Role of Irrigation Organizations in Promoting Awareness in Drought Management

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Abstract: *Climate change, declining water resources, and increasing agricultural water demand have made effective, sustainable, and locally based solutions in struggling drought inevitable. While 8.5 million hectares of Turkey's agricultural land (24 million hectares) are economically suitable for irrigation, only 7 million hectares are currently irrigated. Of the 112 billion m^3 usable water potential annually, 58 billion m^3 are consumed. 76% of the consumed water is used in agriculture, 12% for drinking, and 12% in industry. The significant use of water in agriculture highlights the importance of irrigation activities and the irrigation organizations that have a say in this matter. In recent years, drought-related rainfall has decreased, and irrigation water supply has been a problem, particularly in arid regions. Considering all of this, irrigation organizations are directly involved not only in the technical management of water but also in promoting awareness of drought, using resources effectively, and improving society's adaptation to the process. Research reveals that irrigation organizations play an important role in maintaining agricultural production during dry periods, distributing water resources and informing farmers. Their role in drought management extends beyond infrastructure management; they also increase public awareness and encourage behavioral changes through educational activities, awareness campaigns, and technical support. This study attempts to identify the methods irrigation organizations are currently using, or should use, in drought management, drawing on literature. Key recommendations include increasing the institutional capacity of irrigation organizations, integrating scientific data with local knowledge, expanding digital monitoring systems, integrating with drought early warning systems, and developing training programs to encourage the active participation of young farmers. In addition, in order to increase the effectiveness of struggling drought, it is necessary to switch to a risk-based management approach instead of approaches that focus only on moments of crisis.*

KEYWORDS*: DROUGHT MANAGEMENT, IRRIGATION ORGANIZATIONS, RURAL AWARENESS, CLIMATE CHANGE*

1. Introduction

Climate change, declining water resources, and increasing agricultural water demand make effective, sustainable, and locally based solutions to struggle drought indispensable. In this context, the efficient use and conservation of water is more crucial than ever for the sustainability of agricultural production. Especially in semi-arid and arid regions, the need for strategies that protect existing water resources and develop solutions appropriate to local conditions is increasing.

Drought, in general, is the situation where precipitation fails to meet demand. Because the location, time, duration, and purpose of demand vary, the concept of drought takes on different meanings based on these variables, and different drought definitions emerge depending on the precipitation requirement. All sectors and organizations involved in precipitation are affected by drought, giving rise to different drought definitions. To briefly summarize these, meteorological drought refers to the period in which precipitation falls below normal levels for a specific period. Agricultural drought refers to the period in which precipitation falls below plant water needs. Hydrological drought refers to the period in which groundwater and surface water levels, as well as stream flow, fall below normal levels. Economic drought refers to the weakening of the agricultural sector and agriculture-based industries and the resulting economic downturn that results from an agricultural and hydrological drought. Finally, desertification refers to the persistence of agricultural and hydrological drought in a region, basin, or area [1].

These varying definitions of drought make the effective management of water resources more crucial than ever. In this context, Turkey's existing water potential and agricultural irrigation capacity play a decisive role in struggling drought. The impacts of drought types are particularly pronounced on agricultural production, increasing the importance of data on water resource use. Therefore, how and how much water is used to mitigate drought impacts becomes critical. To understand the implications of this situation for Turkey, it is necessary to examine existing irrigation capacity and water usage data.

While 8.5 million hectares of agricultural land (24 million hectares), which constitute approximately 30% of Turkey's surface area, are economically suitable for irrigation, only 7.1 million hectares are currently irrigated. According to data from the State Hydraulic Works (DSI), the target is to irrigate 7.63 million hectares by the end of 2027. Of Turkey's annual usable water potential of 112 billion m^3, 57 billion m^3 is consumed, 76% of which is used in agriculture, 12% for drinking, and 12% in industry. Although Turkey has a per capita water supply of 1,308 m^3/year, this value is below 1,700 m^3/year, making the country unable to be considered rich in terms of water potential [2, 3].

Turkey's three-month meteorological drought map for the period April 2025-June 2025 is given in Figure 1. Accordingly, although drought in the country appears to be largely normal, there are also significant areas experiencing mild or severe drought.

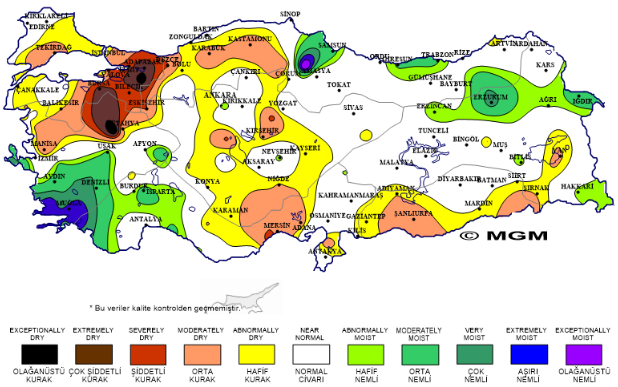

Fig. 1 *Turkey's three-month (April 2025-June 2025) Meteorological Drought Map [4]*

In this regard, irrigation organizations play a key role in ensuring the efficient, equitable, and sustainable management of agricultural water. The institutional capacity of irrigation organizations is crucial, particularly for the proper planning of limited water resources, fostering collaboration among farmers, and ensuring the efficient operation of irrigation infrastructure. The ability of irrigation organizations to establish one-on-one contact with producers at the local level and to encourage participatory approaches to water management directly impacts the success of practical solutions to struggle drought.

Considering all this, irrigation organizations are directly involved not only in the technical management of water but also in promoting drought awareness, utilizing resources effectively, and developing community-based adaptation strategies. Therefore, irrigation organizations play a critical role both in creating more conscious people about climate change and in adopting participatory and holistic approaches to water management.

2. Drought management and drought studies

Drought management refers to activities that include measures taken before, during, and after a drought to mitigate the negative impacts of potential drought risks and solve drought problems [5]. Drought management is linked to many areas, including the sustainable use of water resources, agriculture, energy production, and ecosystem protection. An effective drought management strategy encompasses both the establishment of early warning systems by monitoring meteorological data and the development of activities such as efficient water use, public awareness, and drought mitigation.

There are two basic approaches to drought management: crisis management and risk management. Crisis management encompasses the work undertaken after a drought occurs and offers solutions such as making new physical investments, water transfers between basins and countries, desalination of marine and saline marginal waters, cloud seeding, and water harvesting. Risk management encompasses activities implemented before a drought occurs and includes solutions such as integrated water resources and basin management, implementation of optimal irrigation programs, modernization of water distribution systems, efficient water use in agriculture, and the use of marginal waters [6, 7].

Because measures against drought constitute one of the cornerstones of drought management, studies and activities undertaken in this area are of great importance. These measures include basin improvement, minimizing evaporation from reservoirs, switching to a closed system instead of open channels for water conveyance, maintaining soil moisture, reviewing water management, properly determining irrigation timing and water amounts, adapting agriculture to rainfall conditions, cultivating drought-resistant plants, establishing a drought-resistant plant production system, and reassessing socio-economic constraints [8]. Reducing the high dependence of people in rural areas on agriculture and livestock for their livelihoods is also one of the measures that can be taken against drought. In these cases, non-agricultural activities (e.g., handicrafts and tourism) can be encouraged during drought periods [9].

Before struggling drought, being able to predict when, where, and how severe it will occur is crucial. Drought predictions play a vital role in water resources planning, agricultural production management, and disaster risk reduction. As the frequency and severity of droughts increase, particularly with the impacts of climate change, early warning systems based on scientific prediction methods enable societies to be prepared for such crises. Effective drought management requires, first and foremost, the timely identification of risk and the ability of decision-makers to act based on this information. Therefore, drought prediction is not merely a technical activity; it is a strategic necessity that underpins economic, environmental, and social sustainability.

Drought indices are perhaps the most widely used methods for drought prediction. This concept can be defined as the potential outcome indicated by the interactions of numerous and diverse meteorological data. Primary drought indices include percent of normal, standard precipitation index, surface water content index, and the Palmer Drought Index. Satellite imagery, which serves many areas today, also serves as a modern resource for drought prediction studies [10].

Studies on drought analysis are crucial for establishing scientific foundations for water management policies. These analyses reveal critical parameters such as drought duration, severity, frequency, and spatial distribution, enabling both understanding of past trends and future strategic planning. Some of these studies are presented in this section.

A study conducted in the Konya Closed Basin indicated that the basin was becoming increasingly arid and developing arid climate. It was also noted that while the basin was already experiencing water scarcity, this water scarcity would become even more pronounced if necessary measures were not taken [11]. A study conducted in Antalya determined that drought can occur not only in the summer months but also in the winter months. For this region, the risk of a drought exceeding moderate intensity is always a possibility [12]. A study was conducted in Adana province on the relationship between irrigation practices and drought. It was concluded that because the rainfall expected in Adana, particularly between June and August in dry and normal years, is very low, the rainfall during these months is not important in planning irrigation schedules [13]. In a study conducted for the Yozgat-İkikara Basin, when annual total flows were grouped according to the considered drought indices, it was determined that there was an increase in the basin's average annual total flow values as the dry periods moved from wet periods to wet periods due to increasing precipitation conditions. However, according to the Bagnouls–Gaussen Drought Index, the average annual total flow values in the basin decreased as the very dry periods moved from subhumid to humid periods [14]. A study conducted in the Harran Plain demonstrated that future investment plans and water-related practices should be made in accordance with the hydroclimatological elements of the field [15]. In a provincial study conducted in Turkey, humid and subhumid areas were observed only along the Black Sea coast, while a transition from arid to very arid climate was observed in Central and Eastern Anatolia. In just 15 years (2001-2016), drought tendency in Turkey has increased by 1.80% in area [16].

In the Shabelle region of Somalia, water resources management has been challenged by drought and flood pressures, and these environmental extremes have had significant impacts on agriculture, local economies, and the livelihoods of communities in Jowhar, Afgooye, Awdhigle, and Balcad [17]. A study in the Netherlands, through a survey of national and regional water authorities, found that with increasing drought severity, water managers increasingly rely on field measurements, Data Information Systems (DIS), stakeholder consultation and legislation [18].

3. The role of irrigation organizations in drought management

The sustainability and efficiency of agricultural production are directly related to the efficient and balanced use of water. Therefore, the planning, operation, and management of irrigation activities have become one of the most critical elements of modern agriculture. In countries like Turkey, where water resources are limited and agricultural areas are extensive, it is of great importance to provide an institutional structure for irrigation management. Irrigation organizations, shaped by different legal and administrative structures in response to this need, aim to ensure that agricultural irrigation is carried out sustainably, efficiently, and in accordance with local needs. In this context, the structure, duties, and operational models of irrigation organizations operating in Turkey are among the fundamental dynamics of agricultural development.

Agricultural irrigation management in Turkey is generally divided into five groups: public irrigation management, local government irrigation, community irrigation, irrigation cooperatives and irrigation associations. Public irrigation management refers to the management of large-scale irrigation projects planned and designed by the State Hydraulic Works (DSI). Local government irrigation is managed by municipalities or neighborhood units. In community irrigation, farmers irrigate their lands using their own resources [19].

Irrigation cooperatives are private legal entities established for the purpose of establishing agricultural irrigation facilities such as land leveling, in-field irrigation, and drainage, or to operate, maintain, and commission established irrigation facilities, for the agricultural use of water supplied or to be supplied by the state, or to be extracted from agricultural fields by any means [20]. According to data from the Ministry of Commerce, the number of irrigation cooperatives in Turkey is 2,497 [21].

A large portion of irrigation operations in Turkey (35-40%) are carried out by irrigation associations. Since 1995, these associations have been operating and operating irrigation facilities constructed by the State Hydraulic Works (DSI) in accordance with project objectives. The number of irrigation associations operating in Turkey was reduced to 181 by Presidential Decree dated February 19, 2022 [22].

The establishment purposes of irrigation associations include the following: using and operating irrigation facilities constructed or currently being constructed or planned to be constructed by the General Directorate of State Hydraulic Works in accordance with their purposes in order to benefit from public waters for the rational use of the country's water assets and resources; having them operated with the approval of the General Directorate of State Hydraulic Works; carrying out the maintenance, repair and management responsibilities of these facilities; developing new projects to develop the facility, having them built or renovating the facility [23].

A significant portion of irrigation associations are not yet systematically prepared for climate change adaptation policies, which include sustainable water management and the implementation of methods and technologies that will ensure the effective and efficient use of water resources [24]. This situation exacerbates local risks, particularly in the face of future scenarios where water scarcity is predicted to increase. Many associations still rely on traditional irrigation methods and fail to adequately implement digital monitoring systems, infrastructure investments to reduce water losses, or planning processes based on drought scenarios. Furthermore, lack of institutional capacity, a lack of technical personnel, and limited financial resources weaken these organizations' resilience to climate change.

On the other hand, in some regions (Aegean), it has been observed that even in difficult drought conditions, the drought period was overcome by cooperating with the three institutions without damaging the crops by resorting to water-saving methods such as rotational water distribution and new water fee mechanisms among the DSI, the Irrigation Association and water users to cope with this crisis [25].

Research shows that irrigation associations play a crucial role in maintaining agricultural production during dry periods, allocating water resources, and informing farmers. In particular, diversifying resources (groundwater, surface water, recycled water) and equitably sharing these resources are more efficiently achieved in organized irrigation structures [26].

Supporting this assessment, local-scale studies also provide evidence on the effectiveness of irrigation organizations during drought periods. In the case of Turkey, various field studies have demonstrated how irrigation organizations develop flexible planning strategies according to regional climatic conditions and how they prioritize during periods of water scarcity.

A drought analysis study conducted by the Aydın Irrigation Association concluded that summer precipitation is not important in planning irrigation schedules, given that rainfall is expected to be quite low in dry years. Given the differences in rainfall distribution, it was emphasized that irrigation planning should be tailored to changing local conditions [27].

In a study investigating tomato producers' responses to drought in Izmir, producers stated that the drought was largely due to insufficient rainfall. Other factors cited included global warming, inadequate facilities, irrigation errors, erosion, and over-planting. When producers were asked how much drought influenced their choice of crops, the vast majority responded that drought was extremely influential [28].

Producers in Erzurum province experienced yield losses ranging from 3% to 72% in crop production during the 2020-2021 production season. Input costs increased between 25% and 134% during the same production period. The study found that farmers did not take any precautions against drought and that yields decreased across all crops they planted. It concluded that input costs in production increased significantly in 2021 compared to 2020 [29].

A study conducted in the Ceyhan Basin to determine water users' levels of concern about drought and their willingness to take precautions against it was asked how much they were worried about the drought, and found that it was highly concerning. Half of the users stated that the impact of the drought would reach serious levels in the next decade [30].

In a drought study conducted for the Çivril-Baklan Plain, solution suggestions were made such as reducing open channel irrigation and switching to a closed pressurized system, supporting the farmer registration system, directing farmers to plants with low water consumption, establishing monitoring and early warning systems, and disseminating rainwater harvesting techniques [31].

Some studies conducted outside Turkey have also evaluated producers' responses to drought. In Chile, farmers in arid regions were observed to reduce their cropping activities, which are at high risk of drought, and to select crops with shorter growing seasons and lower capital and technology costs, such as grains. In regions where droughts are more frequent, farmers preferred legumes, grapes, fruits, and vegetables. The study results indicate that small-scale farmers are sensitive to recent drought events, and their responses are greater depending on the drought intensity [32].

A study conducted in Spain found that water user association authorities' establishment of hydraulically linked systems and resource diversification increased drought resilience. These structures enabled farmers to maintain production during dry periods, thus reducing socio-economic losses [33].

Similarly, a comprehensive analysis of Water User Associations in China highlighted that the institutional effectiveness of these organizations is largely related to the transparency of public administration and farmers' awareness of the organization. The participatory governance model fosters solidarity and information sharing among rural communities, which in turn enhances collective resilience in struggling drought [34].

When all these findings are considered together, it becomes clear that irrigation organizations and water user associations, both in Turkey and internationally, are important structures in struggling drought, not only as technical units distributing water but also guiding farmer behavior, contributing to the diversification of water resources, and enhancing local resilience. However, the institutional capacity of these organizations, their relationships with farmers, management models, and levels of preparedness for climate risks vary across countries and even regions. In Turkey, strengthening irrigation associations to adapt to climate change and adopting a participatory and transparent governance approach that integrates local knowledge with technology will form the cornerstone of sustainable drought management.

Irrigation organizations hold a significant position in agricultural irrigation, and it is reported that agricultural irrigation in Turkey plays a significant role in reducing the risk of drought in agriculture. Given that global warming will lead to a decrease in precipitation and available water resources, the need to ensure efficient water use has been emphasized [35]. A field study in Iran demonstrated that the implementation of technical irrigation methods significantly reduces drought-related vulnerability in the rural economy. The widespread use of drip and pressurized irrigation systems, as well as drought-resistant varieties, has been made possible through irrigation organizations [36].

The critical role played by irrigation organizations in struggling drought is not limited to the implementation of irrigation techniques; it also encompasses a multifaceted process, including the effective operation, sustainable management, and support of these systems through farmer participation. Strengthening technical infrastructure, coupled with participatory, transparent, and functional organizational structures, are key factors in determining the resilience of irrigation activities to drought. Therefore, the success of irrigation organizations is directly linked not only to their physical infrastructure but also to their institutional capacity, management style, and relationships with farmers. A study conducted in Ghana determined that user-managed irrigation dams fail to achieve the expected drought-fighting effectiveness due to inadequate maintenance, lack of participation, and infrastructure problems [37]. This situation highlights the need to increase the technical capacity of irrigation organizations and strengthen their management structures.

The role of irrigation organizations in drought management is not limited to infrastructure management. These organizations also increase the knowledge of rural people and encourage behavioral changes through educational activities, awareness campaigns, and technical support [38]. Such activities contribute to preventing water waste by promoting farmers' awareness of the right use of water at the right time and with the right methods. Practical training provided by irrigation organizations facilitates the transition to modern irrigation technologies and increases the capacity of local people to adapt to climate change. Furthermore, the technical guidance provided by these organizations allows producers to make more informed decisions on issues such as which crops to choose during drought periods and how to adjust irrigation timing. In this respect, irrigation organizations are considered not only water distributors but also institutional structures that provide information and adaptation.

All this data demonstrates that irrigation organizations are not only technical implementers but also key players in building a resilient rural community against climate risks. The educational, organizing and coordinating roles of irrigation organizations enable increased local awareness, information sharing and correct water management decisions. In addition, correct agricultural water management is a key issue for sustainable management of water resources particularly in arid and semi-arid environments. In that context, reconstruction of crop patterns in favor of low water consuming crops by considering current water supplies is vital important for such ecologies [39 - 42].

4. Conclusion and Recommendations

The role of irrigation organizations in struggling drought encompasses a multifaceted area of management, technical, and social interaction that extends beyond water distribution. Studies conducted in Turkey and internationally demonstrate that irrigation organizations play a critical role in ensuring the sustainability of agricultural production, the efficient use of water resources, and raising awareness among rural residents. However, the effective use of this potential requires not only the adequacy of technical infrastructure but also strengthening management capacity, farmer participation, and institutional flexibility.

A more active role for irrigation organizations in drought management is crucial for the sustainable use of water in agriculture. In this context, this study offers several recommendations. Increasing the institutional capacity of irrigation organizations ensures more effective planning and streamlined decision-making during drought periods. Integrating local knowledge with scientific data allows farmers to develop more applicable and region-specific drought management strategies by combining their field experience with scientific analyses such as climate data and hydrological models. Expanding digital monitoring systems enables real-time monitoring of water use, soil moisture, and meteorological data, enabling early warning of drought risk and efficient resource management. Integration with drought early warning systems allows irrigation organizations to integrate drought-related forecasts and warnings into their current decisions, enabling timely adaptation of water allocation and irrigation programs based on risks. Developing training programs to encourage the active participation of young farmers supports the adoption of innovative approaches to combating drought and the transfer of sustainable water management practices to future generations. However, in order to increase the effectiveness of struggling drought, it is necessary to switch to a management approach that creates risk plans rather than approaches that focus on crisis moments.

As a result, irrigation organizations ensure the localization of drought management, increase farmers' ability to adapt to climate change, and pave the way for the equitable, efficient, and sustainable use of water resources.

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