

DETERMINANTS OF WATER USE IN AGRICULTURE: AN ANALYSIS OF
IRRIGATION UNIONS IN TÜRKİYE

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submitted by **MEHMET EMİN BİLDİRİCİ** in partial fulfillment of the requirements for the degree of **Master of Science in Economics, the Graduate School of Social Sciences of Middle East Technical University** by,

Prof. Dr. Sadettin KİRAZCI
Dean
Graduate School of Social Sciences

Prof. Dr. Onur YILDIRIM
Head of Department
Department of Economics

Assoc. Prof. Dr. Pınar DERİN GÜRE
Supervisor
Department of Economics

Examining Committee Members:

Assoc. Prof. Dr. Münis Seven AĞIR (Head of the Examining Committee)
Middle East Technical University
Department of Economics

Assoc. Prof. Dr. Pınar DERİN GÜRE (Supervisor)
Middle East Technical University
Department of

Prof. Dr. Hakkı Ozan ERUYGUR
Ankara Hacı Bayram Veli University
Department of Economics



I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last Name: Mehmet Emin BİLDİRİCİ

Signature:

ABSTRACT

DETERMINANTS OF WATER USE IN AGRICULTURE: AN ANALYSIS OF IRRIGATION UNIONS IN TÜRKİYE

BİLDİRİCİ, Mehmet Emin

M.S., The Department of Economics

Supervisor: Assoc. Prof. Dr. Pınar DERİN GÜRE

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Water is an indispensable resource for life on Earth. Due to its indispensability for life, the fact that the price of water is far below its economic and life value prevents the formation of an awareness of use that will be proportional to its limited resource. With the prediction that the water scarcity problem will become more severe with global warming, developing policies to reduce water use is essential. It is usual for these policies to be implemented with priority to the agricultural sector, which has the largest share in water use, such as Türkiye. Therefore, this thesis analyses the determinants of water use in terms of parameters such as water use handling fee (WUHF), number of rainy days, evaporation rate, and cultivated area. To the best of our knowledge, this is the first research conducted in Türkiye examining the factors determining agricultural water usage, integrating climatic data with an econometric analysis of water use handling fee. As a scope, the data of irrigation unions operating in the areas under the responsibility of the regional directorates of the General Directorate of State Hydraulic Works across Türkiye are aggregated at the regional level. The coefficients are estimated using the maximum likelihood structural equation model. The results support the first hypothesis that water use handling fee,

cultivated areas, and water consumption values from the previous year statistically affect water consumption. The study provides statistical data on the effects of agricultural water use.

Keywords: Irrigation Unions, Water Price, Irrigation Water



ÖZ

TARIMSAL SU KULLANIMINI BELİRLEYEN FAKTÖRLER: TÜRKİYE'DEKİ SULAMA BİRLİKLERİ ÜZERİNE BİR İNCELEME

BİLDİRİCİ, Mehmet Emin

Yüksek Lisans, İktisat Bölümü

Tez Yöneticisi: Doç. Dr. Pınar DERİN GÜRE

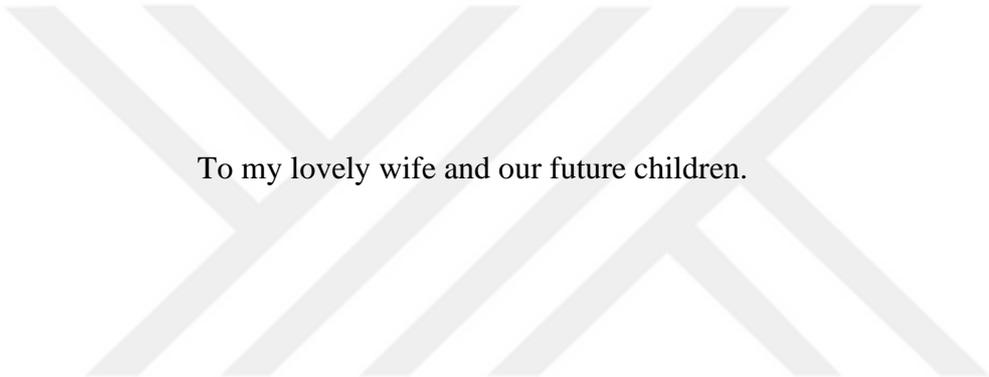
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Su, yeryüzündeki yaşam için vazgeçilmez bir kaynaktır. Yaşam için vazgeçilmez olması nedeniyle suyun fiyatının ekonomik ve yaşam değerinin çok altında olması, sınırlı kaynağı ile orantılı olacak bir kullanım bilincinin oluşmasını engellemektedir. Küresel ısınma ile birlikte su kıtlığı sorununun giderek daha ciddi bir hal alacağı öngörüsüyle, su kullanımını azaltmaya yönelik politikalar geliştirilmesi elzemdir. Bu politikaların Türkiye gibi su kullanımında en büyük paya sahip olan tarım sektörü öncelikli olarak uygulanması gayet normaldir. Bu nedenle bu tez, su kullanımının belirleyicilerini su kullanım hizmet bedeli (SKHB), yağışlı gün sayısı, buharlaşma oranı ve ekili alan gibi parametreler açısından analiz etmektedir. Gerçekleştirdiğimiz literatür taramasına dayanarak ifade etmek gerekirse, bu çalışma Türkiye'de tarımsal su kullanımını etkileyen faktörleri inceleyen ve iklimsel verileri su hizmet bedelinin ekonometrik analiziyle birleştiren ilk çalışmadır. Kapsam olarak, Türkiye genelinde Devlet Su İşleri Genel Müdürlüğü'ne bağlı bölge müdürlüklerinin sorumlu olduğu alanlarda faaliyet gösteren sulama birliklerinin verileri bölgesel düzeyde birleştirilmiş ve maksimum olasılık yapısal eşitlik modeli ile katsayılar tahmin edilmiştir. Sonuçlar, su kullanım hizmet bedelinin, ekili biçili alanın ve önceki yıla

ait su tüketim değerlerinin su tüketimi üzerinde istatistiksel olarak anlamlı bir etkisi olduğu yönündeki ilk hipotezi desteklemektedir.

Anahtar Kelimeler: Sulama Birlikleri, Su Fiyatı, Tarımsal Sulama





To my lovely wife and our future children.

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LIST OF ABBREVIATIONS

BC – Bias Corrected

BIC – Bayesian Information Criteria

CA – Cultivated Area

GMM – Generalized Method of Moments

ML-SEM – Maximum Likelihood Structural Equation Modelling

QML – Quasi-Maximum Likelihood

RD – Rainy Day

SRMR – Standardized Root Mean Square Residuals

TE – Total Evaporation

TR – Total Rain

WC – Water Consumption

WUHF – Water Use Handling Fee

CHAPTER 1

INTRODUCTION

The "rule of thirds," agreed upon by many studies on survival in the wild, states that humans can survive 3 minutes without air, three days without water, and three weeks without food. Based on this argument, it is again clear how vital water is for human life. Water is undeniably essential not only because of its direct impact but also in terms of food security. Throughout history, the agricultural sector, which has always been synchronized with food, has continuously developed in areas where natural water resources are abundant and regular.

It is undeniable that water is an indispensable resource for efficient agricultural production. The agricultural sector, carried out around natural water resources with surface irrigation methods, has also spread to more comprehensive and relatively arid areas in terms of water to feed the increasing human population. In order to overcome the lack of water in these arid areas, humankind has used technological developments and ensured sustainability in agriculture. With the expansion of agricultural areas and decreased water resources, the idea of charging for water has yet to emerge throughout history. Although the issue of charging for water varies in many countries and cultures, it is generally organized to protect existing water resources instead of pricing an economical product. In Türkiye, although there are regional differences in this regard, the idea of a water usage service fee has been adopted instead of a water price. With the pricing of water, its economic analysis has also come to the agenda, and many academic studies have been published worldwide and in Türkiye. These studies, shared in the literature review section, generally aimed to explain the relationship between water fees and water consumption and the effects of possible changes on economic welfare. In this context, mainly when the domestic literature is analyzed, it is observed that there are many review articles on

agricultural irrigation methods and policies. However, a country-wide Türkiye study on the economic relationship between water consumption and price has yet to be conducted. In this context, this thesis is the first study that not only facilitates the understanding of the structure and legal infrastructure of irrigation unions, which have the largest share in agricultural irrigation in Türkiye but also reveals the statistical relationship of the factors determining water consumption with a nationwide data set in Türkiye. The most significant output of the thesis is that it shows the expected negative and statistically significant relationship between water consumption and water use handling fees. In this way, it provides a scientific basis for the idea that water use handling fees can be used as a tool in policies to be established to encourage water saving. Nevertheless, raising water prices may impose an additional strain on agriculture amid escalating production costs. Hence, policymakers should explore alternative policy combinations, such as increasing water prices to deter unnecessary usage while subsidizing farmers to alleviate production expenses, thereby ensuring uninterrupted agricultural production and averting further price escalation, especially during periods of hyper inflation. The following chapters of the thesis explain the history of agricultural irrigation in Türkiye and irrigation unions' legal and historical development.

The study's data set and model section present the characteristics of the data used in the study and the theoretical background of the model. The thesis concludes with the results of econometric analyses and policy recommendations based on the outputs.

1.1. History of Irrigation in The Territory of Türkiye and The Historical Development of Irrigation Institutions

Two primary water resources of Mesopotamia, Euphrates and Tigris, spring from the eastern part of Anatolia. Besides these rivers, there are several more water resources like Kızılırmak and Yeşilirmak. Due to these water resources, the land called Anatolia, where the modern Republic of Türkiye resides, has always been considered decadent regarding water resources. Many civilizations, including the Hittites, Rome, and Egypt, competed with each other to capture control of these water resources. Having many water resources and rich farmlands made Anatolia one of the most developed

parts of Earth in terms of water management and distribution systems. The remains of dams, irrigation canals, and water collection structures date back to the 2nd millennium BC, the Hittite period in Central Anatolia. Several dams, irrigation canals, and qanats date back to the first half of the 1st millennium BC, the Urartu period in Eastern Anatolia (Öziş, 2015). When Rome ruled Anatolia, they constructed long-distance water conveyance and distribution systems to provide enough water for big cities. Each civilization, from the Hittites to Rome and Byzantine, which reigned over Anatolia, inherited the water distribution systems and tried to develop even more. When it comes to the Ottoman era in Anatolia, the population of the major cities like İstanbul and Konya increased significantly, and as a result of this, providing water for the people who lived in these cities became one of the major problems of the ruling dynasty.

To solve this problem, Ottomans built great aqueduct bridges to deliver fresh water to the cities. In addition to building water infrastructure for household usage, there were many intentions to develop irrigation water systems like the Konya Plain Irrigation Project.

The Ottoman Empire did not catch up with the Industrial Revolution's technology. Consequently, Ottomans could not convert their economic activity from agriculture to industry. Unlike its competitors, its economy strictly relied on agricultural production even in the late 1800s. Due to this situation, there were many attempts to improve irrigation infrastructure, yet many failed because of the beginning of the Balkan Wars and the First World War.

In Türkiye, the construction of water structures during the Ottoman Period was primarily undertaken by charitable organizations. However, unlike projects like the Konya Plain Irrigation, significant advancements in water infrastructure were limited. The pivotal shift towards systematic water management began with the establishment of the "Umur-u Nafia Directorate-i Umumiyesi" in 1914, as part of the Ministry of Public Works restructuring efforts. This Directorate assumed critical responsibilities, including irrigation, flood protection, river transport, and water distribution, laying the groundwork for organized water resource management. Türkiye embarked on comprehensive efforts to harness and develop its water resources, particularly during

the 1930s. Despite the establishment of Water Works Directorates in key regions like Bursa, Adana, Ankara, Edirne, and İzmir in 1925, progress was hindered by inadequate monitoring and financial constraints, limiting the extent of infrastructure development. The severe drought and famine of 1929 underscored the urgent need for centralized water management, leading to the establishment of the "General Directorate of Waters." One of the hallmark achievements in Türkiye's water infrastructure was the construction of the Çubuk I Dam, which became operational in 1936, serving as the Republic's inaugural dam and providing vital water supply to Ankara. This milestone marked the beginning of a series of ambitious dam projects across the country. In subsequent years, initiatives such as the Gölbaşı Dam (1938) in Bursa and the Gebere Dam (1941) in Niğde were launched, further bolstering Türkiye's water management capabilities. Additionally, significant efforts were directed towards the construction of dams in various regions, including the Sihke Dam (1948) in Van and the Porsuk I Dam (1949) in Eskişehir, addressing both water supply and hydroelectric power generation needs. Furthermore, comprehensive studies and discussions were conducted on the arrangement and utilization of natural lakes, such as Gölcük in Isparta, Keşiş, Doni, and Armenians in Van, Işıkli in Denizli, Marmara in Manisa, and Eymir in Ankara. The establishment of the "Directorate of Water Works" in 1939, under the auspices of the Ministry of Public Works, marked a significant milestone in Türkiye's water management journey. Subsequent legislative measures, including the "Law on Rice Cultivation" (1936) and the "Law on Protection against Floods and Floods" (1943), laid the foundation for the establishment of the State Hydraulic Works under Law No. 6200, further solidifying Türkiye's commitment to comprehensive water resource management and infrastructure development.

The Water Works Organization was reorganized in 1953. With the law numbered 6200, which was accepted on 18.12.1953 and entered into force on 28.02.1954, its powers were increased, and the General Directorate of State Hydraulic Works was established under the Ministry of Public Works, with an annexed budget and legal personality. As of February 2024, the State Hydraulic Works operates through 26 regional directorates (State Hydraulic Works, 2021).

With the foundation of State Hydraulic Works, water management and distribution infrastructure have become significant concerns for this institution. Through time, the State Hydraulic Works mainly manages and distributes water for irrigation. However, to make it more efficient and reliable, the management of some irrigation water resources is delivered to private organizations like irrigation associations. The legal status of water associations has changed many times, but they currently work under the authority of State Hydraulic Works with their legal entity.

The State Hydraulic Works has also operated the areas opened for irrigation. Until 1993, State Hydraulic Works handed over the small grids with an area of less than 2000 hectares to the users. Since 1993, the transfer work has been accelerated, and the transferred area has reached 2.090.330 hectares at the end of 2008. The total net area opened for irrigation by State Hydraulic Works at the end of 2013 is 3.443.000 hectares, and the transferred area is 2.745.751 hectares. 1.954.494 hectares of this have been transferred to irrigation unions (Kaya and Çiftçi, 2016)

Irrigation management is operated by five organizations: governmental organizations, water cooperatives, water associations, local authorities, and civil irrigations. Most of the facilities operated by other than public authorities were built by State Hydraulic Works and then delegated to non-public organizations (Özçelik, 1999). Irrigation unions now operate 84.9% of the delegated facilities (State Hydraulic Works, 2021). This statistic indicates that irrigation unions manage the vast majority of irrigation. The first legal process for irrigation unions was taken with the Municipality Law No. 1580, which entered into force in 1930. With this law, irrigation unions are like local administration unions, and the General Directorate of Local Administrations of the Ministry of Interior carried out their establishment and administrative control. The regulation numbered 4272, enacted in 2004, was amended in the municipal law. However, since this law does not contain a special section on establishing irrigation unions, a legal gap has emerged for the unions. This gap was tried to be filled with the Local Administrations Law No. 5355 enacted in 2005, but it could not offer a permanent solution that would solve the problems in the activities of the unions. In order to find a permanent solution to these problems, Law No. 6172 on Irrigation Unions was issued and put into effect in 2011. With this law, the establishment of

irrigation unions has become possible by the direct water user farmers with the approval of the relevant ministry. With Law No. 6172, irrigation unions have become legal entities that choose their management. Between 2011 and 2018, many operational problems arose in the irrigation unions managed by their assemblies and managers, and irrigation unions have yet to become unable to carry out their primary task, irrigation activities. In order to find a permanent solution to these problems and to make irrigation activities sustainable, some arrangements were made in law no. 7139. After this change, the legal personality of the irrigation unions continued; only their presidents were appointed from among public employees for a limited time.

1.2. Irrigation Unions and Role of Unions in Agricultural Water Usage in Türkiye

Concurrently with the global shift towards agricultural irrigation management being handled by entities that directly benefit from irrigation services rather than the government, the extensive irrigation projects administered by the State Hydraulic Works in Türkiye have been delegated to independent organizations with legal autonomy.

In this context, Table 1 presents the allocation of irrigation areas transferred by the State Hydraulic Works to water user organizations. The majority of these transferred irrigation areas are managed by irrigation unions, as depicted in Table 1. Consequently, policies related to agricultural irrigation must consider the operational mechanisms of these irrigation unions and the factors that influence their water consumption. By considering these factors, the relevant policies can achieve the desired outcomes.

Table 1. Allocation of Irrigation Areas Transferred by the State Hydraulic Works

	Percentage Allocation
Irrigation Union	85%
Irrigation Cooperatives	6%
Municipality	6%

Others	3%
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Source: State Hydraulic Works, 2021.

The first irrigation union in Türkiye was established in 1967. Despite this, there has been no significant development in irrigation unions due to the policy that the state mainly does irrigation management. Since the mid-nineties, the number of irrigation unions has increased, and significant developments have been experienced in the unions' structures, with the policy of transferring the irrigation fields operated by the public hand to the organizations with their legal personality. While 183 irrigation unions were responsible for the irrigation of 893.764 hectares of land in 1995, the number of irrigation unions increased to 287 in 1998, and the area irrigated by these unions increased to 1.350.955 hectares. Today, according to the data for 2021, a total of 183 irrigation unions continue their activities actively, and these unions operate an area of 2.303.584 hectares (State Hydraulic Works, 2021).

1.3. Institutional Structure of Irrigation Unions

1.3.1. Membership

Law No. 6172 on Irrigation Unions defines the real or legal person who makes or will do irrigation in the field of duty of irrigation unions as a water user. The rights and responsibilities of the irrigation union members are recorded by the mutual agreement signed with the union presidency when the water user becomes a union member. This contract is called "Utilization of Irrigation Facility Contract". Since this contract is a legal agreement between two parties, it is an essential legal basis.

Although the irrigation business is a public service, irrigation unions are businesses managed according to private law rules. For this reason, this agreement on irrigation between the parties is insufficient for evaluating the relevant work by public law. This contract, a condition for being a union member, was brought to increase the participation rate of the management of the irrigation union. The rights and responsibilities of the said enterprise and water users have been clearly stated, and it has been ensured that they receive fairer, faster, and quality service in cooperation and solidarity with the irrigation union.

Law No. 7139 has been arranged in such a way as to constitute a participatory structure that allows each water user within the jurisdiction of the irrigation union to communicate with the union management and convey their demands without any discrimination.

The membership statistics of irrigation unions, indicating the current status, can be found in Table 2, which provides relevant information.

Table 2. Membership Statistics of Irrigation Unions

	2016		2017		2018		2019		2020	
	Water User	Union Members	Water User	Union Members	Water User	Union Members	Water User	Union Members	Water User	Union Members
T O T A L	616.512	255.631	642.434	261.571	689.986	328.013	756.359	431.725	756.918	491.606

Source: State Hydraulic Works, 2021.

As evident from the data presented in Table 2, membership figures show a consistent upward trend. This data suggests that the recent amendment in Law No. 6172 has favorably impacted the participation rate.

1.3.2. Organizational Structure of Irrigation Unions

The enactment of Law No. 7139 resulted in consolidating all operational, maintenance, and management responsibilities under the leadership of the union presidency, requiring union presidents to be appointed from among public officials. The primary

objective of appointing public officials as union presidents is to prevent potential harm to the public and ensure cost-effective determination of water usage fees by maintaining strict financial discipline. The union's organizational structure comprises three key components: Union Manager, Operation and Maintenance Unit, and Administrative and Financial Affairs Unit. The union president establishes the union's organization by acquiring the responsibilities and authorities outlined in Law No. 7139 and obtaining approval from the State Hydraulic Works Regional Directorate. Figure 1 visually represents the irrigation union's organizational structure and institutional body.

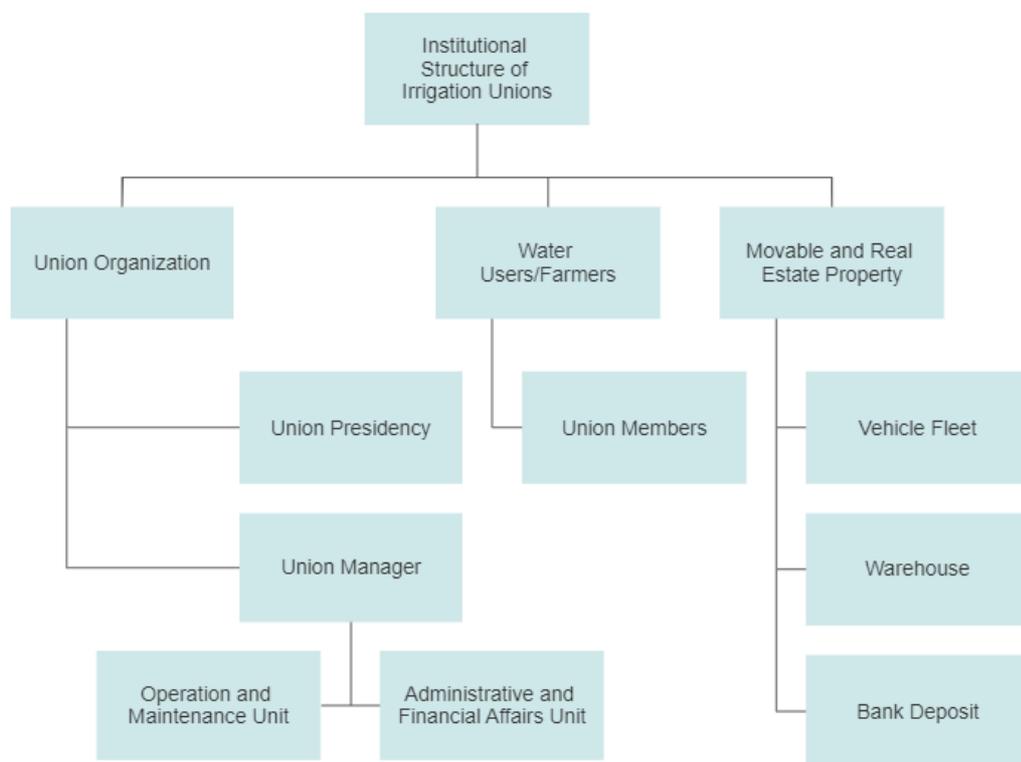


Figure 1. Institutional Structure of Irrigation Unions

The union manager assumes responsibility for efficiently operating the union's irrigation facilities, developing work programs for the maintenance and repair units, and ensuring coordination among the various units. To qualify as union manager, individuals must hold a degree from a faculty or a high school that provides essential training in irrigation planning, plant water consumption, and maintenance and repair services for irrigation facilities.

The operation and maintenance unit comprises an adequate number of employed personnel responsible for operating, maintaining, repairing, and managing the union's facilities.

The administrative and financial affairs unit is responsible for handling internal and external communication for the union and managing the collection and recording of income and expenses.

Water users are the actual or legal persons who make or will do irrigation in the field of duty of irrigation unions, as described before. Union members are the ones who signed the "Utilization of Irrigation Facility Contract" with the union.

The vehicle fleet consists of equipment like excavators and trucks to run the union's daily operations and maintain the facility.

The warehouse is the storage facility to keep union equipment like water pump. Bank deposit refers to placing money or funds into a bank account in the union's name.

1.3.3. Water Use Handling Fee

The water use handling fee, which serves as the primary income for irrigation unions, should not be mistaken as the actual "price of water." The term "Water Use Handling Fee" refers to the costs associated with operating, maintaining, and repairing the infrastructure required to transmit and distribute water from its source to the field without any profit included. Consequently, the Water Use Handling Fee does not encompass the investment costs of the irrigation system and its components, the opportunity cost of choosing the irrigation project over the next best alternative, and any external costs. It also does not incorporate additional values, such as the enhanced productivity resulting from snow and irrigation.

Irrigation unions utilize the income generated from the water use handling fee to cover all expenses related to the transmission and distribution of water from the source to the field.

The tariffs for the water use handling fee imposed by these unions differ from one another due to various factors, including the qualitative and quantitative characteristics of the facilities (such as the irrigation system, water supply method, pumping technique, and age of the facility), as well as the specific irrigation method, rate, plant pattern, and agricultural practices employed by the beneficiaries of the facility.

The water use handling fee in irrigation unions can be calculated based on various factors, such as the type of irrigated crops, the area of land irrigated (in TL/da), the number of irrigation cycles (in TL/trip), the duration of irrigation (in TL/hour), or the volume of water used (in TL/m³). In irrigation networks where water can be measured in cubic meters, the water use handling fees are determined by considering a threshold fee per cubic meter, as stated in the tariff.

In 2020, the water use handling fee was determined primarily based on the land area irrigated, accounting for 89% of the irrigated water. The amount of water used contributed to 7%, the number of irrigation cycles accounted for 3%, and the irrigation duration contributed 1% of the irrigated water. In terms of irrigation methods in 2021, 71% of the total irrigated area relied on gravity water supply, 19% came from pumped irrigation fields, 3% from underground irrigation wells, and 6% from unregistered underground irrigation wells (State Hydraulic Works, 2021).

As irrigation unions must maintain a balanced budget without generating profits, they use data from the current year to determine the following year's water use handling fee tariffs.

1.4. Literature Review

In order to create a model and investigate the determinant factors influencing water demand in Türkiye, we began by conducting a comprehensive review of existing research on a global scale as well as within Türkiye. Following our research efforts, we have compiled a list of articles and reports believed to be relevant to our study area, presented in Table 3.

Table 3. Literature Review

Article	Focus of Study	Scope of Data
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Welfare and Distribution Effects of Water Pricing Policies, Ruijs (2009).	Water Pricing Residential Water Usage	Metropolitan Region of São Paulo/Brazil
---------------------------------------------------------------------------	---------------------------------------	-----------------------------------------

Table 3. (continued)

Water pricing policies, public decision making and farmers' response: implications for water policy, Varela-Ortega et al. (1998)	Water Pricing Agricultural Water Usage	Spain
Simulating the Impact of Pricing Policies on Residential Water Demand: A Southern France Case Study, Rinaudo et al. (2012)	Water Pricing Residential Water Usage	Southern France
Land, Water and Agriculture in Egypt: The Economywide Impact of Policy Reform, Robinson and Gehlhar (1995)	Water Usage Policies	Egypt
Is irrigation water price an effective leverage for water management? An empirical study in the Middle reaches of the Heihe River Basin, Zhou et al. (2015)	Water Pricing	North West China
Analysing the diversity of water pricing structures: the case of France, Montginoul (2007)	Water Pricing	France
Changing Roles in Canadian Water Management Decisions and Data-Sharing, Corkal and Dias (2009)	Water Management	Canada
Economics of Irrigation Water Management- A literature Survey on Partial and General Equilibrium Models, Dudu and Chumi (2008)	Water Management Partial and General Equilibrium Models	Worldwide
Water Resources Management, Allocation and Pricing Issues: The Case of Türkiye, Uzel and Gurluk (2016)	Water Pricing	Türkiye
Agricultural Water Pricing in Turkey, Cakmak (2010)	Water Pricing	Türkiye
Water Pricing: Issues and Options in Turkey, Unver and Gupta (2003)	Water Pricing	Türkiye

Although the leading sector of water consumption in countries is generally agriculture, the number of econometric studies analyzing the relationship between water consumption and water price in this field is relatively low. When the studies on water pricing are analyzed, it is observed that these studies are generally focused on

household water use. In this context, the studies of Ruijs (2009) and Rinauda et al (2012) analyzing the relationship between water price and household water consumption are prominent publications. In his study, Ruijs (2009) analyzed the water and electricity consumption of people living in the Sao Paulo metropolitan area. The proposed method in the study is to calculate the welfare changes of the block pricing tariff used in water consumption for both households and the water distribution company. The most important finding of his study is that policies to protect low-income groups in water pricing can significantly affect the water distribution company. When implementing policies, the household and water distribution companies should be considered. Rinauda et al. (2012) conducted a similar study for Southern France. The study aimed to show the effect of water price changes on consumption demand by calculating the price elasticity of household water demand. The study's most important finding is that the price elasticity of water consumption is relatively low, which the authors associate with the current price policy being below the actual water value. Another exciting feature of the study is that while examining the relationship between water consumption and price, climatic factors affecting water consumption are also included in the same analysis. The authors use the days exceeding 28 degrees Celsius between May and August and the total number of days without precipitation in a year as climatic variables.

There are also significant studies on agricultural water consumption, which constitutes an integral part of water consumption in the world. One of the first studies in this sense is the article by Varela-Ortega et al (2008). In this study, the authors drew attention to the increasing water scarcity problem in Spain and stated that it is necessary to implement policies that encourage water consumption. The most basic of these policies is that water prices can be used as a water-saving policy instrument. The study includes a dynamic mathematical model that shows the effects of a possible water price change on farmers' income and government earnings. The study's main finding is that irrigation policy should be tailored to each region. In this context, it argues that a single water pricing policy that ignores regional differences will fail.

Another group of studies analyzing the relationship between water consumption and price is studies that ignore climatic data. In their study on Egypt, Robinson and

Gehlhar (1995) analyzed the effects of land and water use policies implemented in the agricultural sector on the economy. The general equilibrium model presented in the study reveals econometrically the effects of the change in water price policies in the agricultural sector on the other sectors. Zhou et al. (2015) investigated whether water price can be an effective policy tool in irrigation management. Although the study found a relationship between water consumption and water price that can be used as a policy tool, it was concluded that the price elasticity of water demand is relatively low. The authors attributed this situation to the fact that the price of water is far below its vital value, just as in the study of Rinaudo et al (2012).

Review articles are the last cluster in which studies on agricultural irrigation and water consumption can be grouped. Montigonoul (2007) analyzed the pricing models used in 429 irrigation unions in France and the historical development of these models. The study indicated significant differences in irrigation pricing methods even within irrigation unions growing similar crops in the same country. Corkal and Dias (2009), on the other hand, analyzed the competition between different sectors in water consumption and the problems in water distribution in Canada. The study highlighted the problems that can be experienced due to issues such as the distribution of water resources and sectoral competition, even in a country that is not classified as water-poor in terms of the amount of water per capita. The study, co-authored by Dudu and Chumi (2008), analyses equilibrium model studies that reveal water management policies and their economic effects.

There are also many studies on water management and water pricing in Türkiye. The main characteristic of these studies is that they generally analyze the current situation in Türkiye. A model-based study examining the relationship between agricultural water use and water price with econometric analysis methods was not found in the literature review. Among the published studies on Türkiye, Uzel and Gurluk's (2016) study on the problems of water management and pricing is one of the most noteworthy publications in this field. In their study, Uzel and Gurluk state that problems such as water distribution and pricing should be solved urgently for sustainable development. Another publication on Türkiye is the OECD report written by Cakmak (2010). In this report, Cakmak (2010) states that radical measures should be taken to prevent the

water crisis, which is becoming increasingly evident due to climate change and the increasing urbanization rate, by elaborating on Türkiye's current situation and problems. Cakmak (2010) makes policy recommendations in his report, including introducing volume-based water pricing. Ünver and Gupta (2003), on the other hand, argue in their study that a volume-based pricing policy, as stated in Cakmak's (2010) report, would be more beneficial for water management than the currently used area-based policies. Ünver and Gupta (2003) propose solutions to the problems in water management in Türkiye by presenting examples from different countries such as the UK and Canada.

The existing body of literature on agricultural water usage and policies in Türkiye is extensive, but some areas remain incomplete. Many review articles have discussed water pricing policies in Türkiye but often lack a statistical analysis or mathematical modeling using Turkish data. To contribute to this literature, We have suggested conducting an econometric analysis to identify the factors influencing water demand in the agricultural sector and to assess price elasticity.

CHAPTER 2

DATA SET and MODEL

2.1 Data Set

Data for the economic analysis aimed at identifying factors influencing agricultural water use were gathered from the State Hydraulic Works. The data gathered from State Hydraulic Works are water consumption, water use handling fees, and cultivated areas. Additionally, data on factors believed to impact water use, namely the total number of rainy days, total rainfall, and the total evaporation rate, were sourced from the General Directorate of Meteorology. Total water consumption (WC) is the dependent variable. On the other hand, water use handling fee (WUHF), the total number of rainy days (RD), the total amount of rain (TR), total evaporation (TE), and cultivated area (CA) are independent variables, as specified in equation 2.1 and equation 2.2.

$$WC_{it} = \beta_{0it} + \lambda y_{i,t-1} + \beta_{1it}WUHF + \beta_{2it}RD + \beta_{3it}TE + \beta_{4it}CA + \epsilon_{it} \quad (2.1)$$

$$WC_{it} = \beta_{0it} + \lambda y_{i,t-1} + \beta_{1it}WUHF + \beta_{2it}TR + \beta_{3it}TE + \beta_{4it}CA + \epsilon_{it} \quad (2.2)$$

The Water Use Handling Fee (WUHF), water consumption (WC), and cultivated (CA) data were compiled by consolidating information from irrigation unions operating within the jurisdiction of 22 of 26 regional directorates of the General Directorate of State Hydraulic Works. This compilation was organized on a regional basis. The relevant data were meticulously prepared to represent the average values derived from the statistics of the irrigation unions operating within their respective areas of duty. Information regarding WUHF and water consumption spans from 2020 to 2022. Information regarding the annual total of rainy days (RD), total rainfall (TR), and the total surface evaporation rate (TE), believed to influence water

consumption, was acquired from the General Directorate of Meteorology. This data pertains to 2020 and 2022 and encompasses the 22 regions under examination. The regional directorates of the State Hydraulic Works are listed in Table 4. Data on water consumption is presented in cubic meters, the water usage service fee is stated in Turkish Lira (TL), the number of rainy days is specified in days, the total open surface evaporation rate and total rainfall are indicated in millimeters, and cultivated area data is quantified in a square kilometer. Table 5 provides specific statistical details about the data.

Table 4. State Hydraulic Works Regional Directorates

Region ID	City	Region ID	City
1	Bursa	14	İstanbul
2	İzmir	15	Şanlıurfa
3	Eskişehir	16	Mardin
4	Konya	17	Van
5	Ankara	18	Isparta
6	Adana	19	Sivas
7	Samsun	20	Kahramanmaraş
8	Erzurum	21	Aydın
9	Elazığ	22	Trabzon
10	Diyarbakır	23	Kastamonu
11	Edirne	24	Kars
12	Kayseri	25	Balıkesir
13	Antalya	26	Artvin

Source: State Hydraulic Works, 2021.

Table 5. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Consumption	66	850.55	1.128.7	47.43	4.845.73
WUHF	66	95.537	59.749	43	412
Rainy Day	66	90.182	23.558	54	147
Total Rain	66	488.13	166.692	167	870
Total Evaporation	66	1366.236	464.167	557	2509
Crop Area	66	8691.11	9101.56	395.17	36790.82

After the evaluation of the basic statistics of the data, diagnostic tests are run to determine best-fit model for our data.

The initial assessment aims to determine if our data exhibits cross-sectional dependency. For this examination, Pesaran (2004) and Friedman (1937) tests are is

employed. In panel data models, a commonly assumed condition is that the error terms are independent across cross-sections, primarily used for identification rather than descriptive accuracy. In situations characterized by a substantial number of time periods (T) and a limited number of cross-sectional units (N), the LM test statistic introduced by Breusch and Pagan (1980) is typically applied to gauge cross-sectional dependence. However, when dealing with cross-sectional time-series datasets featuring a small number of time periods (small T) and a large number of cross-sectional units (large N), the validity of the Breusch-Pagan test diminishes. To overcome this limitation, De Hoyos and Sarafidis (2006) scrutinize the hypothesis of cross-sectional independence in panel data models with small T and large N. It achieves this by implementing two semi-parametric tests proposed by Friedman (1937) and Frees (1995), along with the parametric testing procedure advocated by Pesaran (2004).

Both Pesaran (2004) and Friedman (1937) test has a null hypothesis is that the there is no cross-sectional dependence. Table 6 shows the test statistics for both Pesaran (2004) and Friedman (1937) tests.

Table 6. Cross-Sectional Test Statistics

Test of Cross-Sectional Dependence	Test-Statistics
Pesaran	7.019**
Friedman	12.091

**p<0.05, **p<0.01*

Since the null hypothesis is the same for the tests which are, there is no cross-sectional dependence. While the Pesaran test rejected the null hypothesis, Friedman test failed to reject. Although, according to Baltagi, cross-sectional dependence is a problem in macro panels with long time series like 20-30 years, which is not in our case, we assume that there is cross-section dependency in the data to eliminate the risk of having biased and inconsistent regression results (Baltagi, 2005).

After concluding that there is a cross-section dependence problem in our data, the next step is to check for the stationarity of our model. However, Baltagi (2005) cites

Karlsson and Loethgren on page 247 that “*For small T, panel unit root tests have low power and there is potential risk of concluding that the whole panel is nonstationary even when there is a large proportion of stationary series in the panel.*”. There are lots of unit root tests in the presence of cross-section dependency, but most of them require a minimum of at least $T=25$, so applying those tests with very small T values like 3 could end with the misleading results. Since the data used in our research is panel data with short time series, unit root and cointegration tests are not necessary (Pu *et al.*, 2020).

The next test for the model is heteroscedasticity. Lagrange Multiplier LM Test, Likelihood Ratio LR Test, and Wald Test are calculated to test heteroscedasticity. The null hypothesis for all three tests is homoscedasticity. Test results are presented in Table 7.

Table 7. Heteroscedasticity Test Statistics

Tests	Test Statistics
Langrange Multiplier LM Test	42000**
Likelihood Ratio LR Test	76.41**
Wald Test	5590000**

* $p < 0.05$, ** $p < 0.01$

Since the null hypothesis is homoscedasticity and all test statistics reject the null hypothesis then we can conclude that there is heteroscedasticity in our model. We should consider a model that has a robust estimate against heteroscedasticity.

The next test is Wooldridge test for auto correlation in panel data. According to simulation evidence presented by Drukker (2003), this test demonstrates reliable size and power properties even in reasonable sample sizes. In the absence of serial correlation (the null hypothesis), the residuals from the regression of the first-differenced variables are expected to display an autocorrelation of -0.5 . This implies that the coefficient on the lagged residuals in a regression of the lagged residuals on the current residuals should be -0.5 . Table 8. Presents the results of the Wooldridge test for auto correlation.

Table 8. Wooldridge Test for Auto Correlation Results

Test Statistics	136.73**
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*p<0.05, **p<0.01

Since the null hypothesis is no first-order auto correlation and test statistics rejects the null hypothesis, we can conclude that there is auto correlation in our model.

After diagnostic tests, we conclude that our data has cross-section dependency, autocorrelation and heteroscedasticity problems.

The next step is determining a best-fit model for our data and evaluating estimation results. Since our data has heteroscedasticity, cross-sectional dependence and autocorrelation problems, we should find a model that has robust results under these problems.

2.2. Model

Panel analysis is a widely used statistical method in social science, epidemiology, and econometrics. It is employed to analyze two-dimensional panel data, which usually includes both cross-sectional and longitudinal information. This data is typically collected over time from the same individuals, and the analysis involves conducting regression analysis across these two dimensions. In contrast, multidimensional analysis is an econometric approach that involves gathering data across more than two dimensions. This often includes dimensions such as time, individuals, and an additional third dimension.

A typical regression analysis using panel data takes the following form as $y_{it} = \alpha + \beta x_{it} + \varepsilon_{it}$ where y is the dependent variable, x is the independent variable, α and β are coefficients, i and t are indices for individuals and time, ε_{it} is error term. The distinctions between fixed effects and random effects models are based on assumptions about the error term. In a fixed effects model, it is assumed that the error term ε_{it} does not vary stochastically across both individual i and time t, resembling a one-dimensional dummy variable model. Conversely, in a random effects model, the error

term ε_{it} is assumed to vary stochastically across both i and t , necessitating unique handling of the error variance matrix (Hsiao, Pesaran and Tahmiscioglu, 2002).

Panel data analysis encompasses three primary approaches: the Pooled Ordinary Least Squares Model, the Fixed Effects Model, and the Random Effects Model. The choice among these approaches is contingent on the analysis's objective and the issues related to the exogeneity of the explanatory variables.

Although, these methods are widely used in area, they are not applicable in case of heteroscedasticity and cross-sectional dependency problem. There are few approaches to solve these problems while constructing a fixed or random effect model. Table 9 gives an overview of selected models that produce robust standard error estimates for panel data analysis.

Table 9. Models and Stata commands with relevant properties

Model	Robustness	Methodology
Maximum Likelihood Structural Equation Modelling (ML-SEM)	Non-normality, Heteroscedasticity, Cross-Sectional Dependence, Auto-Correlation	Uses ML SEM approach to solve incidental parameters problem without need of any other assumptions about the initial conditions. (Williams, Allison and Moral-Benito, 2018).
Unconditional quasi-maximum likelihood estimator of Hsiao, Pesaran and Tahmiscioglu (QML)	Non-normality, Heteroscedasticity, Cross-Sectional Dependence, Auto-Correlation	Uses transformed likelihood approach to overcome the incidental parameter problem. (Hsiao, Pesaran and Tahmiscioglu, 2002)
Bias Corrected Estimation in Dynamic Panel Data Models (BC)	Non-normality, Heteroscedasticity, Cross-Sectional Dependence, Auto-Correlation	Utilize a bias-corrected estimator for least square dummy variable estimator. (Bun and Carree, 2005)

Given that our dataset has a time data of $T=3$ and a horizontal cross-section data of $N=22$, methods such as ML-SEM (Williams, Allison and Moral Benito, 2018) and QML (Hsiao, Pesaran and Tahmiscioglu, 2002), utilizing maximum likelihood, along with iterative bias-corrected estimator (Bun and Carree, 2005), which employs a bias corrected method of moments, have recently seen broader application, particularly in fields like medicine and social sciences. These methods appear to be more suitable for our dataset. In the upcoming sections, the ML-SEM model that is better suited for our dataset is provided by delving into the underlying theory it relies on, which is better suited for our dataset.

2.2.1. Maximum Likelihood Estimation of Structural Equation Models

To analyze the determining factors of the agricultural water usage for the intervening 3 years, we utilize maximum likelihood estimation within structural equation models (ML-SEM). ML-SEM is preferred over other methods like the generalized method of moments (GMM), particularly when dealing with limited observations in a panel (Williams, Allison and Moral-Benito, 2018). Moreover, ML-SEM provides benefits compared to conventional covariance-based SEM techniques. Traditional approaches encounter difficulties in integrating latent variables that remain constant over time and in accurately identifying the suitable covariance structure (Hager and Yoon, 2023)(Williams, Allison and Moral-Benito, 2018). As can be seen from the Table 9. ML based estimators are best fit for our data model.

Structural equation modeling (SEM) is a robust multivariate method increasingly utilized in scientific inquiries to assess and examine causal relationships among multiple variables. SEM integrates two statistical techniques: confirmatory factor analysis and path analysis. Confirmatory factor analysis, initially developed in psychometrics, aims to estimate latent psychological constructs, such as attitudes and satisfaction. Path analysis, on the contrary, originated in biometrics and seeks to identify causal relationships among variables through the creation of a path diagram (Fan *et al.*, 2016).

Previous studies examining ML estimators have encountered the incidental parameters problem (Zortuk and Karacan, 2019). Consequently, early ML estimators introduced

additional assumptions and transformations to address this issue. However, Moral-Benito (2013) and Moral-Benito, Allison and Williams (2009) and demonstrate that it is feasible to circumvent the incidental parameters problem without imposing initial conditions. To achieve this, ML-SEM employs equations (2.3) and (2.4) to define the SEM.

$$y_{it} = \emptyset + \lambda y_{i,t-1} + \beta x'_{it} + \gamma z'_i + u_i + \varphi_t + \epsilon_{it} \quad (2.3)$$

where $i=1,2,3, \dots, N$; $t=1,2,3, \dots, T$, \emptyset represents the intercept term, while β and γ stand for scalar coefficients. The term x'_{it} denotes the vector of weakly exogenous and predetermined variables, z'_i represents strictly exogenous time-invariant variables. The variable u_i signifies the unobserved individual effect, φ_t represents the unobserved time specific effect and ϵ_{it} indicates the random error.

$$E(\epsilon_{it} | y_i^{t-1}, X_i^t, Z_i, \mu_i) = 0 \quad (2.4)$$

The exponential term $(t-1)$ and t imply that X_i^t may not be correlated with ϵ_{it} could be correlated with ϵ_{is} where s represents the earlier period. Equation 2.4 sets the sole condition required for the estimator's consistency and asymptotic normality, thus supporting the use of the SEM approach to estimate equation 2.3 (Williams, Allison and Moral-Benito, 2018). Moreover, equation 2.4 permits weakly exogenous or predetermined time-varying variables.

SEM framework for equation 2.3 comprises reduced form equations as presented in equations 2.5 and 2.6, alongside T equations outlined in equation 2.3 (Moral-Benito, Allison and Williams, 2019).

$$y_{i0} = \epsilon_{i0} \quad (2.5)$$

$$\begin{aligned} X_{i1} &= \epsilon_{i1} \\ &\cdot \\ &\cdot \\ &\cdot \\ X_{iT} &= \epsilon_{iT} \end{aligned} \quad (2.6)$$

The log-likelihood function for SEM can be derived as following, using the matrix model in equation 2.7 (Moral-Benito, Allison and Williams, 2019).

$$BR_i = DU_i \quad (2.7.)$$

The sample vector R_i , error vector U_i and coefficient matrices B and D are represented by equations 2.8, 2.9 and 2.10, respectively. The covariance matrix of errors ($\text{cov}(U_i) = \Sigma$) reflects the conditions imposed by equation 2.4.

$$R_i = (y_{i1}, \dots, y_{iT}, y_{i0}, X_{i1}, \dots, X_{iT}) \quad (2.8.)$$

$$U_i = (\mu_i, \epsilon_{i1}, \dots, \epsilon_{iT}, \epsilon_{i0}, \varepsilon_{i1}, \dots, \varepsilon_{iT}) \quad (2.9.)$$

$$B = \begin{pmatrix} 1 & 0 & 0 & \dots & 0 & -\alpha & -\beta & 0 & \dots & 0 \\ -\alpha & 1 & 0 & \dots & 0 & 0 & 0 & -\beta & \dots & 0 \\ 0 & -\alpha & 1 & \dots & 0 & 0 & 0 & \vdots & 0 & -\beta \\ \vdots & \dots & & -\alpha & 1 & 0 & 0 & \vdots & 0 & -\beta \\ 0 & \dots & & & 0 & & & & & \\ \vdots & & & & \vdots & & & & & \\ 0 & \dots & & & 0 & & & & & \end{pmatrix} \quad (2.10.)$$

$$D = (dI_{2T+1}) \quad (2.11)$$

Where d is a $1 \times (2T + 1)$ vector with T ones and T+1 zeros. Here, joint distribution of R_i is equation 2.12 with the log-likelihood in equation 2.13 under normality.

$$R_i \sim N(0, B^{-1}D\Sigma D'B'^{-1}) \quad (2.12.)$$

$$L \propto -\frac{N}{2} \log \det(B^{-1}D\Sigma D'B'^{-1}) - \frac{1}{2} \sum_{i=1}^N R'_i (B^{-1}D\Sigma D'B'^{-1})^{-1} R_i \quad (2.13.)$$

2.2.1.1. Model Fit Criteria for Maximum Likelihood Structural Equation

Models

Structural Equation Models (SEMs) offer assessments of the overall model adequacy, allowing us to evaluate both the fixed and random effects, along with the dynamic models discussed. To grasp these evaluations, we examine the null hypothesis of

$$\begin{aligned}\mu &= \mu(\theta) \\ \Sigma &= \Sigma(\theta)\end{aligned}\tag{2.14}$$

where μ and Σ are the means and covariance matrix of the observed variables, while $\mu(\theta)$ and $\Sigma(\theta)$ denote the model-suggested means and covariance matrix of observed variables. The θ included in the model-derived means and covariance encompasses the unfixed parameters (such as coefficients) of a model. Every model we define entails a distinct set of parameters to be estimated. Furthermore, each model specification suggests a specific structure for $\mu(\theta)$ and $\Sigma(\theta)$, which forecast the means and covariance matrix. When the model is accurate, having the parameter values will precisely replicate the means and covariance matrix (μ and Σ) of the observed variables. Conversely, if the model is flawed, $\mu(\theta)$ and $\Sigma(\theta)$ will not replicate (μ and Σ) accurately, even in the population. Therefore, the null hypothesis in equation 2.14. serves as a test for model's validity. Rejecting it indicates that the model is incorrect, while failure to reject it means the model's consistency with the data (Bollen and Brand, 2010). The method of maximum likelihood estimation (MLE) offers a convenient statistic, denoted by T. This statistic follows a chi-square distribution with a number of degrees of freedom determined by formula $df = \left(\frac{1}{2}\right)P(P + 3) - t$. Here, P represents the number of variables observed in the data, and t represents the number of parameters estimated in the model using MLE. The null hypothesis for this likelihood ratio test is stated in Equation 2.14. as given previously (Satorra and Saris, 1985). Another method of evaluating adequacy is through alternative measures of fit that have surfaced in the SEM literature. Generally, it is recommended to present multiple fit indices alongside the chi-square test statistic (T), degrees of freedom, and p-value. Below, we list several indices that we have found valuable. Two independent measures of adequacy are the Standardized Root Mean Square Index (SRMR) (Steiger and Lind, 1980) and the Bayesian Information Criterion (BIC) (Schwarz, 1978). The SRMR (Standardized Root Mean Square Residual) is calculated as the difference between the observed correlation and the correlation matrix implied by the model. It provides a measure of the average magnitude of disparities between observed and expected correlations, serving as an

absolute indicator of model fit. A value below 0.10 or even 0.08 indicates a good fit, with the latter being a more conservative threshold (Hu and Bentler, 1999).

The BIC was introduced by Schwarz (1978) as a method to estimate the Bayes factor for comparing statistical models. Raftery (1992, 2005) has examined the application of the BIC in SEM. A helpful equation for the BIC is expressed as

$$BIC = T_m - df_m \ln(N) \quad (2.16.)$$

In this expression, T_m represents the chi-square test statistic, df_m denotes its degrees of freedom, $\ln(\cdot)$ indicates the natural logarithm, and N represents the sample size. In this format, the BIC contrasts the assumed model with the saturated model, where negative values favor the assumed model, while positive values favor the saturated model. Typically, lower BIC values indicate better model fit. Jeffrey (1961) proposed guidelines for interpreting BIC magnitudes, which we adopt Raftery's (2005) adaptation of: BIC absolute values ranging from 0 to 2 indicate weak differences, 2 to 6 suggest positive evidence, 6 to 10 indicate strong evidence, and values exceeding 10 indicate very strong evidence (Raftery *et al.*, 2005)(Bollen and Brand, 2010). After outlining the theoretical underpinnings of the ML SEM approach and the metrics assessing the congruence between model outcomes and the dataset, findings will be presented from various models and variables to investigate the factors influencing agricultural water usage, our primary hypothesis.

CHAPTER 3

FINDINGS

3.1. Empirical Analysis and Key Findings

To understand which independent variables are linked to the dependent variable and to explore the nature of these relationships, we utilized panel data analysis on Equations (2.1) and (2.2). This equation establishes the connection between the variables using both cross-sectional data and the time dimension. Maximum Likelihood Estimation with Structural Equation, Quasi-maximum likelihood fixed, and Bias-correlated linear dynamic models were applied to the data (Equation (2.1) and Equation (2.2.)) using Stata-Software. To determine the most suitable model, the Bayesian Information Criterion and Wald test statistics were calculated.

Moreover, for auto-correlation the Wooldridge-Drukker (WD) (Drukker 2003; Wooldridge 2010) test is applied and WD test indicates to reject no first-order autocorrelation null hypothesis. Langrange Multiplier LM Test and Wald Test is applied for heteroscedasticity and both tests suggest to reject null hypothesis with homoscedasticity. Pesaran (2004) cross-section dependence test indicates that our dataset is subject to cross-section dependence problem.

The diagnostic tests mentioned earlier indicate the necessity of selecting a model featuring a robust estimator tailored to address issues of heteroscedasticity, auto-correlation and cross-section dependence within our dataset. Additionally, given the short duration of our dataset ($T=3$) along the time axis and the insufficient number of cross-sections ($N=22$) required by several models, we also considered panel data analysis models tailored for datasets with limited temporal coverage. Consequently, it is determined that the models outlined in Table 9 and referenced in earlier sections

are well-suited for analyzing our dataset. The estimation outcomes of these models are detailed in Tables 10 and 11.

Table 10 presents outcomes from a model incorporating water usage service charges, rainy day frequency, total evaporation levels, and cultivated area using diverse estimation techniques to elucidate agricultural water consumption. Table 11 displays results from an alternate model estimating agricultural water usage based on total rainfall volume instead of rainy day frequency while holding other factors constant.

Table 10. Model Regression Results

	QML	ML	BC
Consumption _{t-1}	0.067 (0.418)	0.192* (0.026)	0.069 (0.402)
WUHF	-0.557 (0.204)	-1.46* (0.015)	-0.565 (0.193)
Rainy Day	-1.38 (0.168)	-1.28 (0.252)	-1.39 (0.169)
Total Evaporation	0.077 (0.253)	0.045 (0.560)	0.077 (0.253)
Crop Area	0.15** (0.000)	0.163** (0.000)	0.147** (0.0000)

Values in the parenthesis are the Z statistics. * $p < 0.05$, ** $p < 0.01$

Table 11. Model Regression Results

	QML	ML	BC
Consumption _{t-1}	0.033 (0.42)	0.135 (1.43)	0.036 (0.47)
WUHF	-0.387 (-0.91)	-1.23* (-2.07)	-0.40 (-0.98)
Total Rain	0.031 (0.19)	0.0214 (0.15)	0.030 (0.19)
Total Evaporation	0.091 (1.44)	0.05 (0.64)	0.091 (1.44)
Crop Area	0.138** (5.28)	0.146** (5.01)	0.14** (5.35)

Values in the parenthesis are the Z statistics. * $p < 0.05$, ** $p < 0.01$

Table 12 presents the data indicating the anticipated signs and levels of statistical significance of the factors outlined in my initial hypothesis regarding the influences on agricultural water consumption.

Table 12. Expected Signs of Coefficients and Statistical Significance

Variables	Expected Signs	Statistical Significance
Past value of Consumption	+	Significant
Water Use Handling Fee	-	Significant
Rainy Day	-	Significant
Total Rainfall	-	Not Significant
Total Evaporation	+	Not Significant
Crop Area	+	Significant

To elucidate the expectations outlined in Table 12 and their rationale, the anticipation that past water consumption levels will influence current consumption stems from understanding traditional consumption patterns. Given that traditional open surface irrigation is the most prevalent method in agricultural practices, it is inferred that individuals draw from past experiences when determining their water usage. Consequently, this parameter is expected to exert a statistically significant impact on present agricultural water consumption. In establishing the expected sign of this effect, the absence of practices penalizing excessive water usage or incentivizing water conservation plays a role. Traditionally, farmers recognize that inadequate irrigation can lead to diminished harvest yields, while there are no immediate repercussions beyond the cost of water for excessive usage. Therefore, it is presumed that current water usage will at least equal past levels, leading to a positive sign for its effect.

In the preceding sections, it was elaborated that the water usage service fee does not represent a price for water. However, instead, it is structured to sustain current services without generating profit, thus not reflecting its economic worth. Consequently, it is inferred that this fee may not perfectly align with Marshall's law of demand as outlined in his work "Principles of Economics." Nonetheless, given that surface irrigation methods constitute the majority of agricultural water usage and pricing in this method is typically determined by factors such as irrigated area size or duration, it is assessed that a correlation between water consumption and the price paid for water could exist.

Consequently, the law of demand might present a negative and statistically significant relationship between water consumption and water price.

The primary irrigation objective in agricultural production is to supply the necessary water and moisture crops require for optimal plant growth (Friedman, 2023). As per the Food and Agriculture Organization, supplementary irrigation is unnecessary if the required water amount for crops is adequately supplied by rainfall (Brouwer, C. Heibloem, 1986). Consequently, it was assessed that farmers, believing their crops receive sufficient water from rainfall, would not perceive the need for extra irrigation. Given that the parameter of rainy days is easily observed and understood by farmers of all educational backgrounds, its effect was anticipated to be statistically significant and negative.

Similar to the number of rainy days expectations, a negative correlation between total rainfall data and agricultural water consumption was anticipated for analogous reasons. However, unlike the easily observable data on rainy days, it was conjectured that the total rainfall data, requiring specialized measurement methods and knowledge, would not be meaningfully tracked by farmers. Consequently, the relationship between total rainfall and water consumption was statistically insignificant.

Given these preliminary assessments regarding the number of rainy days and total rainfall data, each dataset was individually utilized rather than incorporated simultaneously into the model. The hypothesis that the number of rainy days would yield more meaningful outcomes within the modeling framework than total rainfall was also examined.

It is conjectured that the total evaporation and total rainfall data will be assessed with equal statistical significance, with an anticipated positive and negative impact on water consumption, respectively. It is believed that the expectation of their lack of statistically significant effect stems from the fact that, akin to total rainfall data, most farmers lack the necessary technological measuring devices and knowledge to monitor the relevant parameters accurately.

Consequently, it was assessed that there would be a distinct positive and significant correlation between cultivated area and water consumption, aligning with the production law. Given that cultivated area is the foremost determinant of water consumption in Türkiye, where surface irrigation methods dominate agricultural water usage, it was included in the model to underscore the robust statistical relationship between cultivated area and water consumption.

Upon scrutinizing the models in Table 9, it is determined that the ML-SEM approach is the most appropriate candidate model for our dataset. This assessment aligns with the estimation outcomes presented in Tables 10 and 11. Upon examining the results in these tables, it becomes evident that the ML-SEM model yields more statistically significant findings than other models. Furthermore, these results are consistent with the coefficient signs and statistical significance outlined in the initial hypothesis.

Once the prediction model is selected, the crucial next step is identifying the independent variables to be included. Models incorporating both variables and the corresponding test statistics were generated to decide between the total rainfall and the number of rainy days. The results shown in Tables 10 and 11 indicate that rainy days are better suited for our model since the number of significant parameters increased when rainy days are used. It is clear from Table 11 that the sign of the coefficient for total rainfall is not in the same direction as expected. This supports our hypothesis that the number of rainy days parameter would be a better choice in the models to be used to explain water consumption. Therefore, we chose a cross-lagged dynamic model to represent the model outlined in equation (2.1), and the results are presented in Table 13.

Table 13. Model Regression Results

Variables	Coefficients
Consumption _{t-1}	0.192* (0.026)
WUHF	-1.46* (0.015)
Rainy Day	-1.28 (0.252)
Total Evaporation	0.045 (0.560)

Table 13. (continued)

Crop Area	0.163** (0.000)
Wald test	97.40 ⁺⁺
BIC	3270.58
LR Test (model vs saturated)	4.231 ⁺⁺
SRMR	0.001

Values in the parenthesis are the Z statistics. * $p < 0.05$, ** $p < 0.01$, ⁺⁺ $p > 0.01$

Upon examination of the results in Table 13, it is noted that the value of water consumption one year prior significantly and positively influences current water consumption, consistent with our initial hypothesis. Similarly, as anticipated, the water use handling fee variable exhibits a negative and statistically significant impact on agricultural water consumption. Additionally, the relationship between cultivated area and agricultural water consumption shows a positive and statistically significant effect at the 1% level, which aligns with expectations. Regarding the total evaporation parameter, while the effect on agricultural water consumption aligns positively with our hypothesis, it lacks statistical significance at the 5% level. The only deviation from our initial hypothesis pertains to the relationship between the number of rainy days and water consumption. While the anticipated negative relationship regarding the sign is observed, the model output indicates a statistically insignificant effect.

After reviewing the additional results of other dynamic panel estimations presented in Table 10 alongside the ML-SEM model, it becomes evident that the signs corresponding to the factors impacting agricultural water consumption remain consistent across all models, aligning with our initial hypothesis. Differences in statistical significance among outputs of various models are attributed to the resilience levels of these models in low-dimensional panel data analysis.

Analysis of the models in Table 9 indicates that the ML-SEM model is the most suitable for our dataset, leading to the conclusion that the statistical significance levels of this model serve as a reliable basis for our study. Furthermore, since the directional impact of independent variables on agricultural water consumption remains consistent

across all models, it is inferred that the selected independent variables and their relationships in explaining agricultural water consumption exhibit coherence.

The observed coefficients for number of rainy days and total evaporation align with expectations. It is being considered that the lack of statistical significance in total evaporation term may stem from the insufficient know how and technology to keep track of the parameter. The absence of a statistically significant effect of the number of rainy days on agricultural water consumption contradicts our initial hypothesis. The notion in our hypothesis that the number of rainy days, being a readily measurable parameter, would influence the irrigation volume used by farmers for agricultural purposes is not upheld by our model's output. Potential reasons for this discrepancy include the nationwide scope of the study without differentiation by plant types or regional breakdowns. It is surmised that the lack of effectiveness of water consumption in regions with limited rainfall might impact the study results.

Furthermore, despite the nationwide estimation, the statistical insignificance could be attributed to insufficient data depth. Despite the absence of statistical significance, all model results in Table 10 indicate a negative relationship between agricultural water consumption and the number of rainy days. Consequently, an examination of climate-induced changes in the number of rainy days and their effects on water consumption has been conducted. Concerning the statistical insignificance of total evaporation and the number of rainy days, it is presumed that farmers may lack the technological tools needed to accurately measure soil evaporation rates. Consequently, they rely on traditional methods inherited from previous generations to estimate water consumption volumes.

While keeping all other variables constant, a reduction of one day in the number of rainy days will lead to an increase in water consumption by approximately 1.2 million cubic meters. This amount is equivalent to the daily water consumption of more than 4 million people (Daily water consumption per person, 0.229 Cubic Meters, TURKSTAT, 2022). To put it differently, an additional 1.2 million cubic meters of water will be required to irrigate areas for each decrease of one rainy day in a year. Global warming is an undeniable fact and it is well-known that Türkiye will be the most effected countries due to the great increase in temperatures. Over the past four

decades in Türkiye, Lake Beyşehir, the Türkiye's largest freshwater lake, has experienced a threefold increase in size, while its associated wetlands have diminished by twenty-five times. To put it differently, Türkiye has lost half of its wetland area, equivalent to the size of the Sea of Marmara, reducing the total wetland coverage to 2.5 million hectares. According to the report titled "What Awaits Türkiye," prepared by the General Directorate of Electrical Works Survey and submitted to the Parliamentary Committee on Global Warming, several impacts are anticipated in Türkiye due to rising sea levels and temperatures, leading to increased floods, storms, and erosion. The key points of the report are as follows:

- Between 1901 and 2000, temperatures in Türkiye increased by 2 degrees, accompanied by an average 10% decrease in rainfall.
- By 2030, Türkiye is expected to experience the effects of a dry and hot climate, with winter temperatures rising by 2 degrees and summer temperatures by 2-3 degrees.
- Night temperatures in major cities, especially Istanbul, will rise, and between 2071 and 2100, the western part of the Samsun-Adana axis is projected to warm by 3-4 degrees, while the eastern part will experience a 4 to 5-degree increase.
- Turkish territorial waters are anticipated to rise by 12-18 cm, leading to floods in coastal cities and resulting in significant changes to the landscape.(Hekimoglu, Burhan Altındeger, 2008)

The other statistically significant parameter is cultivated area. In Türkiye, 12.5 million hectares of agricultural land are suitable for irrigation. However, according to studies, the current water potential allows for the technical and economic irrigation of only 8.5 million hectares. It is anticipated that 6.5 million hectares will be managed by the State Hydraulic Works (State Hydraulic Works, 2021), 1.5 million hectares by the Ministry of Agriculture and Forestry (KHGM), and 0.5 million hectares through communal irrigation. As of the end of 2003, a total of 4.9 million hectares (4.4 million hectares net) of land have been opened for irrigation in Türkiye. Of the 8.5 million hectares that can be technically and economically irrigated, 58% are currently in use, with 57% managed by State Hydraulic Works. In the existing irrigation practices, 93% of the irrigated area is irrigated using surface methods (furrow, basin, and flood), 6% using

sprinkler irrigation, and 1% using drip irrigation. If the entire 8.5 million hectares of technically and economically irrigable land are fully irrigated, it is expected to result in a significant increase in production through irrigation (Tuğay, 2019). The expansion of irrigated land will lead to a corresponding increase in cultivated areas. With a constant set of parameters, cultivating 2 million hectares of land would require approximately 7 billion cubic meters of water. This quantity is equivalent to 11% of Türkiye's annual water consumption, as reported by TURKSTAT in 2020. (*Su ve Atıksu İstatistikleri, 2020, 2021*)

Another factor influencing current agricultural water consumption, which exhibits a statistically significant and positive relationship as anticipated by the model, is the one-year lagged value of agricultural water consumption. The primary reasons for incorporating this parameter into the model are the conventional belief that past preferences can impact current consumption levels and the inclusion of other unobservable factors within the delayed consumption parameter. The statistical significance of this parameter suggests that agricultural water consumption aligns with general consumption theory. Moreover, the robust statistical significance of this parameter implies that other unaccounted-for factors also influence agricultural water consumption.

The coefficient for the water use handling fee align with expectations. The calculation of the water usage service fee is designed to be non-profit. Moreover, a widespread implementation of a volumetric pricing policy, which directly measures water consumption, is unfortunately lacking nationwide. In regions employing surface irrigation methods, pricing is typically based on either irrigation frequency or the size of the irrigated area. This setup is believed to create an indirect volumetric pricing impact. Consequently, the statistically significant negative correlation between agricultural water consumption and the water usage service fee is attributed to this arrangement. Our findings suggest that 1 Turkish Lira increase in the water use handling fee will result with decrease in water consumption by approximately 1.5 million cubic meters.

CHAPTER 4

CONCLUSIONS AND POLICY RECOMMENDATIONS

This thesis examines the factors influencing water consumption in irrigation unions by utilizing field data in Türkiye. It aims to enhance the understanding of irrigation by providing a historical overview of irrigation, detailing its developments over time, discussing the legal framework, and outlining the organizational structure of irrigation unions. Additionally, the study involves the development of a ML-SEM panel model using a nationwide data. In order to implement a sustainable and attainable irrigation policy, it is crucial to accurately identify the underlying factors. Consequently, our study compiles comprehensive data essential for understanding irrigation unions and the state of nationwide irrigation infrastructure. The econometric analysis yields the following findings:

- Although our model fails to show that the amount of rainfall significantly influences water consumption, we infer from the estimation results in Table 13, indicating that precipitation is a key parameter affecting farmers' water usage behavior. Given the projections of decreasing rainfall in Türkiye due to climate change, our findings suggest that farmers may increasingly resort to irrigation, exacerbating the strain on already limited water resources. This trend could lead to more severe consequences than anticipated.
- Farmers' water usage is closely linked to the cultivated area, signifying that as the cultivated area expands, there will be a greater demand for water. Given the diminishing water resources due to global warming and climate change, expanding cultivated lands without ensuring sufficient irrigation water will prove challenging.
- While the water use handling fee is not designed to reflect the economic worth of water, it does exert a statistically significant and negative influence on water

consumption due to indirect pricing effects. Given the geographical location of Türkiye and global climate fluctuations, it is imperative to develop policies to regulate agricultural water usage, which constitutes a significant portion of our overall water consumption. Unlike climatic factors impacting agricultural water consumption, data on water usage service fees is institutionally compiled and can be readily regulated, making it a potential policy tool for controlling water usage. Our study suggests that utilizing the water use handling fee as a policy tool is statistically feasible. However, any decrease in producer welfare resulting from an increase in the water usage service fee should be offset by alternative support programs. Otherwise, implementing fee-centric policies aimed at conserving water in Türkiye, which faces significant food inflation, may exacerbate inflationary pressures.

As part of future research, our study can be expanded in two ways:

- To enhance the credibility of our results, conducting on-site surveys among members of irrigation unions is recommended. These surveys would inquire about the factors influencing water consumption, and the responses collected and summarized would serve as a cross-check to validate our findings.
- It is deemed beneficial to develop a demand elasticity model for agricultural water usage and explore both a partial and general equilibrium model incorporating this demand elasticity. This approach aims to assess the economic repercussions of proposed hikes in the water usage service fee intended to regulate agricultural water consumption, as well as to gauge their potential ramifications on agricultural production.

These two extensions also hold significant potential to contribute to the existing literature.

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APPENDICES

A. TURKISH SUMMARY / TÜRKÇE ÖZET

Bu çalışma, Türkiye’de toplam su tüketiminin %77’sini (DSİ, 2023) oluşturan tarımsal sulamayı etkileyen faktörleri ekonometrik analiz yöntemleri kullanarak incelemektedir. Çalışmanın esas aldığı tarımsal su tüketimi, su kullanım hizmet bedeli ve ekili biçili alan verileri Devlet Su İşleri Genel Müdürlüğü’ne bağlı 22 adet bölge müdürlüğünün görev alanlarında faaliyet gösteren sulama birliklerine ait 2020-2022 yılları arasındaki verilerin bölge bazlı birleştirilmesi ile oluşturulmuştur. Çalışma da yer alan ve su tüketimini etkilediği düşünülen yağışlı gün sayısı ve toplam buharlaşma oranı gibi iklimsel veriler ise ilgili bölge müdürlüklerinin bulunduğu coğrafi alanlar için Meteoroloji Genel Müdürlüğü’nden temin edilmiştir. Çalışma da ayrıca Türkiye’de tarımsal sulamanın tarihçesi ve sulama birliklerinin yasal ve tarihsel gelişimi sunulmaktadır. Çalışma tarımsal su tüketimi ile su fiyatı arasındaki ilişkiyi ekonometrik analiz yöntemleri ile ülke çapında ortaya koyması açısından gerçekleştirilmiş ilk çalışma niteliği taşımaktadır.

Su, insanların hayatta kalması ve tarımsal kalkınma için çok önemli bir kaynaktır. İnsanların havasız sadece üç dakika, susuz üç gün ve gıdasız üç hafta hayatta kalabildiği bilinmektedir. Bu durum, suyun gıda güvenliği ve bol su kaynaklarına sahip bölgelerde tarımın gelişmesindeki etkisini açıkça göstermektedir. Tarım alanlarının genişlemesi ve su kaynaklarının azalmasıyla birlikte insanoğlu, özellikle kurak bölgelerde su kıtlığı sorunu ile karşı karşıya kalmıştır. Bu durumun üstesinden gelmek için ise teknolojik gelişmeleri kullanmıştır. Türkiye’nin topraklarının büyük bölümünü oluşturan Anadolu coğrafyası da sulama alanındaki bu teknolojik gelişmelerin önemli bir bölümüne ev sahipliği yapmıştır. Urartular’dan günümüze ulaşan su kanalları, Bizans döneminde büyük şehirleri su taşımak için inşa edilmiş

devasa su kemerleri ve Osmanlı-Türkiye Cumhuriyeti döneminde gerçekleştirilen sulama projeleri Anadolu topraklarındaki sulamanın teknolojik gelişiminin gözlemlenebileceği başlıca eserlerdir. Özellikle tarımsal üretimi artırmak ve sürdürülebilirlik amacıyla gerçekleştirilen projelere ek olarak, sulama sisteminin



nasıl yönetileceđi konusunda çözüme kavuşturulmak istenmiştir. Bu anlamda sulama işletmeciliđi fikri ortaya çıkmıştır. Türkiye’de su tüketiminin büyük çođunlu tarımsal sulama amacıyla kullanıldıđından suyun etkin kullanımı ve sulama işletmeciliđinin yönetilmesi her zaman bir öncelik olmuştur. Bu nedenle Türkiye Cumhuriyetinin ilk yıllarında devlet tarafında yürütölen sulama projeleri zamanla kendi tüzel kişiliđine sahip kuruluşlara devredilmiştir. Sulama işletmeciliđinde yaşıanan bu devir süreci ile birlikte sulama birlikleri ve sulama kooperatifleri gibi farklı işletmecilik modelleri ortaya çıkmıştır. Bu işletmecilik modelleri içerisinde ise günümüzde sayıca en fazla olanı sulama birlikleridir. Sulama birliklerinin sayısı doksanlı yılların ortalarından bu yana hızlı bir artış göstererek günümüzde 2,3 milyon hektarlık bir alanının (Devlet Su İşleri, 2021) işletmeciliđi yapacak konuma ulaşmıştır. Sulama birliklerinin sulama işletmeciliđindeki payının artması ile birlikte kendisine özel bir kanuni alt yapı oluşturulma zorunluluđu da doğmuş ve bu ihtiyaçlar göz önünde bulundurularak sulama birlikleri kanunu hazırlanmıştır. Sulama birliklerinin organizasyonel yapısını ve faaliyetlerini nasıl yürüteceđine dair ayrıntılar 6172 sayılı kanun ile düzenlenmiştir.

Sulama birliklerine üyelik 6172 sayılı Kanun'da tanımlanmıştır ve "Sulama Tesisi Kullanım Sözleşmesi" adı verilen yasal bir anlaşma ile kayıt altına alınmaktadır. Sözleşme, su kullanıcılarının ve sulama birliđinin hak ve sorumluluklarını ana hatlarıyla belirlemektedir. Sulama birliklerinin üyelik istatistikleri istikrarlı bir artış eğilimi göstermekte olup, bu durum kanunda yapılan son deđişikliklerin katılım oranını olumlu yönde etkilediđini düşündürmektedir. Sulama birliklerinin örgütsel yapısı Birlik Müdürü, İşletme ve Bakım Birimi ve İdari ve Mali İşler Birimi olmak üzere üç temel bileşenden oluşmaktadır. Birlik başkanı ise sulama birliđinin faaliyetlerini sorunsuz ve tarafsız olarak devam ettirebilmesini sağlamak, birliđin faaliyet alanında yer alan su kullanıcılarının zarar görmesini önlemek ve su kullanım ücretlerinin uygun maliyetle belirlenmesini sağlamak amacıyla kamu görevlileri arasından atanmaktadır. Birlik müdürü, birliđin sulama tesislerinin verimli bir şekilde işletilmesi sorumluluđunu üstlenirken, işletme ve bakım birimi tesislerin bakım ve onarımından sorumludur. İdari ve mali işler birimi, birliđin iç ve dış iletişimini yürüterek gelir ve giderlerin toplanması ve kaydedilmesini yönetir.

Suyun ücretlendirilmesi fikri, suyun ekonomik bir ürünün fiyatlandırılması amacıyla deđil mevcut su kaynaklarının korunması amacıyla ortaya çıkmıştır. Türkiye'de de su

fiyatı yerine su kullanım hizmet bedeli kavramı benimsenmiştir. Sulama birliklerinin başlıca geliri olan su kullanım hizmet bedeli, gerçek "su fiyatı" olarak algılanmamalıdır. "Su Kullanım Hizmet Bedeli" terimi, suyun kaynağından tarlaya iletilmesi ve dağıtılması için gereken altyapının işletilmesi, bakımı ve onarımı ile ilgili maliyetleri ifade eder ve herhangi bir kar içermez. Sulama birlikleri, su kullanım ücretinden elde edilen geliri, suyun kaynaktan tarlaya iletimi ve dağıtımını ile ilgili tüm giderleri karşılamak için kullanmaktadır.

Sulama birlikleri tarafından uygulanan su kullanım hizmet bedeli tarifeleri, tesislerin niteliksel ve niceliksel özellikleri (sulama sistemi, su temin yöntemi, pompalama tekniği ve tesisin yaşı gibi) ile tesisten yararlananların uyguladığı sulama yöntemi, oranı, bitki deseni ve tarımsal uygulamalar gibi çeşitli faktörlere bağlı olarak birbirinden farklılık göstermektedir.

Sulama birliklerinde su kullanım hizmet bedeli, sulanan ürünlerin türü, sulanan arazinin alanı (TL/da cinsinden), sulama döngüsü sayısı (TL/trip cinsinden), sulama süresi (TL/saat cinsinden) veya kullanılan su hacmi (TL/m³ cinsinden) gibi çeşitli faktörlere dayalı olarak hesaplanabilir. Suyun metreküp cinsinden ölçülebildiği sulama şebekelerinde, su kullanım hizmet bedeli, tarifede belirtildiği gibi metreküp başına bir eşik ücret dikkate alınarak belirlenir.

2020 yılında verilerine göre, su kullanım hizmet bedeli, sulama yöntemlerinin %89'unu oluşturan sulanan arazi alanına göre belirlenmiştir. Kullanılan su miktarına göre fiyatlandırılan alan toplam sulanan alanın %7'sine, sulama döngüsü sayısına göre fiyatlanan alan toplam sulanan alanın %3'üne ve sulama süresine göre fiyatlanan alan ise toplam sulanan alanın %1'ine tekabül etmektedir. Sulama yöntemleri açısından 2021 yılında toplam sulanan alanın %71'i cazibeli su kaynağından, %19'u pompajlı sulama alanlarından, %3'ü yeraltı sulama kuyularından ve %6'sı kayıtsız yeraltı sulama kuyularından sağlanmıştır (Devlet Su İşleri, 2021).

Türkiye'de tarımsal sulama işletmeciliğinde hakim bileşen sulama birlikleri olduğundan dolayı ülke çapında bir çalışma için sulama birliklerine ait verilerin kullanılmasının uygun olacağı değerlendirilmiştir. Bu bağlamda suyun fiyatlanması, tarımsal sulama ve su tüketimini etkileyen faktörleri inceleyen çalışmalar

araştırılmıştır. Bu çalışmalardan bizim çalışmamız ile ilgili olabileceği düşünülen bazıları literatür taraması kapsamında özetlenmiştir. Su tüketimi ve bu tüketimi belirleyen faktörler konusu incelendiğinde bu alanda yapılmış çalışmaların 3 ana grupta toplanabileceği görülmüştür. Bu gruplar: hane halkı su tüketimini inceleyen çalışmalar, tarımsal su tüketimini inceleyen çalışmalar ve sulama işletmeciliği konusunda mevcut uygulama örneklerini açıklayan inceleme çalışmaları şeklindedir. Hane halkı su tüketimi üzerinde yapılan çalışmaların çoğunlukta olması bu alanda toplanabilecek su verinin diğer sektörlere göre daha kolay olmasından kaynaklandığı değerlendirilmektedir. Hane halkı su tüketimini inceleyen çalışmalar arasında Ruijs (2009) ile Rinauda ve arkadaşları (2012) tarafından kaleme alınan makaleler ilk göze çarpan örneklerdir. Ruijs Sao Paolo metropol bölgesinde yaşayan insanların elektrik ve su tüketimlerini bu tüketimlerin kullanılan ürünlerin fiyatları ile arasındaki ilişkiyi incelemiştir. Farklı tüketim grupları için farklı fiyatlandırma politikası örnekleri oluşturmuş ve bu örneklerin uygulanması sonucunda ortaya çıkabilecek olası refah değişikliklerini açıklamaya çalışmıştır. Ruijs (2009) tarafından gerçekleştirilen çalışmanın diğer çalışmalardan ayrılan önemli bir özelliği de bu fiyat değişimlerinin refah üzerindeki etkisini sadece hane halkı üzerinden değil aynı zamanda su dağıtım şirketi açısından da değerlendiriyor oluşudur. Benzer şekilde Rinauda ve arkadaşları da Fransa'nın güney bölgesinde yer alan alanlar için hane halkı su tüketimini belirleyen faktörleri belirlemeyi amaçlayan bir çalışma gerçekleştirmiştir. Bu çalışmanın da odağı hane halkı su tüketimidir. Rinauda ve arkadaşlarının (2012) çalışmasının ayrıştığı önemli bir alan ise su tüketimini etkileyen faktörleri belirlerken sadece su fiyatını değil aynı zamanda iklimsel faktörleri de göz önünde bulundurmuştur. Bu bağlamda kullanılan bir yıl içerisinde yağışlı olmayan gün sayısı ve Mayıs-Ağustos döneminde sıcaklığı 28 santigrat dereceyi aşan gün sayısı gibi verileri kullanmıştır. Kullanılan bu veriler bizim çalışmamızda kullanılacak iklimsel değişkenler açısından da fikir vermiştir.

Tarımsal su tüketimini inceleyen çalışmalara bakıldığında ise bu alanda gerçekleştirilen çalışmaların genel olarak iklimsel parametreleri göz ardı ettiği görülmektedir. Örneğin Varela-Ortega ve arkadaşları (2008) tarafından gerçekleştirilen çalışma İspanya genelinde tarımsal su tüketimi ve bu tüketimin su fiyatı ile arasındaki ilişkiyi açıklamaya çalışmıştır. Yazarlar önerdikleri dinamik

matematiksel model ile su fiyatlandırma politikalarında yapılacak deęişikliklerin çiftçilerin refahu ve hükümetin elde ettiği sulama geliri üzerindeki etkilerini göstermiştir. Yazarlar çalışma sonucunda yaptıkları politika önerilerinde su fiyatının bir politika unsuru olarak kullanılabilceğini fakat tarım alanlarında bölgesel olarak ciddi farklılıklar olduğunu ve uygulanacak sulama politikasının her bir bölge için özel olarak tasarlanması gerektiğini aksi takdirde uygulanan politikaların başarısız olacağı görüşünü belirtmiştir. Tarımsal su tüketimi ile su fiyatı arasındaki ilişkiyi inceleyen bir çalışma ise Mısır'a ait veriler üzerine Robinson ve Gehlhar (1995) tarafından kaleme alınmıştır. Yazarlar Mısır tarafından tarım sektöründe uygulanan su ve toprak politikalarının genel ekonomi üzerindeki etkilerini incelemiştir. Oluşturdukları genel denge modeli ile tarım sektöründe gerçekleşen bir sulama politikası deęişiklięinin genel ekonomi üzerindeki etkilerini ortaya koymuştur. Zhou ve arkadaşları (2015) ise su fiyatının tarımsal sulama alanında bir politika aracı olarak kullanılıp kullanılmayacağı konusunu ele almıştır. Çalışma sonucunda su tüketimi ile su fiyatı arasında istatistiksel olarak anlamlı bir bağlantı olduğu tespit edilmiştir. Yazarlar, bu bağlantıya rağmen su tüketimi ile su fiyatı arasındaki etkinin oldukça düşük olmasını su talebinin fiyat esneklięinin oldukça düşük olduğu şeklinde yorumlamıştır. Bunun nedeni olarak ise belirlenen su fiyatının suyun iktisadi deęerinin çok altında olmasından kaynaklandığını tezini savunmuşlardır. Tarımsal su tüketimi konusuna odaklanan çalışmalar genel olarak incelendiğinde su tüketimi üzerinde en az su fiyatı kadar etkileyici olduğu düşünölen iklimsel parametrelerin göz ardı edildięi görölmüştür.

Sulama yönetimi ve su tüketimi ile su fiyatı arasındaki ilişki üzerine yazılmış son çalışma grubu ise bu alanda kaleme alınmış inceleme çalışmalarıdır. Bu çalışmaların genel odağı sulama işletmecilięi özelindeki uygulamaları ve hukuki alt yapısını çeşitli ölkelerden örnekleriyse ortaya koymaktadır. Bu alanda göze çarpan çalışmaların ilki Montigonoul (2007) tarafından Fransa'da yer alan 429 sulama birlięinin su fiyatlandırma modellerini inceleyen makalesidir. İlgili makalede yazar sulama birliklerinde uygulanan fiyatlandırma politikalarını açıklamıştır. Ayrıca çalışmanın aynı ölkede içerisinde aynı tür bitki çeşidi yetiştirseleler bile farklı sulama birliklerinde farklı su fiyatlandırma politikalarının uygulandığı bulgusu oldukça dikkat çekicidir. Corkal ve Dias (2009) ise su tüketimi konusunda farklı sektörler arasındaki rekabeti inceleyen bir

çalışma kaleme almıştır. Yazarlar su tüketiminin sektörel dağılımı konusunda diğer ülkelerle ciddi oranda ayrılan Kanada verisi üzerine gerçekleştirdikleri çalışma ile su konusunda yaşanacak kıtlığın sadece iklimsel etkiler nedeni ile olmayacağını aynı zamanda sektörel rekabet nedeni ile de yaşanabileceği vurgulamıştır. Çalışma ortaya koyduğu bu durum ile su kaynakları bakımından oldukça zengin olan Kanada için bile sektörel rekabet kaynaklı olarak yaşanabilecek su grubuna giren ülkeler için dikkat edilmesi gereken çıktılar üretmektedir. Dudu ve Chumi (2008) ise dünya genelinde sulama politikaları ve bu politika değişimlerinin genel ekonomi üzerindeki etkilerini ortaya koyan genel denge modeli örneklerini sunan bir inceleme makalesi kaleme almıştır. Bu çalışmada özellikle sulama politikalarındaki değişikliklerin ülke ekonomisi üzerinde ortaya çıkarabileceği olası değişikliklerin anlaşılabilmesi için bir çok uygulama örneği içermektedir.

Dünya’da olduğu gibi ülkemizde de sulama işletmeciliği ve tarımsal sulama fiyatlaması konuları araştırmacılar için oldukça ilgi çekici bir alan olarak ortaya çıkmaktadır. Bu nedenle bu konu başlıklarında kaleme alınmış çok sayıda makale yer almaktadır. Bu çalışmalar arasında ilk göze çarpan çalışma Uzel ve Gürlük (2016) tarafından gerçekleştirilen çalışmadır. Yazarlar gerçekleştirmiş oldukları çalışma ile su yönetimi ve fiyatlandırma politikaları ile ilgili mevcut uygulama örneklerini ve bu alanda yaşanan sorunları ele almıştır. Çalışmalarını sürdürülebilir bir kalkınma için bu alanda yaşanan sorunlara kalıcı çözüm olabilecek politikaların acil olarak uygulanması gerektiği önerisi ile noktalamışlardır. Türkiye’de tarımsal sulama işletmeciliği üzerine yazılmış en ayrıntılı dökümanlarda birisi de Cakmak (2010) tarafından kaleme alınan OECD raporudur. Raporda Türkiye’de ki tarımsal sulama uygulamaları ile ilgili bilgiler sunulmakta ve hacim bazlı fiyatlandırma politikasına geçilmesi gerektiği savunulmaktadır. Ünver ve Gupta (2003) ise Türkiye’de ki su yönetimi konusundaki problemlere yönelik uygulanabilecek çözümleri Birleşik Krallık ve Kanada uygulama örnekleri ile açıklamaktadır. Yazarlar çalışmalarını bu konuda ki sorunların kalıcı çözümünün hacim bazlı fiyatlandırma politikası geçilmesi ile sağlanabileceğini belirtmektedir.

Su tüketimi, su fiyatı ve tarımsal sulama işletmeciliği gibi konularda kaleme alınmış çalışmalar küresel ve Türkiye çapında incelendiğinde bu alanda gerçekleştirilmiş bir çok çalışma olduğu görülmüştür. Bu çalışmalar mevcut su yönetimi türleri, su tüketimi

ve su fiyatı arasındaki ilişiki ve sulama işletmeciliğinin sorunlarının çözümleri gibi konularda literature önemli katılar sağlasalarda özellikle tarımsal su tüketimini belirleyen faktörler konusunda bir ekonometrik çalışma eksikliği olduğu yapılan inceleme sonucunda gözlemlenmiştir. Bu bağlam da litetürde eksik kalmış noktaya katkı sağlamak amacıyla Türkiye’de tarımsal su tüketimini belirleyen faktörleri ülke çapında ekonometrik analiz yöntemleri ile belirleyen bir çalışmanın kaleme alınmıştır.

Tarımsal su tüketimini belirleyen faktörler isimli çalışmamızda kullandığımız su tüketimi, su kullanım hizmet bedeli ve ekili biçili alan verisi Devlet Su İşleri Genel Müdürlüğünden temin edilmiştir. Bu veriler 2020-2022 yılları aralığında ve Devlet Su İşleri’ne bağlı 22 bölge müdürlüğünün sorumlu olduğu alanlarda faaliyet gösteren sulama birliklerinin birleştirilmiş verileridir. İklimsel etkileri gözlemek için kullanılan toplam buharlaşma miktarı, toplam yağış miktarı ve yağışlı gün sayısı gibi veriler ise 22 bölge müdürlüğünün yer aldığı il merkezleri için Meteroloji Genel Müdürlüğünden temin edilmiştir. Yağış miktarı ile ilgili olarak kullanılacak yağışlı gün sayısı ve toplam yağış miktarı verileri bulunmaktadır. Bu iki veri ayrı ayrı olarak modellerde kullanılmış ve hangi verinin çalışmamız için daha uygun olduğuna yapılan modelleme sonuçları ile karar verilmiştir. Veri setimizi 22 bölge ve 3 yıl için toplam 66 gözlem ile oluşturduktan sonra ekonometrik modellemeye geçmeden önce veri setimize uygun modeli belirleyebilmek için gerekli tanı testlerini yapılmıştır. Bu testlerin ilki veri setimizde yatay kesit bağımlılığı sorunu olup olmadığı üzerinedir. Baltagi’nin (2005) yatay kesit bağımlılığının 20 30 yıl gibi uzun zaman serilerine sahip panel veriler için bir sorun teşkil edebileceği şeklindeki yaklaşımına rağmen gerçekleştireceğimiz çalışmanın sonuçlarının yanlışlık ve tutarsızlık gibi sorunlara karşı dayanıklı olmasını istediğimizden yatay kesit bağımlılığı kontrol edilmiştir. Gerçekleştirilen Pesaran (2004) ve Friedman (1937) yatay kesit bağımlılığı testleri sonucunda Pesaran testi veri setimizde yatay kesit bağımlılığı olduğunu gösterirken Friedman testi böyle bir sorun olmadığını gösterir şekilde sonuçlar üretmiştir. Her iki testin farklı sonuç üretmesi ve bu testlerin esas itibariyle verimli sonuçlar üretebilmesi için daha geniş zaman serisi verisine ihtiyaç duyduğu bilindiğinden çalışma sonuçları üzerindeki soru işaretlerini ortadan kaldırmak için veri setinde yatay kesit bağımlılığı sorunu vardır şeklinde kabul yapılarak ilerlenmiştir. Yatay kesit bağımlılığının varlığı kabul edildikten sonra control edilecek ikinci adım durağanlık testleri olarak

belirlenmiştir. Fakat Baltagi (2005) kitabında Karlsson ve Loethgren'den alıntı yaparak küçük zaman eksenini değerlerine sahip panel verilerde durağanlık testi yapmaya gerek olmadığını ve zaman ekseninde veri az olduğu için durağanlık testlerinin tutarlı sonuçlar üretemeyeceğini belirtmiştir. Literatürde kullanılan durağanlık testlerinin bir çoğu tutarlı sonuçları üretebilmek için en az 25 yıl gibi bir zaman serisine ihtiyaç duyduğundan bizim örneğimizde 3 yıl gibi kısa bir süre için durağanlık testi uygulanmasının yersiz olacağı sonucuna varılmıştır. Veri setimiz ile ilgili olarak yaptığımız bir diğer kontrol ise değişen varyansa sahip olup olmadığıdır. Bununla ilgili olarak Langrange Çarpan Testi (LM), Benzerlik Oranı Testi (LR) ve Wald testi uygulanmıştır. Üç testte kuvvetli bir şekilde modelimizde değişen varyans sorunu olduğunu göstermiştir. Son olarak ise Drukker (2003) tarafından küçük örneklem sayıları için bile kuvvetli sonuçlar üretecek şekilde sunulan Wooldridge otokorelasyon testi uygulanmıştır. Test sonucuna göre veri setimizde aynı zamanda otokorelasyon sorunu da bulunmaktadır.

Tüm bu testler sonucunda veri setimize uygun ve problemlerine karşı dayanıklı kestirim sonuçları üretebilecek bir model arayışına girilmiştir. Panel veri analizinde yaygın olarak kullanılan sabit etkiler modeli ve rassal etkiler modeli ile bu sorunların üstesinden gelinemeyeceğinin anlaşılması üzerine ekonometrik analiz literatüründe çok fazla sayıda örneği bulunmayan fakat özellikle düşük gözlem sayıları içeren veri setlerinde kayda değer sonuçlar üreten maksimum olabilirlik, yarı yarı maksimum olabilirlik ve yapısal eşitlik modelleri gibi modeller incelenerek çalışmada sunulmuştur.

Maksimum Olabilirlik-Yapısal Eşitlik Modeli (Williams, Allison ve Moral-Benito, 2018), Koşulsuz Yarı Maksimum Olabilirlik Modeli (Kripfganz, 2016) ve Yinelemeli Yanlılığı Düzeltilmiş Kestirim Modeli (Breitung, Kripfhanz ve Hayakawa, 2022) gibi yöntemler veri setindeki değişkenlerin normal dağılım göstermesi harici herhangi bir ön koşul gerektirmedikinden dolayı veri setimiz için uygun olduğu değerlendirilmiştir. Ayrıca bu modellerde yapılacak Satorra-Bentler hata terimi düzeltmesi gibi düzeltmelerle normallik ile ilgili ön koşulda aşılabilmektedir.

Tarımsal su tüketimi üzerinde etkili olan iklimsel faktörlerden yağış faktörünü açıklayabilmek adına toplam yağış miktarı ve yağmurlu gün sayısını bağımsız değişken olarak içeren iki farklı model hazırlanmıştır. Her iki modelde de bağımlı değişken olarak tarımsal su tüketimi yer almıştır. Yağış parametresi haricindeki diğer bağımsız değişkenler ise su kullanım hizmet bedeli, ekili biçili alan ve toplam buharlaşma miktarı verileridir. Her iki yağış parametresi için de 3 farklı model oluşturulmuştur. Toplamda elde edilen 6 modelin tamamında su tüketimi ile su kullanım hizmet bedeli arasındaki ilişkinin beklenildiği gibi negatif olduğu gözlemlenmiştir. Benzer şekilde 6 modelin tamamında bir önceki yılın su tüketimi, toplam buharlaşma oranı ve ekili biçili alan parametreleri ile su tüketimi arasındaki ilişkinin beklenen yönde olduğu gözlemlenmiştir. Modellerin farklılaşmasına neden olan toplam yağış miktarı ile yağmur gün sayısı parametrelerinde ise bir ayrışma olmuştur. Yağmurlu gün sayısını içeren 3 adet modelde yağmurlu gün sayısı ile su tüketimi arasında beklenildiği gibi negatif bir ilişki olduğu gözlemlenmiştir. Öte yandan toplam yağış miktarı parametresinin kullanıldığı modellerde toplam yağış miktarı ile su tüketimi arasında beklenen aksine pozitif bir ilişkinin varlığı gözlemlenmiştir. Bu durum yağış miktarı parametresinin toplam su tüketimi üzerinde beklenen etkisi ile uyumsuz bir davranış göstermektedir.

Kestirim için kullanılan 3 farklı yöntem açısından istatistiksel açıdan en fazla anlamlı değişken üreten model ise Maksimum Olabilirlik-Yapısal Eşitlik Modelidir. Yağmurlu gün sayısı parametresinin kullanıldığı bu modelde tarımsal su tüketiminin güncel değeri ile, su tüketiminin bir yıl önceki değeri, su kullanım hizmet bedeli ve ekili biçili alan parametrelerine ait çıktılarının hem istatistiksel açıdan anlamlı hem de işaretinin beklenen yönde olduğu gözlemlenmiştir. Modelde yer alan toplam buharlaşma oranı ve yağmurlu gün sayısı parametreleri ise istatistiksel olarak anlamlı bir sonuca sahip olmamak ile birlikte su tüketimi üzerindeki etkilerinin yönü beklenildiği gibidir.

Değişkenlerin etkileri bireysel olarak incelendiğinde, toplam buharlaşma miktarı ile su tüketimi arasında ki ilk hipotezimiz istatistiksel olarak anlamlı olmayacağı şeklindedir. Bunun temel nedeninin ise ilgili parametrenin ölçülmesi için gereken teknolojik alt yapıya tarımla uğraşan kişilerin sahip olmaması durumu olduğu değerlendirilmektedir. Her ne kadar anlamsız bir ilişki de olsa toplam buharlaşma miktarında meydana gelecek 1 metreküplük artış tarımsal su tüketiminde 45.000

metreküplük bir artışa neden olacağı söylenebilir. Toplam buharlaşma oranının aksine yağmurlu gün sayısının istatikselsel olarak anlamlı bir şekilde su tüketimini etkiliyor olacağı ilk hipotez olarak değerlendirilmiştir. Yağmurlu gün sayısını takip etmenin kolay olması ve herhangi bir teknolojik araç gerektirmemesi bu düşüncenin arkasında yatan en temel nedenlerdir. Toplam buharlaşma oranında olduğu gibi yağmurlu gün sayısı verisi de istatikselsel olarak anlamlı olmasa bile etkinin yönü itibariyle beklentileri karşılar niteliktedir. Mevcut model çıktısına göre yağmurlu gün sayısında yaşanacak bir günlük azalış yaklaşık 1.2 milyon metreküp daha fazla suya ihtiyaç olacağı anlamına gelmektedir. Küresel iklim değişimi de göz önünde bulundurulduğunda ülkemizde değişen iklim koşulları ile özellikle bazı bölgelere yağmurlu gün sayısının azalacağı ve bu durumun yarattığı olumsuz etkiyi gidermek için daha fazla suya ihtiyaç olacağı aşıkardır. Genel olarak yağmurlu gün sayısı ve toplam buharlaşma oranı ile su tüketimi arasındaki istatikselsel olarak anlamsız ilişkinin gözlem sayısındaki kısıttan kaynaklandığı değerlendirilmektedir.

Bir yıl önceki yıla ait su tüketimi verisinin, güncel yıl su tüketimi üzerindeki etkisi pozitif ve istatikselsel olarak anlamlıdır. Bu durum başlangıç hipotezimiz ile uyumludur. Bir önceki yıla ait su tüketiminin katsayısı 0.192 şeklindedir. Bir başka deyişle, bitkiler iklimsel nedenlerle hiç sulama ihtiyacı hissetmese bile çiftçiler tarafından tecrübelerinden yola çıkılarak yıllık en az 192.000 metreküp su tüketmeye devam edeceklerdir. Bu durum iklim koşullarının hızlı bir şekilde değiştiği günümüz şartlarında çiftçilerin davranışlarını güncellemelerini sağlayacak bilgilendirme çalışmalarının ne kadar önemli olduğunu göstermektedir.

İstatikselsel olarak anlamlı olan ve başlangıç hipotezinin etrafında şekillendiği su kullanım hizmet bedeli ise su tüketimi üzerinde oldukça kritik bir etkiye sahiptir. Çalışmamızın çıktılarına göre su kullanım hizmet bedelindeki 1 liralık artış su tüketiminde yaklaşık 1.5 milyon metreküp azalışa neden olacaktır. Bu durum su kullanım hizmet bedelinin su tüketimini denetlemek amacıyla uygulanabilecek bir politika da araç olarak kullanılabilceği anlamına gelmektedir. Su tüketim ile su kullanım bedeli arasındaki bu anlamlı ilişkinin, hakim sulama fiyatlandırma yöntemi olan kullanılan alan başına ödenen bedelden kaynaklı ortaya çıkan dolaylı bir hacim bazlı fiyatlandırmadan kaynaklandığı değerlendirilmektedir.

Modelimizdeki anlamlı son deęişken ise ekili biçili alan parametresidir. Ekili biçili alan ile kullanılan su tüketimi arasındaki ilişkinin pozitif ve anlamlı olması ilk hipotezimiz ile uyumludur. Tarımsal üretimi artırmaya yönelik çalışmalar ülkemizin kalkınma planları arasındadır. Devlet Su İşleri verilerine göre ülkemizde potansiyel olarak tarım için kullanabilecek alan miktarı 12.5 milyon hektardır. Potansiyel tarım alanının ülkemizdeki su kaynakları göz önüne alındığında mevcut olarak sadece 8.5 milyon hektarı teknik ve ekonomik olarak sulanarak tarım yapılabilecek potansiyele sahiptir. Sulanabilecek 8.5 milyon hektar tarım alanının ise yaklaşık olarak %58'i aktif olarak tarım için kullanılmaktadır. Teknik ve ekonomik olarak sulanarak tarım yapılabilecek 8.5 milyon hektar tarım alanının 6.5 milyon hektarı Devlet Su İşleri Genel Müdürlüğü ve bölge müdürlüklerinin bulunduğu alanlarda faaliyet gösteren sulama birlikleri tarafından sağlanmaktadır. Bu durumda mevcut olarak kullanılmayan 2 milyon hektar tarım alanının sulamaya açılması durumunda ek olarak 7 milyon metreküp su gerekecektir. Bu miktar Türkiye'nin yıllık su tüketiminin %11'ine denk gelmektedir (TURKSTAT,2020).

Tüm bu model sonuçları göz önüne alındığında;

- Modelimiz yağmurlu gün sayısı ve toplam buharlaşma oranı ile su tüketimi arasındaki ilişkiyi istatistiksel olarak anlamlı olacak şekilde açıklamada başarısız da olsa, tezimiz yer alan diğer modeller ve su tüketimi ile yağmurlu gün sayısı ile arasındaki ilişki incelendiğinde bu parametrenin su tüketimi üzerinde negative yönlü bir etkisi olabileceği değerlendirilmektedir. İklim deęişikliği nedeniyle ülkemizin özellikle güney bölgelerinde meydana gelebilecek yağışlı gün sayısındaki azalış ve buharlama oranındaki artış ile birlikte ortaya çıkacak ek su talebi için önlemler alınması gerektiği değerlendirilmektedir.
- Ekili biçili alan ile tarımsal sulama miktarı arasındaki ilişki beklenildiği gibi doğru orantılı ve istatistiksel olarak anlamlı şekilde bulunmuştur. Bu nedenle gereken ek su tüketim miktarını karşılayacak bir çözüm bulunmadan ekili biçili alan miktarını artırmanın zor olacağı değerlendirilmektedir.
- Su kullanım hizmet bedeli mevcut olarak iktisadi bir şekilde fiyatlanmamasına rağmen tüketim üzerinde ters orantılı bir etkisi olduğu tespit edilmiştir. Bu

durumun su kullanım hizmet bedelinin mevcut hali ile bile bir politika aracı olarak kullanılabilceđi anlamına geldiđi deđerlendirilmektedir. Su tüketimini kısıtlamak amacıyla yapılacak olası fiyat artışları sonucu ortaya çıkacak çiftçi refah kaybının alternatif araçlarla karşılanması gerektiđi aksi takdirde bu politikanın gıda enfasyonu üzerinde olumsuz etkileri olabileceđi deđerlendirilmektedir.

- Çiftçilerin bir önceki yıla ait su tüketim miktarlarının güncel tüketim miktarları üzerinde de etkili olduđu düşünöldüğünde, su tüketimini kısıtlamak için uygulanacak su kullanım hizmet bedelli politikalara destek olacak şekilde tüketici davranışlarını deđiştirebilecek bilgilendirme çalışmalarının da yapılması gerektiđi deđerlendirilmektedir.

Gelecek çalışma alanı olarak;

- Çalışma çıktılarının doğrulanabilirliğini artırmak için sulama birliklerinin üyeleri arasında bir anket çalışması yapılarak çalışma bulguları ile anket sonuçlarının karşılaştırılmasının faydalı olacağı düşünölmektedir.
- Çalışmamızda tespit ettiğimiz tarımsal su tüketimi ve su kullanım hizmet bedeli arasındaki esneklik verisi kullanılarak, olası su kullanım hizmet bedeli deđişimlerinin ekonomi üzerindeki etkilerini gösteren bir kısmi ya da genel denge modeli oluşturulmasının literatür açısından oldukça faydalı olacağı deđerlendirilmektedir.

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YAZARIN / AUTHOR

Soyadı / Surname : Bildirici
Adı / Name : Mehmet Emin
Bölümü / Department : İktisat / Economics

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