the operating quarry licenses are in Burdur, Isparta, Antalya, Muğla, Denizli and Afyonkarahisar located in the Western Taurus and the vicinity. These licenses were mostly granted in carbonate aquifer areas containing abundant groundwater. These aquifers and the large springs are under threat from the quarries. Aquifers are being destroyed and reduced in size by excavation every passing day. As a result, the groundwater level is falling, the springs are withdrawn and pollution is inevitable (Fig. 8).

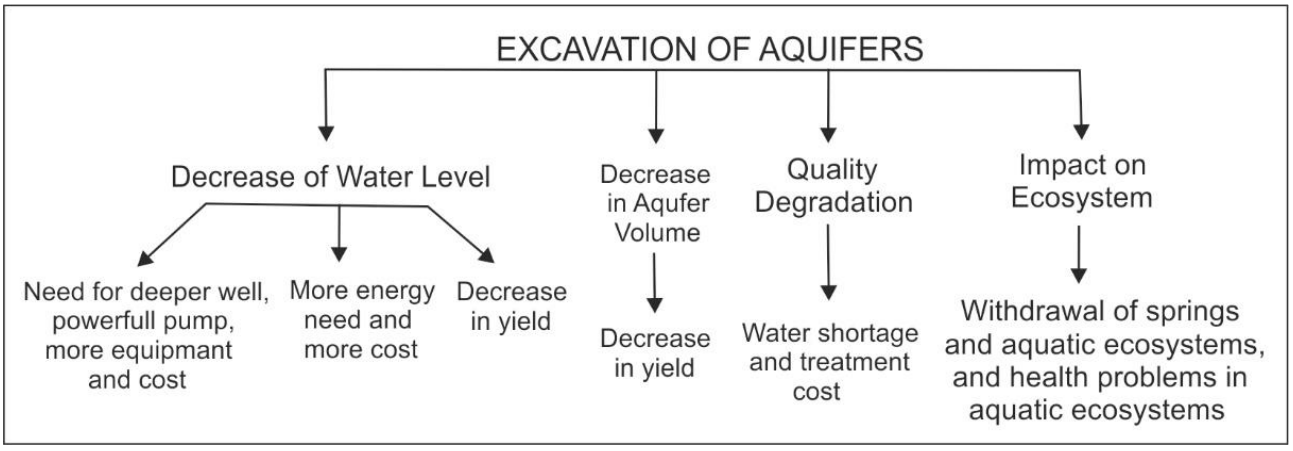

Fig. 8. Undesirable results of stone, marble and sand-gravel mining in Türkiye

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3. LEGAL AND ADMINISTRATIVE APPROACH TO THE IMPACTS

There is no direct provision regarding water in the 1982 Constitution of the Republic of Türkiye. However, there is a provision that can be indirectly related to water in Article 168. Article 168 states that natural resources are under the sovereignty and control of the state and that the right to explore and operate these resources belongs to the state.

In Türkiye, groundwater issues are handled by the State Hydraulic Works (DSI) in accordance with the provisions of the Groundwater Law No. 167. This law and related legislation cover the exploration, protection and licensing of groundwater. In accordance with this law, first the Groundwater Regulation (1960) and later the DSI Groundwater Technical Regulation (1972) were put into effect. Later, Solid Waste Control Regulation (1991), Regulation on Assessment of Environmental Impacts (1992), Medical Waste Control Regulation (1993), Toxic Chemical Substances and Products Control Regulation (1993), Hazardous Waste Control Regulation (1993), Water Pollution Control Regulation (2004) and Regulation on the Protection of Groundwater Against Pollution and Deterioration (2012), Communiqué on Determination of Protection Areas of Aquifers and Resources Supplying Drinking Water (2012), General Directorate of State Hydraulic Works Groundwater Measurement Systems Regulation (2013), Regulation on Monitoring of Surface Waters and Groundwater (2014) were put into effect. Within the scope of this legislation, the provisions and implementation approach on anthropogenic impacts on groundwater are explained below.

3.1. Overexploitation

There is no provision in the main text of the Law of Groundwater regarding the groundwater level or the decrease in yield. Article 12 states that "According to the observations and researches made for the purpose of operating the groundwater reserve within the safe limit without depleting it, the amount of safe water to be withdrawn from the wells may be decreased or increased as necessary. In this case, the license holders are notified by DSI and the necessary revisions are made to the license. At the same time, the previously determined beneficial need of the land or well owners is also adjusted in accordance with the change in the groundwater storage capacity." Thus, a precaution is considered against excessive decrease in the water level indirectly. Article 15 states that "The amount of water to be allocated for beneficial need can never be higher than the safe yield of the groundwater reserve".

The "General Directorate of State Hydraulic Works Groundwater Measurement Systems Regulation" prepared based on the "Law on Groundwater" aims to control the amount of water to be withdrawn from wells, drainages, galleries, etc. constructed to obtain groundwater by obtaining a usage license. The main purpose of the regulation is to measure the amount of groundwater used and to prevent the use of more water than permitted. It states the installation of automatic meters in wells for industrial purposes in Türkiye, and the installation of meters in all wells in the Ergene basin (NW Türkiye) and Konya Closed basin (Central Türkiye). The ultimate goal of this application is to prevent the water level in the aquifer from falling to undesirable levels and to protect the groundwater system.

There are no provisions in the legislation regarding the concepts of subsidence and sinkhole formation or any provisions related to them. However, the provisions regarding the prevention of

excessive use and excessive fall in groundwater levels serve to prevent this subsidence event indirectly to some extent.

The Groundwater Law generally aims to protect the amount of groundwater and the rights of the people and to define the authority of the State. The provisions regarding the prevention of excessive use and excessive fall in groundwater levels are not sufficient to protect the ecosystem in which the groundwater is located or interacts.

The concept of "safe yield" in the legislation should be replaced by the concept of "sustainable yield" and "sustainable management". Safe yield refers to protecting the groundwater bodies, while sustainable yield and management refers to protecting both the groundwater and all water environments associated with it by affecting them the least. This issue is generally mentioned in the Regulation on the Protection of Wetlands. The Regulation states that "It is essential not to pollute wetlands and to protect their natural structures and ecological characters. The protection of the functions and values of wetlands will be ensured in all land and water use planning."

3.2. Groundwater Pollution and Quality Degradation

There are no direct preventive provisions in the Groundwater Law regarding quality degradation due to excessive drops in water levels or other reasons. While the protective provisions of the Groundwater Law are generally aimed at protecting the quantity, there is a provision regarding saltwater intrusion. The Groundwater Technical Regulation draws attention to the issue by stating that "If it is deemed necessary to open a well in coastal areas; the well location should be selected far enough from the coast to prevent seawater from mixing with the well water, taking into account the geological condition of the formation".

Provisions to prevent groundwater pollution were implemented for a while in the Water Pollution Control Regulation that came into force in 2004, and as of 2012, prohibitions and permits for direct and/or indirect discharges into groundwater bodies have been implemented within the framework of the Regulation on the Protection of Groundwater Against Pollution and Deterioration. Accordingly, pollution monitoring studies to be carried out in groundwater for all kinds of regular storage activities are carried out in reference and observation wells within the framework of Table 23 in the annex of this regulation. For this purpose, it has been stipulated that an observation network consisting of wells will be established (in fact, DSI has had a quality observation network since the 1960s). This law states that "In case any pollution is detected in groundwater as a result of activities; the Ministry shall take action in accordance with the Environmental Law and relevant legislation. Those causing pollution are obliged to eliminate the pollution they have created and to bring the quality of the groundwater to the quality determined before the activity begins in the reference monitoring well and to cover all expenses in this regard."

With the entry into force of the 'Regulation on the Protection of Groundwater Against Pollution and Degradation' in 2012, in order to harmonize the implementation of the European Union Water Framework Directive with Turkish legislation, we have encountered some concepts. These are new concepts such as groundwater mass, quality and quantity monitoring assessments of masses, pressure-impact-risk, threshold value, trend analysis, measures program, and groundwater protection area. These concepts have started to take place in the works of DSI and the General Directorate of Water Management. The purpose of the regulation is to reveal the current status of

groundwater, protect it, prevent its pollution and deterioration, and cover the principles of taking the necessary measures for the improvement of waters.

One of the most radical principles of this regulation is the one expressed in Article 5. This article states that “Direct discharge of wastewater into groundwater is prohibited regardless of its quality.” This provision was transferred from the Water Pollution Control Regulation. Direct discharge into groundwater is prohibited even if the water is purified. The indirect discharge of purified wastewater into groundwater bodies is permitted by the Ministry of Environment and Urbanization as a result of engineering studies to be carried out by taking into account the intended use of the groundwater, its quality, and the tolerance capacity of the groundwater in case the purified water to be given mixes with the groundwater, in accordance with the provisions of the Regulation on Permits and Licenses to be obtained by the Environmental Law that entered into force in 2009. However, what is meant by direct and indirect discharge is not explained.

The regulation also includes the determination of ecosystems that have hydraulic connections with groundwater. This is a new issue that has not been included in the legislation before. Another important innovation is the introduction of the concept of protection areas, especially for drinking water facilities and resources. Thereupon, the Communiqué on the Determination of Protection Areas of Aquifers and Resources Supplying Drinking Water was published by DSI in the same year (2012). The natural and anthropogenic impacts on the groundwater bodies defined in the regulation were determined, and the effects on the bodies were started to be monitored in quality and quantity. Quality monitoring is carried out in two ways observational and operational. The parameters of the groundwater body are first monitored in a surveillance manner, and after the surveillance monitoring is completed, operational monitoring is carried out for the parameters exceeding the threshold value.

The regulation also addresses important issues related to level changes, pollution and overdrafts. Accordingly; the analysis of the impacts on groundwater resulting from human activities and the effects resulting from these impacts is prepared by SYGM by obtaining all necessary information, documents and inventory from relevant institutions. The evaluation of the effects of changes in groundwater levels is carried out or commissioned by DSI and reported to SYGM once a year. The evaluation of the pollution effects on groundwater quality is carried out or commissioned by SYGM and DSI and according to this evaluation, the groundwater masses at risk are determined by the working groups to be established by SYGM and DSI. In groundwater uses, it is essential to maintain the balance of recharge and withdrawal and not to use more water than the allocated amount.

Another innovation brought by the regulation is that it brings a standard and a framework to the subject of monitoring. In this regard; in order to review the effects of human activities on groundwater, DSI determines the number and location of groundwater observation wells that will represent each aquifer and groundwater levels are monitored with sufficient frequency. A standard has been introduced stating that "Monitoring of the quantity and chemical status of groundwater bodies is carried out by DSI after the characterization of the groundwater bodies."

In addition, “harmful substances that can be carried by wastewater or rainwater and mixed into groundwater cannot be directly stored on the ground within the groundwater feeding basin. In order to take precautions to prevent groundwater pollution, storage tanks for all kinds of chemicals, process and treatment sludges, special wastes and similar substances are made leak-proof. When it is necessary to use radioactive tracers, substances that will not cause water pollution are selected and if

irrigation is carried out with wastewater, the irrigation water quality, quantity and irrigation program are arranged in a way that minimizes the risk of these waters leaking into groundwater and causing permanent pollution" provisions have been put into effect.

The purpose of the Regulation on Monitoring of Surface Waters and Groundwater, which was put into effect in 2014, is to determine the quantity, quality and hydromorphological status of all surface waters and groundwaters in Türkiye, to determine the ways and methods for monitoring waters and ensuring coordination of institutions and organizations. The regulation also states that a groundwater monitoring network will be established by DSI after receiving the opinions of the relevant institutions and organizations. The monitoring network has been operating for 10 years.

3.3. Urbanization on the Aquifers

There is no provision in Groundwater Law No. 167, the Groundwater Regulation and the DSI Groundwater Technical Regulation regarding the zoning application in aquifer areas, and their protection by keeping them away from construction and industrialization. Until 2012, DSI experts who were asked for their opinions on groundwater in areas where zoning applications will be made were giving their opinions based on the general protection provisions of the legislation at that time. The provision that 'It is necessary to obtain a positive opinion from DSI for zoning application in groundwater recharge areas' was included in the measures program section of the 'Regulation on the Protection of Groundwater Against Pollution and Deterioration' that entered into force in 2012. This statement means that if DSI's opinion is negative, zoning will not be permitted.

According to the "Circular on Streambeds and Floods" published by the Prime Ministry in 2010, there is a provision stating that "the measures and recommendations of DSI shall be meticulously followed during the preparation of zoning plans for large and medium-scale planned settlements such as provinces, districts and towns, and all kinds of small-scale settlements made according to local plans." However, this provision is only intended to prevent construction in areas with flood risk. It can be used for aquifers entering the flood area, but it is not intended to directly protect aquifer areas.

3.4. Excavation of Aquifer Formations

There is no provision on this subject in the Groundwater Law, the Groundwater Regulation and the DSI Groundwater Technical Regulation. In the Measures Program section of the Regulation on the Protection of Groundwater Against Pollution and Deterioration, it is stated that "It is prohibited to obtain material from any formation with aquifer character that contains groundwater reserves. However, DSI may permit the collection of material from groundwater recharge basins on condition that the groundwater bodies are not damaged." This provision was previously included in the Water Pollution Control Regulation.

There are some restrictions and prohibitions in the Regulation on the Collection, Operation and Control of Sand, Gravel and Similar Materials. In summary, there is a provision that states, "It is not permitted to open and operate sand and gravel quarries in the continental surface water resources that provide drinking and utility water and in the flowing and dry streams that feed them, and in any formations with aquifer characteristics that contain groundwater reserves." The Circular on Stream Beds and Floods includes the provision that "Sand, gravel and stabilized material quarries operating activities within stream beds or in areas adjacent to stream beds shall be carried out in accordance

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with the opinions of DSI. In cases of irregular practices, the permits of the quarries shall be cancelled by the administrations that issue the licenses." Similar provisions of these two legislations aim to protect aquifers against sand and gravel mining, but there is no provision in the legislation regarding marble and stone quarries.

4. Conclusion

In Türkiye, the main anthropogenic impacts on groundwater resources are overuse, pollution, urbanization, reduction of recharge and destruction by excavation. In addition to these, there are other impacts such as reducing recharge by building reservoirs on rivers and water use from streams. Reduction in stream flow rates, either through direct use from streams or storage in reservoirs, reduces recharge to the aquifer, but four main impacts are the most effective and destructive. Even if the abstraction is completely stopped in an aquifer whose water level has extremely decreased due to excessive water withdrawal, it takes a very long time for the aquifer to be completely renewed. This period can take decades, centuries or even millennia depending on factors such as the type, type, thickness and distribution area of the aquifer, and its hydraulic conductivity. Natural cleaning of polluted aquifers requires an even longer period or it is not possible to return to its original fresh state at all. In aquifers that are covered with impermeable material by urbanization or damaged by excavation due to mining, it is too late to return.

The administrators of the big cities, especially in the arid and semi-arid regions of Türkiye, obtain their water from large dams, but when there is not enough water in the reservoirs during long-term droughts; groundwater resources in the city and its vicinity are needed. For this reason, the protection of water resources in terms of both quantity and quality should not be ignored when making city development plans. Unfortunately, while cities, which are becoming increasingly industrialized and whose populations are increasing, are trying to find more costly drinking water resources from far away in order to meet their water needs, it is a great contradiction that the development plans of the cities are directed towards areas with groundwater.

The gaps in the legislation against anthropogenic impacts on groundwater and sometimes the failure to implement the legislation weaken the sustainable protection of groundwater resources. Groundwater in Türkiye, which is already under the impact of drought and global climate change, should be evaluated as a strategic resource and must be protected for future generations by preserving its original state and even improving it if possible, as stated in the European Union Water Framework Directive.

As stated in the introduction section, the perception of the public and decision-making authorities that the impact on groundwater resources is largely due to global climate change is an obstacle to the solution of the problems. First of all, a new paradigm is needed that focuses on anthropogenic impacts that humans can prevent or control. However, this may not be enough, because for success it must be supported by the determined and sustainable implementation. Some restrictive decisions may be temporarily painful, but it should be comprehended that they will benefit humanity in the long term.

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Journey of the Nile River Basin Toward a Permanent Institution

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Abstract

The success and shortcomings of transboundary watercourse cooperation are strongly allied with the existence and effectiveness of institutional arrangements. The case of the Nile River basin is no exception from this reality. In addition to the Permanent Joint Technical Commission established by Egypt and Sudan for themselves, the basin has had *ad-hoc* organizational structures, such as HydroMet, *Undugu*, and the Technical Cooperation Committee of the Nile River Basin. Although these *ad-hoc* structures were compelled to cease operations due to limited composition and the hydro-hegemonic influence of the two utmost down riparian states coupled with other contributing factors, they laid fertile groundwork and institutional experiences for the establishment of the Nile Basin Initiative. This establishment has been operating since 1999 and intends to serve as a transitional organization until a basin-wide legal and institutional framework is in place. Fortunately, the Nile River Basin Cooperative Framework Agreement entered into force on 13 October 2024, following the accession of South Sudan, the sixth riparian state, and its deposit with the African Union. Consequently, this basin-wide legal framework will bring an end to the Nile Basin Initiative structure; instead, the Nile River Basin Commission will soon become the permanent institution of the basin.

Keywords: Nile River, Nile Basin Initiative, Nile River Basin Commission, Permanent Institution, Cooperative Framework Agreement

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1. Introduction

The Nile River is geographically located in East-Northen Africa and is comparatively considered the longest-flowing one on Earth (Arsano, 2011; Lie, 2010). This river comprises two main tributaries: the White Nile and the Blue Nile, which supply about 15% and 85% of the flow, respectively (Dellapenna, 1997). The White Nile originates from the mountain of Uganda and then flows through Burundi, the Democratic Republic of Congo (DRC), Kenya, Rwanda, Tanzania and South Sudan (Mohammed, 2017). In contrast, the Blue Nile originates from the mountain of Ethiopia then flows across Sudan and merges with the White Nile in Khartoum (Hamza, 2006; Mohammed, 2017; Werner, 2018). The

two jointly flow to Egypt and finally discharge into the Mediterranean Sea (Mohammed, 2017; National Geographic, n.d.).

Although the river is blessed with magnificent natural water resources, it has been the subject of contestation. The two extreme downstream riparian states, Egypt and Sudan, contribute almost nothing but apportion the entire river flow among themselves. The remaining upstream riparian states contribute nearly the whole bulk of the Nile River flow but get no portion of it. These arrangements are deeply intertwined with the legacy of the colonial era, which mainly descends from the 1902 Anglo-Ethiopia, 1929 Anglo-Egypt and 1959 Egypt-Sudan Agreements.

The Agreement on the Frontiers (1902) were aimed to strictly restrain Ethiopia from "*arresting*" the Blue Nile flow, while the (1929) Exchange of Notes and the (1959) Agreement for the Full Utilization quantified the total Nile River flow just among the two downstream states, Egypt and Sudan (Waterbury, 1997). Although these are the only available treaty regimes dealing with watercourse quantification, they have been rejected by the upstream riparian states, asserting they serve only the best interests of the two downstream states at their expense (Bulto, 2008; Mekonnen, 2010; VCLT, 1969, Arts. 34–35). Hoping to establish common grounds and use the Nile River equitably and reasonably, upstream and downstream states have had dialogues in the post-colonial era.

These dialogues have not only resulted in numerous bilateral and trilateral treaties signed between/among some riparian states but also paved the way for some institutional arrangements in the Nile River basin. Of all, the Nile River Basin Cooperative Framework Agreement (CFA), crafted in the presence and proactive engagement of all riparian states, has been open for signature since 2010 (Mekonnen, 2010; NBI, n.d.). After getting minimum ratifications, it entered into force on the 13th of October 2024 (Mohammed, 2024; NBI, n.d.; Salman, 2024). This marks the establishment of the first-ever permanent institution, the Nile River Basin Commission (CFA, 2010, Art. 15). Against these backgrounds, this article first highlights the journey of *ad-hoc* institutional arrangements exhibited in the Nile River basin and then, addresses the permanent organizational structure that will be established in the Nile River basin.

2. *Ad-hoc* Institutional Structure in the Nile River Basin

In transboundary watercourses, there needs to be cooperation among riparian states. A robust institutional structure along with proper management fosters cooperation across a river basin, which proves to be resilient (Berlin Rules, 2004, Arts. 32 (e), 34 (f), 35 (d); UN Watercourses Convention, 1997, Art. 33 (2)). This seems to be the case even in a region, like the Nile River basin, where other geo-political hostilities remain intact (Vollmer et al., 2009). Having these institutional models, this section evaluates the *ad-hoc* institutional arrangements of the Nile River basin.

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2.1 Permanent Joint Technical Commission

Among decisive colonial agreements that shaped the hydro-politics of the Nile River basin, the 1929 Exchange of Notes between the United Kingdom and Egypt is on the first row. These notes allocated the bulk of the river for the two utmost downstream riparian states, i.e., 48 - 4 Billion Cubic Meters (BCM) to Egypt and Sudan, respectively (Exchange of Notes, 1929; Mohammed, 2023; Waterbury, 1997). Considering this allocation as baseline discourse and acquired rights, the two riparian states came up with the 1959 Agreement and concurred to repartition the total river flow as 55.5 BCM for Egypt, 18.5 BCM for Sudan, and 10 BCM to evaporate into the atmosphere (Agreement for the Full Utilization, 1959, Arts. 1-2 (4); Bulto, 2008; Mohammed & Acer, 2024).

The 1959 treaty between Egypt and Sudan also established the first-ever institution, "Permanent Joint Technical Commission" (PJTC), in the Nile River basin (Hodges, 1979). This PJTC, which contains equal members and gets a budget from both states, is established to effectively implement the foregoing agreement and technically ensure cooperation between the two riparian states. It, in particular, is empowered to conduct research and a hydrological survey as well as design, execute and supervise hydraulic projects on the river course (Agreement for the Full Utilization, 1959, Art. 4 (1) (a-d)). The PJTC is also tasked with studying and negotiating a proposal for a "unified view" against any hydraulic project/s and claim/s made by upstream riparian state/s (Agreement for the Full Utilization, 1959, Art. 5).

However, this PJTC is just an arrangement for the two utmost down riparian states and does not encompass the remaining majority of basin riparian states; thus, it can not be considered a basin-wide structure serving all basin riparian states. Moreover, Egypt and Sudan have not adhered to the "unified stand" approach against upstream riparian states; instead, they have separately pursued negotiating with upstream states, notably Ethiopia (Dellapenna, 1997). Whence Sudan brokered the 1991 "Accord on Peace and Friendship" while Egypt also signed the 1993 "Framework for General Cooperation" with Ethiopia and, accordingly, agreed to use the Nile River equitably and reasonably but not to cause significant harm to each other (Dellapenna, 1997; Lencho, 2014; Mtua, 2017). The two downstream states seem to have returned to the PJTC arrangement and recently issued a joint statement via the commission on their stand on the coming into force of the CFA and expressed their objection to the basin-wide legal framework (Daily News Egypt, 2024).

2.2 HydroMet, *Undugu* and TECCO-Nile

Aside from the above commission, there were attempts to establish a basin-wide structure in the Nile River basin with the help of international international financial institutions. The Hydrological Metrology, otherwise commonly known as "HydroMet," was set to be the first initiative that came into existence in coordination with the United Nations Development Program (UNDP) in 1967 and was in place for about 25 years (Johnston, 2009). As the name itself indicates, this initiative was established to study the hydrological climatology of the White Nile, thus intended to collect available

data and analyze them to monitor the water level at Lake Victoria and take precautionary measure/s in case of flooding (Johnston, 2009; Mtua, 2017).

Although the HydroMet initiative attempted to include all riparian states in its structure, its scope was practically limited to the White Nile basin thus it contained other riparian state/s, notably Ethiopia and the DRC (formerly Zaire) as observers (Johnston, 2009). Moreover, there are also critiques against the initiative, arraigning it for not turning planned projects into action and not playing a positive role in exploring common grounds on diverging interests of down and upper riparian states (Arsano, 2007; Mtua, 2017).

With the HydroMet structure on one side, another initiative known as "*Undugu*," meaning brotherhood in the African Swahili language, was established in 1983 (Paisley & Henshaw, 2013). This initiative was launched for the wider Nile River basin and structured mainly to serve not only as an information hub but also as a forum for overall experience exchange on non/watercourse areas (Johnston, 2009). However, the initiative is said to have failed due to member defects (having Ethiopia, Kenya and Tanzania as observers) and trust issues raised against Egypt's hydro-hegemonic role (Brunnee & Toope, 2002; Johnston, 2009; Paisley & Henshaw, 2013).

When the HydroMet initiative phased out, the basin was in need of a new institutional structure. With financial incentives from the Canadian International Development Agency (CIDA), the five riparian states of the Nile River basin – DRC, Egypt, Rwanda, Sudan, Tanzania and Uganda – formed a new initiative named after the "Technical Cooperation Committee" for the Promotion of Development and Environmental Protection of the Nile River basin (TECCO-Nile) in 1992 (Johnston, 2009; Mtua, 2017).

The TECCO-Nile initiative was established to further basin-wide cooperation and advance riparian states' commitment toward equitable & reasonable use of the Nile River basin. In this vein, the initiative strived to create a moderate connection in the basin via infrastructural projects, foster technical cooperation among riparian states through training, and craft a grand "Nile Basin Action Plan" along with its national master plan for implementation, in particular (Mtua, 2017). Despite its ambitious plan, the initiative failed to achieve its objective because of financial constraints, its composition of having four riparian states (Burundi, Eritrea, Ethiopia and Kenya) as observers and hydro-hegemonic domination of downstream riparian states (Johnston, 2009; Paisley & Henshaw, 2013).

2.3 Nile Basin Initiatives

The "Nile Basin Action Plan," designed by the TECCO-Nile initiative, had set a fertile ground for another significant structure (Mtua, 2017). This structure is called the Nile Basin Initiative (NBI), established in 1999. Unlike its predecessors, this initiative is inclusive and has had multiple donors, thus comprised of all riparian states (Except Eritrea as an observer), and received financial assistance from the United Nations Development Programme (UNDP), the World Bank and the CIDA (Johnston, 2009).

Having the "Shared Vision" and "Subsidiary Action" programs at the center, the initiative has created two sub-structures: the Nile Equatorial Lakes (NEL-SAP) and the Eastern Nile (EN-SAP) Regions, each composed of riparian states from the White Nile and the Blue Nile basin (NBI, n.d.). Although these sub-structures are criticized for viewing the Nile River as two river systems from the Integrated Water Resource Management perspective, it has been structured as such in order to establish a proper project management system in the provided regions (Johnston, 2009).

Unlike previous initiatives, the NBI is a well-organized institution with its Nile-SEC, a secretariat office established at Entebbe, Uganda (NBI, n.d.). Furthermore, its Nile-COM structure serves as the upper decision-making body comprising the Ministers of Water from member states, while its Nile-TAC serves as a technical advisory committee, constituting one expert from each riparian state, to assist the Nile-COM with technical issues (Mtua, 2017; NBI, n.d.).

The NBI establishment was not meant to be the permanent institution of the Nile River basin. Instead, it was structured as a temporary initiative awaiting a basin-wide legal framework along its permanent institutional structure (Abdalla, 2008). Serving as a transitional institution to foster basin-wide cooperation, the NBI platform played a proactive and alternative role during decade-long negotiations on the basin-wide draft CFA.

When the draft CFA was finalized, it was made open for ratification and accession in 2010 (NBI, n.d.). While Ethiopia, Rwanda, Tanzania, Uganda and Burundi have ratified the framework, a newly independent state, South Sudan, has recently acceded to it (Muzaki, 2023; NBI, n.d.; Salman, 2024; Sudans Post, 2024). Attaining the minimum six riparian states' threshold of ratification and accession as required by Article 43, the CFA entered into force on 13 October 2024, following South Sudan's deposition of the sixth legal instrument of accession with the African Union (Mohammed, 2024; NBI, n.d.; Salman, 2024). This triggered the transitional process of transforming the NBI into a permanent Commission of the Basin as prescribed under Article 31 of the CFA.

3. Permanent Institutional Establishment in the Nile River Basin

The Nile River basin has lacked a basin-wide legal framework. Not anymore. The CFA's entry into force has changed this fact once and for all (Mohammed, 2024; Salman, 2024). Although it may face geopolitical and hydro-political challenges in due course of time, it offers many advantages to the basin (Okello, 2024; Tekuya, 2024). Most importantly, the framework enables the establishment of the Nile River Basin Commission (Commission), a permanent institutional organization for the basin (CFA, 2010, Arts. 2 (2) & 15). The Commission will soon take over the NBI and is expected to advance the Nile cooperation to the next level (CFA, 2010, Art. 31).

The Commission is an intergovernmental body empowered with full institutional authority to carry out its assigned responsibilities (CFA, 2010, Art. 19). Its purpose and objective are to enhance and foster "the implementation of the principles, rights and obligations" prescribed under the framework (CFA, 2010, Art. 16 (a)). Having customary international law principles like equitable-reasonable

utilization and obligation not to cause significant harm as its cornerstones, the commission is authorized to oversee principles such as water/ecosystem protection and conservation, regular exchange of data and information, notification on planned measures, and protection of the watercourse during armed conflict per international humanitarian laws, among others (CFA, 2010, Arts. 3, 4–14).

In the above context, the Commission, after articulating all pertinent factors provided under Article 4 (2) along with the realities on the ground, will make sure all riparian states effectively use the Nile River equitably and reasonably per the provided rules and procedures (CFA, 2010, Art. 4 (6)). While doing so, the Commission will put in place prevention plus mitigation strategies and strive to regulate riparian state/s so as not to cause significant harm to other/ecosystems (CFA, 2010, Arts. 5 & 11). The commission will also serve as a forum where riparian states harmonize their national water policies per the basin-wide framework and exchange information on any hydraulic planned measures along its environmental impact assessment among themselves per its rules and procedural obligations (CFA, 2010, Arts. 8, 6 (2), 7 (3)).

The commission is a forum where riparian states settle their dispute amicably. As such, in case disputes arise between/among riparian states, the framework provides a procedure that needs to be observed (CFA, 2010, Art. 34). The basin states shall negotiate first to settle their differences. If their negotiation fails to bring the desired result, they may resolve their dispute/s through mediation, reconciliation, arbitration or the International Court of Justice (ICJ) within six months (CFA, 2010, Art. 34 (1) (a)). If they cannot settle as such in a given period, the Commission needs to establish a Fact-Finding Commission thus the dispute ought to be brought to this Commission when any of the concerned disputing party requests to do so (CFA, 2010, Art. 34 (a) (b)).

In connection with the aforesaid procedures, the Commission is already entrusted to resolve disputed issues related to the "water security" provided under Article 14 (b) of the CFA. Although the legalese problemata originates from Article 3 (15) of the framework stipulating the principle of "water security" given its inexistence in lex lata of international watercourse law, the diverging stand on the originally drafted statement vis-à-vis the proposed reservation sparked a huge debate among upstream and downstream riparian states (Mekonnen, 2010; Mohammed, 2017).

Standing on Article 14 (b) which read "*The Nile Basin States agree, in a spirit of cooperation, not to significantly affect the water security of any other Nile Basin States*," the two utmost downstream states proposed to replace the phrase "*not to significantly affect the water security of any other Nile Basin States*" by "*not to adversely affect the water security and current uses and rights of any other Nile Basin State*" (CFA, 2010, Art. 14b: Attachment). Asserting that this reservation proposal is meant to impose colonial treaties that serve only the best interest of downstream riparian states, the upper riparian states have rejected it (Woldetsadik, 2017).

Once the commission commences its work, it shall establish an independent Fact-Finding Commission, having one representative from each riparian state and a neutral Chairman to be

nominated by the already selected representative (CFA, 2010, Annex 1). Accordingly, the Commission shall resolve the dispute at hand within six months upon the recommendation provided by the Fact-Finding body (CFA, 2010, Art. 14b: Attachment).

Like the NBI, the basin-wide Commission will have its headquarters in Entebbe, Uganda, but with more comprehensive institutional structures (CFA, 2010, Art. 18). It will have five levels of organizational structures: the Conference, Council, Technical Advisory Committee, Sectoral Advisory Committees, and the Secretariat. The Conference is a structure constituting a member of heads of State and Government of the basin tasked with the highest policy-making authority of the commission, having adopted its rules and regulations (CFA, 2010, Arts. 20–21).

The Council will comprise the Minsters of Water of the basin states, have the second decision-making authority next to the Conference and be entitled to oversee the overall management of the Commission (CFA, 2010, Arts. 22, 23, 24 (14)). While meeting once a year, the Council will take effective measures to implement the CFA fully plus authorized to provide interpretations and recommendations on the framework upon request (CFA, 2010, Art. 24 (1, 2, 13)). Moreover, it is empowered not only to review and approve administrative regulations, plans, and budgets for the Technical Advisory Committee, Sectoral Advisory Committees and the Secretariate (CFA, 2010, Art. 24 (8, 15)). The council is a vital structure responsible for effectively implementing equitable and reasonable use of the Nile River thus will determine equitable share for each riparian state, taking into account all relevant factors provided under Article 4 (2) of the framework (CFA, 2010, Art. 24 (12)). When conditions require, it will also decide to initiate joint project/s in the Nile River basin (CFA, 2010, Art. 24 (16)).

The Technical Advisory Committee (TAC) is an arrangement formed by two senior officials from each riparian state of the basin (CFA, 2010, Art. 25 (1)). Gathering twice a year for meetings, TAC serves as an engine for the Council thus it proposes, guides and provides recommendations on the overall implementation of the Commission and the CFA so that the Council can execute its functions properly and achieve its authority efficiently (CFA, 2010, Art. 25 (3), 26).

The Sectoral Advisory Committee (SAC) is a conditional structure, constituting one expert from each riparian state, established by the Council to address specific issue/s related to the Commission (CFA, 2010, Art. 27 (1-2)). The SAC will deal with issue/s in question as required by the Council per the provided rules and regulations within a given period of time (CFA, 2010, Art. 27 (3), 28).

The Commission will have the Secretariat, based in Entebbe, led by an Executive Secretary and other senior officials appointed by the Council (CFA, 2010, Arts. 24 (9), 29 (1 & 5)). The Secretariat officially represents the Commission thus will serve as a secretariat for all official gatherings of the establishment, provide service/s to all structures of the Commission, and bridge international plus inter-organizational structures to have a smooth working environment with the Commission (CFA, 2010, Arts. 30 (1, 2, 3, 7, 8 & 10)). Furthermore, it needs to submit annual plans, budgets and studies as well as physical and financial reports to the TAC (CFA, 2010, Art. 30 (4, 5, 6 & 10)).

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Apart from the above structure, the Commission will have decentralized systems and, consequently, will establish subsidiary institutions, such as sub-basin organizational structure/s and national focal point/s from each riparian state of the basin (CFA, 2010, Arts. 32–33). This arrangement will promote effective communication and cooperation between the Commission and riparian states of the basin.

4. Conclusion

Effective management of a transboundary watercourse requires a proper institutional structure, as such an arrangement can usually withstand even when non-watercourse-related geopolitical issues persist in a basin ("Water Organizations," n.d.; Vollmer et al., 2009, p. 11). In this vein, the article has contemplated the journey of the Nile River basin toward permanent organizational structures. Although this river is the lengthiest flowing one covering a huge catchment area along eleven riparian states, colonial treaties like the (1902) Anglo-Ethiopia Agreement on the Frontiers, the (1929) Anglo-Egypt's Exchange of Notes and the (1959) Egypt-Sudan Agreement for the Full Utilization have brought paramount benefits to the two utmost downstream states while disproportionately disregarding the interests of the upstream states. These, in turn, have negatively impacted the management of the Nile River basin and the journey of its institutional initiatives, in particular.

Save the PJTC structure established just for the two downstream riparian states per the (1959) Agreement for the Full Utilization, the basin has had HydroMet, Undugu, TECCO-Nile and NBI organizational structures. The first three initiatives had become defunct and ineffective due to their scope and representation in having major riparian states, notably Burundi, DRC, Ethiopia, Kenya, and Tanzania as observers, the hydro-hegemonic influence of downstream riparian states, and insufficient funds, among others. Taking advantage of the TECCO-Nile positive "Action Plan," the NBI, in contrast, was established constituting almost all riparian states (Except Eritrea, an observer) and has more funds receiving financial incentives from the UNDP, World Bank and the CIDA. With its Nile-COM, Nile-TAC and Nile-SEC organizational structure, it has strived to achieve its "Shared Vision" and "Subsidiary Action" through the NEL-SAP and EN-SAP sub-regional structures.

However, the NBI is structured as an *ad-hoc* institution serving as a transitional structure pending the coming into force of the basin-wide legal framework, the CFA, and the permanent institution, the Commission. The CFA entered into force on 13 October 2024, after South Sudan, the sixth riparian state, acceded to the legal framework and deposited it with the African Union. With its modest and comprehensive organizational structures (like the Conference composed of state leaders and the Council comprised of Ministers of Water along with its TAC, SAC and Secretariat structures), the Commission, therefore, will soon take over the NBI and start the journey of Nile River basin toward the permanent institutional initiative.

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Enhancing Water Productivity and Unit Efficiency in Dry Regions of Palestine

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Abstract

Payments for irrigation water (PIW) have gained popularity as an effective approach for protecting and restoring active ecosystems and watershed services. However, the emergence and persistence of these innovative financing tools and governance systems remain poorly understood. Water resources in Palestine are limited and scarce. As a result, there is a growing discussion about "adaptation" in development planning. This is seen to reduce risks associated with resource scarcity, environmental change, and the effects of climate change. The available resources are becoming increasingly limited and require careful management. The purpose of this study is to develop policies and methods for addressing water crises in dry areas. This will involve identifying the technical, social, economic, and political challenges associated with water scarcity and sustainable water management. To accomplish this, we will rely on secondary data and literature reviews from international sources such as ICARDA, as well as national experiments like NARC. We will also collect secondary data from previous studies and analyze the results to gain a better understanding of our strengths and weaknesses. By taking this approach, we hope to develop effective solutions to managing water resources in dry areas. A comprehensive study was conducted to examine the current state of water scarcity in dry areas, with a particular focus on Palestine (WBG), under different water conditions. The findings indicate an urgent requirement for more information and data on the characteristics of various water management methods to assess the water status and devise national water strategies for the inhabitants of (WBG). The study also delved into elucidating policies and adaptation techniques for agriculture in dry areas, grappling with a shortfall of water resources.

Keywords: Palestine, Dry Areas, Water, ICARDA**,** NARC, Environmental**.**

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Introduction

In the realm of food security and agricultural water management, robust policies are indispensable for the growth and prosperity of nations, especially in dry areas where water scarcity is already a pressing issue (Lu et al., 2015; Magidi et al., 2021). Unfortunately, there are millions of people around

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the world who are unable to sustain their livelihoods due to a lack of adequate water supply. This dire situation has seriously hampered their chances of escaping poverty. Therefore, it is imperative that we address this critical water shortage with utmost urgency to uplift the lives of these individuals and foster economic development (He and Lorenzo., 2023; Musie et al., 2023; Mahmoud et al., 2024). The intricate correlation between poverty and water is a convoluted matter, yet the significance of water as a valuable resource necessitates responsible management to ensure its long-term sustainability for forthcoming generations, as per Pimentel et al. (2004). The indispensability of water for life cannot be emphasized enough, and an adequate supply of water for agriculture and domestic purposes is an indispensable prerequisite for human and economic development. It has been widely recognized that human behavior can have a profound impact on water and the global ecosystem, thereby making it imperative to regulate human behavior to stabilize and sustain our future. In the Palestinian Territories, water is the most precious natural resource, and its relative scarcity poses a formidable obstacle to economic development.

The equitable distribution and management of water resources among Palestinian households and landowners is a pivotal matter that demands careful consideration in the ongoing multilateral peace negotiations regarding water rights (Oweis, 2010). The water resources in Palestine are not only limited but also scarce. The Israeli government's stringent regulations on Palestinian water utilization and their persistent denial of access to groundwater aquifers, including the Jordan River, have led to a significant reduction in the quantum of water available. The dearth of permits for constructing water reservoirs and structures to capture runoff water has further exacerbated the problem of utilizing rainwater, particularly in recent times. Presently, Palestine's fresh water supply emanates from just four primary water aquifers (MOA, 2019).

The aqueous content from these subsurface reservoirs is conveyed to the surface via wells or natural springs. Given the acute dearth of water in agriculture, the Palestinian populace has fashioned techniques to circumvent this predicament. These techniques encompass a variety of water management systems and informal methodologies, including the implementation of active policy measures pertaining to rainwater harvesting, as posited by Gemma et al. in their 2011 study. In the realm of development planning, the discourse around "Adaptation" has gained significant momentum to mitigate the hazards presented by resource scarcity, environmental degradation, and most notably, climate change. It is becoming increasingly clear that limited resources exacerbate these challenges, thus necessitating the adoption of adaptive measures. Our study follows the first study and aims to search types of integration about water management policies in dry areas, by Explaining some policies, and methods of adaptation for agriculture in the dry environment for facing water scarcity, highlighting Maximizing management for water quantities available: where first study interested in water supply management, and our objectives now managing of water demands available by offering a lot of methods and tools can help the interested decision-makers after Putting the qualitative results in front of them, planners', and farmers to evaluate their acceptance for adoption the suggestion methods and regulations, By optimizing the utilization of available water resources through the implementation of appropriate agricultural investments and diversification of species, we can enhance the efficiency and yield of farm investments.

This can be accomplished by ensuring that investments are aligned with the amount of water supplied, taking into consideration the appropriateness of different plant and animal species. (ICARDA, 2010). The study will explain the water status in the world, obstacles, and the Scientist's

vision to manage developing water scarcity in dry areas and will explain Some innovations for the management of Pasture and desert development. In addition to explaining the useful methods to producing according to what you need and what you have from water, where importing several experimental stations results related to the International Center for Agriculture in Dry Land (ICARDA), focusing on producing multiple crops efficiently within one cubic meter to meet our needs and strategies for weight, calories, protein, and price.

After conducting an extensive study, it can be concluded that further research is needed to fully understand how water management policies can aid in developing the agricultural sector under conditions of scarcity. This requires a multidisciplinary approach that considers both social and technical aspects of the problem. The goal is to present these findings to policymakers and donors in a manner that ensures the continuous and sustainable use of resources. The issue at hand is complex and will require a great deal of expertise and qualified studies to address.

Palestine in this Study

This research project was carried out in the Palestinian Authority (PA), formerly known as the West Bank and Gaza (WBG), as part of the Oslo Agreement in 1994. Historically, the region of Palestine covered an area of approximately 27,000 km^2, extending from the Mediterranean Sea to the Jordan River. However, a significant portion of this land was occupied by Israeli Zionists in 1948, while Palestine was still under British mandate. The remaining area, including the West Bank (including East Jerusalem) and the Gaza Strip, was occupied during the 1976 war between Israel and Egypt. Currently, the West Bank is estimated to cover an area of 5572 km^2, while the Gaza Strip is approximately 367 km^2. According to the latest population projections from the Palestinian Central Bureau of Statistics (PCBS) in 2022, the WBG is home to around 4.17 million people, with 3.25 million residing in the West Bank and 2.3 million in the Gaza Strip.

Palestinian Water Resources

Israeli consumers enjoy an abundance of water while their Palestinian counterparts face a dire shortage of basic resources. Incontrovertibly, Israelis have access to about four times more water than Palestinians. Israel has exclusive access to the Jordan River water, while Palestine is left with nothing. The distribution of the coastal aquifer is heavily skewed, with Israel enjoying 82% of the access and Palestine a mere 18%. The mountain aquifer is no different, with Israel holding 83% of the access and Palestine only 17%. And to add insult to injury, Israel monopolizes all other sources of water, leaving Palestinians with no access at all. It's worth noting that Palestinians only consume an average of 56 liters per day, which is a mere 55% of the WHO recommended minimum of 100 liters per day (Mizyed, 2013). The annual precipitation in Palestine amounts to approximately ten thousand million cubic meters, however, a mere 20% of this volume proves beneficial by percolating into the ground, while the remaining 80% is lost due to evaporation (60-70%) or swiftly flows towards the sea (PCBS., 2019). The estimated average annual groundwater recharge within Palestine's borders ranges between 698 to 708 million cubic meters per year. Of this, about 648 million cubic meters per year are recharged in the West Bank and 50-60 million cubic meters per year in the Gaza Strip. It is worth noting that the Jordan River serves as the only source of surface water in the West Bank (Haddad, 2011).

Objectives

The primary objective of this study is to devise policies and methods to combat the water crisis prevalent in dry areas. Through this study, we aim to identify the technical, social, economic, and political challenges that impede the sustainability of water management practices. Our goal is to devise innovative solutions that can effectively tackle these challenges and ensure the efficient and sustainable management of water resources in these regions. Our study follows the first study and aims to search types of integration about water management policies in dry areas, by Explaining some policies, and methods of adaptation for agriculture in the dry environment facing water scarcity, highlighting Maximizing management for water quantities available: where the first study interested in water supply management, and our objectives now managing of water demands available by offering a lot of methods and tools can help the interested decision-makers after Putting the qualitative results in front of them, planners', and farmers to evaluate their acceptance for adoption the suggestion methods and regulations, By increasing water efficiency through suitable agricultural investments and diverse species, and maximizing productivity based on investment suitability (plants, animals) to available water quantities.

To create water management policies, it is necessary to analyze the current state and conditions of water resources in WBG and propose strategic plans for active development. The present investigation entailed a comparative analysis of the plans that generated regulations and standards vis-a-vis the international and regional experiments. The findings were subsequently presented to the stakeholders for their assessment of the adaptability of the novel methods and innovations and their conformity with the extant norms and regulations. This study serves as a springboard for more focused research endeavors, encompassing a variety of techniques concomitant with water development and management policies, as well as in-depth inquiries aimed at augmenting the advantages of farmers and the agricultural sector. Furthermore, the study incorporated a comprehensive scrutiny of various extant studies.

Material and Methods

The principal modus operandi employed is predicated on the systematic analysis of secondary data, coupled with the comprehensive review of international (ICARDA) and national (NARC) experimental literature. The secondary data, gleaned from prior studies and various sources, are scrutinized meticulously to discern our strengths and weaknesses. This technique also serves to illuminate the trailblazers in the relevant domain, their methodologies, and innovative approaches to water management policies in dry areas. This methodology offers a potent instrument to unravel the intricacies and elucidate the salient aspects of the subject matter. In the interest of advancing water management practices and policies in arid regions, we have undertaken a thorough review of literature from both international and domestic sources, in addition to closely scrutinizing localized data from relevant institutions. By utilizing the SWOT technique to identify and evaluate our strengths, weaknesses, opportunities, and threats, we have gained vital insights into the optimal methods and innovations to foster the widespread adoption of these practices among farmers, institutions, and policymakers.

The territorial confines of historic Palestine are delineated by the frontiers of the West Bank and Gaza, while Israel has encroached upon the surrounding areas, as delineated in Figure 1. Regrettably, all

subterranean aquifers and surface water resources, especially those situated in the north and along the Jordan River, remain under the dominion of Israel. This seemingly invidious situation is attributable to the inequitable water pacts between Palestine and Israel, such as the Oslo Agreement, which has resulted in our forfeiture of the right to regulate water resources.

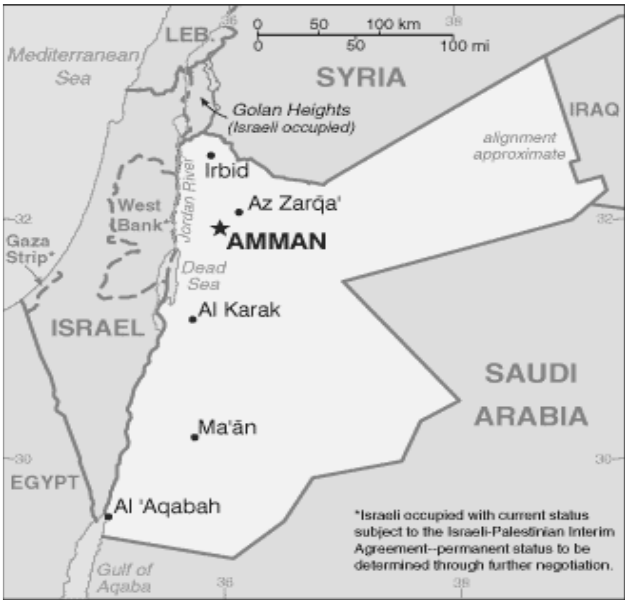

Fig 1. Palestine general location map.

Results and Discussion

Why Water is Limited

All resources, irrespective of their renewable or non-renewable nature, are limited to a greater or lesser extent. Non-renewable resources such as fuels and minerals are confined to the amount present on our planet, while water is considered a renewable resource. Water resources denote the sources of water that are useful or potentially useful for diverse activities, including agriculture, industry, household, recreation, and environmental activities (PCBS, 2019). Freshwater, which is a renewable resource dependent on annual precipitation, is crucial for most human uses. However, the world's groundwater supply is continuously declining, with the MENA region witnessing the most prominent depletion. The natural renewal rate of freshwater is uncertain, and it is unclear whether ecosystems are threatened by its usage. The framework for distributing water resources to water users, where applicable, is known as water rights (Mizyed, 2013). Dry areas across the globe are witnessing a continuous decline in water resources for agricultural purposes. It is estimated that irrigation accounts for a staggering 70% of the world's water usage, with 15-35% of irrigation withdrawals being deemed unsustainable. It is noteworthy that producing enough food to meet the daily dietary needs of a single individual demands a substantial amount of water, ranging from 2,000 to 3,000 liters, which is significantly higher compared to the mere 2-5 liters needed for drinking purposes (Haddad, 2010).

To cater to the ever-increasing population of over 7 billion people on the planet today, the production of food requires a colossal amount of water - enough to fill a canal that is 10 meters deep, 100 meters wide, and stretches a staggering 2100 kilometers in length. Many countries in the world are living with

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chronic water scarcity in different percentages according to position and geological situation (Mizyed, 2013). Where the surface water is mostly tapped because of low precipitation in the driest areas, also ground is over-exploited, Climate change conditions rising last year adds to the problems that are causing high evaporation and leading to marginal quality, small amounts, not environment-friendly, and not healthy water (Abu-Zreig, 2000).

In dry areas, accessing renewable water resources can be a daunting task. Erratic rainfall patterns that vary in both space and time add to the uncertainty and risks associated with agricultural production (Oweis, 2010). The transitory fluctuations in the climate are anticipated to be exacerbated by the enduring climatic changes. The climate models indicate that the regions of West Asia and North Africa (WANA) will encounter intensified heat and aridity, along with modifications in the temporal and spatial patterns of precipitation, as well as a surge in the incidence and magnitude of severe weather phenomena such as droughts and floods. Nations situated in dry areas with primarily agrarian economies and a high reliance on agriculture will be the most susceptible to the adverse impacts of fluctuations in seasonal climatic patterns and alterations in contentious hydrological cycles. The paucity of freshwater resources in dry areas is a daunting challenge with numerous countries already falling below the "water poverty" benchmark of 500 m^3/capita/year.

Currently, a whopping 75% of the scarce water resources are earmarked for agricultural use. However, the burgeoning population and the escalating competition from the burgeoning industrial and domestic spheres are exacerbating the downward trend in the allocation of these resources (ICARDA, 2013). In many dry areas, governments are incessantly endeavoring to pioneer novel methodologies and approaches to mitigate the water scarcity crisis. Among these techniques is desalination, which is often deemed a costly and intricate solution. Another alternative is to import water from foreign countries, yet this can be impeded by exorbitant expenses and political impediments. The average annual water availability across various regions worldwide is elucidated in Figure 2.

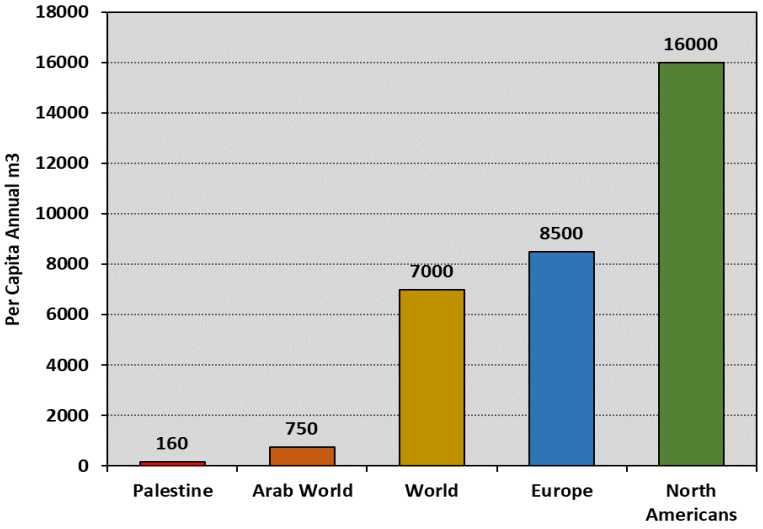


Fig 2. Average water annual among different regions/ per capita and Palestine.

The previous Figure 2 focuses on the average water/ per capita annual m^3 available, whereas we can note Palestine has very limited water quantities comparing other world on average, and compared

with North America which represents the highest, which leads us to think about real solutions may leading and rising our share of water.

The graphical representation in Figure 3, elucidates the gradual reduction in the proportion of water accessible for agricultural purposes, which is attributed to the depletion of water resources and the deleterious effects of climate change. The foremost cause of this phenomenon is the conspicuous decrease in precipitation across dry areas. This, in turn, has a direct bearing on the portion of water resources allocated to the agricultural sector, which undergoes a diminishing trend as time elapses. As such, policymakers must devise efficacious strategies to counter this unfavorable trend.

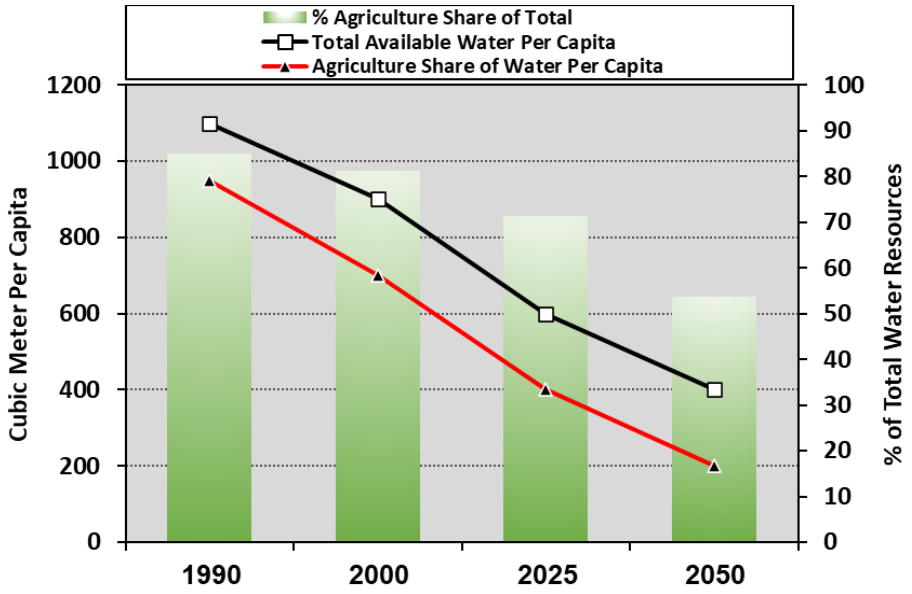


Fig 3. shows the percentage of water for agriculture in dry areas is declining.

Management with Less Water by Increasing Efficiency/Productivity

Globally, agriculture is the largest consumer of water resources, accounting for most of the water withdrawal in the MENA region, which is a staggering 85%. However, the utilization of water resources in agriculture remains highly inefficient, with only a minuscule portion of the water diverted for plant growth being effectively utilized. The remaining water is lost through drainage or evapotranspiration, as highlighted in a report published by ICARDA in 2011. As humanity multiplies and prosperity proliferates, the necessity for sustenance and consequently agricultural water for irrigation is burgeoning. Alas, the amount of water endowed with adequate quality is dwindling. Additionally, there is an escalating demand to shift a greater proportion of the water utilized in agriculture to higher-value urban and industrial uses. Hence, the only recourse is to augment productivity with reduced usage.

Research has extensively examined water efficiency in agriculture for countless years. However, it is arduous to discover universally applicable solutions, particularly due to the assorted contexts and highly specified agricultural practices. Nevertheless, efficiency gains are frequently possible by selecting suitable crops, scheduling irrigation meticulously, implementing potent irrigation techniques, and utilizing alternative water sources for irrigation. It should be observed that enhancing water efficiency frequently yields benefits that extend well beyond diminished water consumption (Oweis, 2008).

Traditional Strategies

The traditional approaches to production Still control in most irrigated farming in Palestine where most farmers believe the production increases as water quantities increase, increasing production because of increasing water quantities considers the traditional thinking against productivity and may be useful when we have excess water, where water considering one of the main factors will affecting on productivity. Figure 4 shows the traditional effect on wheat productivity at one cubic meter of water is presented, one ton/hectare and 8 ton/hectare were produced from wheat seedlings whose height was 200 mm and 600 mm, respectively.

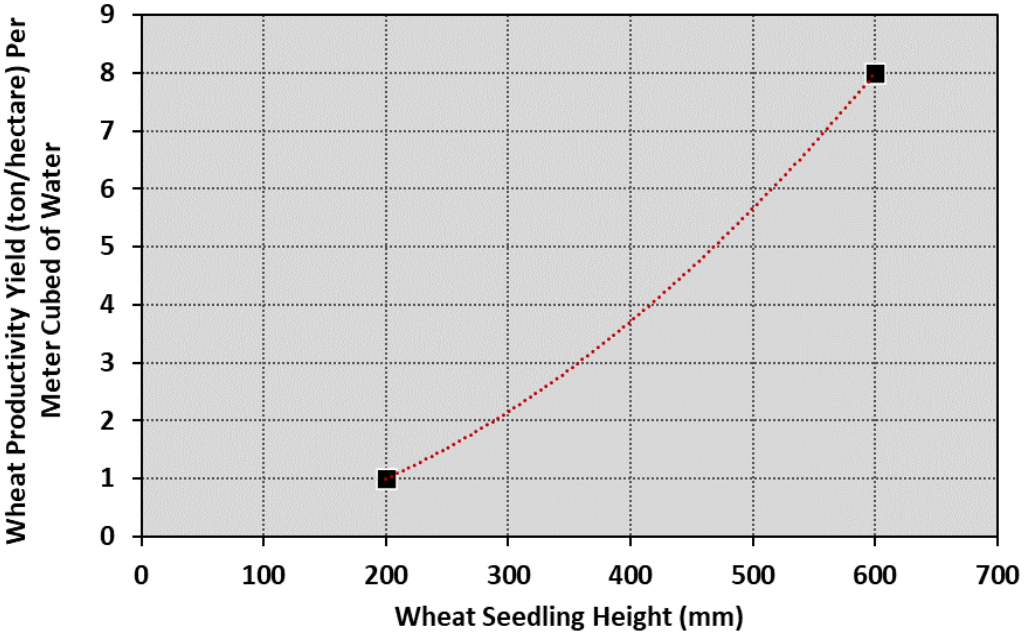


Fig 4. The traditional affecting about percentage of water in wheat productivity.

Integrated Management of Water and Land

Farmers toiling on the dry earth are plagued by water scarcity. At present, an array of factors, such as population expansion, land decay, and climate change-induced shifts, are compounding the woes of dry regions across the globe. These trends are heightening the uncertainty that rural, impoverished farmers face as they rely heavily on dwindling natural resources, which are rapidly degrading in the face of a changing climate. This time as a result of limited resources, Sustainable increases in future food supplies must come from increased productivity of both rainfed and irrigated crops, in addition to producing more crops per drop (ICARDA, 2010).

The present study endeavors to establish a nexus between research and policy in the domain of water and land management, with the overarching objective of enlarging the partnership base to encompass civil society and local research institutes. The study postulates that the focal point of research should be on appraising the quantity and quality of available water resources for agriculture, encompassing rainwater, surface water, groundwater, and marginal-quality water in dry areas. It is further recommended to evaluate the water and land productivity in agriculture at variegated levels, viz. plant, field, farm, domestic, and basin levels. Additionally, the study underscores the importance of

assessing the active and efficient potential of using water-use efficient practices, and their concomitant effects on crop productivity, while simultaneously preserving the environment sustainably. Furthermore, the study accentuates the significance of considering the availability and potential use of marginal-quality water in agriculture in dry areas, and the environmental ramifications of its usage. Finally, the study advocates the development of multi-scale tools and methods to assess land uses and degradation, encompassing location, extent, causes, impacts, and consequences. To implement these recommendations, water benchmarks can be established in agriculture fields in Palestine through initiatives, such as the Water and Livelihood Initiative project, and the Irrigation Active Management for Improved Crops (ICARDA, 2011).

Increasing Efficiency of Water Usage

The primary objective of sustainable agriculture is to elevate agricultural production whilst efficaciously utilizing water resources and mitigating environmental degradation. To this end, a recent study enumerates a plethora of measures that farmers can undertake to augment their water efficiency and optimize farming operations across varying systems. These measures encompass bolstering irrigation system performance, ameliorating recoverable losses, enhancing irrigation system efficiencies, optimizing farm or crop use efficiencies, and scheduling agricultural irrigation based on evapotranspiration rates, soil moisture deficits, climate conditions, and exacting crop water requirements per diem. By judiciously accounting for these multifarious factors, farmers can quantify the economic impact of their irrigation practices to optimize their farming operations. Maximizing the use of water resources requires providing crops with the exact amount of water they need. Water use efficiency is the ability to achieve the desired outcome with minimal effort, time, expenses, and waste (Haddad, 2010).

This is measured by the ratio of input energy to actual work output. Despite progress in water use efficiency, there is still ample room for improvement, particularly in increasing crop yield per unit of water and mitigating the risk of diffuse pollution from over-irrigation. Enhancing the agricultural irrigation system can help accomplish these objectives. Using a drip irrigation system is a smart way to increase irrigation efficiency compared to traditional methods like gravity systems, which flood entire fields and use shallow channels or ditches to deliver water to crops. If farmers choose to use pumping systems for irrigation, it's important to make sure that the pump and pipe size match their needs to prevent water and energy wastage, and subsequent leaks caused by over-irrigation. Evaluating infield irrigation performance involves assessing the irrigation matchmaking, a critical component of the process, as Pimentel et al. highlighted in their 2004 study.

There are several techniques that farmers can use to improve the efficiency of crop irrigation. These techniques can increase the yield per unit of water applied and reduce water loss due to various factors. Improvements can be made through smart design and management of water delivery and application schemes. Furthermore, decision support systems integrated with sensor networks can monitor soil and plant water status, helping farmers efficiently allocate limited water resources. These improvements can have a significant impact on the water use efficiency of crop irrigation. Irrigation efficiency is a way of measuring how efficiently water is used in irrigation within defined boundaries. Water use efficiency can be measured in various ways, some of which are traditional and widely used, while others aim to encompass the whole system and the temporal factors of efficiency. However, unlike productivity, which is measured in units, efficiency is expressed as a percentage. It is a measure

of the net to gross water use or net days of irrigation for crops to gross days of irrigation used. (Basin Water Management, 2010)

Using Water Productivity to Facing Water Scarcity

A third of the world is currently facing water shortages due to the poor management of water resources and excessive water usage, particularly in agriculture. The International Water Management has reported that water scarcity is increasing faster than originally anticipated. Agriculture alone accounts for 80% of global water usage. Poor water management is causing billions of people worldwide to face water shortages. If water productivity is not improved, the consequences will be even greater water scarcity, according to Oweis (2010).

This section focuses on enhancing water productivity through water management interventions in the production of different crops such as lentils, potatoes, wheat, olives, dates, and beef. The evaluation is based on the amount of water used (1 m3) in production within experimental stations, regardless of the source of water, whether it is rain or irrigation. The ranking of water is based on Freed's assessment in 2009. Productivity is a measure of the economic or biophysical gain obtained from using a unit of irrigation water in crop production. It is expressed in productive units, such as kilograms per cubic meter or dollars per cubic meter and can also be used for livestock watering. This measurement represents the product obtained from the irrigated crop that the diverted water was intended for.

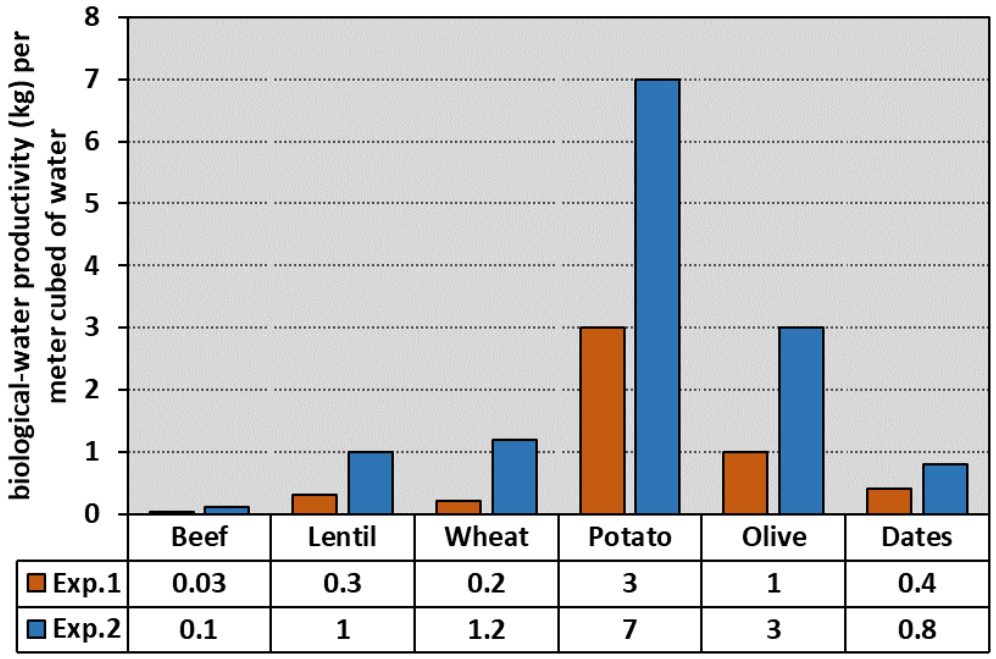
Measurement of Crop Yield per Unit Volume of Water Used in Agricultural Selection

Productivity is the correlation between the yield of a unit and the investment of a unit. Within this context, the term "water productivity" is exclusively employed to allude to the quantum or worth of agricultural produce over the extent or value of water exhausted or redirected for crop or alternative agricultural usage. The worth of the product might be communicated in diverse terms, such as biomass, grains, or currency. For example, the so-called "crop per drop" approach concentrates on the quantum of yield per unit of water utilized in agriculture. Another approach contemplated in this study is the differentiation in nutritional values for heterogeneous crops or the fact that the same quantum of one crop nourishes more individuals than the same amount of another crop with the same value of use. When engaging in discourse about food security, it is imperative to consider specific criteria (Renault and Wallender, 2000).

Additionally, a significant aspect to consider is how to articulate the social benefits and effects of agricultural water productivity on livelihoods. There are various options posited for this purpose, including 'nutrient per drop', 'capita per drop', 'jobs per drop', and 'sustainable livelihoods per drop'. There isn't a singular definition of productivity, and the value assigned to the numerator ratio may depend on the focus and the availability of accurate information derived from field data. However, water productivity expressed as kilogram per drop is a lucid and efficient concept when comparing the productivity of water in diverse areas of the same system. Furthermore, it is a useful metric when assessing the productivity of water in agriculture with different cultivated crops (ICARDA, 2011).

Figure 5 below explains the calculated relationship between different crops (lentil, potato, wheat, olive, dates, and beef) and the consumption of one m3 of water in experimental conditions carried out at the ICARDA station. Upon scrutinizing the outcomes depicted in Figure 5, it was discerned that when farmers employ one m3 of water in the production of various crops, the weight

productivity is pronouncedly greater in the cultivation of potatoes, followed by olives, and lastly, there is a low yield of weight from beef production. Ergo, if the production strategy is designed to enhance the weight productivity from each unit of water consumed, farmers should make a concerted effort to invest in potato and olive farming. By doing so, they can escalate the productivity of their produce and attain high production efficiency, considering all other pertinent factors.



	Beef	Lentil	Wheat	Potato	Olive	Dates
Exp.1	0.03	0.3	0.2	3	1	0.4
Exp.2	0.1	1	1.2	7	3	0.8

Fig 5. Biological-water productivity (kg) from one m^3 used.

Revenue-Water Productivity ($) from One m^3 Used in Selection Crops

Upon scrutinizing the findings illustrated in Figure 6, it was discerned that the utilization of one cubic meter of water to produce diverse crops can engender varying revenues. The cultivation of olive crops was found to yield the highest return, followed by date crops. Conversely, beef production resulted in a comparatively lower return on investment, albeit still superior to that of weight production, owing to the exorbitant price of meat. Ergo, if the objective is to augment revenue for each cubic meter of water consumed, farmers ought to contemplate undertaking the cultivation of olives and dates, contingent upon the suitability of other variables, such as temperature and labor. This can culminate in heightened productivity and efficiency in agricultural production.

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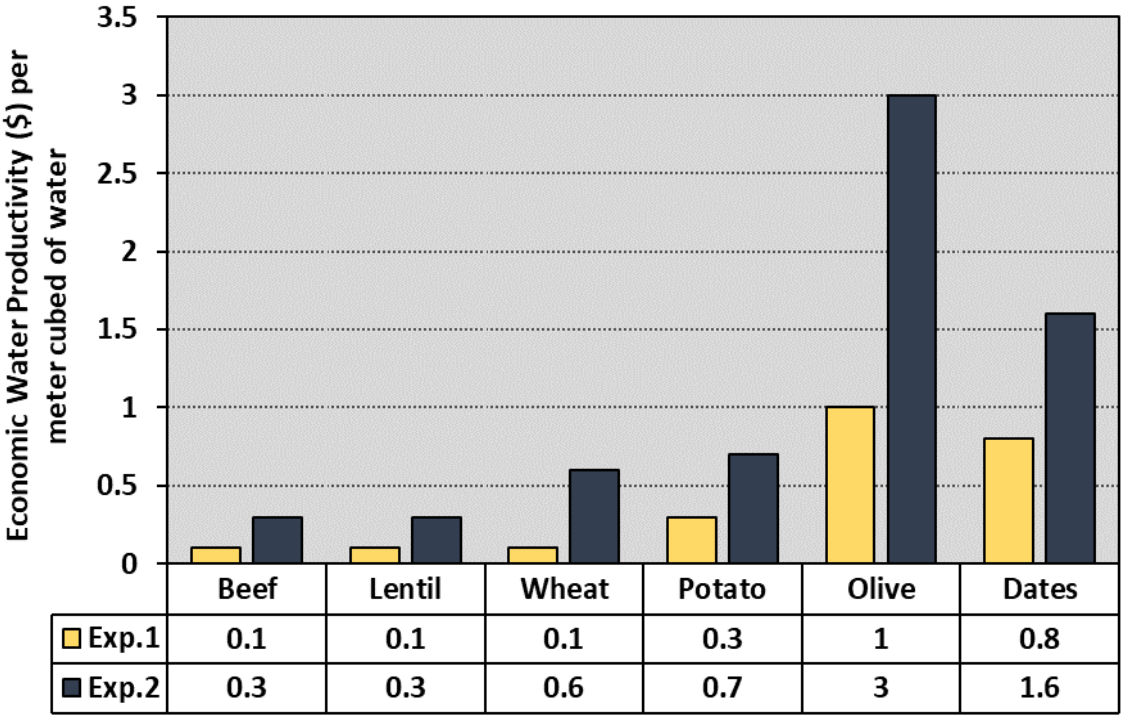
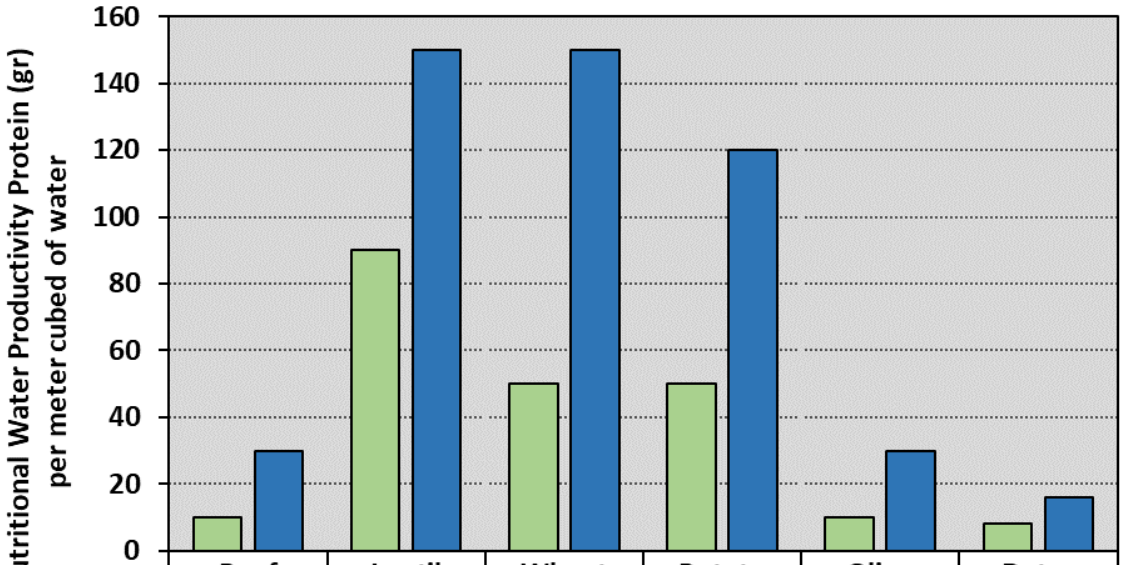


	Beef	Lentil	Wheat	Potato	Olive	Dates
Exp.1	0.1	0.1	0.1	0.3	1	0.8
Exp.2	0.3	0.3	0.6	0.7	3	1.6

Fig 6. The revenue-water productivity in US dollars ($), per unit of water used (1 m^3).



	Beef	Lentil	Wheat	Potato	Olive	Dates
Exp.1	10	90	50	50	10	8
Exp.2	30	150	150	120	30	16

Fig 7. The nutrition-water productivity (protein) obtained from using one cubic meter of water.

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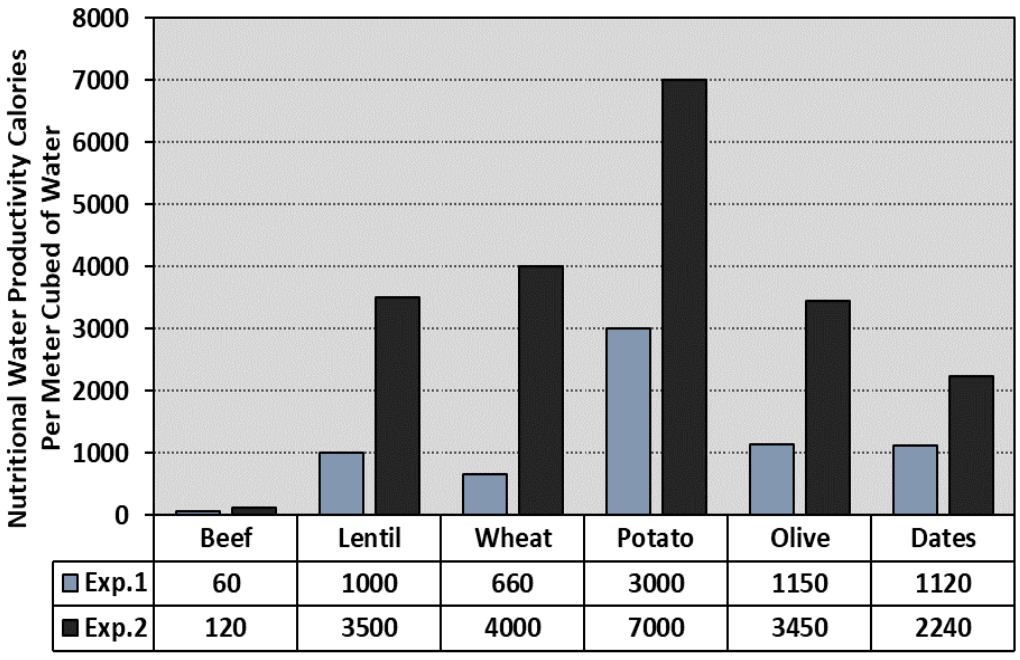
Nutrition-water productivity from calories, (calories) for one m^3 used in selection crops

Nutrition- Water Productivity from Protein, (gm) For One m^3 Used in Selection Crops

By analyzing the results shown in Figure 7 noticed that, when we use one m^3 of water in the production of different crops, founded that the highest nutrition revenue from protein by using one m^3 of water will be higher in wheat than lentil crops production, and low return revenue from protein from olive, dates, and beef production, where the wheat and lentil protein crops more than potato and olive, by the way, beef product mainly protein products as we noticed in the previous paragraph higher than the others, but the main reason for decline it's percent representing in calculation according one m^3 water unit where the beef production needs a lot of water according the production cycle. That means if our production strategy looking to increase the revenue form protein for every m^3 consumed, the suitable investment in wheat then lentil production, if the other production factors are constant where we can increase the productivity of protein from water unit, and leading to the high efficiency of production, after installing all the other factors.



	Beef	Lentil	Wheat	Potato	Olive	Dates
Exp.1	60	1000	660	3000	1150	1120
Exp.2	120	3500	4000	7000	3450	2240

Fig 8. The amount of nutrition-water productivity (in calories) obtained from using one cubic meter (m^3) of water.

Upon scrutinizing the findings depicted in Figure 8, it was discerned that the utilization of one cubic meter of water to produce diverse crops led to disparate nutritional outcomes. Notably, the optimal calorie revenue was attained from potato cultivation, which was followed by wheat, while beef production exhibited the most calorie returns per unit of water. This can be attributed to the fact that potato and wheat are high-calorie crops, whereas beef is primarily a protein-based commodity with a negligible calorie content. Ergo, if the aim is to maximize calorie revenue per cubic meter of water utilized, investing in potato and wheat production would be the most judicious decision. This would boost calorie productivity from each unit of water employed and, ceteris paribus, augment production efficiency.

Water harvesting (WHO) by developing rangelands (Badia)

Rainwater harvesting is a widely used technique in Palestine to collect and preserve precipitation, particularly in areas with large desert regions. This technique helps prevent rainwater from drifting away in deserts by using simple methods to create sustainable pastures. These methods involve developing contour lines in the desert, creating deep pits using large tractors, and planting seeds deeply. This leads to the collection of water around the seeds and the production of pastures for livestock using simple water harvesting techniques (ICARDA, 2011). In dry rangeland areas, where rainfall is limited and land degradation is a pressing concern, utilizing micro-catchment contour ridges and semicircular bunds for rainwater harvesting can be a game-changer. Not only does it allow for the effective use of scarce rainfall, but it also enhances productivity and helps to combat land degradation.

Fig 9. The integrated technologies used by the WHO for grazing management.

In Figure 9, we can observe the use of World Health Organization (WHO) methods in the Jordan desert. These methods aim to collect the vast advantages of rainwater by using simple techniques like drilling contour lines. The main goal is to assemble the largest amount of rainwater, prevent water flow, and maximize the collection of rainwater, which is scarce in these areas. These techniques have proven to be efficient in managing water and developing sustainable nature pastures. They have a high impact on animal production sustainability by making feed more available and affordable. This is crucial since feed prices are one of the main obstacles to animal production systems, as stated by Issa A. Gammoh and Theib Y. Oweis (2010). Rainwater harvesting is a sustainable practice utilized for the collection and storage of precipitation from various surfaces such as rooftops, land surfaces, road surfaces, greenhouse tops, or rock catchments. This technique involves the usage of rudimentary technologies like pots, tanks, and cisterns, as well as more intricate methods including underground check dams (Abu-Madi, 2009). The significance of this method stems from the fact that due to the sloping nature of West Bank lands, 90% of the groundwater is not under the control of Palestinians. Moreover, the water rights of the Palestinian people are restricted by several water agreements, resulting from the Oslo agreements. Israel maintains veto power over any new project or digging of

new wells that may impact the water aquifers under occupation control (PCBS, 2019). The harvested rainwater is a renewable source of clean water that is ideal for domestic and landscape use in houses and some farms and can be implemented through several models (Abu-Zreig et al, 2000).

Water conservation systems offer adaptable and invaluable resolutions that can efficaciously cater to the exigencies of novel and extant sites, besides small and large farms dispersed in West Bank areas. Utilizing a water conservation system is a continuing process that can be optimized over time. The preponderant attraction of a rainwater harvesting system is the inexpensive cost, accessibility, and facile maintenance at the household and farmers' level (Abdulla and Al-Shareef, 2009). Owing to water paucity and limited supply, it is imperative to manage water resources effectually and maximize the utilization of every droplet of precipitation. As a result, water management projects are pivotal policies that policymakers need to enforce to hoard and utilize the utmost quantum of water in Palestine. Water harvesting techniques are widely prevalent in numerous parts of the globe, particularly in arid and semi-arid nations such as Jordan and African countries (Abu-Zreig et al, 2000). Precipitation runoff is augmented by collecting rainfall from designated zones and storing it in tanks and silos that are designed for human and animal consumption, in addition to supplementary irrigation in most agricultural crops (MOA, 2019). In 1983, the United Nations Environmental Program promulgated a report that enumerated diverse stratagems of amplifying the runoff from households and agricultural areas. Such stratagems included abluting inclined surfaces before use, mechanical treatment encompassing compacting the surface, contour terracing, and smoothing it to be congruous for planting sundry crops. Additionally, the deployment of chemicals to curtail infiltration and surface-binding materials to seal the surface was recommended, as well as covering the catchment area with a rigid or flexible surface for optimal control of water evaporation.

However, collating rainfall in tanks of differing sizes may prove exorbitant and might culminate in the squandering of voluminous amounts of water due to evaporation and defective mechanical connections (Abdulla and Al-Shareef, 2009). This is especially salient in arid and semi-arid regions where the quantity of evaporation exceeds the available quantity of rainfall by a substantial margin. To mitigate the issue of water evaporation, one plausible resolution is to employ enclosed storage tanks that are situated in a sheltered and fortified location. Although this solution can be rather effective in reducing water evaporation, the expenses can be exorbitant due to the utilization of perishable and costly materials. Alternatively, a feasible approach is to directly store accumulated rainfall in the soil for crop production and to implement a mono-cropping system by planting certain field crops between trees and mountain glades (Abdulla and Al-Shareef, 2009).
In sloped areas like the West Bank, the utilization of terraces, rippers, contour ridges, and micro-catchments is widely acknowledged to augment soil water storage and agricultural productivity. These techniques utilize the soil profile as a storage medium, thereby obviating the need for expensive storage tanks while minimizing water evaporation at a nominal cost, rendering them an economical solution (Lange et al., 2012).
Generally, in numerous parched and semi-dry locales, notably in Palestine, it is imperative to devise efficacious methodologies as part of water administration and national agrarian policies to enhance precipitation and ensure adequate water reservoirs for irrigation. Such measures are vital for the agricultural sector and contribute towards promoting sustainable agricultural development while preserving farm profitability.

Conclusion

The present study endeavors to conclude and characterize the extant scenario of water dearth in dry areas, particularly in Palestine (WBG), whilst factoring in distinct water usage conditions. The study asserts that an exigent requirement for more data and information, accurately portraying the diverse water management methodologies, is imperative. This is indispensable to competently assess the water status and formulate national water strategies that are better aligned with the aspirations of the Palestinians residing in (WBG).

The study's primary goal is to provide comprehensive guidelines for adapting agriculture to dry environments with scarce water resources. The study aims to achieve this by maximizing the available water quantities through managing water demands, using suitable agricultural investment, and increasing the efficiency and productivity of farm investment. The following are some of the guidelines the study recommends making this happen:

1. Land utilization and cropping patterns should be carefully evaluated to ensure that they are suitable for the available water quantities. By doing so, it will be possible to increase the efficiency of water usage.

2. The study recommends providing specialized training and mentoring in irrigation. Additionally, sound institutional orientations should be considered when developing irrigation guidelines.

3. Allocating water to more water-efficient practices is another recommendation of the study.

4. The study recommends developing water-use-efficient germplasm by creating varieties that are resistant to drought and can adapt to the reality of water in dry areas.

5. Addressing socio-political issues related to water valuation is a crucial aspect of the study. This includes conducting socioeconomic research and raising public awareness. It is also important to start with the farmers' needs regarding crop patterns.

6. Utilizing marginal-quality water is another recommendation of the study.

7. Finally, the study recommends building new proactive policies to initiate change in our water situation.

As per the findings of this study, it is imperative to involve farmers in the decision-making process of water management projects right from the inception stage, alongside the political and technical aspects. It is crucial to impart training to them on a range of complex issues such as financial, environmental, legal, institutional, and economic aspects related to water utilization. Moreover, granting them the opportunity to participate in the development of standards would usher in sustainable and valuable water use efficiency, thereby expediting water management. This dissertation delves into diverse policies from disparate stakeholders to discern the causes of water restrictions. It presents plausible remedies for water demand management, sustainability, and

curtailing the depletion of fresh water for irrigation purposes. The study advocates for expanding the utilization of water productivity and efficiency through investment and development of crops that are compatible with our production strategies (in terms of weight, monetary value, protein, and calories). These methods will promote the efficient allocation of water units, while also considering the socioeconomic aspects and raising public awareness about the benefits of these initiatives.

The predicament of Palestine is exacerbated by a dearth of potable water, consequent to regulatory measures implemented by Israel. To redress this issue, an alternative approach could be employed, namely, rainwater collection from the desert. Utilizing the technique of contour line drilling, the maximum quantity of rainwater can be amassed through silos and tanks, precluding the dissipation of the meager rainfall in these regions. These methods have demonstrated their efficacy in water resource management and the development of sustainable pasturelands. Although these technologies were ubiquitous throughout much of Palestine, their implementation was not widespread. By raising awareness of the social impact, potential, and performance of partial rainwater harvesting, families residing in small dwellings and engaged in agricultural pursuits may derive benefits from this practice.

There exist other ongoing investigations that pertain to the current political milieu. These inquiries are aimed at implementing active national policies to develop the agricultural sector as a crucial component of our national economic and sustainable strategy. The priority is to augment productivity from every unit of water utilized in diverse national strategic crops, which will ultimately result in an overall increase in water efficiency.

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A Brief Legal&Institutional Analysis on Pollution In Black Sea Türkiye's Case

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Abstract

This paper intends to assist those interested in mapping the (potentially extensive) range of Turkish national legislative & institutional measures relevant to control of pollution of the Black Sea environment. It is based on a preliminary work covering relevant regulations on pollution in Black Sea; EU Environmental *Acquis* (already transposed/approximated and expected to be transposed/ approximated); relevant national legislation (key ones on pollution in Black Sea).
In this regard, it firstly focuses on international and regional scales, focusing on Black sea cooperation and the EU requirements. Afterwards, it discusses notable features of national framework in terms of legislative & institutional structures. As a conclusion, it makes an overall evaluation over its findings.

Keywords: Black sea, gap analysis, marine pollution, water pollution, Türkiye.

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1. Introduction

This paper is based on identifying and characterising key relevant Turkish legal&institutional framework for water and marine pollution in Black Sea. While conducting this brief country-specific analysis, it is aimed to involve:

- An identification of specific legislative and institutional features in national framework vis-à-vis international and regional legislation on water, marine, inland, and coastal pollution across the Black Sea region; and
- An assessment of institutional arrangements, as well as institutional capacities.

Thus, it is intended to identify issues and themes to be investigated further and analysed with a view to making practicable recommendations for improvement of environmental outcomes for the Black Sea environment.
In accordance with this aim, it gathers the whole structure with four Annnexes which put all relevant regulations of Türkiye on Black Sea pollution in a frame, and list those related to the European Union (EU) *acquis* as already transposed or expected to be transposed in line with the EU *acquis.*
In this respect, it firstly focuses on relevant regulations of Türkiye on Black Sea water&marine pollution at both international and regional scales. Under regional level, as it is essential not only go through Black Sea regional cooperation instruments, but also European Union(EU) measures are also taken into account. That is because, although the EU accession process seems to have lost its former importance recently, it still remains a process that should be taken into consideration for Türkiye, especially through the learning and participation processes in EU-financed projects. Then, it discusses

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notable features of national framework in terms of legislative & institutional structures. In conclusion, it provides an overall assessment based on its research.

2. Relevant Regulatıions at International and Regional Scales

2.1 International Scale

Under Turkish Environmental Law(TEL), international environmental treaties have become part of the national law having the force of law, if they duly put into effect. If they also involve provisions on rights and freedoms, such provisions would prevail over national law (Art. 90, Turkish Constitution). So, Türkiye's stance on whether or not to become a party to an international agreement has direct effects on its national law. As seen in Annex I, in most of the legal frameworks and institutions related to addressing problems and solutions on Black Sea pollution, Türkiye is part of the process as a signatory or party state. Though there are also treaties to which it is still not party to, they are not much in number.

2.2 Regional Scale

2.2.1 Under Black Sea Regional Cooperation

Türkiye is party to the Bucharest Convention on Black Sea pollution, and most of the relevant protocols, and be part of the plans/programmes (see Annex I). In line with them, it is expected to promote the practice of integrated pollution prevention and control approach on the basis of best available technologies and also environmental practices (Avaz, G. *et.al*, 2008).

2.2.2 In the Scope of EU Requirements

In addition to the Black Sea regional cooperation process, the EU accession process and the necessity of compliance with the relevant EU *acquis* in this process have been also important factors that contribute to Türkiye's efforts to protect the water and marine environment and thus to the formation of the national legal and institutional framework for the control of marine pollution in the Black Sea (Savaşan, 2021; 2020a; 2019a). In particular, based on three documents, namely the European Union Integrated Environmental Harmonization Strategy (EUIEHS) (2007-2023);[4] the National Action Plan for EU Accession (2016-2019); and the National Water Plan (2019-2023), it has become clear that, Türkiye has transposed many directives, except the Marine Strategy Framework Directive (MSFD), as relevant to controlling Black Sea marine pollution into national law, with the support of EU's related projects[5] (see Annex II, III).

2.2.2.1 Bathing Waters Directive (BWD)

[4] The EUIEHS (2007-2023), approved by the High Planning Council on 07 February 2007, has been updated for the 2016-2023 period.

[5] These projects are established within the scope of Turkey-EU Financial Cooperationor Instrument for Pre-accession (IPA-I, II) in accordance with the Negotiating Position and Strategy Document. For the projects of 2002-2006 Turkey-EU Financial Cooperation, see at: http://www.ab.gov.tr/files/SEPB/cevrefaslidokumanlar/list_of_2002_2006_projects.pdf. For those of 2007-2013 IPA-I; and also IPA II Period (2014-2020), see at: https://www.ab.gov.tr/chapter-27-environment_92_en.html.

Pursuant to the EU Directive, for the management of bathing water quality, there is basically secondary legislation. These are about bathing water quality and the health principles of swimming pools (see Annex-IV).

2.2.2.2 Marine Strategy Framework Directive (MSFD)

The EU Marine Strategy aims to achieve good environmental status for the EU marine waters. Therefore, it requires member and candidate states to develop their own strategies by following an adaptive management approach. These strategies should also be regularly monitored, updated and validated every six years. In line with concerning EU directive, although there have been attempts to develop Türkiye's own national strategy document and prepare an action plan through the Marine Environment Strategy Development Project which was started in 2018, the EU Marine Strategy is still pending for Türkiye, hence regulation on addressing marine pollution in the context of the MSFD still remains an important gap that needs to be filled.

2.2.2.3 Maritime Spatial Planning (MSP) Directive

Regarding land-use planning/ development control legislation, there are some major regulations such as the Soil Protection and Land Use Act and the Zoning Act, drawing the framework for creating necessary rules, procedures and principles on the land-use planning system in Türkiye. In addition to them, there is also secondary legislation, i.e., By-law on the Construction of Spatial Plans. Also some other relevant acts like the Acts on the Metropolitan and Town Municipalities, also Coastal Act, and By-Law on the Implementation of the Coastal Act can all be taken into account regarding land-use planning/ development (see Annex IV).

In particular, the process of preparation of the Türkiye's Spatial Strategy Plan (TSSP) was shaped within the framework of the decision taken at the Urbanization Council held in 2009. In this process, the spatial strategy plan was included in the planning legislation for the first time in 2011 and the task of preparing the spatial strategy plans was given to the Ministry of Environment, Urbanization and Climate Change (MoEUCC) (Presidential Decree No. 1, Art. 97/d, 102/a). With the amendment made in the Zoning Act in 2018 (Art.5, para.16), the spatial strategy plan is considered as complete with its report and was defined as the plan,

"directing the physical development and sectoral decisions by associating the economic, social and environmental policies and strategies with the space, prepared throughout the country and in the regions deemed necessary..."

In the By-law on Spatial Plans Construction, which entered into force in 2014, the definition of spatial strategy plans, planning principles, and their place in the plan stratification and research topics were also explained. The basic approach to the preparation of the spatial strategy plan was also completed by the Ministry of Environment and Urbanization (MoEU) in 2013 (climate change was added to the name of the Ministry with the Presidential Decree No. 85 published in the Official Gazette No. 31643 dated October 29, 2021). In the last quarter of 2018, in line with the protocol signed between the MoEU and Istanbul Technical University, preliminary preparations and research on the subject were carried out. Subsequently, in 2019-2021, analyses and spatial evaluations were made within the scope of the *Preparation of the Türkiye Spatial Strategy Plan (TSSP) Project*. Currently, a draft TSSP (2053) was already completed within that project. However, there is need for more progress and effort in this field from an environmental-oriented perspective, with direct references to environmental/ pollution

control.[6] Under the By-law on Spatial Plans Construction, the following provisions are just relevant: a) reference to "sustainable development" (Art.1); b) relevant provisions regarding environmental plan (Arts.18-20), in which "ecological and economic decisions are evaluated together in accordance with the purpose of sustainable development (Art.19.1c); c) land use integrity is ensured in order to protect the continuity of the natural structure, ecological balance and ecosystem (Art.19.1e); d) land use decisions are made relying on preventive strategy for the sources that cause environmental problems and policies (Art.19.1g) etc; e) specific provisions on Black Sea pollution; f) provisions on the ICZM plans (Arts, 4, 29).

2.2.2.4 Nitrates Directive (ND)

The main provisions of the related By-law (By-Law on Water Protection Against Agricultural Nitrate Pollution) are to identify polluted or threatened waters, to identify nitrate-sensitive areas, to prepare a Code of Good Agricultural Practices, to establish Agricultural Action Plans in Sensitive Areas and to establish a monitoring network and reporting system. The General Directorate of Agricultural Research and Policies carries out a relevant project for the establishment and mapping of a relevant database. Thus, it would be possible for all practices related to the determination of pollution control and management to be monitored and evaluated through an information mechanism relying on a web based system (see Annex II, III).

2.2.2.5 Urban Wastewater Treatment Directive (UWTD)

All relevant regulations have been adopted regarding this Directive; though, there are some provisions that still need to be transposed, such as the specific legal requirement to connect to the sewerage / wastewater treatment network for pre-existing buildings or new buildings; for buildings / occupiers in areas without sewerage network access; or to construct any alternative wastewater treatment system (Annex-II).[7]

2.2.2.6 Water Framework Directive (WFD)

The Directive is mostly transposed into national legislation. Yet further effort is needed for national legislation to fully harmonize with it. In fact, the Framework Water Act is still not fully adopted and secondary legislation is still to be put into action in such a way that will reduce the challenges regarding implementation, compliance and enforcement (Annex-II, III).

2.2.2.7 Horizontal Measures

2.2.2.7.1 Environmental Impact Assessment (EIA)

The relevant By-law of Türkiye on EIA is basically in paralell to the EU *acquis* (By-Law on EIA, OG Date:29.07.2022; No.31907), except for a few problematic areas, such as transboundary impact assessment and public participation in consultations (Türkiye is not party to the related Conventions on Transboundary Environmental Impact Assessment (informally called as Espoo Convention)[8] and on Accession to Information on Environmental Issues, Public Participation in Environmental

[6] See at: https://mekansalstrateji.csb.gov.tr/

[7] For a detailed information on general waste management law and policy in Türkiye, see (Budak, 2021).

[8] For countries that are party to the Convention, see https://treaties.un.org/Pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-4&chapter=27&lang=en.

Decision-Making and Application to the Judiciary (informally Aarhus Convention).[9]

2.2.2.7.2 Strategic Environment Assessment (SEA)

The EU SEA Directive (dated 27.6.2001 and numbered 2001/42/EC), is one of the first regulations that comprehensively includes the principles and procedures regarding the strategic environmental assessment process and provisions that are largely similar to the Espoo Convention (UN 1991), SEA (Kyiv) Protocol (UN 2003), which is the most important international law text regarding the implementation of SEA. In order to support Türkiye's EIA process within the framework of the EU accession and harmonization process, Türkiye is also expected to ensure that a SEA is made in respect of the plans/programs that form the framework of the projects expected to be involved in these processes in line with this Directive (Gökalp Alıca, 2021).

In response to this expectation, firstly, with the amendment (Art.7) introduced with Act No. 5491 in 2006, the definition of SEA was included in the Environment Act (Art.10) and it was stated that the procedures and principles related to SEA would be included in a By-law to be issued. Then, the relevant SEA By-law was later published in 2017 (OG Date: 8.4.2017, No:30032).

3. Notable Features of National Framework

3.1 Legislative Framework

Turkish Constitution has many provisions about environmental protection and development, e.g., Art.43-45; Art.56.1; Art.57; Art.63; Art.169-170. Besides, Environment Act establishes the founding basis for Turkish Environmental Law (TEL) which is mainly regulated by public law through administrative acts, actions and regulations (OG Date: 11.08.1983; No.18132).[10] Complementing the Environment Act, there are also several secondary regulations including a range of different by-laws, many circulars, and others, on different dimensions of environmental protection, such as air quality, air &waterpollution, environmental impact assessment, pollution control etc.[11]

First and foremost, the Environment Act forbids the discharge of petroleum-derived wastes, sewage, garbage and hazardous wastes in environmental sources, like lakes, streams, or drinking and utility water sources, irrigation and drainage channels (Art.20(ı), (n), Environment Act). As pollution made through indirect or indirect ways is forbidden, in cases where there is a possibility of pollution, the concerned parties all are obliged to prevent it. Under TEL, not only the State, but the citizens are also responsible of protecting the environment (Art.3(a), Environment Act). However, in line with the pollutor pays principle, the polluter must take all precautions regarding pollution (Art.8, Environment Act); the same rule applies in all processes in the treatment and disposal of waste and in obtaining the required permits (Art.11, para.1, 22, Environment Act).

3.2 Institutional Framework

Fundamental powers, such as taking the necessary precautions regarding environmental law and policies, directing and managing the current system, and taking action against those responsible of the violations, mainly belong to the MoEUCC. The Ministry may allow some of these powers to be used, if necessary, through general directorates in the central organization and through provincial

[9] For countries that are party to the Convention, see: http://www.unece.org/env/pp/aarhus/map.html.

[10] For relevant Turkish legislation, see at: mevzuat.gov.tr; resmigazete.gov.tr.

[11] For a list of related legal documents adopted so far, see at: https://cygm.csb.gov.tr/kanunlar-i-438.

directorates in the local organization (Art. 12, 15, 24, Environment Act). It should exercise its powers in accordance with the relevant By-Laws, such as by-laws on environmental inspection, on EIA and on Environmental Permit and License.

In order to effectively implement the regulatory framework, environmental management units involving envronmental experts should also be establihed by related institutions/firms of which business can result in environmental pollution or damage to the environment (see under Supplementary Item 2 of the Environment Act). All rules, procedures and conditions regarding them who will carry out environmental management services, should rely on the principles and rules of the relevant secondary legislation, i.e., By-law on Environmental Inspection (OG Date:12.06.2021; No.31509); By-law on Environmental Permit and License (OG Date:10.09.2014; No.29115); By-Law on Environmental Management Services (OG Date:30.07.2019; No. 30847).

The By-law on Environmental Inspection (OG Date:12.06.2021; No.31509) which was adopted amending By-law (OG Date:21.11.2008; No: 27061), regulates the rules and procedures, observed by the units of the MoEUCC to supervise the facilities or activities, and the competences of relevant General Directorates, like General Directorates of EIA, of Permit and License, of Inspection; of Environmental Management; of Protection of Natural Assets and Provincial Directorates. The supervision powers of institutions and authorities authorized by other environmental legislation are subject to Art.7 of By-law on Environmental Inspection. Competence certificates of laboratories (both private and public) that will conduct environmental measurements and analyzes are also authorized by the MoEUCC. By-Law on Environmental Measurement and Analysis Laboratories (OG Date:25.12.2013; No.28862), on the other hand, includes rules on conducting environmental measurements and analyses, qualification certificates are also needed for laboratories (both private and public) authorized by the MoEUCC.[12]

As also mentioned above, in line with the pollutar pays principle, those directly or indirectly causing pollution and so environmental damage with their actions/business services should be admitted as responsible for all the costs drived from combating pollution (Art. 2, 3g, Environment Act, see also Art.28-39, By-law on Environmental Inspection). That is, all the necessary expenditure emerging from the pollution in all phases from prevention to responses are got from the polluter, in conformity with the provisions of the Act regarding the public receivables collection (OG Date:28.7.1953; No. 8469). As well as administrative measures, and several administrative fine classification (Art. 20(a-z)), some judicial fines also exist which can be applied according to the Environment Act (Art.26).

While everyone faced with environmental harm can ask for measures or activity suspension; mainly the MoEUCC, but also Directorate General of the EIA or Provincial Directorates, if necessary, can make a decision on the application of those measures (Art. 15, 30(1), Environment Act).

Overall, the present system regarding both reporting and monitoring displays that, the system is mostly designed in conformity with the relevant international&regional requirements. There are several relevant provisions on reporting and monitoring in different secondary regulation, e.g., by-laws on water pollution control (see Art.54); on pollution control emerging from dangerous substances in water and its surrounding (see Art.12-15); on surface and ground waters' monitoring (see Art.16); on the water basins' protection and also management plans' preparation (see Art.12(2,4)); and also communique on continuous wastewater monitoring systems etc.

[12] For competent laboratories, see at:https://elab.cevre.gov.tr/LabSorgu/.

On environmental liability, the Environment Act is still the only regulation involving directly relevant provisions (Art. 28, Environment Act). In the Civil Code, Obligations Code and some other acts, there are also related/relevant articles which can be applied for environmental liability as well (Art. 730, 737, Civil Code; Articles 49, 66-68, 69- 71, Obligations Code; Art. 14, Biosafety Act; Art.22(4), Turkish Petrol Act); but they are not about environmental liability in a specific and direct manner; and so it is required to make an evaluation over that specific case's conditions to decide on the existence of environmental liability So, it is argued that Türkiye also needs a specific act on environmental liability.

Under criminal law, the Criminal Code (OG Date:12.10.2004; No.25611) is very crucial, as the Code not only incorporates environmental protection among its objectives (Art.1); but also involves a separate category for environmental crimes (Arts.181-184). There are also some others indirectly related to the environmental protection, such as Articles 171-174, Articles 185, 186, 193. In addition to the crimes regulated in the Criminal Code, it is also possible to find two crimes set out in Article 26, Environment Act; and misdemeanors (Art.20, Environment Act). Under Misdemeanor Act (OG Date: 31.3.2005, No.24772 (repeated)). as well, there are some relevant provisions which can be applied for environmental issues, such as Articles 36(1),41(1-6), and 42, 44.[13]

Last but not least, it is also remarkably significant to refer to the resources that are used for being in compliance with the international &regional requirements. In particular regarding water pollution in Türkiye, it is seen that, in addition to the MoEUCC's own resources, projects conducted for improving the harmonization process by the financial cooperation between the EU and Türkiye (called as Instrument for Pre-accession (IPA-I, II)) are highly crucial.[14] On the other hand, regarding marine pollution, other than the EU, regional cooperation through the tools of Black sea economic cooperation intiative is quite effective for ensuring the improvement of resources in the required areas. Finally, with respect to the issues like the preparation of spatial & ICZM plans, and land use, developments are generally based on national initiatives. Indeed, the impact of EU or regional cooperation is less visible in this field, in comparison with others, such as water management especially.

4. Conclusion

In conclusion, based on the analysis, it may be argued that, legal & institutional framework is usually in parallel with the EU *acquis* and the requirements of the regional approach adopted under BSC structure. In fact, all explained and analyzed in detail so far acknowledge that Türkiye has made progress in terms of transposing relevant requirements on Black Sea pollution, particularly on water pollution control& management issues. Indeed, legislation on water issues is already under the implementation phase in many aspects. Yet, the legislation regarding marine pollution is still in the development process. There so appears that, to deal with Black Sea pollution, there is a wide scope of legislative&institutional framework in Türkiye, particulary on the water-based aspects of this pollution; but marine pollution, which is perhaps a much more important part, still remains the missing piece of the puzzle (see Annexes I-IV). Additionally, how comprehensive legal &institutional framework a state has is not a guarantee of proper implementation and compliance in practice.

[13] For the period before 2005, see also (Savaşan, 2020b).

[14] For the list of projects completed within the scope of Financial Cooperation in between the EU and Türkiye, of 2002-2006, of 2007-2013 IPA-I; and of IPA II Period (2014-2020), see at: https://www.ab.gov.tr/chapter-27-environment_92_en.html.

Indeed, although to protect the environment has been always on the agenda of Türkiye since almost its foundation, and it still constitutes one of the main foreign policy issues;[15] there has always been difficulty in maintaining the balance between development and environmental protection in Türkiye, and development goals are usually prioritized over environmental concerns due to concerns about economic growth capacity (Savaşan, 2021; Üstün, 2012). So, it is fundamentally essential for the country to make a perspective change in its policies, and thus, to establish a compliance-based system (Chayes and Chayes, 1995; Chayes, Chayes and Mitchell, 1995, 1998; Crossen, 2003; Faure& Lefevere, 1999; Najam *et.al.*, 2006; Raustiala, 2000; Raustiala, and Slaughter, 2002; Savaşan, 2019b), driving from good governance principles (Harman, 2005; Smouts, 1998; Zaelke, Stilwell, and Young, 2005), involving accessibility, accountability, efficiency, participation, predictability, and transparency (Savaşan, -).

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Misdemeanor Act No. 5326 (OG Date: 31.3.2005, No.24772 (repeated).
Obligations Code No.6098 (OG Date: 4.2.2011; No.27836 (amended version with Act No.6353).
Presidential Decree No. 1 (OG date:10.7.2018; no.30474).
Presidential Decree No. 85 (OG date: 29.10.2021; no. 31643).

SEA Directive (dated 27.6.2001 and numbered 2001/42/EC).
Turkish Constitution 1982. Constitution of Turkish Republic.
Turkish Environment Act, No.2872 (OG Date: 11.08.1983; No.18132).
Turkish Petrol Act, No.6491 (OG Date: 11.6.2013; No.28674).

ANNEXES I-IV

Annex I: Relevant Regulations on Pollution in Black Sea
ANNEX II: Relevant EU Environmental Acquis (already transposed/approximated)
ANNEX III: Relevant EU Environmental Acquis (expected to be transposed/approximated
ANNEX IV: Relevant National Legislation (key ones on pollution in Black Sea).

Annexes (I-IV): Relevant Regulations of Türkiye on Pollution in Black Sea

Each of the following annexes contains relevant regulations intended to assist those interested in mapping the (potentially extensive) range of national legislative measures relevant to control of pollution of the Black Sea environment:
Annex I: Relevant Regulations on pollution in Black Sea;
ANNEX II: Relevant EU Environmental Acquis (already transposed/approximated);
ANNEX III: Relevant EU Environmental Acquis (expected to be transposed/approximated;
ANNEX IV: Relevant National Legislation (key ones on pollution in Black Sea).

List of Abbreviations

BAT	Best Available Techniques / Technology
BMC	Basin Management Committee
BWD	Bathing Waters Directive
DIPMP	Domestic and Industrial Pollution Monitoring Programme
EC	European Commission
EcoQO	Ecological Quality Objective set out under the Black Sea Commission Strategic Action Plan
EIA	Environmental Impact Assessment
EIAD	Environmental Impact Assessment Directive
EQS	Environmental Quality Standard
EU	European Union
EUND	EU Nitrates Directive
GES	Good Environmental Status (EU Marine Strategy Framework Directive)
LBP	Land Based Pollutants
MoAF	Ministry of Agriculture and Forestry
MoEUCC	Ministry of Environment, Urbanization and Climate Change
MoH	Ministry of Health
MSFD	EU Marine Strategy Framework Directive
NAP	National Action Plan
NGO	Non-Governmental Organisation
NIS	Nitrate Information System
NWIS	National Water Information System

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OG	Official Gazette
RBMP	River Basin Management Plan
SAP	Strategic Action Plan
SEA	Strategic Environmental Assessment
SEAD	Strategic Environmental Assessment Directive
UWTD	Urban Wastewater Treatment Directive
WFD	EU Water Framework Directive

ANNEX I: Relevant Global/Regional Regulations on Pollution in Black Sea		**TURKIYE's SITUATION**		
		Signed	**Ratified**	**Party (Entry into force)**
International Treaties[16]	UN Framework Convention on Climate Change	-	2004-02-24 (accession)	2004-05-25
	UN Convention to Combat Desertification	1996-11-22	1998-02-11	1998-05-16
	UN Biodiversity Convention	1992-06-11	1997-02-14	1997-05-15
	Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)	1979-12-24	1984-02-20	1984-09-01
	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES Convention)	1994-27-09	1996-06-20	1996-12-22
	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)	1993-12-28	1994-05-17	1994-11-13

[16] https://treaties.un.org/

		Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (22 March 1989) Amendment to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (22 September 1995)	1989-03-22	1994-06-22 2003-08-27	
		Stockholm Convention on Persistent Organic Pollutants (22 May 2001	2001-05-23	2009-10-14	
		Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (10 September 1998)	1998-09-11	2017-09-21	
Regional Treaties[17]		Convention on the Protection of the Black Sea Against Pollution (Bucharest Convention)	1992-04-21	1993-12-07	1994-12-14
	1	Protocol on the Protection of the Black Sea Marine Environment against Pollution from Land Based Sources	1992-04-21	1994-03-29	1994-03-29
	2	Protocol on Cooperation in Combating Pollution of the Black Sea Marine Environment by Oil and Other Harmful Substances (Emergency Protocol)	1992-04-21	1994-03-29	1994-03-29
	3	Protocol on the Protection of the Marine Environment Against Pollution by Dumping	1992-04-21	1994-03-29	1994-03-29
	4	The Black Sea Biodiversity and Landscape Conservation Protocol to the Convention on the Protection of the Black Sea against Pollution	2002-06-14	2004-08-12	2011-06-20
		Protocol on the Protection of the Black Sea Marine Environment against Pollution from Land Based Sources an Activities	2009-04-17	pending	pending

[17] https://www.ecolex.org/

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Others (Plans, Reports, Documents, Papers etc.)	**Black Sea Strategic Action Plan** - Strategic Action Plan on the Protection and Rehabilitation of the Black Sea,	1996 (Amended in 2002 and Updated in 2009)		
	Black Sea Contingency Plan (to the Emergency Response Protocol)	2003		
	Land Based Sources Pollution National Action Plan for Turkey There is also a Turkish Report submitted to the Ministry of Environment, Urbanization and Climate Change (MoEUCC) for the Black Sea with the title of "National Action Plan on Land Based Pollutants" in the 2004 version prepared within the scope of the same project.	(2004, submitted to UNEP MAP) Not available online		
	-**Land Based Sources Pollution National Action Plan** for Turkey There is also a Turkish Report submitted to the MoEU for the Black Sea with the title of "National Action Plan on Land Based Pollutants" in the 2015 version prepared within the scope of the same project.	(2015, submitted to UNEP MAP) Not available online		
	Assessment Reports of those projects -The Project on Marine Environment Strategy Development for Turkey -The Capacity Building on Marine Strategy Framework Directive in Turkey Project (MARinTURK))	Not available online		

*** Türkiye is not party to those Treaties:**

- 1982 UN Convention on the Law of the Sea (UNCLOS)
- 1989 Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal
- 1991 UNECE Convention on Environmental Impact Assessment in a Transboundary Context (informally called the Espoo Convention)
- 1992 UNECE Water Convention
- 1997 UN Watercourses Convention
- 1998 UNECE Convention on Access to Information, Public Participation in Decision-Making, and Access to Justice in Environmental Matters (informally called the Aarhus Convention)
- 2003 UNECE Protocol on Strategic Environmental Assessment (SEA)

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ANNEX II
Relevant EU Environmental Acquis
(Already transposed/approximated)

No.	EU *acquis* to comply with	Object /Purpose	National Key Legislation(s)	Key Institution
1.	EU WFD Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy ---------- Directive 2008/105/EC of The European Parliament and of The Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council ---------- ---Directive 2013/39/EU of The European Parliament and of The Council of 12 August 2013 amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy	Achieving the objectives of relevant international agreements, aiming to prevent and eliminate pollution of the marine environment	By-Law on the Protection of Water Basins and the Preparation of Management Plans (OG 17.10.2012; No: 28 444) By-law on Preparation, Implementation, and Follow-Up of Basin Management Plans (OG 17.10.2012; No:28444) Communique on Establishment, Duties, Working Principles and Procedures of Basin Management Committees (OG 20.05.2015; No: 29361) Water Management Coordination Board, established by 2012/7 numbered Prime Minister's Circular	Ministry of Agriculture and Forestry (MoAF)
			By-law on Surface Water Quality Management (30.11.2012; No: 28483)- Directive 2008/105/EC; Directive 2013/39/EU	MoAF
			By-Law on the Monitoring of Surface and Groundwaters (11.02.2014; No: 28910)	MoAF
			By-Law on Determination of Sensitive Water Masses and Areas Affecting These Masses and Improvement of Water Quality (26.12.2016; No: 29927)	MoAF
			By-Law Control of Water Use in Irrigation Systems and Regulation on Reducing Water Losses (16.02.2017; No: 29981)	MoAF
			By-Law on The Protection of Drinking Water Basins (28.10.2017; No: 30224	MoAF
			By-law on Preparation, Implementation and Monitoring of the Flood Management Plans (12.05.2016; No: 29710)	MoAF

	2006/118/EC Directive on the protection of Groundwater against pollution and deterioration	To prevent and control groundwater pollution, complementing the provisions preventing or limiting inputs of pollutants into groundwater already contained in Directive 2000/60/EC, and thus aims to prevent the deterioration of all bodies of groundwater.	By-Law on the Protection of Groundwater Against Pollution and Deterioration (23.12.2016; No: 29927)	MoAF
	98/83/EC Directive on Water Intended for Human Consumption	To protect the water quality and so human health from the adverse effects of any sort of water contamination	By-Law Amending the Regulation on Water Intended for Human Consumption (07.03.2013; No: 28580)	Ministry of Health (MoH)
2.	Bathing Waters Directive Directive 2006/7/EC of the European Parliament and of the Council of 15 February 2006 concerning the management of bathing water quality and repealing Directive 76/160/EEC	Management of bathing water quality; by complementing Directive 2000/60/EC	By-Law on Bathing Water Quality (09/01/2006; No: 26048) By-Law on the Health Principles of Swimming Pools (06.03.2011; No: 27866)	MoH& Ministry of Environment,Urbanization and Climate Change (MoEUCC)
3.	Urban Wastewater Treatment Directive Council Directive of 21 May 1991 concerning urban waste water treatment (91 /271 /EEC)	Protecting the environment from the adverse effects of the waste water discharges	-By-Law on Urban Wastewater Treatment (08.01.2006; No: 26047) -By-Law on Determination of Sensitive Water Masses and Areas Affecting These Masses and Improvement of Water Quality (23.12.2016; No: 29927) -By-law on Wastewater Collection and Disposal Systems (06.01.2017;	MoH& MoEUCC& MoAF

			No:29940), 2 Annexes on Technical Bases -By-law on the Methods and Principles to be Followed in Determining The Tariff For Wastewater İnfrastructure and Domestic Solid Waste Disposal Facilities -By-law on the Procedures and Principles to Be Followed When Wastewater Treatment Plants Benefit From Incentive Measures According To Article 29 of The Environment Act - Wastewater Treatment Plants Technical Procedures Communique -Continuous Wastewater Monitoring Systems Communique (OG 22.03.2015, No.29303) - Communique on Sensitive and Less Sensitive Water Areas of By-Law on Urban Wastewater Treatment	
4.	EU Nitrates Directive 91/676/EEC Directive on the Protection of Waters Against Pollution Caused by Agricultural Nitrate	Reducing water pollution caused or induced by nitrates from agricultural sources and preventing further such pollution	-By-Law on Water Protection Against Agricultural Nitrate Pollution (OG Date: 18.02.2004; No: 25377) -By-Law Surface Water Quality (30.11.2012; No: 28483) -By-law on the Identification and Protection of Sensitive Water Bodies and of Areas Affecting Those Bodies (23.12.2016; No: 29927)	MoAF

	Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)	Ensuring registration, evaluation, authorisation and restriction of chemicals; promoting alternative methods for the evaluation of the substances in this process; and enhancing competitiveness and innovation, to guarantee high level protection of human health and environment	By-law on Registration, Evaluation, Authorization and Restriction of the Chemicals (23.06.2017; No: 30105)	MoEUCC
	Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC	Environmental and human health protection against negative effects of persistent organic pollutants (POPs)	By-law on Persistent Organic Pollutants (25.03.2021; No: 31434)	MoEUCC
5.	Environmental Impact Assessment Directive- Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment Text with EEA relevance	Evaluation of the environmental effects of related/relevant public and private projects which are likely to have environmental impacts	By-Law on Environmental Impact Assessment (25.11.2014; No: 29186) By-Law on Environmental Impact Assessment (12.06.2021; No.31509)	MoEUCC
6	Strategic Environmental Assessment Directive-Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment (SEA Directive)	Evaluation of the environmental effects of related/relevant plans and programmes which are likely to have environmental effects	By-Law on Strategic Environmental Assessment (08.04.2017; No: 30032)	MoEUCC

7	Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) Chapter II (Article 23)	Regulating the procedures and principles for the environmental inspections, qualifications of the inspectors, and obligation of the industrial enterprise to establish environmental management department/to employ environmental consultants, within a period from the initiation of the activity or operation of the facility to the end of the activity or the facility's closure	Amending the By-law on Environmental Inspection (21.11.2008; No: 27061) - DONE New Version: By-law on Environmental Inspection (12.06.2021; No.31509) - With the new regulation, the title of Environmental Audit Officer was changed to Environmental Auditor. - To become an Environmental Auditor, it is necessary to take part in the environmental units of the Ministry and Provincial Directorate, to graduate from engineering, architecture or science faculties of universities, to have completed environmental auditor education and to participate in at least 15 environmental audits as an environmental auditor candidate. - The conditions for becoming an Environmental Volunteer were also updated and the conditions were limited to not being banned from public services and to participating in the environmental volunteer training organized by the ministry.	MoEUCC
8	EU Marine Strategy Framework Directive Dırectıve 2008/56/EC of The European Parlıament And Of The Councıl of 17 June 2008 establishing a framework for community action in the field of marine environmental policy	Developing ecosystem-based marine strategies Establishing a framework to achieve good environmental status in the marine environment	NONE	---------- ---------- ---

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ANNEX III
Relevant EU Environmental Acquis
(Expected to be transposed/approximated)

1. Primary Legislation

No.	EU acquis to comply with	Object and Purpose	Key National Legislation (To be enacted/ amended)	Key Institution	Current Situation
1.	EU WFD-Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy	Acting in line with the objectives of relevant international agreements, aiming to prevent and eliminate marine environmental pollution	Water Framework Act (Act on Waters (No.831), OG Date: 10.05.1926; No.368)	MoAF	Planning to be adopted till 2023 at latest (NWP, 2018)
2.	Env. Liability Directive 2004/35/CE of the European Parliament and of the Council of 21 April 2004 on environmental liability about the prevention and remedying of environmental damage	Establishing a framework of environmental liability, to prevent and remedy damage to the environment	Env. Liability Act	MoEU CC	Not available
3.	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora - Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds	Avoiding pollution or deterioration of habitats	Act on Conversation of Biodiversity	MoAF	-Draft submitted for 4 times to Turkish Grand National Assembly (TGNA)
4.	EU Marine Strategy Framework Directive	Establishing a framework to achieve good environmental status in the marine environment Developing ecosystem-based marine strategies	Relevant Act, by-laws, communiques	Not available	Not available

2. Secondary Legislation

No.	EU acquis to comply with	Object and Purpose	Key National Legislation (To be enacted/ amended)	Object and Purpose	Key Institution
1.	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy	Achieving the objectives of relevant international agreements	Communiqué on Implementation of the By-law on Control of Loss of Water in the Drinking Water Supply and Distribution Systems	Ensuring the management of supply and distribution systems Reducing the loss of water	MoAF
			By-law on Preparation, Implementation and Monitoring of the Flood Management Plans	Mitigating the negative effects of floods on human health, environment, cultural heritage and social and economic activities, through flood management plans	MoAF
			Amending the By-law on Monitoring of Surface Waters And Ground Waters (OG: 11.02.2014/28910)	Following the finalisation of the specific pollutants list to be identified for Türkiye, rearranging the list of chemical monitoring parameters	MoAF
			Communiqué on Surface Waters, Ground waters, Sampling Sediments and Biological Sampling	Ensuring standardization in sampling re water quality monitoring	MoAF
			Communiqué on Biological Monitoring	Determining the procedures and principles for national biological monitoring studies	MoAF
			Communiqué on Hydromorphological Monitoring	Determining the procedures and principles for national	MoAF

				hydromorphological monitoring studies	
			By-law on Surface Water Quality Management	Transposing the environmental quality standards and specific pollutants identified for Türkiye; aligning the water quality classification methodology; updating the priority substances list; integrating the priority substances to environmental quality standards	MoAF
			By-law on the Quality of Irrigation Water and Reuse of Waste Water	Monitoring the quality, preventing the overuse, identifying the measures to be taken to improve the quality, regulating the principles and procedures on the quality criteria required for the reuse of waste water particularly for the purpose of irrigation	MoAF
2	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora- Directive 2009/147/EC of	Tackling with habitats pollution or deterioration	Relevant by-laws, communiques		MoAF

	the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds				
3	Bathing Waters Directive	Improving the quality of the environment an human health by complementing Directive 2000/60/EC.			MoAF
4	Urban Wastewater Treatment Directive Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment	Coping with adverse effects of the wastewater discharges.	By-law on the Identification and Protection of Sensitive Water Bodies and of Areas Affecting Those Bodies (23.12.2016; No: 29927) Directive 91/676/EEC;2000/60/EC		MoAF
5	Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC	Establishing an European Pollutant Release and Transfer Register (E-PRTR) with publicly accessible electronic database in line with UNECE Protocol on Pollutant Release and Transfer Registers And facilitating public participation in environmental decision-making	By-law on Pollutant Release and Transfer Register	Establishing the infrastructure for E-PRTR in Türkiye --- The Draft Regulation on Pollutant Release and Transport Registration, prepared within the scope of relevant project has been opened for comment on the website of the General Directorate of EIA, Permission and Inspection.	MoAF
6	Regulation (EU) No	Establishing national	By-law on Export and Import of Hazardous		MoAF

	649/2012 of the European Parliament and of the Council of 4 July 2012 concerning the export and import of hazardous chemicals	decision-making processes concerning the export and import of hazardous chemicals; and thus preventing the possible damage by certain hazardous chemicals on human health and the environment	Chemicals		

3. Others (Plans, Reports, Documents, Papers etc.)

No.	Name	Object and Purpose	Key Institution	Current situation
1	River Basin Management Plans	Converting the Basin Protection Action Plans to River Basin Management Plans in accordance with the WFD; and enhancing the national capacity during this process	MoAF	In progress
2	National Monitoring Network	Establishing the National Monitoring Network in accordance with the WFD	MoAF	In progress
3	Water Resources Modelling Strategy, Roadmap and Modelling Action Plan (MODEP)	Planning the modelling study until 2023 for the management of water resources in Türkiye at level of basins with regard to quantity and quality, in accordance with the WFD	MoAF	In progress
4	Revision of the National Implementation Plan for WFD	Determining the details regarding the procedures, institutional structure and schedule for the implementation of the WFD	MoAF	In progress

ANNEX IV
Relevant National Legislation

(Key ones on Pollution in Black Sea)

RELEVANT TOPICS	Primary legislation		Secondary legislation		
WATER POLLUTION				**1**	By-law on Water Pollution Control (OG 31.12.2004; No: 25687)
				2	By-law on Control of Pollution Caused by Dangerous Substances in Water and Its Environment (26.11.2005; No: 26005)
				3	By-Law on Water Protection Against Agricultural Nitrate Pollution (OG Date: 18.02.2004; No: 25377)
				4	By-law on Urban Wastewater Treatment (08.01.2006; No: 26047)
				5	By-law on Wastewater Collection and Disposal Systems (06.01.2017; No:29940)
				6	By-Law on the Protection of Water Basins and the Preparation of Management Plans (17.10.2012; No: 28 444)
				7	By-law on Preparation, Implementation, and Follow-Up of Basin Management Plans (17.10.2012; No:28444)
				8	By-law on Surface Water Quality Management (OG 30.11.2012; No: 28483)
				9	By-Law on Determination of Sensitive Water Masses and Areas Affecting These Masses and Improvement of Water

					Quality (26.12.2016; No: 29927)
				10	By-law on Registration, Evaluation, Permission and Restriction of Chemicals (23.06.2017; No: 30105)
				11	By-Law on the Protection of Groundwater Against Pollution and Deterioration (23.12.2016; No: 29927)
				12	By-Law on Determination of Sensitive Water Masses and Areas Affecting These Masses and Improvement of Water Quality (26.12.2016; No: 29927)
				13	By-Law Control of Water Use in Irrigation Systems and Regulation on Reducing Water Losses (16.02.2017; No: 29981)
				14	By-Law on The Protection of Drinking Water Basins (28.10.2017; No: 30224)
				15	By-Law on Bathing Water Quality (09.01.2006; No: 26048)
				16	By-Law on the Health Principles of Swimming Pools (06.03.2011; No: 27866)
				17	By-law on Persistent Organic Pollutants (25.03.2021; No: 31434)
MARINE POLLUTION	**1**	The Law on the Approval of the Convention on the Protection of the Black Sea against		**1**	By-Law on Bathing Water Quality (09/01/2006; No: 26048)

		Pollution and its Additional Protocols (14.12.1993; No: 21788)			
	2	Act on the Emergency Response and Compensation of Damages in Pollution of the Marine Environment with Oil and Other Harmful Substances (No. 5312) (OG 11.03.2005; No:25752)		**2**	Communique on the Shore Facilities Mandatory Financial Liability Insurance for Marine Pollution (OG 25.04.2018; No: 30402)
	3	Act on Conservation of Cultural and Natural Property (No. 2863) (23.07.1983; No:18113)			
LAND USE/PLANNING	**1**	Soil Protection and Land Use Act (19.07.2005; No: 25880)		**1**	By-law on Spatial Plans Construction (OG Date:14.06.2014; No.29030)
	2	Zoning Act (09.05.1985; No: 18749)		**2**	By-Law on Control of Soil Pollution and Point Source Contacted Fields (08.06.2010; No: 27605)
	3	Metropolitan Municipality Act (No.5216) (23.07.2004; No: 25531)		**3**	By-Law on Soil Pollution Control and Point Source Contacted Fields Communique on Qualification Certificate (17.06.2011; No:27967)
	4	Municipal Act (No.5393)			

		(13.07.2005; No: 25874)			
	5	Act on the Establishment of Metropolitan Municıpalities and Twenty Seven Districts in Fourteen Provinces and Amending Some Acts and Decisions (No.6360) (06.12.2012; No: 28489)			
	6	Coastal Act (No. 3621) (OG Date: 17.04.1990; No. 20496)		**4**	By-Law on the Implementation of the Coastal Act (03.08.1990; No. 20594)
INSPECTION **(Monitoring, reporting, enforcement)**	**1**	Turkish Environment Act (No.2872) (11.08.1983; No.18132)		**1**	By-Law on Environmental Impact Assessment (12.06.2021; No.31509)
	2	Turkish Criminal Code No. 5237 (12.10.2004; No.25611)		**2**	By-Law on Strategic Environmental Assessment (8.4.2017, No:30032)
	3	Misdemeanors Act No. 5326 (31.3.2005; No. 25772 (repeated))		**3**	By-Law on Environmental Permits and Licenses (10.09.2014; No.29115)
	4	Act on the Right of Access to Information (9.10.2003; No. 4982)		**4**	By-law on Monitoring of Surface Waters and Ground Waters (11.02.2014; No: 28910)
	5	Act on the Collection of Public Receivables, No. 6183		**5**	By-law on Preparation, Implementation and Monitoring of the Flood Management Plans (12.05.2016; No: 29710)

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		(28.7.1953; No. 8469)			
				6	By-Law on Qualification of Environmental Measurement and Analysis Laboratories (25.12.2013; No.28862)
				7	By-Law on Environmental Management Services (30.07.2019; No. 30847).

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Seepage Control of Irrigation Water:

A Critical Constituent in Disaster Avoidance and Loess Project Management

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Abstract:

Water penetration in loess slopes has a notable impact on the physical and mechanical attributes of the soil. Within loess landscapes, certain pathways are favored for water seepage, highlighting the necessity of investigating preferential flow to grasp the water seepage process in loess. The identification of cracks, particularly microscale cracks, is facilitated through the utilization of electrical resistivity tomography and geological radar techniques. Furthermore, to monitor the seepage process, an in-situ single-ring infiltrometer test is performed in the hidden fracture locations. The findings from these on-site tests serve as the basis for developing both a single-seepage model and a dual-seepage model, which aim to replicate the seepage process occurring in the preferential channel. For engineering purposes, the examination of a landslip that occurred at the rear edge of most loess plateau is underway. Within the numerical framework, two types of irrigation conditions are simulated: high intensity with short duration and low intensity with extended duration. In instances of high-intensity irrigation, the preferential flow rate takes precedence and exerts a beneficial effect on seepage. Rapid infiltration of irrigation water occurs in the deep soil, causing groundwater levels to rise, while the top matrix region remains devoid of saturation. In instances of low intensity, matrix flow takes precedence, resulting in a saturated seepage condition. Seepage control of excessive irrigation water plays a crucial role in disaster prevention and the effective management of loess projects.

Keywords**:** Hidden Crack; Preferential Channel; Seepage Process; Dual-Seepage Model; management of loess projects; seepage control of irrigation water

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1. Introduction

1.1 Research significance

The management of water has emerged as a critical factor in disaster prevention and the effective execution of loess projects. To avert the calamitous consequences of water-induced loess, engineers must initially delve into the mechanisms through which water infiltrates the loess. The natural loess slope is riddled with numerous fractures, including concealed cracks that remain hidden beneath the surface. Unfortunately, these buried cracks are often disregarded in irrigation activities and the design of water control systems for engineering purposes. The preferred routes for water seepage on engineered slopes encompass the boundaries formed by filling and excavation, cracks resulting from unloading, and subterranean pipelines. Water within these preferential channels can swiftly permeate to the lower layers, thereby underscoring its significance in water control for engineering purposes. Consequently, it is imperative to thoroughly investigate the seepage characteristics of water within these dominant channels.

A considerable number of countries around the world exhibit the prevalent loess distribution region (P. Li. and Q. Hui, (2018)). However, the increase in human endeavors like city expansion, industrial growth, and energy consumption has escalated the need for water, causing pollution in both land and water resource (P. Li. and Q. Hui, (2018), P.Li, H. Qian, K. Howard and J. Wu,(2015), E. Saibaba Reddy, K. Rama Sastri et K. Bhaskar ,(2010)) . Consequently, the loess plateau is currently confronted with significant challenges in terms of water resource development and environmental preservation. A thorough comprehension of the properties of loess and a comprehensive understanding of the current water resources situation in the loess plateau area are of utmost importance (W. Shao, T. Bogaard and M. Bakker,(2015) , P. Li. and Q. Hui, (2018)) .

Water serves as a fundamental element for driving economic development and safeguarding the environment in the loess plateau on a global scale. The loess plateau grapples with the formidable environmental challenges of drought and water scarcity, which have profound implications for the advancement of ecological civilization and economic growth (P. Li. and Q. Hui, (2018) , I. Smalley, S. Marković and Z. Svirčev,(2011) , P. Garcia-Chevesich, X. Wei, J. Ticona and G. Martínez,(2020)) . River water and groundwater are the predominant water resources harnessed in research field, catering to diverse needs and applications. As per the available literature, the water supply in the research region is predominantly reliant on river water, which contributes to a substantial 77.3% of the total. In contrast, groundwater plays a comparatively smaller role, accounting for 22.7% of the overall water resources (I. Smalley, S. Marković and Z. Svirčev,(2011), P. Li. and Q. Hui, (2018)). In the loess plateau, the main utilization of river water revolves around agricultural irrigation and industrial production. However, for domestic water supply, the primary reliance is on groundwater(P. Garcia-Chevesich, X. Wei, J. Ticona and G. Martínez,(2020)) .

The region frequently experiences irrigation-induced landslides, which can be attributed to the seepage of water through surface fissures and sinkholes (Y. Liang, J. Qiao and C. Xie, (2019) , L. Zhu, J. Hu and J. Jia(2013), J. Dong, (2017) , P. Garcia-Chevesich, X. Wei, J. Ticona and G. Martínez,(2020)). Not only does irrigation play a role in triggering landslides in this area, but the occurrence of a landslide can

also increase the likelihood of additional landslides happening subsequently, as demonstrated in studies conducted in the Jiaojiayatou region of the People's Republic of China (J. Jia, L. Zhu and W. Hu (2013)) .Studies have uncovered a distinct relationship between variations in groundwater table levels (as a result of agricultural irrigation) and the history of landslides (P. Garcia-Chevesich, X. Wei, J. Ticona and G. Martínez,(2020) , Y. Dong, P. Sun, M. Zhang, X. Cheng and J. Bi,(2013)). The Heifangtai loess plateau has witnessed water table elevations surpassing 20 meters for over four decades in specific locations, as reported by Zhang (M. Zhang,(2013)) in their study. Xu et al.(L. Xu, F. Dai, X. Tu, L. Tham, Y. Zhou and J. Iqbal,(2013)) projected an annual rise of 0.18 m in the aforementioned region. Additionally, Xu et al.(L. Xu, F. Dai, L. Tham, X. Tu, H. Min and Y. Zhou, (2011)"). executed a model to evaluate the water-related impacts of watering on the stability of a loess face face at Heifangtai (G.-C. Pablo et al 2021).

Their findings revealed that the establishment of extensive agricultural fields played a pivotal role in triggering persistent landslides within this geological formation. Irrigation's effect on the stability of the loess terrain was also investigated on the Heifangtai Plateau.(Gu et al.2018), in independent research efforts, along with the study by Wu et al. (W. Wu, X. Su and X. Meng,(2014)) ,both studies concluded that the primary cause of recent landslides in the area was the surplus water generated from agricultural irrigation methods. These findings align with the conclusions drawn by Hou et al 2018. regarding the instability of the Heifangtai platform, as well as the research conducted by Duan et al. (2019) on the instability of the Jingyang loess platform situated in the northern Chinese province of Shaanxi (P. Garcia-Chevesich, X. Wei, J. Ticona and G. Martínez,(2020)). Li and Jin (2012) conducted an analysis in the same region and investigated the initial stage of deep landslides. Their findings indicated that the primary factor triggering these landslides was the rise in water tables, which was attributed to the extensive irrigation activities. Similarly, Gu et al.(2015) Gao et al. (2019), and Qui et al. (2019) reached comparable conclusions in their respective studies on landslides in Gansu, Sichuan, and Wuhai provinces.

Extensive scholarly research has been conducted to explore the strategies employed in determining and altering the seepage coefficient in different scenarios, which serves as a key parameter for evaluating soil seepage (B. Zhou and Z. Chen(2019), H. Hu (2018)). The findings reveal that the seepage coefficient of Malan loess experiences a substantial decrease from saturated to unsaturated conditions, declines with an increase in dry density, and eventually stabilizes (B. Hong, X. Li and G. Chen(2016), , T. Wang, T. Yang and J. Lu (2016, K. Zhao, Q. Xu and X. Zhang (2018)). The configuration of loess can be scrutinized to comprehend the mechanisms of water seepage. The seepage of water within loess materials is a complex phenomenon. Several investigations have been carried out on the seepage behavior of water flow in loess (J. Lu and and B. Chen (2007), T. Wang, N. Li and D. Xie (2004)) ,the relationship between soil and water (P. Li, T. Li and A. Wang (2013)) , and the water retention properties through field seepage tests and laboratory experiments (Q. Mu, Y. Dang and Q. Dong (2019),). Some researchers suggest that vertical loess joints play a significant role in surface water seepage, along with pore seepage. Ground fissures and sinkholes are highlighted as the main channels through which surface water flows (L. Xu, H. Li and D. Wu(2008)). In the study of water field simulation in loess, researchers have examined various aspects such as the water field of unsaturated loess subgrade (T. Wang (2008)) , pore flow modeling method, and pore velocity distribution(Y. Liang(2011),). Moreover,

investigations have been carried out on the three-dimensional seepage of loess landslide drainage system (A. Zhang, S. Kang and P. Li(2004),), coupling analysis of phreatic seepage field and slope stability in Heifangtai irrigation area (P. Sun, M. Zhang and Y. Dong (2013),), and pore flow characteristics of porous media using transparent soil technology (Y. Liang, P. Chen and J. Lin (2019),) . The numerical simulation of seepage under the combined influence of preferential flow and matrix flow has been investigated by several researchers (E. Saibaba Reddy, K. Rama Sastri et K. Bhaskar ,(2010)) .The seepage of water is influenced by the presence of a preferential channel, leading to the need for studying this phenomenon (W. Shao, T. Bogaard and M. Bakker,(2015) , T. Vogel, H. Gerke and R. Zhang (2000)).

Considerable advancements have been achieved in studying the infiltration of water in loess. However, the emphasis has primarily been on laboratory tests conducted on remoulded soil, neglecting the complexities of soil in the field. While the exploratory well sensor monitoring method is frequently employed for field experiments, it fails to accurately depict the in-situ two-dimensional seepage process. The seepage characteristics of water in the preferential channel of loess were explored by utilizing the rear edge landslip on a loess plateau as a test site. Through field seepage testing and numerical simulations that did not disturb the site, the seepage behavior of water in the preferential channel of loess was investigated. These findings could potentially lay the groundwork for water management strategies and disaster mitigation measures on the loess plateau.

1.2 What is the challenge we are addressing and what incentivizes us to pursue this research?

Prior to 1967, the mountainous area being examined, which encompasses 13.7 km^2, was unpopulated (X. Hou, S. Vanapalli and T. Li (2018),). In order to facilitate dam construction, inhabitants of the reservoir region were resettled to the loess highland, where they engaged in farming practices. In response to farming needs, a multitude of irrigation canals have been established over time, featuring the ability to extract water from the main river through pumping mechanisms. The collective area covered by these irrigated lands is approximately 7.53 km^2 (L. Xu, F. Dai, L. Tham, X. Tu, H. Min and Y. Zhou, (2011, X. Hou, S. Vanapalli and T. Li (2018),). In the 1980s, the annual irrigation water volume per unit area was recorded at about 0.89 m^3, which then dropped to 0.64 m3 in the 1990s. Despite the region experiencing relatively low yearly precipitation levels, ranging from 316 mm/a to 400 mm/a, the annual evaporation rate remains high at around 1568 mm/a. The substantial impact on the natural hydraulic balance is attributed to irrigation water.

The escalation of groundwater levels in the region resulted in over 70 landslides (Fig. 1(b)), attributed to the prolonged use of flood irrigation for agricultural activities. Despite the significant impact of irrigation-induced landslides, traditional flood irrigation methods persist, especially in areas characterized by multiple cracks along the plateau's periphery. The field harbors a plethora of concealed fractures that reach into the plateau, thereby facilitating the unhindered infiltration of irrigation water into the soil. Field investigations, field monitoring, and indoor experiments are employed in this study to develop a single-seepage model and a dual-seepage model that replicate the seepage process within the designated channel. The research focuses on investigating the seepage

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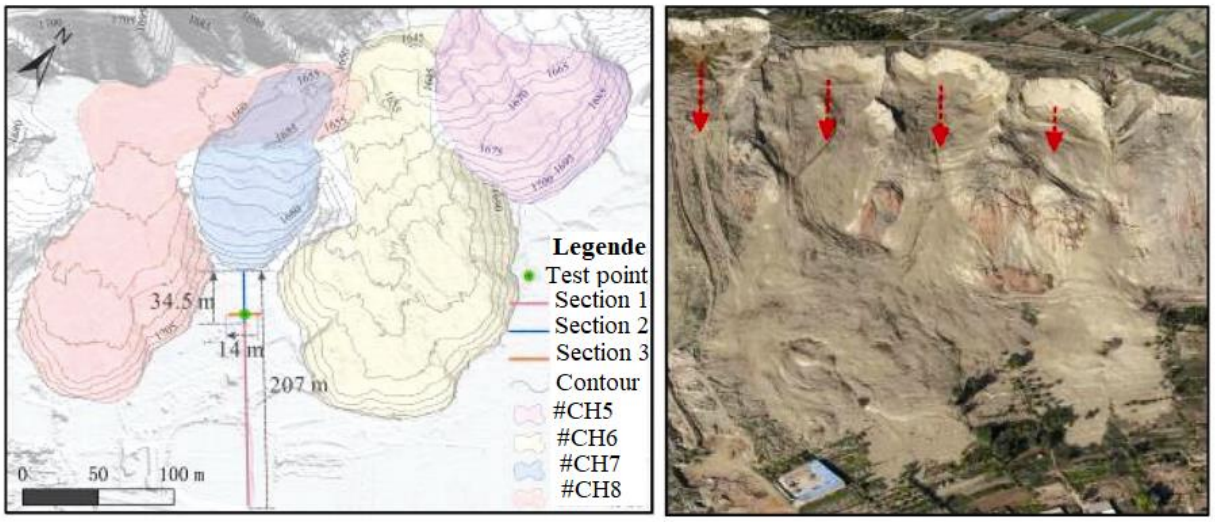
characteristics of water in the presence of concealed cracks by utilizing the back edge of the #CH7 landslip as a field test area (Fig. 1(a)).



(a) Field test section **(b) Landslide due to flood irrigation**

Fig. 1 Overview of the research environment

2. Materials and methods

2. 1 Seepage model

The numerical simulation in the Fluid Flow module of COMSOL software relies on the adoption of the Richards equation. In order to effectively simulate the role of the preferential flow domain in the seepage process, the single seepage model, referred to as the single Richards equation, is initially employed for calculating the seepage characteristics exclusively in the case of matrix flow. Following this, the dual seepage model incorporates two Richards equations, specifically Eqs. (1) and (2), which are able to undergo conversion and interplay with one another (H. Gerke. and M.Genuchten(1993),). The water mass exchange coefficient, as defined by Eqs. (3) and (4) in reference (C. Ray, T. Ellsworth and A. Valocchi (1997)), is employed to characterize the seepage behavior in situations where both the flow domain and matrix domain are present simultaneously. The section where the flow domain extends allows for the dispersion of water into the adjacent soil surrounding the channel domain. This altered water will travel as matrix flow, thereby promoting a faster seepage through the underlying layers.

$$\left[C_f + \Theta_f S_s\right]\frac{\partial h_f}{\partial_t} = \nabla\left[K_f\left(\nabla h_f + \nabla_z\right)\right] - \frac{\Gamma_w}{w_f}, \quad (1)$$

$$\left[C_m + \Theta_m S_s\right]\frac{\partial h_m}{\partial_t} = \nabla\left[K_m\left(\nabla h_m + \nabla_z\right)\right] + \frac{\Gamma_w}{w_m}, \quad (2)$$

$$\Gamma_w = \alpha_w K_a\left(h_f - h_m\right), \quad (3)$$

$$K_a = \frac{K_f + K_m}{2}, \tag{4}$$

In the given formula, the subscripts *f* and *m* are assigned to represent the preferential flow and matrix flow respectively. $C(L^{-1})$ is used to denote the water content, while Θ *(1)* signifies the soil saturation. The variables *h (L)*, *t(T)*, and *z* represent the head height, time, and vertical coordinate respectively. Additionally, $K(LT^{-1})$ stands for the isotropic hydraulic conductivity, $Ss(L^{-1})$ indicates the unit volume water capacity, and *w (1)* represents the volume proportion. Furthermore, $\Gamma_w(T^{-1})$ is the water exchange coefficient of the two equations, $\alpha_w(L^{-2})$ denotes the water conversion rate, and $K_a(LT^{-1})$ signifies the average hydraulic conductivity of the two models (B. Arora, B. Mohanty and J. Mcguire (2011) , H. Laine-kaulio, S. Backnas and T.Karvonen (2014) , W. Shao, T. Bogaard and M. Bakker,(2015)).

The total volume ratio of the two models is equivalent to 1.

$$w_f + w_m = 1, \tag{5}$$

The overall volumetric water content of the soil is the median volumetric water content of the two simulations.

$$\theta = w_f \theta_f + w_m \theta_m; \tag{6}$$

Likewise, the complete hydraulic conductivity of the soil can be calculated.

$$K_s = w_f K_{sf} + w_m K_{sm}; \tag{7}$$

In accordance with this, the initial fixed flow assigned to the model can be apportioned to each model.

$$i = w_f i_f + w_m i_m. \tag{8}$$

The Brooks-Corey function simultaneously characterizes the matrix and preferential flow domains (R. B. a. A. Corey (1964), T. Bogaard and M. Bakker,(2015) , S. Wei , B. Thom , S. Ye et . B. Mark (2016)).

$$\Theta = \frac{\theta - \theta_r}{\theta_s - \theta_r} = \begin{cases} |\alpha_{BC} h|^{nBC} & (\alpha_{BC} h < -1) \\ 1 & (\alpha_{BC} h \geq -1) \end{cases}, \tag{9}$$

$$K = K_s \Theta^{2/n_{BC} + l_{BC} + 2} = K_s |\alpha_{BC} h|^{-2 - n_{BC}(l_{BC}+2)}, \tag{10}$$

$$C = -\frac{d\theta}{d|h|} = \begin{cases} \alpha_{BC} n_{BC} (\theta_s - \theta_r) |\alpha_{BC} h|^{-n_{BC}-1} & (\alpha_{BC} h < -1) \\ 0 & (\alpha_{BC} h \geq -1) \end{cases}, \tag{11}$$

The formula incorporates various elements. The volumetric water content is represented by $\Theta(L^3L^{-3})$, with the subscripts *s* and *r* indicating the saturated and residual water content respectively. The

saturated seepage coefficient is denoted as K_s (LT^{-1}), while the parameters α_{BC}, l_{BC}, and n_{BC} are employed for curve fitting, considering the qualities of the soil and water.

2. 2 Boundary conditions

The geometric dimensions of the numerical simulation are 3 meters wide and 2 meters high, with the upper 1 meter consisting of unsaturated loess, when combined with the field test results. To capture the effects of the seepage domain of the upper unsaturated loess on the moisture content of the lower soil layers, the numerical simulation in Fig. 2 designates the bottom 1 m as saturated loess. The change in the bottom saturated layer can be evaluated when a flow domain is present. The left, right, and lower boundaries are characterized as non-flow boundaries, with the top boundary allowing for seepage flow. Research indicates that Heifangtai practices flood irrigation, with a specific intensity of around 25 mm/h during irrigation sessions. These sessions typically last for close to 4 hours and are conducted approximately 8 times throughout the crop growth cycle. Thus, within the numerical simulation, a high-intensity irrigation rate of 25 mm/h was designated, with a simulation duration of 32 hours. To contrast the simulation results between high and low intensity, a low-intensity irrigation rate of 2 mm/h was employed, with a simulation duration of 400 hours. The total irrigation volume in both scenarios remains unchanged.

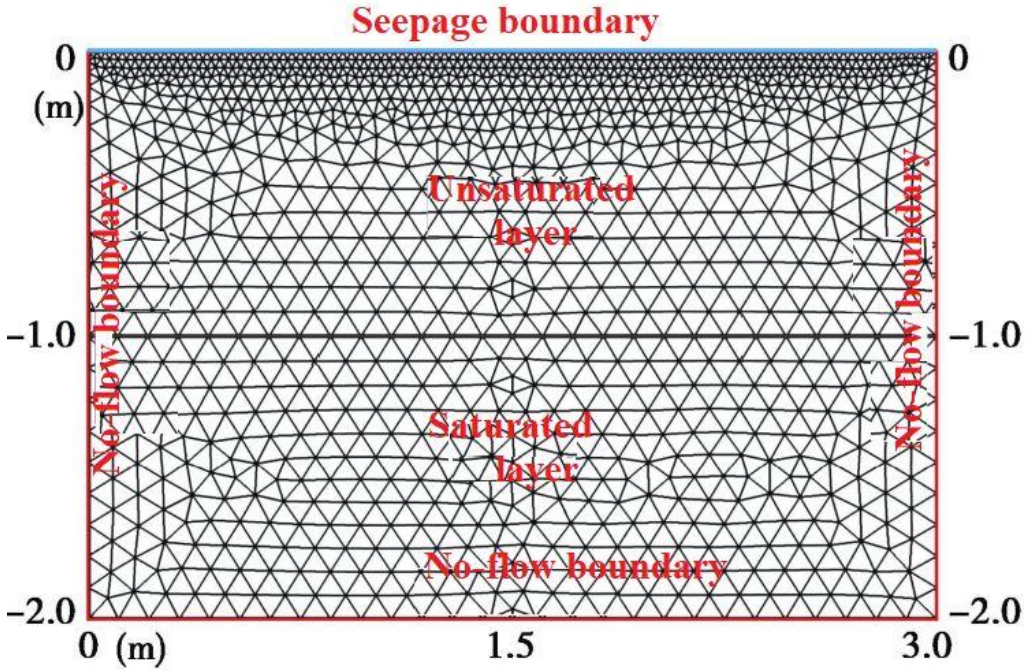


Figure 2 Computational mesh and boundary conditions

2.3 Parameter selection

The flow domain in the soil is characterized by a sparse distribution of channel domains, resulting in a volume ratio *wf* of 0.1. In the single-seepage model, the hydraulic conductivity K_s remains consistent with that of the flow domain. However, in the dual-seepage model, K_s is adjusted by the volume ratio to account for both matrix flow and the flow domain. The determination of K_s is achieved via a single

ring test. Reference (W. Shao, T. Bogaard and M. Bakker,(2015)). provides data on the water conversion coefficient α_w, as well as the Brooks Corey fitting parameters α_{BC}, l_{BC}, n_{BC}, which delineate the relationship between substrate flow and flow domain. Table 2 provides a detailed description of these particular criteria.

Table 1. Parameter Details

Symbol	Designation	Numerical value
θ_s	Saturated water content	0.4
θ_r	Residual water content	0.04
K_s	Saturated seepage coefficient/(cm·h^{-1})	2.56
K_{sf}	K_s/(cm·h^{-1}) of dominant flow	23.49
K_{sm}	K_s/(cm·h^{-1}) of matrix flow	0.2349
α_w	Water conversion coefficient/m^{-2}	0.2
α_{BC}	Brooks-Corey fitting parameters/cm^{-1}	0.068
n_{BC}	Brooks-Corey fitting parameters	0.322
l_{BC}	Brooks-Corey fitting parameters	1

3. Results and discussion

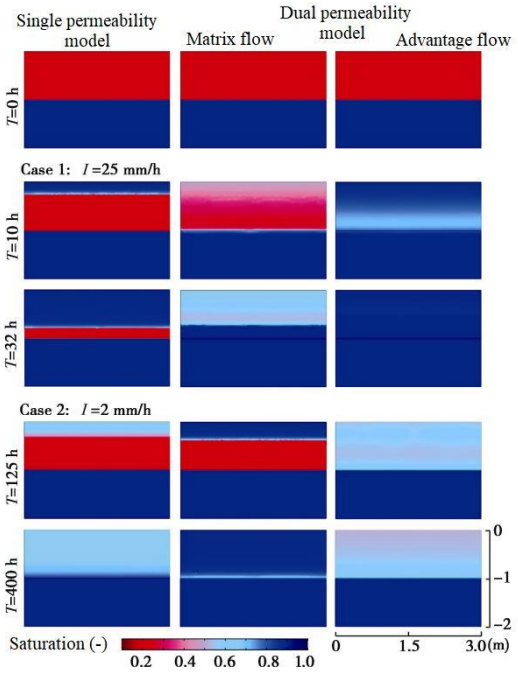


Figure 3 Saturation distribution by different models

3.1 Two-dimensional seepage characteristics

In the field seepage test, a constant water head is applied to mimic high-intensity irrigation practices. The numerical simulation incorporates two simulation conditions: high-intensity irrigation and low-intensity irrigation. The distribution of effective saturation in a two-dimensional manner is visualized in Fig. 3, based on the simulation findings. The left column represents the single seepage model, while the middle column illustrates the matrix flow in the dual seepage model. Lastly, the right column displays the preferential flow in the dual seepage model. For a more thorough analysis of seepage characteristics in different simulation conditions, it is vital to maintain uniformity in the initial simulation conditions and the saturation of the field soil across all simulations.

In the simulation process, the propagation of the wetting front in the single seepage model occurs parallel to the downward direction during both high-intensity irrigation and low-intensity irrigation. Upon reaching the saturated layer, the soil becomes saturated when the irrigation intensity is 25 mm/h. At an irrigation intensity of 2 mm/h, seepage takes place in an unsaturated condition. The dual seepage model's response to saturation demonstrates greater intricacy compared to the single seepage model, due to the interplay between matrix and preferential flows. When high-intensity irrigation is implemented, the irrigation intensity is 10.5 times greater than the saturated seepage coefficient of substrate flow in the dual seepage model. This leads to a linear increase in the effective saturation of matrix flow, reaching approximately 0.6. Following a time span of 28 hours, the groundwater level undergoes an increase, resulting in the saturation at a depth of 0.9 meters attaining a value of 1. Nevertheless, it is crucial to emphasize that the entirety of the area remains unsaturated, as indicated in Fig. 4(a). Concurrently, the effective saturation of the region influenced by the preferential flow wet front steadily rises until it reaches a value of 1, as depicted in Fig. 4(b).

Rapid infiltration of water into the deep layers and subsequent elevation of the groundwater level are attributed to the high saturated seepage coefficient of the preferential flow. The primary mode of water transfer in this context is from the preferential flow to the matrix flow, as shown in Fig. 4(e). The aforementioned statement elucidates that the upper layer of soil remains unsaturated, while the lower layer, known as the saturated layer, continues to experience an increase in moisture content. When low-intensity irrigation is employed, wherein the irrigation intensity is lower than the saturated seepage coefficient of the substrate flow, the water seepage is primarily governed by the flow of the substrate. As the wet front progresses towards the observation point, the saturation of the matrix flow swiftly reaches a value of 1 (Fig. 4(c)).

The findings suggest that the migration of matrix flow in this particular scenario is characterized by saturated migration, a phenomenon that contradicts the simulation outcome of the single permeability model. The effective saturation of the dominant watershed reaches approximately 0.6 after 100 hours and remains constant (Fig. 4(d)). It is evident that the dominant seepage process in this instance is unsaturated.

3.2 Water quality conversion characteristics

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Through the analysis of water quality conversion features under diverse irrigation conditions (Fig. 5), it is observed that at an irrigation intensity of 25 mm/h, considered high intensity, the water seepage undergoes a transformation from preferential flow to matrix flow in all sectors, with the latter emerging as the dominant conduit. Infiltration of water into the matrix basin occurs as it diffuses and seeps through.

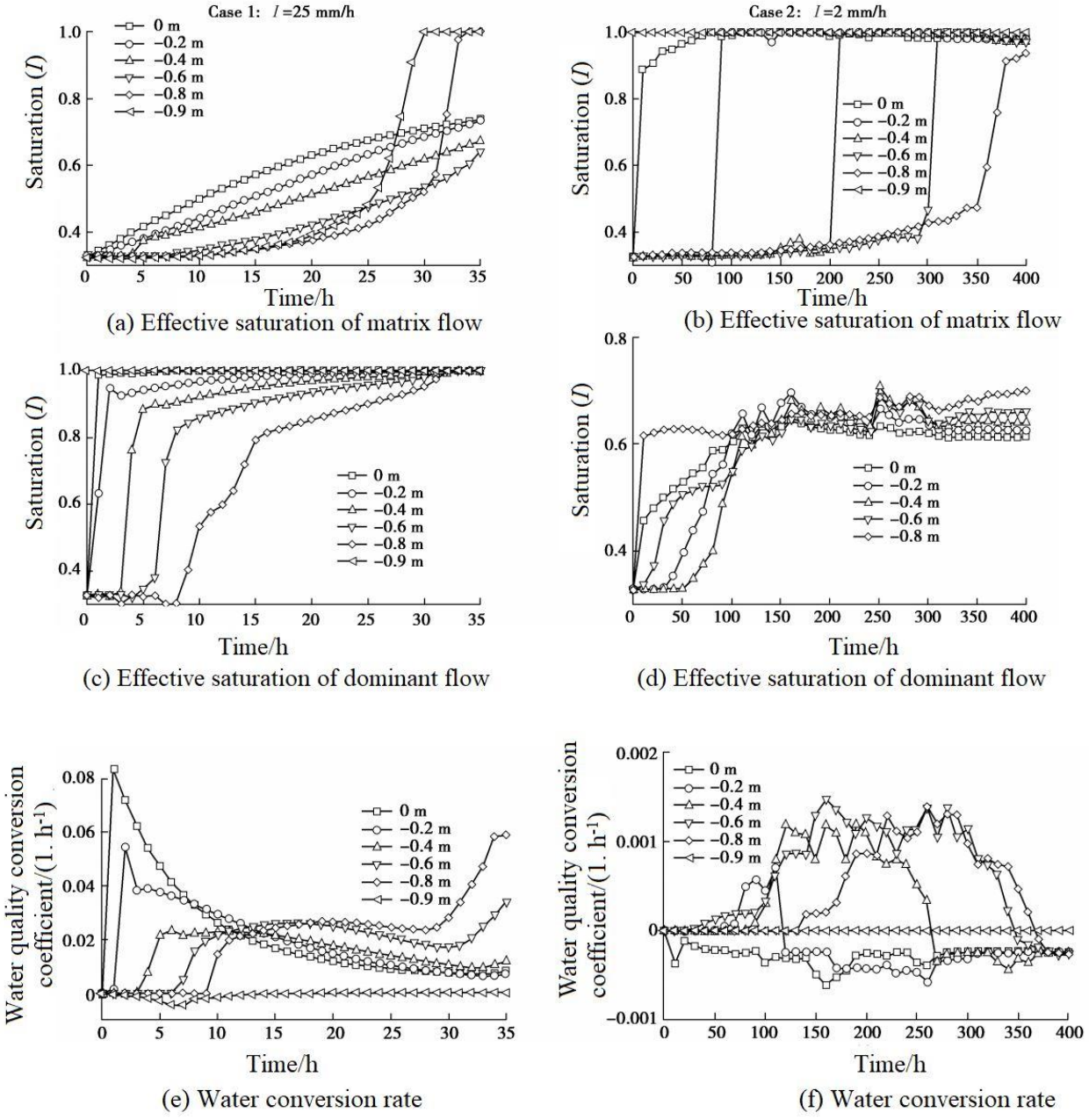

Figure 4 Saturations and water exchange rates by different models

(*Note: The flow from dominant flow to substrate flow is positive,*

and the flow from substrate flow to dominant flow is negative)

The rapid preferential flow enables quick infiltration to the base, causing an elevation in groundwater levels. After 32 hours of seepage, the water level rises, with water quality conversion taking place only near the water level. When the irrigation intensity is set at 2 mm/h, indicating low intensity, the primary water exchange occurs from the substrate basin to the dominant basin. The presence of preferential flow results in a positive water exchange rate during the initial seepage phase. Upon reaching the observation depth, the seepage of the substrate undergoes a transition to negativity, signifying a shift from substrate flow to preferential flow of water. Following a duration of 350 hours, the entire area experiences a negative water exchange rate, indicating the movement of the matrix into the saturated layer.

According to the simulation results, the occurrence of preferential flow facilitates the rapid movement of high-intensity irrigation water towards the base of the slope through the dominant channel. Consequently, this leads to an elevation in the groundwater level, while the top layer of soil remains devoid of moisture. During this computational experiment, various models of infiltration were constructed to assess how preferential flow impacts the infiltration mechanism. It is crucial to acknowledge that the movement of water through soil is a complex phenomenon, and the concept of preferential flow is inherently subjective. Macro-pores and joints within the soil play a significant role as preferential seepage channels for water. Consequently, it is imperative to undertake further investigation and advancements in understanding the impact of preferential flow on the macro seepage process and the underlying mechanism.

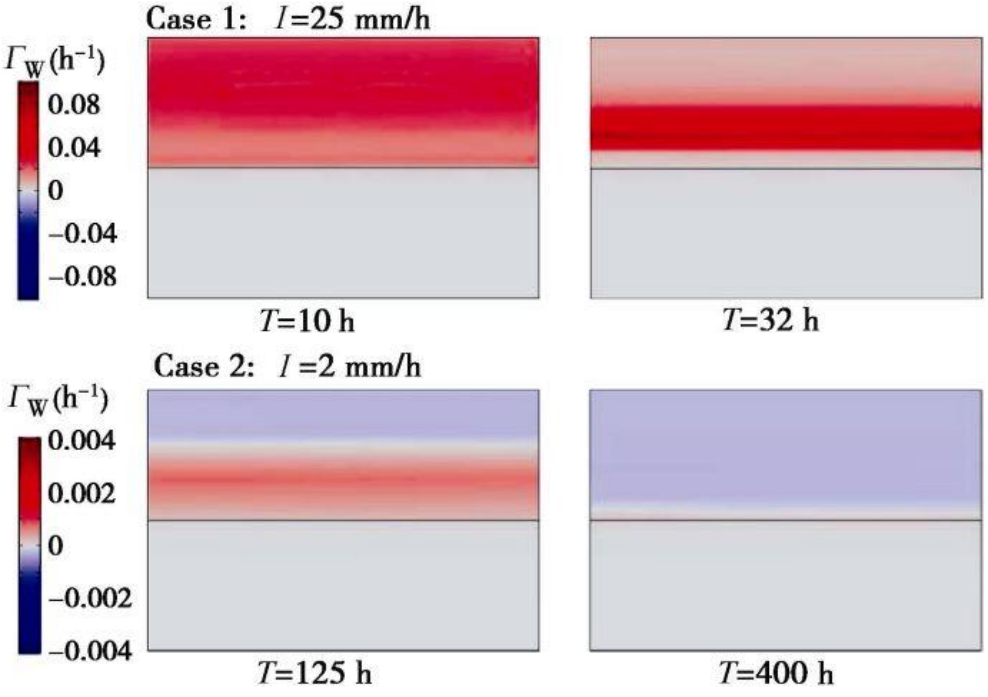

Figure 5 Distribution of water exchange rate

(Note: Red: dominant flow converted to matrix flow,

Blue: matrix flow converted to dominant flow).

4. Conclusion

In this paper, the author delves into the development of characteristic cracks seen on loess plateaus and the process of water seepage that takes place on-site. Furthermore, the study conducts simulations to analyze the water seepage characteristics in the presence of preferential channels, ultimately leading to the formulation some distinct conclusions.

In the realm of numerical simulation, when faced with high irrigation intensity and a short duration, preferential flow assumes a dominant position. This phenomenon allows for the rapid infiltration of irrigation water to the lower layers, consequently leading to an increase in the groundwater level. The unsaturated top matrix flow exhibits high intensity during actual production. The concentrated irrigation or intense precipitation can easily infiltrate the bottom of the slope through preferential channels. In situations where irrigation intensity is low and duration is long, the matrix flow assumes a dominant role. Actual agricultural production may benefit from the utilization of unsaturated seepage, a method that entails prolonged irrigation periods and low irrigation intensity for optimal water conservation and efficiency.

Overall, this research contributes to the existing knowledge on loess plateau fractures and their relationship with water seepage. The findings enhance our understanding of the geological processes occurring in these regions and provide a foundation for future studies aimed at sustainable land management and hazard prevention.

Data Availability

The article provides the data used to support the results of this research.

Declaration of competing interest

No conflicts of interest to disclose.

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Water Scarcity – Türkiye - Konya and Niğde

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Abstract
Water scarcity has become a critical issue globally, exacerbated by climate change, with significant implications for Türkiye, particularly in regions like Konya-Karapınar and Niğde in Central Anatolia. This study examines the causes of water scarcity and its growing consequences in these areas, where once-abundant water resources have dwindled significantly. Through a comprehensive literature review and field observations, the research identifies the primary factors contributing to water scarcity, such as groundwater depletion, improper irrigation practices, and the over-extraction of water through numerous individual wells. The findings highlight the negative effects of water scarcity, including flooding and inundation, and stress the importance of adopting sustainable water management practices. The study emphasizes the need for an integrated approach to water resource management, including the development of collective irrigation systems, proper regulation of water usage, and the implementation of soil conservation and land consolidation strategies. Additionally, it calls for a rethinking of water pricing to ensure equitable access, particularly in light of the anticipated water shortages Türkiye is likely to face in the 2030s. The research concludes that a forward-looking, holistic approach to water, energy, and soil management is essential to address the current and future challenges of water scarcity.

Keywords: Land Use Planning, Urban and Rural Landscapes, Urban and Environment Problems, Water Policies, City and Regional Planning.

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1. Introduction

The water scarcity issue has become a crucial factor due to our current climate problems. The research's aim is the change in water availability in the world and Turkey. The literature review discussed the sources of water scarcity issues, which were confirmed by field practice. The study pointed out that faulty managerial decisions related to water processes in the past 72 years have contributed to the issue. The ineffectiveness of the right decisions was also decisive. Additionally, the study explored the neglect of technical land use and practices on the ground, particularly in Turkey. Unfortunately, the findings and field samples suggest that the results on water scarcity are increasingly spreading in a negative direction.

An interdisciplinary literature review was conducted in the fields of water, agriculture, energy, food economics, planning and politics. Land use maps received by satellites are also used in agricultural land use data. Some data are given in figures and tables. In addition, institutional projects were

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examined for future findings. Many relational issues should also be briefly discussed in the future. With the changes in the use of natural water resources and the increasing requirements for water, the theoretical background of the study can be formed through global warming and climate change agenda.

Water is one of the most critical global challenges of the 21st century. The EU aims to enhance its diplomatic efforts on water to promote peace and stability, support transboundary and integrated water management, safeguard the right to water and sanitation, and implement the UN Sustainable Development Goals and the Paris Agreement. Additionally, it seeks to strengthen the multilateral system, mobilize both public and private sector partners, and ensure these objectives are reflected in its policy dialogue and development cooperation (Ruiz, 2020).

An article examines the state of peace in the Middle East through both regional and international perspectives, highlighting the unfortunate reality that the region remains far from peace in many ways (Umar, 2020). Another article also focuses on the growing water conflicts among subnational actors, including municipalities, states, and provinces, and examines existing conflicts that require innovative hydropolitical solutions at the subnational level, along with preventive measures for potential future conflicts (Yıldız, 2020).

This paper outlines the situation in the Occupied Palestinian Territories (OPT), focusing on the main water-related issues faced by Israel, including disputes with the OPT and Jordan over shared water resources. These issues, such as water allocation, politicization, and privatization, are discussed in detail and following this, the paper reviews the government policies, initiatives, and partnerships designed to address these challenges. Finally, it examines how these measures contributed to the development of Israel's Water Tech industry, with particular emphasis on its key sectors: desalination, wastewater management, water network management, irrigation, and water security (Tepecik, 2021). After revealing the cultural importance of water for countries, the focus is on the strategic role of water use in Türkiye and all over the world.

We are in a period where climate problems are increasingly experienced, so water scarcity has become a particularly important problem. The study examines the water problem in general terms. The decrease in water availability in the world and in Türkiye is heading towards a disaster. In the research, the sources of water scarcity problems were investigated through literature review. Field applications also make errors in water-related processes visible. According to the findings and field examples, the consequences of water scarcity are increasingly negative and show flood and inundation effects.

1.1 Water resources

Since the past century, it can be summarized as the world population and the amount of annual water in the underlying table. In 1900, the population of the world was one billion, it is eight billion now. The water did not have enough due to demand and supply. Türkiye's per capita annual amount of water per thousand seven hundred cubic meters. Now it has begun to fall below one thousand cubic meters. The world's population and the annual amount of water are compared to the years below (Table 1).

Table 1. The world's population and the annual amount of water compared to the years.

Years	World population	The annual amount of water
1900	One billion	1700 m3
2020	Eight billion	<1000 m3

Underground and surface water resources are gradually decreasing, and the increasing population and urbanization rate create significant environmental pollution. Especially crowded settlements exhibit a fragile structure that is exposed to the negative effects of the climate crisis.

The amount of water per capita is gradually decreasing. One of Türkiye's foremost problems is the reduction of loss rates. The network needs to be renewed with infrastructure investments. While the loss-theft ratio (LTR) in the OECD average is 25%, LTR is 50% in Türkiye (OECD, 2016).

1.2 Global warming

Global warming is caused by greenhouse gases. Global warming also especially affects the climate. if we look at the issues from a broad perspective, climate change can form the main framework of environmental problems. Climate change and the consequent global warming continue to threaten the planet.

In recent years, the probability of experiencing climate change in the region where Türkiye is located has increased gradually. In Türkiye, it is not yet possible for people to have in-depth knowledge of climate change. 90% of the population does not have enough knowledge. One of the problem areas that we need to implement to combat climate change is population planning.

The world's first carbon-neutral continent will be Europe in 2050. meanwhile, Türkiye has declared 2053 carbon neutral.

1.3 The climate change

Climate change, which has been occurring for a long time, has also triggered a series of natural disasters that threaten human settlements and have many negative effects. The adaptation of cities to climate change is becoming an important case for all settlements. The effects of climate change have also been an important parameter in the study in terms of water management.

Therefore, agriculture, food and water crises are among the issues that cause concern both in this period and in the future. Despite all this, economic crises, on the other hand, have been at the forefront of the most recurring main destructive phenomena, although it has been difficult to get used to since the beginning of the last century. We have already entered a new century where the resilience of cities is also being questioned.

Management of adaptation for climate change is difficult day by day on this planet. The study focused on agricultural land use planning and rural studies with developments of eco-politics in Türkiye about water resources. The study scope also covers some topics related to hydropolitics (agricultural land use planning, agriculture-food-water policies, city and regional planning, politics, rural development, etc).

The author showed in the last years, the formation of sinkholes was primarily driven by the collapse of karstic cave ceilings, a process accelerated by the excessive use of water in agriculture, which depletes underground water reserves. Administrative records from the last study highlight the urgency of addressing the root causes and reassessing the visible consequences. Failure to do so will only exacerbate the environmental degradation, leading to increased natural and societal losses (Kocalar, 2023).

1.4 Environmental problems, nature-human relationship, and sustainability

The most important reason for the environmental problems increasing with the effect of urbanization is the planning and design approaches where the human-nature relationship and interaction are not analyzed and evaluated, and landscape ecology is not considered (Yıldız, 2017).

In establishing the nature-human relationship, natural landscape features should be evaluated as holistic rather than fragmented (Şahin, 2010). A study in which the sustainability indicators of cities (Atıl, Gülgün, & Yörük, 2005) are given in tabular form clearly shows the problems in artificial areas.

It is seen that Bafa Lake Nature Park, which was once a port and was later formed among the important lakes in Türkiye, and the neighboring Latmos Mountains, which have hosted sacred places with rock paintings in history, have many problems such as quarries that are currently being opened, etc (Kocalar, 2020).

1.5 Türkiye's Wetlands, natural protected areas, and agricultural areas

Türkiye's Wetlands are gradually drying up with global warming (Figure 1).

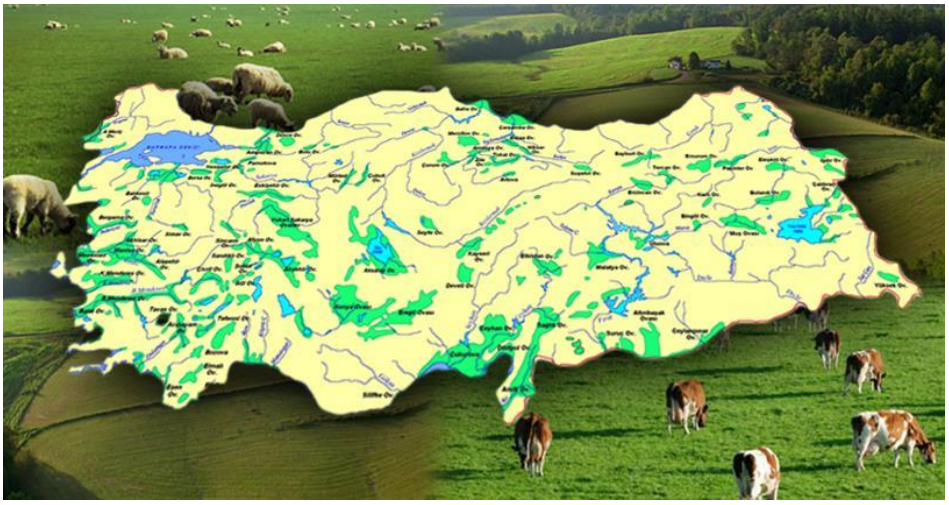

Figure 1. Wetlands of Türkiye.

(Source. https://www.tarimorman.gov.tr/Haber/1102/141-Buyuk-Ova-Koruma-Alani-Olarak-Belirlendi)

Natural protected areas opened for construction by decreasing the protection degree (Figure 2). The natural areas lost in the post-2000 period have increased rapidly.

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Figure 2. Building-zoning decisions and applications in valleys and plateaus (Uzungöl, Trabzon).

Serious losses were also experienced in agricultural areas. As agricultural land is converted into urban land, the images below emerge (Figure 3). Today, urban development is not only losing agricultural lands but also progressing irreversibly by creating continuous destruction in nature. As the peasantry ends, the villages turn into ghost settlements. Those who used to be peasants sold their freedom and became slaves while emigrating to the city.

Figure 3. Examples of urbanization intertwined with agricultural areas (Adana).

Construction was prohibited in these 141 plains, which are under protection against non-agricultural activities in Türkiye (Table 1). Landowners are not allowed to build vineyard houses on these plains, which are under the status of the Great Plain. All kinds of construction activities require the approval of the Soil Conservation Board and the Minister of Agriculture. Buildings can be built for agricultural investment purposes. Within the scope of the Great Plain status, agricultural investments are encouraged in the plains. Within the scope of this investment planning, administrative buildings or houses can be allowed to be built up to a maximum of 75 square meters on agricultural lands in the protected area. Now, there is no application regarding the illegal constructions made on these plains. Among the 141 plains in the list of these plains for which the Soil Conservation Board Decision was taken (Table 2) (Figure 4), 4 of them within the borders of Niğde are presented below.

Table 2. Plains (141 units) for which the Soil Conservation Board Decision was taken.

No	City	Plains
…	…	…
115	NİĞDE	ALTUNHİSAR-ÇUKURKUYU
116	NİĞDE	ÇİFTLİK
117	NİĞDE	AMEN
118	NİĞDE	MİSLİ
…	…	…
141	YOZGAT	BOĞAZLIYAN

(Source. http://www.emlakinfo.com/haberler/m/news.php?id=4396)

The studied area where Akkaya Dam Pond is located was not seen as a plain, and the historically productive vineyards and gardens on the skirts of Melendiz were almost ignored along with this decision. The decisions on Türkiye's agricultural sites are visualized below (Figure 4).

Figure 4. Agricultural protected areas of Türkiye

(Source. T.R. Republic of Türkiye Ministry of Agricultural, Forestry, Rural Affairs-TKİB).

As a result of the lawsuit filed by the Metropolitan Municipality for agricultural lands, which were not on the list in 2016 and which was declared a metropolitan city with the new law, the court decided in favour of the farmers after a long period of research and exploration (RHA Ajans, 2018). High-rise blocks are now rising on the plains that have been opened for construction over time. On the other hand, there are limited lands where agricultural activities continue (Figure 5). The effect created by TOKİ on the texture of Doğanbey residences by distorting the silhouette of Bursa can be seen below (Figure 6).

Figure 5. Agricultural lands where agricultural activities are conducted.

Figure 6. Bursa Doğanbey TOKİ.

(Source. https://www.bursa.net.tr/doganbey-toki-aciklamasi-geldi-11419.html)

An example of the destruction of agricultural lands is also seen in the following statement of the TMMOB Chamber of City Planners (ŞPO/CPO) titled "Cancellation of Southwest Plan is the Decision of Ankara's Need for Balanced Development":

“The economic policies pursued in Türkiye since 1980 have put our cities in a deep impasse. By moving away from industrial and agricultural production, Türkiye is trying to meet the deficit in the production-consumption processes that the capitalist economy needs with ground rent and a construction-based economy that feeds this rent. In line with this model, in the last two decades, our cities have been subjected to continuous demolition and reconstruction processes under the guise of urban transformation, on the other hand, natural and rural areas in the city periphery have witnessed intense structuring.”

While Ankara has lost its historical and cultural values in line with the economic model it has implemented in the recent past, it is seen that the urban sprawl and dense construction in the city periphery have also increased. In this way, Ankara has become a capital city that has lost its rural landscape and production areas as well as its natural areas.

Beyond the construction, irrigation techniques are still not changed. The release irrigation methods in the photo are outdated and leaks, evaporation, etc. It can be used even though it is open to other factors (Figure 7).

Figure 7. Flood irrigation methods and fertile plains should remain in the past.

1.6 Agriculture-Food-Water Ecosystems and Economic-Politics

The fact that agriculture is as vital as energy has become known with the recent increase in food inflation. There is a Living Planet report published every two years. In this report, the loss occurred in fresh waters, where most living things also live. When we look at the living population, it is the life in the water that keeps the water alive. As we play with a living ecosystem, we also play with the quality of the water, we change the time of access to water.

Therefore, we need to look at the sustainability of agricultural activities rather than generating electricity with water. Especially when we think about the increase in the prices of the last agricultural products we live in Türkiye, drought and so on, we need to look at where we should use the water first. Should I first use this water to generate electricity, or should we use it to grow agricultural products?

Apart from energy, which has a large share in the increasing inflation that has occurred since 2021, increases in food inflation also cause serious financial difficulties.

1.7 Cost of Water-Water Rights and Water Policies

Water costs and rights subjects are discussed all over the world. Water cannot be cost-free anymore. Before we can use the water, we lose half of it on the way before we can deliver it. The amount of energy from the water management system you draw from the system to bring the water to the users is also an important cost factor. All of these constitute an economic value.

According to an economist, what can happen when you give water to everyone for free also seems a bit controversial. Then the landscape would be much worse than it is today. Of course, low-income people also must access water, pricing should be done accordingly. There should be equitable access to water, and that is what we must ensure. It is estimated that Türkiye will be water poor in the 2030s.

1.8 Land use in Türkiye

Land use in Türkiye shows the distribution as given in the table (Table 3) below.

Table 3. Land Use in Türkiye

Land Use in Türkiye	%
Flat and Slightly Sloped Areas	8
Medium Slopes and Slightly Wavy Areas	13
Sloping Areas	16
Steep Lands	63

Türkiye-Sentinel-2 10 m. Land Use/Land Cover Timeseries is below (Figure 8).

Sentinel-2 10 m. Land Use/Land Cover Timeseries Downloader: This application provides access to individual 10-meter resolution GeoTIFF scenes for all land masses on the planet, for each year from 2017-2021. All scenes for each year are also available to download as a zip file.

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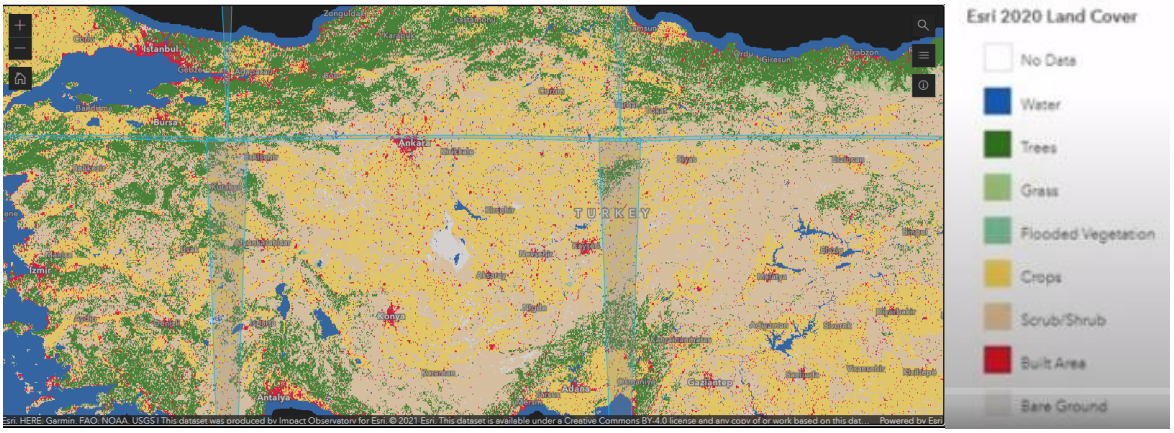

Figure 8. Türkiye- Sentinel-2 (2021). 10 m. Land Use/Land Cover Timeseries (Sentinel-2).

Zip-file: 2017, 2018, 2019, 2020, 2021. Each annual zip download is approximately 60 GB. 10 m. resolution land cover maps - 10 classes (settlement, forest, water surface, agriculture, grassland, open area, etc.) digitized data for 2021.

1.9 Agricultural basins

In 2009, the 30 basins set with the supporting model of agricultural basins in Türkiye are given at the bottom (Figure 9).

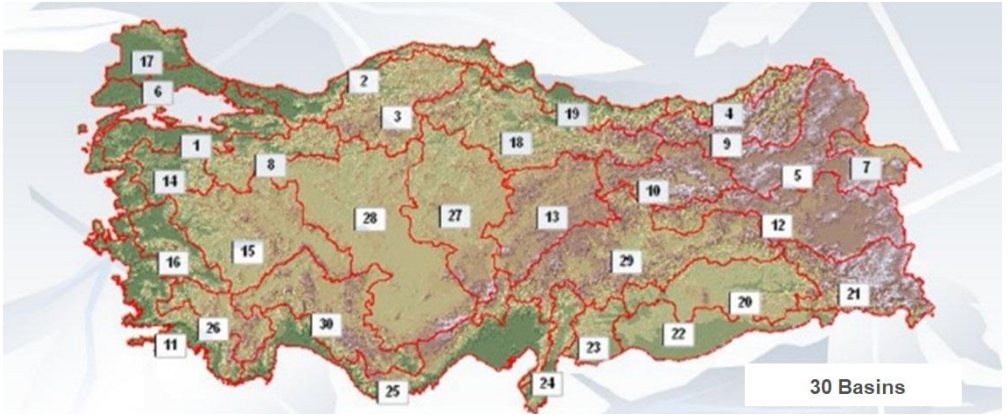

Figure 9. Agricultural Basins Support Model Map (30 basins).

(Source. Republic of Türkiye Ministry of Agricultural, Forestry, Rural Affairs-TKİB).

Among the literature review of the research in agricultural areas, land use problems, as well as water management, are at the forefront. Land use problems have sufficiently revealed the importance of planning. Despite that soil protection and land consolidation are other issues that can bring solutions to the fore in field studies. It can be said that smart water/energy/soil management comes next.

1.10 Soil conservation and land consolidation

Since small family businesses are in most of our country, agricultural lands are increasingly fragmented. Most of the fields have a share ownership structure. Although it changes from time to time according to the Soil Conservation Law, it is not possible to sell agricultural lands under 20 years (5403 numbered and 2005 dated Law). Since there is no individual title deed in shareholding areas, the sale of these areas becomes difficult, and their use remains limited. If the owners of the shared lands can agree, these lands are rented at a certain rate. This rental income is shared by the shareholders for those who save by the rental method. If the land is cultivated by the property owners or by renting, these natural resources are in use. However, other than the cultivated lands, the soil remains uncultivated. This leads to the waste of natural resources, which increases foreign dependency on the country.

1.11 Agricultural water use

Water problems continue to increase in rural areas. Field observations in these areas, which can sometimes be the scene of wild agricultural water use, do not change their destructive character at all because no precautions are taken. However, rural life should set an example for the city and its processes should be protective. Ecological restoration processes should be built to help ecosystem recovery in sensitive areas. Often, an ecosystem in need of restoration has been degraded, damaged, transformed or destroyed as a direct or indirect result of human activities (Society for Ecological Restoration, Science & Policy Working Group, 2004).

1.12 Intelligent resource (soil/water/energy) management

However, the dry agricultural lands of the past, which were brought to water in places, can now be turned into fertile agricultural areas. But these plentiful irrigated areas have also led to wild irrigation. Today's smart water management can be provided with a delay. Therefore, controlling wild irrigation still takes time. In this respect, the importance of intelligent process management is obvious. In addition to water and agriculture, all processes related to energy should be evaluated and managed in parallel from a holistic point of view.

Small family businesses with agricultural activities should be supported and kept alive together with local cooperatives. It should be ensured that they use all natural resources such as water and soil in the most efficient way.

1.13 Konya and Niğde

In Konya and especially in recent years, long-term formations of sinkholes have been important findings for our subject. Similar studies can be done in Niğde, but for now, it is about field trips, geography, and field observations. In the previous field studies conducted in the neighbouring area, these findings are investigated in detail.

An old study revisits the issue of water scarcity by examining the historical evolution of water availability in Niğde, with a particular focus on the findings and field observations concerning water management. A key aspect of the research is its inclusion of a critical field study on the Niğde Akkaya Dam Pond, which has been observed over the past decade. This study highlights the significant changes in water availability in the region, especially in the context of the dam's development. The current state of the Akkaya Dam Pond is a direct consequence of the rapid

changes that have occurred over the last 32 years, reflecting the ongoing shifts in water resource management in the area (Kocalar, 2022).

1.14 Causes of sinkhole formation and solutions

In the field study, the reasons for the formation of sinkholes are discussed under 3 main headings as follows (MTA,2013):

1. Wild watering,

2. Lithological structure,

3. Climate change,

4. Artificial Intelligence (AI) approaches.

The first topic sought for a priority solution should be the prevention of wild irrigation.

1. Wild watering

Although illegal wells can be noticed under control, no deterrent measures have been taken.

The wild irrigation that causes illegal wells is the irrigated farming practices on agricultural land. The cultivated products are corn, sugar beet, etc. and require irrigated agriculture. However, if the region is examined throughout history, it is much more suitable for dry agriculture.

2. Lithological structure

The second topic, which requires an awareness of structural subjects and is the subject of physical field studies, is the increasing changes in the lithological structure. By examining these changes, up-to-date plans should be made, and the right land use decisions should be made accordingly. Risky areas should be moved to new reserve settlements.

With the acidity sensitivity of the soil in the region, the rocks can be dissolved quickly. For this reason, structural dynamics are constantly measured in the field with engineering methods if necessary.

Institutional duties are at the forefront of the measurement requirements. MTA is at the forefront of the relevant institutions due to its duties. Faulting and sinkhole formations in the region are recorded by MTA, and all these field records are the most important plan bases in terms of planning.

In addition, within the scope of various national and international projects, some other institutions and organizations (Development Agencies, Municipalities, Universities, etc.) conduct various measurement studies in the field.

3. Climate change

As far as can be determined from scientific studies and recent field studies, it can be said that climate change continues to increase, creating drought and desertification, especially in the region. In addition, it is known that the dynamics of the earth's crust in the region are constantly changing, and the formation of sinkholes is increasing accordingly.

4. Artificial Intelligence (AI) approaches

The purpose of an article is to highlight how the integration of various methods and techniques can help alleviate agricultural production problems for billions of people in rural areas who base their lives on agriculture and are dependent on agricultural production (Duygu, 2021).

4. Material and Methods

The study re-examines the problem of water scarcity, especially by focusing on this historical change in Konya and Niğde's water presence and the findings and field observations related to water management. Also, Konya and Niğde field studies and findings are particularly important and related references, especially formations of sinkholes.

Previously, studies were conducted on dams and ponds and irrigation canals with a focus on planning the water resources that come to life in Niğde and the visible effects of climate change.

Konya and Niğde Provinces and the visible effects of climate change and water use applications. Throughout history, the place and importance of water in terms of production and sustainability of life have been known for all human settlements. With the climate change in recent years, water is becoming an increasingly valuable mineral.

5. Field Studies

Field studies in Konya and Niğde Province in the Central Anatolia Region are summarized below. While Karapınar and Niğde were rich in terms of water resources in the past, they have become increasingly poor today. It is understood that the groundwater level has fallen to much lower levels than in the past.

5.1 Konya Province

In a report for a project study, research was conducted to determine danger areas by determining the formation mechanisms, development processes and areas of the sinkholes to prevent loss of life and economic losses due to collapses and settlements due to sinkholes, and to guide implementers in agricultural planning. The last chapter is named 'Generalized Conclusions and Recommendations on the development of Sink Development in Konya-Karapınar and its close surroundings' in this report (MTA, 2013).

Groundwater Level

The analysis of the studies conducted during the project and previously in the region showed that the primary factor in the formation of sinkholes is the use of groundwater in the region, which has been increasing since the 1970s. The groundwater level, which is 2-5 m below the surface on average, has decreased to an average of 40 m from the surface in the current (February 2011) location.

Hazardous areas

The nature of the cover over the void areas will also determine the structure of the void that may occur (shallow/deep, dry/wet, narrow/wide diameter etc.). As with other natural disasters, a time-based analysis of when these potentially hazardous areas will collapse is not possible with

currently available data. However, by making regional classifications, general definitions can be made about their relative sizes.

Sinkhole developments

As a result, there is a discontinuity (normal strike fault) detected in the Holocene period activity (about 10 thousand years ago), extending in the NE-SW direction in the north of Karapınar and west of the Sultaniye Plain, which was revealed during the studies conducted by the General Directorate of MTA. Current sinkholes triggered by groundwater level drop depressions (15-20 m in diameter, 8 m in average depth) are also concentrated along this line.

Starting from the north of the Karapınar settlement area, along the NE-SW direction, shallow-depth sinkhole formations occur, while deeper and watery sinkholes develop in the west (city exit-Küpbasan-Akkuyu line) and southwest (İnoba-Hotamış line). It is predicted that in parallel with the increase in the use of groundwater in the periods, the development of potholes will increase.

Water use

It is also beneficial to review the agricultural methods and product types applied throughout the region, which cause excessive water consumption, in a way that will reduce groundwater use. It is of great benefit to switch to the drip irrigation method to prevent the groundwater level from falling due to excessive groundwater withdrawal in the basin.

The recommendations portion of the reports has been extremely valuable to planners and decision-makers.

5.2 Niğde Province

The city taken as an example in the fieldwork is Niğde in the Central Anatolia Region. The environmental relations of Niğde's irrigation dam ponds and especially Akkaya Dam Pond have also been chosen as the research subject.

Niğde is a settlement centre that is seen to have rich water assets in history in terms of water assets. However, today, the underground water level gradually decreases to much lower elevations, giving an alarm for years. In the future, the ponds that have been built recently may also face the danger of drying out because of the climate crisis. According to the project work and the information received from the team identifying the findings in the field, underground water levels decrease in the whole region.

Agricultural activities are quite common in Kaynarca village of Niğde and nearby settlements. However, since irrigated agriculture is prioritized here, there have been occasional collapses in the fields recently. It has moved to its new location near the old ***Kaynarca.***

It is known that similar situations have occurred in the past in Sazlıca, which is adjacent to Kaynarca. However, since these collapsed areas were covered, their exact location is not known. On the other hand, in Sazlıca, zoning is being opened for 2-storey villas in the village.

As stated in previous studies, an open pothole was detected in the mountainous region close to Sazlıca and Kaynarca, as seen in satellite photographs. How this pothole was formed is not known exactly, and since it was not located in a settlement, it remained open.

6. Results

It has been observed that farmers in agricultural basins focus on products that consume more water. Increasingly planting of water-consuming crops in uncontrolled fields has become objectionable.

For this purpose, the results and recommendations of the study are summarized below:

Climate change has turned into a vital crisis.

Cities show serious vulnerability in terms of energy and food supply. We have already entered a new century where the resilience of cities is also being questioned.

Renewable energy projects should be supported excluding water (HES in Turkish or HEPP in English). I think that a hydroelectric power plant should not be built, it is particularly important in agriculture.

Türkiye still needs to make a major reform and improve irrigation systems.

Natural resource management should be brought to the fore with more emphasis. Natural areas and agricultural lands should be carefully protected.

Building decisions should also be discussed in advance with the community.

The welfare of fragile groups needs to be minimally affected by climate change. Their bad affection should be tried to prevent it.

6.1. Discussion

The administrative traces of the research show us that it would be appropriate to critically re-evaluate the apparent results and correct the causes without delay.

7. Conclusion and Suggestion

The subject discussed in this study that the water resource management in agricultural land use planning and rural development. Food, agricultural and energy policies have a strategic importance to ensure that every country, especially Türkiye. For such reasons, the planning area has come to the fore in many current issues that gradually increase its importance. The cities taken as examples in the field study are Konya-Karapınar and Niğde in the Central Anatolia Region. National dynamics adapted to global market conditions, as can be seen from the field examples above, have been turned into products and profit-oriented services, in short, they have been commodified.

As a result of every small farmer drilling a well in his garden, countless holes are formed in the volcanic ground, which has a porous character. These holes can also cause water to escape to quite different areas underground. Numerous wells cause both the reduction of water resources and the indirect pollution of these resources.

In addition, excessive energy is consumed for the water drawn by the motor of each well. In today's consumer society, such comfort conditions cause unnecessary consumption. The preferences that create the possibilities of using water by keeping it under special control in this way are the

predominant consumption preferences of today, rather than agricultural production. However, instead of opening separate wells, a common irrigation system should be established. The water system should operate at appropriate times and irrigate without the need for human supervision. However, only the relevant agricultural lands that are permitted and cultivated need to be irrigated regularly. Thus, wild, and uncontrolled irrigation will be prevented

Although the Central Water Administration (DSI) knows about the illegal wells in the region, it leaves them unsupervised. In places with an irrigation system, paying a water fee per acre is deemed sufficient, so those who over-irrigate cannot be detected. Unless the type of planting is determined and kept under control, crops that require excessive water will be planted and increased water requirements will come to the fore. Additionally, since it is not on the meter, water usage time and amount cannot be measured.

On the other hand, the importance of soil conservation and land consolidation in rural areas and especially in agriculture is better understood in this study. If the land is cultivated in most agricultural lands, these natural resources are in use. However, waste of natural resources is caused in areas other than cultivated lands.

Dry agricultural lands, which have been brought to water in places, can now be turned into productive agricultural areas. But all these processes should be evaluated and managed in parallel from a holistic point of view. This is only possible with today's smart water/energy/soil management. Otherwise, starting from faulty land uses, the number of faults increases along with the precedents.

Water costs and rights subjects are discussed all over the world. Water cannot be cost-free anymore. Before we can use the water, we lose half of it on the way before we can deliver it. The amount of energy of water you draw from the water management system to deliver the water to the users is also an important cost factor. All of these constitute an economic value.

Of course, low-income people also must access water, so pricing should be done accordingly. There should be equitable access to water, and that is what we must ensure. Since it is predicted that Türkiye will be water-poor in the 2030s, today's water management should be done by considering the difficult conditions of the future.

As climate-related challenges continue to intensify, water scarcity has emerged as a critical issue, particularly in regions such as Konya-Karapınar and Niğde in Central Anatolia, which once boasted abundant water resources but are now facing significant shortages. This study emphasizes the urgent need for improved water resource management, particularly in agricultural land use planning and rural development. The over-extraction of groundwater through numerous individual wells, along with inefficient irrigation practices, exacerbates the depletion and pollution of water resources. The study highlights the necessity of transitioning from fragmented, individual water use to a collective irrigation system, which could significantly reduce waste and ensure more sustainable water consumption.

Additionally, it underscores the importance of proper monitoring and regulation of water usage, especially in areas where irrigation systems are in place, yet excessive water usage remains untracked. The lack of efficient water metering further contributes to the over-irrigation of crops, which is exacerbated by the absence of proper crop-water matching. The study also stresses the

need for land consolidation and soil conservation, which are essential to mitigate the adverse effects of uncontrolled land use and to make the most of available water resources.

Considering the potential water scarcity Türkiye may face by the 2030s, it is crucial to implement strategic, sustainable water management policies today. These should consider future challenges, ensuring equitable access to water while addressing the economic and environmental costs associated with water management. Equitable water distribution, alongside innovative solutions such as smart water, energy, and soil management, will be key to preventing further resource depletion and to safeguarding water availability for future generations.

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