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Research Article

Water efficiency for sustainable agriculture

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Abstract

The agricultural sector is important because it meets the food needs of societies and provides raw materials to other sectors. Increasing productivity in agricultural production is achieved by giving plants with the water they need. The growing world population necessitates the opening of new areas for agricultural production and irrigation. Especially during the last decade, the world's average temperature has been rising. These increases in temperatures have led to more irrigation water use in agriculture. Due to excessive irrigation, the air in the soil pores is replaced by water, leaving the plant roots without air. The roots cannot receive the nutrients the plant needs. In addition, excessive moisture can cause root diseases in plants. Since there is water near the tree roots, the root development of the plants is limited and the roots do not develop deeply. Furthermore, excessive irrigation causes salinization in the soil, which leads to a decrease in plant product yields. Considering that the world's water resources are limited, the efficient use of water in agricultural production becomes a necessity. Water efficiency means the correct management of water, which aims to use water resources in a planned manner by protecting and developing them. Modern irrigation technologies are utilized in the efficient use of water resources in agricultural production. Digital agricultural technologies are used not only in water management, but also in many activities such as phenology monitoring of plants, spraying and fertilization in the field. The amount of irrigation water given to plants affects the contribution of these activities to productivity increase. In this study, works on water efficiency in agriculture, the benefits of smart agricultural systems on water efficiency in agricultural production, water use in urban green areas, activities that can be done for the protection of water resources and the environment, planning and management of water resources are presented.

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Introduction

Water is a fundamental resource for living beings and their vital activities. The demand for fresh water resources is increasing day by day. Fresh water resources are under threat due to the rapid increase in population, industrialization, urbanization, land use change, unconscious irrigation techniques in agriculture and the effects of climate change (ÇŞB, 2011; Bildiren and Sargıncı, 2024). Planning is a subject within the field of study of more than one discipline. Interdisciplinary coordination and cooperation are extremely important in the planning phenomenon, which should be considered multidimensional (Taş, 2011). Furthermore planning must be made to ensure optimum utilization of agricultural areas. The extent to which the natural environmental conditions in which agricultural areas are located affect agricultural activities should be determined (Lu and Daniel, 2009; Taş, 2011). Considering the extent of climate change

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around the world, it is necessary to take measures and make strategic plans to meet the need for water both for human life and for nature as a whole (ÇŞB, 2011; Bildiren and Sargıncı, 2024).
Water is a compound consisting of the elements hydrogen and oxygen that is most beneficial to all living things. In recent years, changes in the life cycles of all living things due to population growth and climate change have led to decreases in water supply, threatening the increase in agricultural production. The main objective of this study is to provide solutions to the problems of excessive water consumption, which is the most important problem threatening the sustainability of agricultural production.

Water Management

Water management is one of the most important discussion topics of the international community today. Water supply and recovery are the most important topics in the management of the upcoming global water crisis. Droughts and floods are straining our ecosystems with devastating consequences for global food security. Agriculture, which accounts for 72% of global freshwater consumption, plays a key role in solving this global crisis among all sectors. Global water demand for agriculture is expected to increase by another 35% by 2050 (FAO, 2018; Perez-Blanco et al., 2020; Şahin, 2024a). In order to overcome these multifaceted challenges, it is crucial to ensure the efficient use of water resources for agriculture (Bhatti et al., 2019; UN, 2020; Şahin, 2024a).

The priority of use in sharing water potential in many resources is listed as follows (Aksoy et al., 2014; Dorak et al., 2019):

- Drinking and usage needs
- Water needs required for animals and the continuation of natural life.
- Agricultural irrigation water needs
- Energy and industrial water needs
- Water needs for trade, tourism, fishing, etc.

Water management is defined as the planned use, distribution and development of water resources. Water management contains many areas such as the quantity of water, its quality and legal right to use, especially agricultural, industrial and domestic use of water. In water management, not only today but also future needs should be taken into consideration and food safety should be ensured. In this respect, it is aimed to manage water resources not only physically but also with an integrated management structure that includes social, economic and environmental factors. Although this approach has recently come to the agenda, it has started to be used in many countries for effective water management. The main approach in integrated management is to see water as a commodity that can change in quality and quantity according to the purpose of use as well as its use as a natural resource. In water resources management, reducing water losses in sectoral use of water, ensuring the effective use of water resources, using new technological machines that will save water and developing water resources at the basin level have become important. In recent years, countries have turned to managements that ensure the use and development of water resources in harmony with the environment while meeting their water needs (Aküzüm et al., 2010; Bilbay, 2020). As part of the adaptation to climate change, practices related to water and soil conservation should be expanded, and measures should be taken to ensure that water resources are transferred without being destroyed for years to come in the face of increasing water demand (Bildiren and Sargıncı, 2024).

Irrigation is the provision of the plant with the water that is not met by rainfall (Gökkür, 2016a). The water requirement of plants during certain periods of the year, such as flowering and development, can only be met by agricultural irrigation during periods of insufficient rainfall (Altan et al., 2020). Deficit irrigation can be defined as providing less water to the plant than it needs. With deficit irrigation, it is possible to increase the variety of products and thus the total yield with the same amount of water, thus increasing the income of farmers (Gökkür, 2016a). Fluctuations in the rainfall regime also affect agricultural plant patterns. In terms of agricultural production, it necessitates the use of crop rotations, water-saving irrigation techniques and drought-resistant plant varieties. The decrease in precipitation in spring and summer months leads to an increase in the need for irrigation and therefore a significant increase in the need for water resources. This situation requires a re-evaluation of the diversity of agricultural products and planting timings. Especially in the dry and hot summer months, the effective and efficient use of water resources is of vital importance. In this case, in order to use water resources effectively, it is of great economic importance to create an optimum plant pattern regionally, especially during dry periods. Action plans such as long-term agricultural planning, development of irrigation systems and drought management strategies should be supported by different analyses. In particular, water saving measures, development of alternative water resources and raising awareness of agricultural business owners about water use are necessary to protect water resources (Mucan and Yıldırım, 2023). What needs to be considered in this regard is that the protection of soil and water resources should be included in the planning phase of the studies to be carried out (Gökkür, 2016a). In places where land consolidation is carried out, irrigation rate and yield increase are initially observed. However, in lands with drainage problems, salinization in the soil caused by over-irrigation leads to a decrease in yield in the following years. A decrease in welfare may occur in those who make a living from agriculture. Therefore, irrigation and drainage projects should be designed together (Gökkür, 2016c). Besides, over-irrigation can cause soil erosion, soil salinization and even yield losses. The important thing is to irrigate up to the irrigation threshold where plants can obtain maximum yield. When the amount of irrigation water exceeds this threshold, yield losses occur (Gökkür, 2016b).

Although the water requirements of plants are mostly dependent on meteorological data such as precipitation and temperature, they also vary from plant to plant. For example, although the water consumption of maize plant varies according to the growing region and development periods, it is generally around 550-600 mm on average. This value corresponds to 550-600 tons of water for irrigation of maize in 1 da area and considering that irrigation is done 10 times in the growing season, the amount of water to be given in each irrigation is approximately 55-60 tons/da. For this reason, it does not seem possible to irrigate this amount even in 1 da area with a drone. In addition, another important issue that should be known in this regard is that irrigation water should be given to the root zone of the plant. Considering the height of the drone from the ground and the presence of environmental factors such as wind, it is not possible to carry out this application with the drone. In addition, irrigation with a drone increases the possibility of fungal and bacterial diseases in the plant due to the increase in moisture in the plant leaves (Özgüven et al., 2022).

The agriculture sector, which is the largest water user sector in many countries, faces two major problems: the increasing need for food due to the growing population and the water potential that is expected to decrease due to climate change. As the demand for increasingly limited water resources increases rapidly, the amount of water used in agriculture is restricted and world food security is endangered (Çakmak and Gökalp, 2011). Our exports and imports should be redesigned according to the water consumption of plants. Including less water consuming crops in exports will allow for more efficient use of our water resources (Gökkür, 2019).

Water conservation is crucial for the protection of water resources. With the increasing need for fresh water resources, alternative methods such as rainwater harvesting are becoming more and more attractive. Rainwater harvested directly from the roofs of buildings is an alternative to water from the drinking water network (Üstün et al., 2020). Installing rainwater harvesting systems during construction allows for fewer errors and lower costs (Dağ and Ay, 2024). Rainwater harvesting can not only increase the quantity of water resources, but also involve the public in water management, making water management acceptable to all. Besides the use of rainwater harvesting systems not only generates economic gains, but also promotes the use of alternative water sources and conserves water resources. In order to ensure efficient use of water and water conservation in new residential and commercial buildings, rainwater harvesting should be made compulsory. Next rainwater harvesting practices and water saving models should be developed in the industrial sector. Special regulations should be issued for industrial sectors and rainwater harvesting should be made necessary (Üstün et al., 2020). Furthermore the quality of harvested rainwater should be checked at specified intervals (Dağ and Ay, 2024). In order to provide more savings in irrigation water, water harvesting methods should be developed in a way that serves practicality in application (Gökkür, 2016a). Rainwater facilities and sewage systems should be inspected and maintained regularly (Dağ and Ay, 2024).

In irrigated agriculture, irrigation scheduling is one of the necessary planning to maximize the yield to be obtained from unit water under both sufficient and limited water conditions. Irrigation scheduling under sufficient water conditions can prevent the occurrence of problems such as high salinity in agricultural areas due to excessive water use. Irrigation scheduling under limited water conditions allows irrigation of more areas with the available water (Uçar, 2010).

Water resources management studies should guide the determination of the location and amount of the most appropriate types of use for the resource, in addition to the goal of meeting today's needs. Efficiency should play an active role in the economic development of the region, taking into account parameters such as agricultural activity, social status, and energy costs related to the resource, not only in terms of water resources (Meriç, 2004). Water is indispensable for life, a source of life. It is necessary for the continuation of biodiversity. Sustainability means being continuously uninterrupted (Gökkür, 2016a). Environmental sustainability is possible by ensuring the improvement of water quantity, quality and ecological aspects as a result of economic activities and preventing its deterioration, and ensuring the sustainable use of water (Kınacı, 2017; Kırtorun and Karaer, 2018). At the same time, a sustainable and effective management of water resources will ensure the continuity of other systems within the ecosystem (Meriç, 2004). The most basic scientific studies that should be carried out in surface water (lakes and rivers) and groundwater basins for the sustainable use of water resources can be given under the titles of hydrology, geology, hydrogeology, hydrogeochemistry and pollution research (Davraz et al., 2016).

Benefits of Smart Agricultural Systems on Water Efficiency in Agricultural Production

The digital age is a time period in which the value of information in the late twentieth and early twenty-first centuries is more widely understood. The number of smartphones, which are products of mobile operating systems, is rapidly increasing along with the increase in the world population. The widespread use of social media has increased the adaptation of humanity to these technologies. Technological advances are accelerating in the digital age. Everything that has not been digitized will lose its sustainability in the long term (Gökkür and Arda, 2022).

Smart irrigation systems are systems that provide irrigation solutions by comparing land and plant status measurements with smart valves and sensor control developed to provide sufficient amount of water to the plant at the right time. There is a serious need for smart water management applications to maintain effective distribution, conservation and water quality standards (AlZu'bi et al., 2019; Hachimi et al., 2023; Şahin, 2024a). Recently, artificial intelligence (AI) management models have been applied in wastewater recycling, water distribution, rainwater harvesting and agricultural irrigation. These applications give signs of how smart water management systems will become widespread in the future (Bouali et al., 2022; Jain, 2023; Jiménez et al., 2022; Khriji et al., 2021; Ndunagu et al., 2022; Şahin, 2024a). With the increase in technological innovations, it has become possible to achieve higher efficiency in agricultural production. Similarly, the Internet of Things is being used very successfully to control and monitor the status of agricultural fields. Nowadays high successes are being achieved in studies on smart irrigation systems that can be controlled via smartphones to control the water distributed in agricultural irrigation (Şahin, 2024a).

When using digital agricultural technologies, it should not be forgotten that the phenology of all varieties of fruit species grown is different. Secondly phenology monitoring should be done on a variety basis. Next, all technologies used in digital agriculture (drone, disease and pest monitoring sensors, systems measuring data on climate parameters, etc. all digital technologies) must have high data storage capacity. Yield estimation systems should be evaluated according to tree age. Since some plant identification programs store location information, they may cause problems with unauthorized collection of genetic resources from nature due to the risks of security vulnerabilities. When using such programs, plant location information should not be shared. Some plant identification programs sometimes give incorrect plant identifications because they have only as much information as they store. This problem can be solved by cooperating with search engines. Data on climate parameters such as temperature, humidity, precipitation, and evaporation may vary in different regions of the same district. If the amount of evaporation increases, the yield decreases because of the fruit size decreases. In order to determine the irrigation program more accurately, the number of meteorological stations can be increased in some regions (Gökkür and Arda, 2022). In addition, continuous research, development and education are needed to improve the design, functionality and usability of agricultural smart irrigation systems. In summary, while smart irrigation systems offer improved opportunities for water management and crop production, their suitability for the average farmer depends on several factors. Farmers should carefully consider their needs, resources, and goals before deciding whether to invest in smart irrigation technology. Collaborating with agricultural experts, suppliers, and colleagues will help farmers make informed decisions and maximize the potential benefits of smart irrigation systems (Şahin, 2024a).

The size of the agricultural area planned to be irrigated is an important parameter to consider when choosing a smart irrigation system. For small plots or garden irrigation, smart irrigation systems can be useful. However, these users may prefer basic sensor-based systems or simpler solutions such as manually controlled drip irrigation. Farms with medium-sized irrigation needs should choose for smart irrigation systems that consist of sensor networks, weather data, and more advanced controllers to optimize water use over larger areas. The use of smart irrigation systems is inevitable for large-scale agricultural operations. These farms usually have a large irrigation area. They can also greatly benefit from the precision and efficiency offered by advanced smart irrigation technologies. It is recommended to use a smart irrigation system combination of sensors, satellite imagery, and automatic control systems to effectively manage irrigation over large areas. While smart irrigation systems can be proposed for farms of different scales of operations, the level of complexity and investment required will vary depending on the size of the irrigated agricultural area, available resources and technical expertise of users (Şahin, 2024a).

The fact that digital agricultural technologies affect the decision-making mechanisms of businesses by evaluating data enables yield and quality increases in areas where cultivation is carried out, despite the narrowing of our agricultural areas, reduction of inputs used and input costs, protection of agricultural lands and natural resources such as water resources and soil with less fertilization and less pesticide use, direct and indirect reduction of CO_2 emissions by spending less fuel, reduction of producer costs and increase of producer income (Gökkür and Arda, 2022).

In short, in hydrological model approaches implemented in water resources planning and management, it has become inevitable to use satellite product data as well as ground data. There are satellite products with different spatial, temporal and spectral resolutions for the same variable, and these products have different advantages and disadvantages. After product validations, these data can be used in impact and verification studies through modeling. Finally, testing newly developed remote sensing products in hydrological modeling studies is valuable in terms of providing ideas to algorithm developers. In particular, the development of decision support systems covering reservoir operation, flood risk analyses, climate change effects, determination of management strategies and the use of various satellite products used to monitor different variables in operational hydrological applications have become necessary and important (Şensoy et al., 2024). The widespread use of digital agricultural technologies should not cause our farmers to move away from their lands in the future. New situations that may arise with the unexpected effects of climate change (new diseases and pests, etc.) can be detected and resolved by farmers' field assessments. Since digital agricultural technologies are being used in all activities from the moment the farmer plants the seed in the field or the sapling to fertilization, irrigation, pruning, harvesting and post-harvest delivery to the consumer, smart agricultural technologies should be added to the structure of the value chain (Gökkür and Arda, 2022). We will observe more of the benefits of digital agricultural technologies in updating irrigation methods and planning water resources and irrigation scheduling in the near future.

Figure 1. Overuse of water resources (Original by Gökkür, 2023)

Water, which is an indispensable value for life, is important in ensuring sustainability not only for living beings but also for manufactured objects (Gündoğdu and Anlı, 2023). The use of alternative water resources is graded depending on the size of the irrigation area, plant pattern, water requirement, climate conditions, socioeconomic status and legal regulations. Excessive water, fertilizer and pesticide use in agriculture, incorrect soil processing methods, discharge of untreated water from use to receiving environments (domestic and industrial wastewater discharges), nature and aquifers, leakage water from solid waste storage and dumping areas, mining areas and septic tanks mixing with groundwater, pollutants carried from the atmosphere to water and soil cause widespread pollution in soil and water resources (Kodal and Ahi, 2018). Water pricing in the most appropriate way will be one of the most effective ways to protect water as a natural resource. In addition to water pricing, wastewater should also be priced to reflect wastewater costs in terms of preventing environmental damage. In this way, those who pollute the environment should pay to prevent the pollution they cause. In determining the costs in pricing, budgets for expansion and new infrastructure needs, as well as maintenance, repair and renewal programs are important (Armut, 2019). The polluter pays principle should be applied to all sectors using water (Kınacı, 2017; Kırtorun and Karaer, 2018).

Agricultural crops need to be grown in regional agricultural basins that have the most favorable conditions in terms of economy and ecology, are of a manageable size in terms of topography, climate (Altan et al., 2020). Regardless of the land use status (forest, agriculture, rangeland, residential area, industrial facility, etc.) in a basin, it has an impact on the hydrological system of that basin. Determining the purpose of use in a water collection basin means evaluating the soil characteristics, climate elements, and vegetation data of that basin to reveal the causes of degradation in the area. This is a basin management principle. The fulfillment of this principle can be achieved by using the lands in accordance with their purpose. As a result, the main purpose of basins is to produce water. The most basic way to ensure water production is to ensure the protection and use of all natural resources in basins, especially soil and vegetation resources. In this way, erosion in the land can be prevented and water production can be ensured to be of the desired quality and quantity (Erol, 2007).

Large amounts of water are consumed in economic production processes. Much more water is used in production processes such as food, clothing, etc. than the amount of water consumed by people for drinking and utilization. "Virtual water" is defined as the water required in the production process of an agricultural, industrial product or service. With virtual water transfer, it is easier to put into practice the integrated management of water resources and contributes to the prevention of pollution in basins. The implementation of the virtual water transfer option instead of "Inter-basin Water Transfer", which creates very serious negative effects on ecosystems, is also of great importance in terms of protecting ecosystems and preventing basin pollution (Anaç et al., 2011).

By managing water on a basin basis, it is possible to increase economic efficiency, ensure social equality and ensure environmental sustainability. Equal opportunities should be provided in water use in rural, urban and industrial areas. Furthermore economic efficiency is possible through activities such as preventing water loss and leakage, switching to modern irrigation in agriculture, using new technologies that provide water saving in industry, informing the public about domestic water use, etc. (Kınacı, 2017; Kırtorun and Karaer, 2018). When water is insufficient or irrigation fees are high, those working in agriculture resort to groundwater irrigation. The decrease in groundwater negatively affects ecology. In order to reduce the dangers created by sinkholes in some regions, groundwater use should be limited. Groundwater withdrawal should be kept at a certain level on coasts exposed to seawater intrusion. Otherwise, our biological diversity will be negatively affected by this situation. Areas covered with meadow and pasture plants help precipitation to feed groundwater and to rehabilitate salty and alkaline soils. Areas that comply with ecological restoration rules for the protection of nature can be covered with these plants and serve to enrich our groundwater resources (Gökkür, 2016b). Besides the use of disease-resistant rootstocks that consume less water in fruit cultivation will benefit the efficient use of water resources (Kellerhals et al. 2017; Şahin, 2024b).

The biggest problem encountered in calculating the hydrological balance of water resources is the lack of regularly measured data. In terms of sustainable use of water resources, the number of meteorological and flow observation stations should be increased and the necessary sensitivity should be shown to measure the amount of water drawn from water resources with the most accurate data (Davraz et al., 2016). To minimize water loss, improving water treatment and distribution infrastructure would be beneficial. It is considered necessary to collect the fees received from water and sewage services in a fund and to cover the investments to be made from this account. The costs of renewing worn-out water lines, reducing water losses and leaks to acceptable levels, and renewing wastewater treatment facilities in the coming years can be covered from this fund (Armut, 2019).

Water Efficiency in Agriculture

With the increase in the population of the countries, it is expected that the amount of water per person will decrease. Therefore, the efficient management of the existing water resources in the world is of vital importance. Water resources play an important role in both industrial production and agricultural production. Economic production cannot be considered without water resources. Water also plays an important role in the production of electricity in thermal power plants. As a result of global warming, water resources in the world will be negatively affected and water wars may occur. Therefore, it is also important for world peace for the countries of the world to successfully manage their water resources (Sertyeşilışık, 2017).

Increasing water efficiency in agriculture can be possible by developing integrated water resources management and water efficiency plans, preventing water losses, evaluating recycling alternatives and adopting "basin management" principles. In this context, optimum product selection, appropriate irrigation time planning, selection of appropriate water transmission and distribution lines, effective irrigation techniques and use of alternative water sources in irrigation are required. In places where irrigation water is limited and expensive, in addition to the selection of new methods that can save water, the application of deficit irrigation is also considered as an alternative. Deficit irrigation is an approach that is applied when certain levels of water deficiency and plant productivity are allowed to decrease. One of the measures that increase water use efficiency and provide more income with the same water in irrigated agricultural enterprises, both in sufficient and limited water conditions, is the determination of the optimum plant pattern for the enterprise. The goal of optimum plant pattern studies is to maximize enterprise income and use limited water resources effectively (Kodal and Ahi, 2018).

The increase in irrigation efficiency (water transmission and water distribution efficiency) provides water savings. In an irrigation area where water is transmitted and distributed through open channels and surface irrigation is applied, irrigation efficiency will increase if the irrigation network is converted to a pressurized system and sprinkler and drip irrigation methods are applied (Kodal and Ahi, 2018). Water efficiency is an important concept that includes many processes such as the efficient use of water resources, storage and protection of excess. With studies aimed at increasing water efficiency in agricultural production, productivity can be increased without reducing crop quality. In order to correctly assess the impact of climate change on crop yield, it is necessary to take into account how changes in climate parameters affect the phenology of the crop (Gökkür and Şahin, 2024).

In order to reduce the energy cost in irrigation, a policy should be implemented to "encourage efficient use of water". Energy costs, which reach 80% of agricultural production costs and management costs in pumped and groundwater irrigation, constitute a significant problem in irrigation areas, and in areas opened to irrigation, the planting of plant varieties that require a lot of water is restricted in order to avoid irrigation costs, even if they have high returns. This reduces the expected benefit from irrigation investments. In order to prevent this, the products that can be grown in agricultural basins should be investigated in terms of their economic values and water consumption when planning irrigation (Kodal and Ahi, 2018).

The word yield conceptually shows the utilization rate and is an indicator of water efficiency. The main precautions to be taken to ensure sustainable agriculture with efficient use of water are; (1) planning of appropriate water transmission and distribution lines, (2) choosing one of the high-pressure irrigation methods with high water application efficiency, (3) appropriate irrigation time planning, (4) use of alternative water sources (rainwater harvesting, use of grey and treated wastewater and sea water), (5) qualitative protection of water resources (Kodal and Ahi, 2018).

The total water needs of the plants in the basin should be determined by taking into account the environment in which the plant is located, soil and atmospheric conditions, and water source characteristics, and the water taken from the source should be delivered to the field parcel with high efficiency transmission lines (closed pipe systems) and to the plant root zone with an irrigation method with high water application efficiency. There are many methods and tools used in determining plant water needs and planning irrigation times (Kodal and Ahi, 2018). Moreover by using pressurized irrigation systems and planning drainage systems correctly, protecting our soils against water and soil erosion and salinization, rehabilitating the soil structure by determining and implementing the fertilization program according to soil analysis, and implementing soil management practices such as correct soil processing techniques will positively affect the increase in yield in agricultural production areas (Gökkür and Şahin, 2024).

The unconscious irrigation of producers and the high water loss due to evaporation due to the prevalence of open channels have a great impact on agriculture being the sector that uses the most water. With excessive irrigation, nutrients in the soil can be carried to depths that the plant cannot reach, plant roots can rot due to lack of air due to the rise in groundwater. As a result productivity can decrease due to water erosion. Irrigation water salinity should be examined at the beginning and end of the irrigation season. Irrigation methods and programs that will reduce irrigation labor and reduce the amount of irrigation water to be applied and allow more areas to be irrigated should be preferred and the economic analysis of these methods should definitely be done. Since homogeneous water distribution is provided with land leveling, water application efficiency increases and since the irrigated areas increase, productivity also increases. Thus, the total national income of the segment that makes a living from agriculture and the country increases (Gökkür, 2018). In addition water management strategies should be created by examining the changing climate and its parameters from a different perspective. Importance should be given to studies on the development of drought-resistant varieties (Gökkür, 2016a).

To ensure efficient water use in irrigation; (Çakmak and Gökalp, 2011).

- Prevention of excessive water use,
- Monitoring and evaluation of environmental impacts of irrigation,
- Investigation of the effects of climate changes on plant development and water consumption,
- Improving and protecting water quality,
- Water quality monitoring and assessment,
- Develop water management guidelines for different climate scenarios for irrigation-related institutions and organizations,
- Design of irrigation systems according to pressurized irrigation methods,

- Development of alternative water resources (recycling of wastewater, diversion of surface water to areas where water is scarce, development of water-saving irrigation methods and techniques, utilization of wastewater and drainage water),
- In order to minimize water distribution losses, open systems should be abandoned in favor of closed pipe systems,
- Establish a pricing model based on volume (water quantity instead of plant-area),
- Ensuring coordination between institutions,
- Raising awareness of farmers on water conservation,
- A comprehensive water law should be enacted for the effective protection and utilization of water resources

Since lands without drainage systems and excessive irrigation cause pollution of our groundwater, water pricing should be planned according to volumetric water fee in a way that will reduce the use of groundwater. In addition, regional restrictions can be imposed on groundwater withdrawals. Climate change causes changes in the amount of groundwater recharge. The levels of our groundwater should be controlled by opening observation wells in more areas in accordance with the standards. These studies will contribute to preventing uncontrolled drilling well (Gökkür, 2016b).

In the use of water resources, issues such as the use of water harvesting techniques, the implementation of optimum irrigation programs and the preparation of limited irrigation programs and guides, increasing savings in all water-using sectors and preventing water losses in agriculture, the dissemination of pressurized irrigation methods, the transition to a closed system (piped system) in water transmission and distribution systems, ensuring the efficient use of water in agriculture, the reuse of treated wastewater and drainage water in agriculture, and the use of a pricing approach based on the amount of water consumed in irrigation should be taken into consideration (Çakmak and Gökalp, 2013).

Dams can negatively affect climate and therefore ecology. In the selection of dam sites, priority should be given to areas where ecological restoration is not possible and away from agricultural production areas. Changes that dams may cause in the climate of the region and meteorological parameters such as humidity and temperature may cause decreases or increases in yield, increases or decreases in diseases and pests, and differences in harvest dates (Gökkür, 2016c).

Urban green areas (parks, forests, wetlands, etc.) have great hydrological importance in terms of biodiversity, ecological systems, wildlife, microclimate, vegetation, etc. in urban life. These areas provide the absorption of excess water by creating permeable surfaces, while at the same time preventing the evaporation of water above normal by eliminating the heat emitted from structural elements. While reducing the average temperature in afforested areas, it also prevents soil losses due to surface runoff resulting from rains above normal. When viewed from these and similar perspectives, the importance of urban landscape designs in preventing water risk is clearly seen. In addition, the high number of impermeable surfaces in urban areas where dense construction is dominant causes us to experience serious drainage problems caused by rainwater. On the one hand, the need for future water and on the other hand, the problems based on excess water necessitate the creation of some holistic strategies for urban infrastructures. Besides, urban landscape design strategies in general can be: wastewater recycling and grey water use, water efficient plant selection and placement, sustainable drainage systems, water storage systems, sustainable water infrastructures. By combining these suggestions, water management in urban areas can be made more sustainable and water-related risks can be reduced azaltılabilir (Rahımbaylı et al., 2024).

Nowadays, especially in landscape applications, in places where irrigation water is limited, in order to save water, deficit irrigation applications can be considered as an alternative. Especially in landscape architecture applications, in order for the plants used in planting designs not to lose their visual texture and form features, a restriction value specific to each plant can be determined and applied. In this way, the survival of the plants, which are the living material of landscape architecture applications, is ensured while water saving is also achieved (Bayramoğlu et al., 2013).

The concept of water footprint is related to where, when and for what purpose water is used. If the conditions in the relevant basin are not evaluated from a holistic perspective in order to understand the impact of production and consumption processes on water resources, the high or low water footprint alone does not mean anything. In a basin where water is abundant, the impact of the water footprint on society, ecosystems or the economy may be relatively low. However, a high water footprint in a basin experiencing water scarcity may lead to irreversible consequences such as access to healthy and sufficient drinking water, drying up of water resources, the threat of extinction of some living species and the decrease in livelihoods. Reducing the negative effects of the water footprint and ensuring the sustainability of water resources is only possible if all parties that use water resources or have any kind of intervention act together (Turan, 2017).

Education also plays an important role in the protection of water resources. Environmental awareness training, especially at a young age, can reach larger masses with the participation of children and their parents (Gezer and Erdem, 2018). For example, it has been reported that education and awareness campaigns have reduced water consumption by 57% in Melbourne, Australia (Bryx and Bromberg, 2009; Gezer and Erdem, 2018), and reduced water consumption by nearly 20% in California, USA (Zuchowicki and Kuczynski, 2008; Gezer and Erdem, 2018). For sustainable water management and water use in agriculture, a participatory and democratic management style that prioritizes environmental education and information should be developed and implemented (Özkan et al., 2013).

Conclusion

Agricultural production should be carried out according to the water availability in the area to be cultivated. The characteristics of the water source in the lands where agricultural production will be carried out should be known. The choice of irrigation method in agricultural production areas should be based on an analysis of the environmental impacts of irrigation. Plant water consumption should be redetermined according to the life cycle of fruit trees (according to plant age and development) by creating new methods. Since climate change changes the life cycles of some plant species to be used in agricultural production, irrigation programs for these plants must be re-prepared. Due to the unexpected effects of climate change on the life cycle of all plants, more pesticides and therefore more water are used to combat the increase in diseases and pests. Next over-fertilization and over-spraying pollute soil and water resources. In water management, future plans should be made by examining the average, maximum and minimum temperature values, precipitation amount and duration, evaporation amount and humidity values of the region to be examined. The management of water resources should be planned by considering all sectors where water is used, without deviating from the goal of protecting and sustainable use of water resources.

If individual water saving becomes a habit in all societies, water use for domestic, agricultural and even industrial purposes can be reduced. Communities should be educated on what they can do individually to prevent water pollution. Governments can help protect water resources by updating their monetary sanctions against water polluters.

Recommendations

Agricultural production plans should be made by evaluating the water consumption of crops that can be grown in different regions of the country. Giving irrigation water as much as the plant needs can cause decrease in the number of annual observed diseases and pests number. Making regulations that require the use of water-saving dishwashers, washing machines, taps, shower heads and toilets in all newly constructed buildings will slow down the rate of depletion of our water resources. If people's priorities in purchasing products are towards devices and items that are produced using less water, the use of water-saving production methods in the manufacturing industry during the production phase may become more common in the future. When determining water pricing, it should be based on the purposes of water use and water saving. The use of artificial intelligence systems in observation wells used to detect groundwater levels can be beneficial for the protection of water resources. Countries should plan their water consumption in all sectors in advance, considering the increasing number of tourists each year. Treated wastewater can be used in parks, gardens, recreational areas and industry.

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