An Overview of the Concepts of Irrigation Efficiency

Iranian National Committee
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Working Group on

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Foreword

The shortage of freshwater resources in many areas of the world has created constraints for comprehensive and sustainable development. The increasing population, development of agriculture, and industry in some parts of the world, especially in Middle East countries, were not in proportion to renewable water. Hence unsustainable development by harvesting more than the annual volume of renewable water from water sources has caused the most damage to the Environment and water resources. In case that in many arid and semi-arid countries of the world, including Iran, there is a growing demand for water resources beyond renewable water; saving water consumption and, more importantly, increasing agricultural productivity is the most common approach in these countries. Therefore, various equipment and tools have been used to increase irrigation efficiency in agricultural fields, realize water-saving programs in the agricultural sector, and increase water productivity.

Using advanced technology and equipment in Irrigation requires compliance with the principles, guidelines, and regulations. Furthermore, how these principles apply in different areas depends on the weather, soil condition, water resources, human resources, machinery, energy, indigenous knowledge, types of products, and, most importantly, the purposeful application of advanced technology. One of the main reasons for using state-of-the-art technology is to increase irrigation efficiency at the field scale or irrigation networks to save on agricultural water consumption. Part of irrigation losses (Water used to meet the plant's water needs) from the perspective of water accounting and at the scale of an irrigation network or catchment area is considered beneficial losses. Because of the water that sometimes we think is wasted, another consumer may be using it downstream; it may supply the catchment's environmental requirements. However, it can often effectively improve water quality at the catchment level.

From the farmer's point of view, the purpose of Irrigation is to bring water from the source to the plants. In his view, any water extracted from a water source that cannot be stored in the root zone and consumed through evapotranspiration of the plant is a loss. So the farmer's whole endeavor is to bring all or most of the water he has taken from the water source to the root zone and to prevent water loss along with the conveyance, distribution, and application. The farmer prefers to line the canal, seal the gate, level the ground, replace the canal with the pipe, and use advanced Irrigation methods such as; Drip Irrigation, Sprinkler Irrigation, and Subsurface Irrigation to minimize water consumption as little water as possible. However, regarding macro-management of water, such actions do not lead to actual water saving at the catchment area level. However, the paradox between the farmer's interests and the water-saving policy at the catchment area for less water extraction is not deniable. This publication aims to benefit from the latest results of studies on concepts of Irrigation efficiency by the Iranian National Committee's working group on the Development and Management of Irrigation Systems. After pre-preparation of the contents of the publication, it was sent to the executive agencies involved in the water and agriculture of the country and to several University professors. They studied it, and their viewpoints, comments, and suggestions were reviewed and used to improve the book's content.

Here I fully thanks the working group member on the development and management of Irrigation Systems of the Iranian National Committee. Moreover, all of those contributed to this publication's improvement and compilation. Hopefully, the results of this issue will give the water and agriculture sector a clearer perspective on productive investment targeted to increase irrigation efficiency and agricultural water productivity.

Mehrzad Ehsani

Secretary General;

Iranian National Committee on Irrigation and Drainage

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Abstract

One of the goals pursued so far in irrigation development and improvement plans is to increase irrigation efficiency to reduce water losses and increase the amount of available water to the plant for future planning. In this case, the belief is that saved water through increasing irrigation efficiency is a new source of water that can result in an increase in area under cultivation or the possibility of increasing water use for plants with more consumption per unit area. Nevertheless, it has been a while since there has been a new debate on the nature of water loss. Most experts have come to realize that those parts of the water, which we consider irrigation losses that exited from the field in the form of deep percolation or surface runoff, in most cases, become a source of water supply for humans or environmental needs in other areas. Thereby raising Irrigation efficiency leads to disruption of these types of water use, and ultimately increasing the efficiency did not affect the total amount of available water. There is only a shifting of water use at the place of consumption. This publication concludes that controlling the water crisis is impossible by increasing Irrigation efficiency. Instead, the solution through the targeted reduction of water abstraction from the country’s surface and groundwater resources, change the cultivation pattern to crops with fewer water requirements and cultivate the crop in a controlled environment. Moreover, consequently, the release of part of agricultural water's contribution to the Environment or other sectors and sanitarian uses. The solution touring the consequences of this decline is developing and creating jobs in other sectors such as industry, mining, tourism, and services.

Keywords: Irrigation efficiency, catchment area efficiency, Productivity, Water consumption.

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1 Preface

In recent decades, the study and implementation of irrigation development and improvement plans in Iran have multiplied, and a considerable amount of financial resources have been spent on this purpose. The result of these activities and actions on water resources and agricultural production on different scales such as farm level, watershed, and national level is discussable. One of the issues related to this subject is irrigation efficiency. At the time, irrigation efficiency was an essential topic of discussion and debate in scientific and technical centers and institutions involved in the water and irrigation sectors of the country, and what is stated as one of the primary goals of implementing irrigation projects was to increase irrigation efficiency. The creation and justification of irrigation and drainage schemes are also often assumed that high irrigation efficiency is achievable. Hence, addressing such a key and practical issue on Irrigation management and, in general, clarifying the concepts of irrigation efficiency and the various aspects it matters is essential in water resources management in Iran.

The purpose of Irrigation is to supply the water needed for the plant to be consumed by evapotranspiration; Evaporation from the soil surface at the location of the plant's growth, and in some cases, evaporation from the plant's foliage and transpiration from the plant stomata. Irrigation water provides evapotranspiration if there is insufficient rainfall during the plant's growing season. It requires water extraction from wells, springs, Ghana (subterranean), rivers, and water storage structures. Also, water conveyance up to the beginning of the farm, distribute the water at the farm level and store the water at the plant root development zone, and the plant uses this stored water. In the above three stages, namely conveyance, distribution, and water application on the farm, part of the amount of irrigation water harvested from the water source is wasted. In this process, it runs out of the reach of the plant. That is to say, part of the water Harvested from the water source does not consume for evapotranspiration. This wasted water does not enter the field. Alternatively, within the field, it exits from the plant's root zone, running deep into the soil or evaporating from the canals' surface and ditches and leakage from their bed and walls or slopes, or flow as surface runoff and discharges into the drainage. So it is out of reach. It is on this basis that the concept of efficiency comes into play.

By definition, irrigation efficiency is the water volume ratio stored in the plant's root zone. It then is spent as evapotranspiration (after deducing the amount of effective rainfall); to the volume of water harvested from the water source. The definition of irrigation efficiency does not consider the fate and path the wasted water takes (the part of irrigation water that does not reach the plant's evapotranspiration). Based on this issue, along with irrigation efficiency, catchment efficiency becomes meaningful. In defining catchment area efficiency, the fate of wasted water also is followed.

Moreover, depending on whether the lost water is unusable for consumption purposes (other than Environmental consumption) or whether it enters the water consumption cycle again, the efficiency of the catchment area varies. The efficiency of the catchment area may be defined as the ratio of the volume of water used to the plant evapotranspiration in the catchment area (after deduction of the effective rainfall); to that part of the catchment area renewable water (and in some cases, Initial catchment area storage such as static storage of groundwater resources) allocated to the irrigation water. In general, the time and spatial scale of catchment area efficiency are higher than the time and spatial scale of irrigation network efficiency and the farm's time and spatial scale.

In the new version, the policies of the World Bank emphasized the need for comprehensive management of water resources. Increasing the current efficiency is one of this policy's components in the Irrigation field. From the World Bank's view, low irrigation efficiency leads to unequal and unreliable water distribution and exacerbates problems for downstream farmers.

In most technical and professional communities, the national average of irrigation efficiency has been declared low. It is supposed that conventional irrigation methods are the leading cause of low irrigation efficiency. Based on such attitudes to irrigation efficiency, over the past years, to increase irrigation efficiency, substantial financial investment has been made to replace conventional irrigation methods with pressurized and low pressurized irrigation methods.

Most of the statistics on the national average of irrigation efficiency appear to lack a scientific and technical basis. The reported irrigation efficiency of the country generally results from an approximate estimation of water demand, the area under cultivation, and the total water use. Low irrigation efficiency, recited at technical communities and meetings, lacks a scientific basis. In contrast, in some international sources, a high figure is mentioned for irrigation efficiency in Iran. An example of this is described below. Moreover, simply because of low efficiency and without knowing the final fate of the wasted water and the efficiency of the catchment area, it is not possible at all times ruling to change the existing methods of Irrigation without regard to all technical and management parameters.

Issue no.34 of the Iranian National Committee on Irrigation and Drainage, entitled; “Water Supply and Demand in the World from 1990 to 2025 Scenarios and Issues." Which is a translation of a report published by the International water management institute (IWMI)[1]The irrigation efficiency of Iran was reported at 65 percent. Furthermore, the figures for countries expected to have better conditions than Iran were lower than that.

In the editing of the above translation, to address this contradiction in Iran (irrigation efficiency of 30% of national technical assemblies versus 65% of international references) has reduced the efficiency of 65% of the IWRM to 53%. In numerous references and assessments, irrigation networks running across the country's reservoir and diversion dams or surface irrigation systems utilizing groundwater resources that their complete irrigation efficiency has measured and reported of approximately 30 to 35 percent. The difference arises from the fact that in traditional irrigation systems of the country, there is a deficit in Irrigation and generally high water use efficiency in the field.

Thus, it is implicitly pointed out that the national average of 30% irrigation efficiency in Iran and consequently the methods of measuring and evaluating it and the policies and decisions that have been adopted based on the assumption of low irrigation efficiency to change irrigation methods are wrong.

1- Seckler, D.; Amarasinghe, U.; Molden, D.; de Silva, R.; Barker, R. 1998. World water demand and supply, 1990 to 2025: Scenarios and issues. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI); IWMI. vi, 40p. (IIMI Research Report 19 / IWMI Research Report 19)

2 The nature of water use in agriculture

The beneficial use of water by the plant is transpiration through plant stomata and evaporation from the soil surface of the cultivated land. In some Irrigation methods, such as Sprinkler irrigation, the evaporation from the plant's foliage enters the atmosphere from the cultivated lands. Energy is needed to change water from liquid to steam; direct sunlight, and to a lesser extent, the heat of the surrounding air supplies the necessary energy for evapotranspiration. Therefore, the amount of evapotranspiration at each point depends on the available energy. At 20 ° C, 2.45 Mega Jul of energy.[1] It is needed to convert one kilogram of water to steam (equivalent to one millimeter per square meter). The amount of the sun's radiant energy as a solar constant is 0.082 Mega Julper Square meter per minute.I.e., with direct irradiation for half an hour (2.45: 0.082 = 30 min) on the water surface, it evaporates1 mm of water. Of course, only part of the solar energy can reach the Earth's surface. Some parts of this energy that comes to the Earth (including the oceans) provide the necessary energy for evapotranspiration. The rest of the energy reflects directly to space without entering evapotranspiration.

The evaporation power of the sun's radiation varies in different parts of the Earth. Still, at every point, it is definite and sustained up to the equilibrium of the solar system and is not disturbed. This evaporation power at any location with available water appears in the form of transpiration from the plant, evaporation from the water surface, or wet surfaces (such as wet soil or irrigated land). In

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1-Allen, R.G., Pereira, L.S., Raes, D., Smith, M. (1998) Crop evapotranspiration: Guidelines for computing crop water requirements. FAO Irrigation and drainage paper 56. Food and Agriculture Organization, Rome.

these instances, the sum of transpiration and evaporation is the same constant of radiation's evaporation power of the sun at that point. In other words, when all of the received energy is at the latent heat of the giant evaporation, it is saturated. Since then, despite the existence of water, there has been no possibility for further evaporation. Because, for evaporation, other than the water, energy is also required. Therefore, the potential evapotranspiration cannot have much to do with the irrigation method.

Irrespective of the irrigation method, the plant, like other living things, needs water to perform its vital and natural functions, referred to as net water requirement. The amount of net water needed by the plant is not dependent on the irrigation method. The photosynthetic process also requires water, and all of the plant's material needs to be dissolved in water and delivered to the plant. The mechanism of upward movement is the solar energy that transpires in the plant's foliage and, consequently, the continuous movement of water from the root upwards in the plants. Keeping the plant fresh like other organisms requires that part of the water consumed by the plant transpiration.

The soil is a container for storing moisture needed by the plant between irrigation intervals or effective rainfall. Part of the moisture in the soil (stored in the plant root zone) is consumed by the plant, which is called transpiration. Another part of the soil moisture evaporates off the soil surface. Except in certain conditions in the Drip irrigation method, evaporation from the soil surface, the same as transpiration, does not, in practice, depend on the irrigation method. The sum of evaporation from the soil, and transpiration from the plant (after deduction of effective rainfall), is called net irrigation requirement (In), or beneficial irrigation water consumption.

In the process of plant irrigation, part of the moisture in the plant's root zone is stored in the soil and gradually used for consumption (evapotranspiration). Other parts of the moisture exit from the plant's root zone and run into the deep zone of the soil. Alternatively, as surface water gets out of the farm to the farmer's outreach, this part of the irrigation water is called irrigation losses inside the farm. The amount of these irrigation losses vary with different irrigation methods. For example, it is low in the Drip irrigation method, and in Border irrigation methods, irrigation losses are high within the field. Thus, the gross need for Irrigation of the plant and, as mentioned in the references, the need for Irrigation is the total net need for Irrigation of the plant (and other needs such as leaching) plus the total irrigation losses of water from the water source to the root zone.

As mentioned, the net need for plant irrigation is not very dependent on the irrigation method. Only in the Drip Irrigation method does the soil surface's evaporation somewhat reduces if the vegetation cover is not complete. However, when the vegetation is complete, the net irrigation requirement of the Drip irrigation method also does not look different from other irrigation methods, including the flooding method (with a full cover of the land by the plant). For example, in a garden with shade levels reaching 70 to 80 percent or with alfalfa at the full cover stage, soil evaporation is minimal, and vegetation transpiration increases due to increasing vegetation cover in the field. In this case, only the transpiration of the plant occurs. The irrigation methods, such as the Border or Drip, do not significantly affect the plant's evapotranspiration rate. However, as explained below with new approaches, reducing water consumption (evaporation), which has until now been one of the significant advantages of the Drip irrigation method, has been seriously questioned, and there is much uncertainty surrounding it.

3 Characteristics of irrigation losses

As explained in three general processes of irrigation operations, including conveyance, distribution, and application for water storage in the plant's root zone in the field, part of the irrigation water from the source is wasted. The amount of irrigation losses depends on several factors; type of cultivation, crop season (Autumn, Spring, and Summer), farmer's skill in Irrigation, Irrigation method, Type of irrigation canal lining, the canal and offtake structures' erosion rate, Length, and extent of water conveyance and distribution system, Air temperature, the amount of water flowing in the stream, the status of the mud, sediment and plants and algae in the canals, open or closed conveyance and distribution of water conduit.

There is a significant difference between irrigation losses and, for example, energy losses, which has led to misunderstanding and misinterpretation by non-specialists in irrigation science. For example, suppose the efficiency of an electric device is 50%. Half of its electrical power is converted to useful power and kinetic force (such as rotating the pump blades in a pump). Moreover, half of that consumed power is wasted and converted directly to the heat, which in the example above is no longer recyclable in the operation defined for that pump. However, suppose irrigation efficiency is 50%. In that case, half of the volume of extracted water from the source is spent on the plant's evapotranspiration. There is no such facility available at the exact location for the other half of the volume of harvested water. It enters underground or surfaces water sources, or a tiny part of it directly evaporates from the surface of the ditches or irrigation canals and reaches out to the intended farmer. Accordingly, except for direct evaporation from the reservoir's surface, the remaining wastewater at the catchment area scale is generally recyclable and reusable, with a lower quality. Unlike energy wastes, Irrigation losses are a relative concept. They vary depending on whether they accord at the farm or catchment area level.

It should be noted, however, that with the advancement of science and technology, energy losses, the same as water losses, are becoming more and more recyclable, such as combined cycle power plants.

4 Measurements

Irrigation efficiency measurement is difficult and time-consuming. It is highly dependent on factors such as net water amount (evapotranspiration) and gross irrigation requirement, which is affected by channel leakage, water conveyance and distribution system losses, effective rainfall, consumption of water on the farm, and the amount of returned water. These measurements should be carried out in different conditions, such as wet and dry seasons or wet and dry periods, during which the amount of net irrigation requirement, gross irrigation requirement, and cultivated land area vary. Based on this variety, the efficiency of the farm's conveyance, distribution, and application of water generally vary. Scientific sources provide conceptual and straightforward relationships to measure irrigation efficiency. However, complete and accurate irrigation efficiency measurement rarely occurs in practice. Therefore, experts are forced to make assumptions and inaccuracies in estimating irrigation efficiency based on approximate and general numbers they work on the study and operation of irrigation schemes.

5 Attitude to the Irrigation Efficiency

Before human communities emerged on the Earth, all renewable water in each catchment area was the share of the Environment. With the entry of humans into the field of water resources and the formation of population centers, and the development of production and service activities, a new partner for the Environment was found over water, and agriculture, industry, services, drinking, and health were added as new consumption sectors in addition to the Environment. Curiously, this new consumer (community center) in many countries, including Iran, does not accept any right to the original and long-term owner of the water, say, the Environment. It has limited consumption and exclusion of the Environment to the extent possible. The human consumption sector (agriculture, industry, services, drinking, and health) has a demanding role.

Nevertheless, the Environment has usually not had enough power and influence to protect its share. Thus, other consumption sectors violate its share. And so easily, the allocation of the Environment has been gradually reduced and transferred to other sectors. However, some international organizations have already set standards for protecting environmental water allocation.

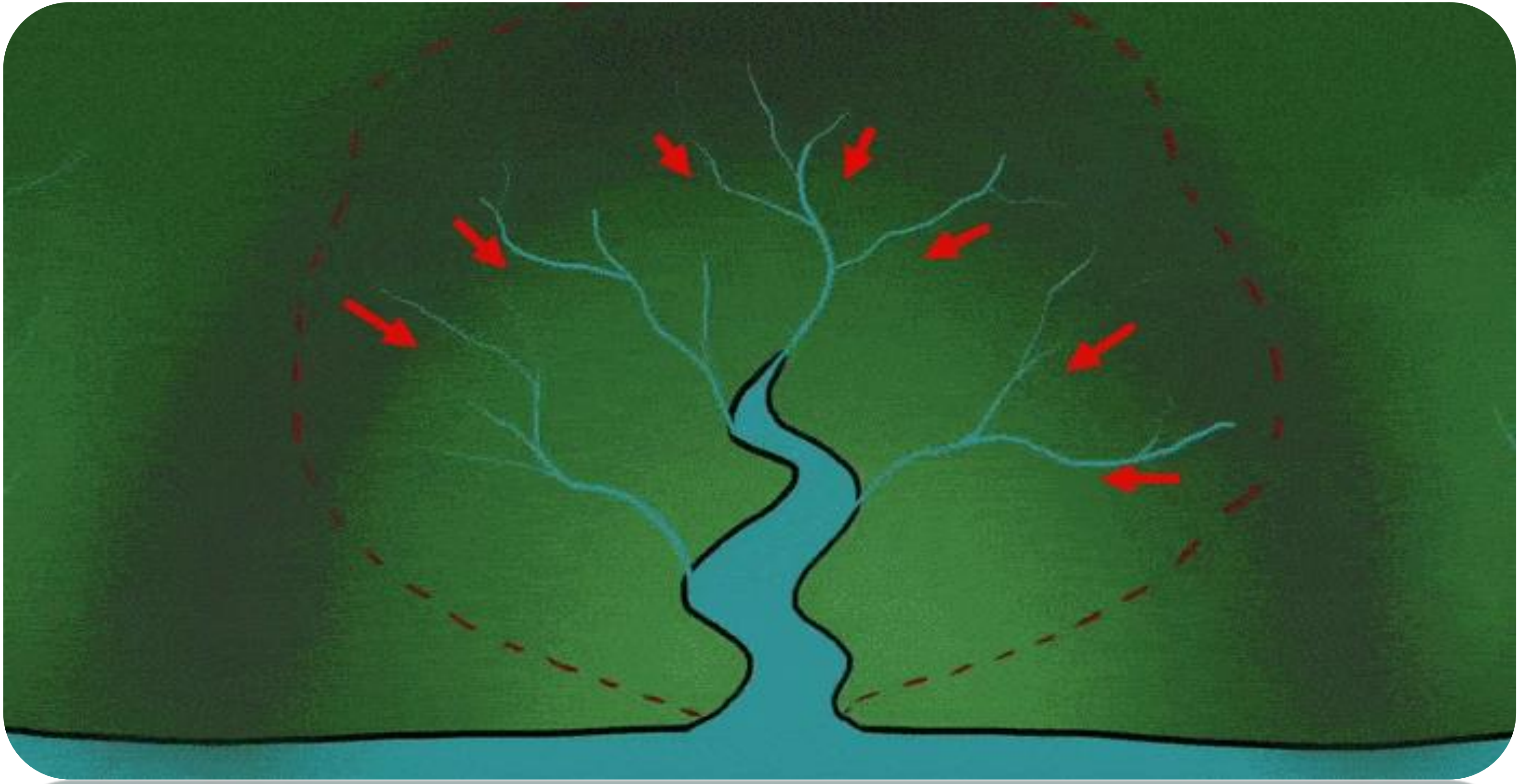
Given that the role of the Environment and its impacts on human life has not been fully understood so far, and nature does not react quickly to the reduction of water allocation, and pollution of water resources, encroachment on the environmental share will usually continue until the crisis stage. The Environment's reaction to the reduction of quotas may appear years after and even after several generations. However, when it appears, it affects all aspects of human life. The solution is not easy, given that the environmental share of water resources has been used for the unsustainable development of human societies. Currently, in Iran, as in many countries in the world, the significant share of water resource consumption is in the agricultural sector. Water consumption efficiency in Iran's agricultural sector is low, so the pressure on water resources (due to the return of lost water) is somewhat reduced. In this section, the attitude of water users, on the one hand, and the custodian of water resources management, on the other hand, towards irrigation efficiency is expressed. A farmer, as a water user, purposes the Irrigation is to bring water from the source to the plant’s root zone. Any water harvested from the source but not stored in the plant's root zone for evapotranspiration is considered wasted. Therefore, the farmer tries his best to bring as much of the water he has extracted or received to the root of the plant.

From the point of view of the farmer as a water user, the purpose of Irrigation is to deliver water from the sources to the plant. Any water taken from the sources cannot be stored in the root development area of the plant and used for evapotranspiration; in his view, it is considered wasted water. Therefore, all the effort of the farmer is to reach as much as possible of the water he has extracted or received to the root of the plant and as little as possible of the water in the path of conveyance, distribution, and application to the root development area of the plant be wasted. So, the farmer; lines the canal, seals the gates, grades the ground, replaces the canal with closed conduits, and employs modern irrigation methods such as Drip Irrigation and Sprinkler Irrigation to minimize water loss and more water to be consumed just for evapotranspiration of plant. Furthermore, if possible, increase the areas under cultivation. It is necessary to explain that the contribution of leaching, such as infiltration losses, must be removed from the root zone to transfer excess salts from the leached soil to the outside of the root zone.

For water resource management, the main object and concern (in arid countries with limited water resources) are that less water is harvested and transferred to the farm. So that water resources remain in equilibrium. All stakeholders and the Environment receive benefits from available water. If the losses did not consume for evapotranspiration and, as in most cases, return to surface water resources (or groundwater aquifers), the water quality falls to the return water quality; generally, the water sources manager considers this as a positive. Hence the two concepts of Irrigation efficiency and catchment area efficiency are discussable in a different approaches. Of course, what needs to be said about the trustee position of water supply management must be addressed "has to." Because in the current situation, unfortunately, his position contrary to his interests is the same as the farmer's position. He also seeks to increase irrigation efficiency. In the current situation, there is no need to improve irrigation efficiency unless increased irrigation efficiency reduces water harvesting. Even if the farmer does not want to consume more water, he has to increase irrigation efficiency. Because in addition to increasing irrigation efficiency and reducing water losses, he needs to purchase less water to save energy, labor, and time and provide less costly and time-consuming irrigation operations. Nevertheless, with increasing irrigation efficiency, there is usually an increase in water consumption (by increasing the area of irrigated land and changing the crop pattern), which results in a loss of water resources.

As a water user, does the farmer worry about the status of the water sources other than harvesting more water? The answer seems to be 'not.' Of course, farmers are generally aware that consuming more water, for example, planting crops with high water demand, pushes the water sources and causes faster empty the sources. However, the short-term interests of the farmer are at odds with the requirements of more sustainable water management. Similarly, it can be stated that the road builder's interests will conflict with the Environment. The road builder tries to locate the road at the lowest cost and, if needed, with the slightest attention to the environmental requirements.

In contrast to this approach, the environmental trustee tries to harm the Environment as little as possible by imposing more costs on the road builder. Environmental responsibility is also closer to the responsibility for water resources management. The water which does not use for the evapotranspiration of the plants or does not use for industry remains in the catchment area and reaches environmental consumption (evapotranspiration).Also, an aquifer with a natural outlet or a reservoir that overflows means that this water evaporates into the Environment.



6 Irrigation efficiency and catchment area efficiency

In computer science, phenomena are presented in real and virtual forms. Likewise, there may be two types of savings or losses in Irrigation. The Irrigation losses in the catchment area, where the central part of these losses returns to surface or groundwater sources, should also be assessed as virtual losses. In terms of water quantity, these losses are not lost; they are returned water from a catchment area that can be thought of as a new source in the catchment area scale. The actual losses are that part of the water generally evaporates into the Environment (deserts, lakes, seas, marshes, and lagoons), wetlands, or irrigation canals. It goes out of reach. In our country, due to the combined exploitation of surface and underground water resources in most catchment areas, water losses are often virtual water. Of course, losses can be assumed to be accurate in the outlet part of the border, such as rivers leading to the Persian Gulf and the Caspian Sea. Although environmentalists today attribute these losses to the sea as unaccountable and as virtual losses at the catchment area scale, unfortunately, regardless of the downstream neighboring countries' needs, every country in the field is trying to bring in as much water as possible.

In some countries, there is no shortage of resources, and the issue of how to extract water from the source is the main issue. For example, saving on the catchment area scale is insignificant in Malaysia, where the annual rainfall is several times as high as evapotranspiration. Because the potential evaporation in Malaysian lands is less than the amount of rainfall, the bulk of the runoff from the rainfall must flow out of the Malaysian land into the ocean. The energy from the sun to the land in Malaysia (say, the power of evaporation on the land) cannot turn all of the precipitation into steam. However, in Iran, the average rainfall is

250 mm, and in contrast, the evapotranspiration potential in Iran is several times that of the above precipitation.

In the Earth's water balance, the average annual precipitation is 1030 mm, and the average evapotranspiration is also1030 mm per year. As can be seen, at the scale of the Earth, as a matter of course, the total precipitation is equal to the total evaporation (provided surface and underground reserves remain constant).This cycle is renewed every year. In every defined area, the same equilibrium with the incoming water volume minus the outgoing water volume (assuming the surface and underground reserves remain constant) equals zero.

Losses are a relative concept in irrigated lands, and from a farmer's point of view, who buys and receives a given volume of water, makes sense. For example, suppose 1000 cubic meters of water were purchased and imported into the border, based on 40% irrigation efficiency. In that case, only 400 cubic meters of this water could be retained in the root zone (the excellent or productive part of the water for the plant). The remaining 600 cubic meters (unproductive, unprofitable, or “losses”) continued to the aquifer or ran out of the farm. It means the farmer pays for 600 cubic meters of water, which is not included in the agricultural production process. It was lost. From the water sources' point of view, there were no losses. As one of the balance sheet inputs, this water returned to the source. Of course, after a loss of quality. From the source's manager's perspective, it is a joyous event. In this situation, if efficiency is increased, but the volume of the harvested water is not reduced proportional to the increase of efficiency, increasing efficiency not only does not help the source balance but also reduces the input of balance and also causes more land drought (lakes, deserts, lagoons, rivers and the Environment in general)

As a result, the low irrigation efficiency is a negative factor for the farmer. However, it is generally considered a positive factor for water resources management, environmental management, and many other areas (especially closed catchment areas).So, the interests of the parties, i.e., farmers, on the one hand, and the water resources and environmental administrators, on the other hand, conflict. Now, if those in charge of water resources management think of increasing irrigation efficiency, but on the other hand, there is no control over harvesting and water consumption in agricultural lands, they will help the farmer harvest more water from the catchment area source. As a result, the part of the water loss that directly or indirectly fed the water of aquifers, rivers, or lakes will be cut off, and the negative consequences of reducing the environmental share will be exacerbated.

Useful consumption water for the plant is that portion of water lost through evapotranspiration and entering the atmosphere during the plant growth period and even before planting and during the field preparation operations, such as the peddling stage in rice cultivation or before wheat sowing in pre-irrigation.

To illustrate the difference between the concept of farm-scale water losses and the catchment area losses, an example, including the figure, is provided. In figure(1), from 100 percent of the water that the farmer purchases, if irrigated water is at 30% efficiency, it means that 30% of the water is stored in the root zone and then transpired by the plant or evaporates from the soil and enters the atmosphere. So, the rest 70 percent goes outside the range of the root zone, and the root does not have access to this water, which is termed a loss. This water is not usable for the plant, but the farmer has paid for it; therefore, it is wasted from his point of view. This wasted water eventually joins the underground aquifer; from the water resources point of view, this 70% is not wasted. It is usable and may be re-harvested from other wells. Alternatively, provide part of the environmental needs of the downstream wetland. By changing the irrigation method to increase efficiency, say to 100%, there is no additional water at the catchment area scale. However, maybe 100% of water provides to the farmer (the water buyer)increases consumption by increasing the cultivation area or changing the pattern, and in turn, reducing the water table of the aquifer.

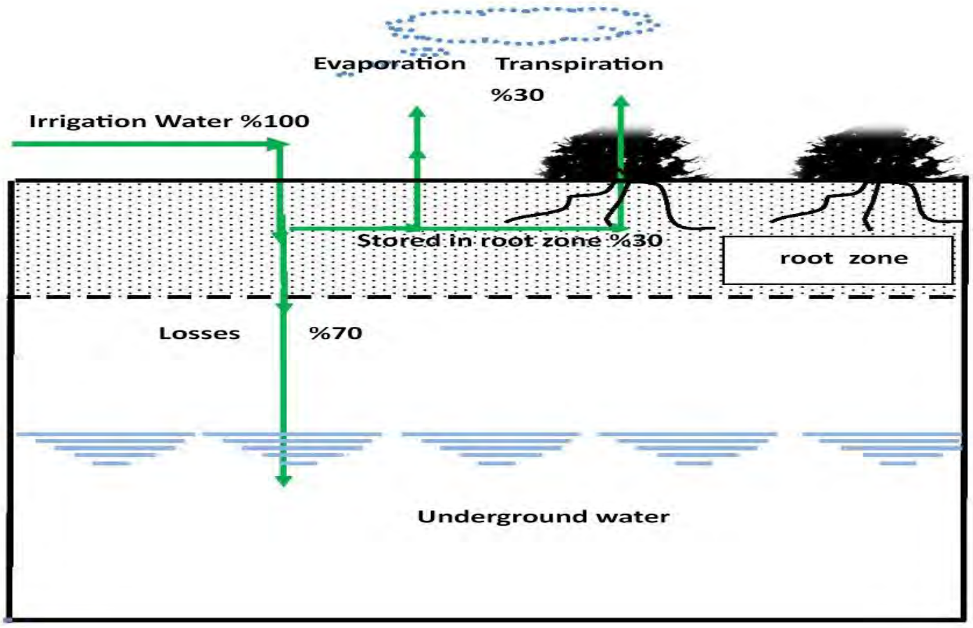


Figure-1 Water balance in the soil

As can be seen, the increase in efficiency did not cause an increase in the amount of available water in the watershed (regardless of its quality). Suppose the water delivered to the farmer is not controlled (at the former evapotranspiration limit). In that case, 70% of wasted water remaining in the aquifer is also provided to the farmer and used for evapotranspiration. As a result, water resources' status is more critical than in the past, leading aquifers to further instability.

Increasing efficiency, of course, can come from other angles. In some African countries that have abundant, pristine, and intact water resources and still harvest resources with primary equipment like Treadle Pump with Manpower and manual watering can, the main problem of such farmers is to provide the initial cost for the purchase of water harvesting and transmission equipment and operation and maintenance costs. Moreover, they are essential to increase irrigation efficiency and prevent water from returning to the source. Nevertheless, the rate at which water is harvested against renewable water is low, and they are not concerned about the capacity of the water source and how to safeguard it. That is to say, in these countries, there is no physical water shortage. However, water scarcity is economical. That is, water resources are not so limited. However, because of financial constraints to invest in water extraction facilities, such as drilling and equipping wells, supplying power, and establishing water storage and diversion facilities, the possibility of water extraction from the resources is limited.

In developed countries with abundant water resources, saving water also means saving energy and the cost of consuming water and maximizing the use of water purchased so as not to return to the source. In these countries, Physical savings are not pursued because the water source is unlimited. Similarly, in arid countries such as Iran, high Irrigation efficiency means maximizing the use of delivered water and preventing it from returning to the source. In other words, in arid countries, regardless of the water source, the economic efficiency of the farmer is pursued, and pressurized irrigation methods, regardless of their impact on the water source, are targeted in this regard. Therefore, if agricultural water saving is targeted at increasing water resources through efficiency, which is the case in Iran, in most cases, it would be meaningless, and perhaps if the cultivation of the crops is not controlled, the pressure on additional resources would increase. However, increasing the country's irrigation efficiency from an economic perspective has benefited the consumer. It has also increased the actual consumption of water and pressure on the resources.

By increasing the efficiency of Irrigation and the efficiency of other uses, a volume of water is saved. However, the same amount of aquifer recharge, i.e., the capacity of underground resources, is reduced. In the best case, no additional water will be obtained to spend on developing the cultivated area or increasing the supply of the current cultivated area unless the share of other sectors, specifically the Environment, is reduced. This condition of reducing the share of some sections to spend in other sections is essentially the case.

What is said about irrigation efficiency is a general trend in the country's plains. However, in some parts of the country, such as the Mohan plain, the Caspian Seacoast, the southern regions of Khuzestan, and the coastal areas of the Persian Gulf, part of the irrigation losses is not returnable. For example, the presence of saline and unusable underground aquifers or the lack of conditions for the formation of aquifers and, consequently, the inability to reuse wasted water and saline drainage, Literally cause irrigation losses to be wasted and unusable. In this situation, increasing irrigation efficiency to the extent that leaching needs are met is emphasized.

In these areas, by increasing irrigation efficiency, additional water is obtained. For example, in the bulk of Khuzestan plain, irrigation losses either deep percolation into the soil layers or lead to land waterlogging and evaporation. Part of this water is drained into the rivers and then pumped from the river. It is reused in agriculture or dumped into the sea if its quality deteriorates. Therefore, much of this plain justifies the change in irrigation methods and other measures to reduce irrigation losses and prevent drainage discharge to water sources.

On the other hand, it should be noted that in these areas, the evaporation rate is high, and in the downstream parts of the catchment area, the water quality is poor. As a result, a large amount of salt remains in the soil that needs to be washed during the irrigation process. Therefore, some of the losses are considered to be leaching and cannot be eliminated. In the Moghan Plain, losses to Aras, then to the Kora River, and finally to the Caspian Sea have been lost if we did not consider any share of the sea. Environmental experts contradict the development plans and argue that what goes into the Environment, including irrigation losses, is less than its actual share and therefore cannot be harvested for other uses. It should even increase.

7 Relation between useful water use and Irrigation method

Section 2 of this publication describes that the irrigation method generally does not affect the net irrigation requirement (evapotranspiration minus other water supply sources, such as effective rainfall and shallow groundwater). Also, Drip irrigation, which was hitherto thought to reduce the net requirement of plant irrigation, has yielded conflicting results. It is believed that the Drip irrigation method can even increase actual water consumption. Due to the short Irrigation interval in the Drip irrigation method, moisture in the plant's root zone is always maintained close to the soil holding capacity. As a result, the plant is not subjected to moisture stress, and transpiration is increased compared to conventional irrigation methods. Of course, the yield of the crop also increases. On the other hand, near saturation conditions of the wet strip around the emitters also increases the evaporation of the wet part of the soil compared to other irrigation methods. As a result, Drip irrigation does not reduce evapotranspiration but can even increase it somewhat compared to other methods, which, of course, is compensated by increasing productivity (Yield).

In this regard, an issue entitled "Does Improved Irrigation Technology Save water?" was published by FAO in 1396. Based on research on this issue, it has been concluded that contrary to public perception, efficiency gains generally lead to an increase in actual water consumption (evapotranspiration). Moreover, the only exception is drip irrigation in the garden, which has reduced consumption (e.g., unlike other studies which conclude that Drip irrigation in the garden has also led to increased consumption). However, the states that invented new irrigation methods, such as Drip irrigation, which initially claimed the extraordinary benefits of these water-saving methods, after years of experience and evaluation of implemented projects, have revised their conclusions and stated that one should not expect too much about water savings due to new methods of Irrigation, in many cases, it may even increase water consumption.

Earlier, an article entitled "Why Increasing Irrigation Efficiency Increases Evapotranspiration."[1] Was presented by professors at the University of Idaho at the 21st Congress of the International Commission on Irrigation and Drainage in Tehran in 2011. This article, based on the results of an extensive study, confirms that under this study, in drip irrigation, an increase in evapotranspiration occurred between 6 to 10% compared to sprinkler and surface irrigation. There are many reasons to vote for this increase. One of the reasons mentioned in this article is that it is true that in Drip irrigation, only a tiny portion of the soil is moistened. However, this wetting for a more extended period than other methods occurs because, in the case of Drip irrigation with a shorter irrigation interval, the soil surface is always moist and losing moisture despite its small size. Although, the Irrigation through the drippers due to high soil moisture provides conditions for increased plant transpiration and consequently increased crop yield.

In Sprinkler irrigation, the plant's transpiration may be reduced significantly during Irrigation. However, this decrease is compensated by increased evaporation due to the diffusion of water into the air and soaked foliage. Moreover, the opposite effect of these two factors does not significantly affect anticipated evapotranspiration. It is important to note, however, that some experts consider the evaporation part unprofitable for the plant's water requirement, but its occurrence is mandatory. The transpiration part is a beneficial component of the plant's water requirement and is effective for the growth of the plant. So increasing the share of evaporation in Sprinkler irrigation means a decrease in the amount of water available to the soil for the plant. At the same time, it should be noted that transpiration functions include cooling the plant. Thus the evaporation of the foliage in Sprinkler irrigation can also be helpful. However, evapotranspiration decreases in humid and greenhouse environments with high humidity.

Furthermore, evapotranspiration decreases in humid environments and greenhouses with high air humidity. However, plant growth is not only interrupted but also intensified. indicating that some part of the plant's evapotranspiration is not an essential component of growth. Instead, it occurs due to moisture exchange between a saturated environment (plant) and an unsaturated atmosphere. The explanation is that the plant's stomata must be left

1-Why Improving Irrigation Efficiency Increases Consumptive Use (2011) open to enter and exit oxygen and carbon dioxide gases. In the meantime, some plant moisture also inadvertently enters the atmosphere.

However, the debate is still open that evaporation from soil cannot be considered useful. According to this group, evaporation has no role in plant growth and can be eliminated by methods such as underground Irrigation. However, in this regard, not enough experience and documentation have been provided yet. Underground Irrigation in dry soil also can increase transpiration. In contrast, evaporation from moist soil reduces transpiration from the plant.

Some expert has argued that part of transpiration also has no role in plant growth and can be eliminated. For example, greenhouse cultivation refers to a decrease in transpiration, but not only is there not a decrease in yield, but Yields are also increasing in greenhouses. There are different views on the different roles of evaporation on the one hand and transpiration on the other hand. It has not yet concluded. Moreover, it is open to discussion.

Except for specific measures, such as the use of organic or plastic mulches that reduces evaporation from the soil before full-plant cover, as well as sub-plastic and especially greenhouse cultivation which is a very effective method for reducing evapotranspiration, more importantly, there is a multiplier increase in productivity (yield per unit of water consumed). There are a few ways to reduce the net plant irrigation requirement (evapotranspiration). The net plant irrigation requirement is almost constant, neither reducing nor significantly increasing, because it mainly depends on the climate and the plant. However, irrigation losses can be significantly reduced by choosing and applying suitable irrigation methods, better management, and proper water distribution and conveyance. In other words, it is increasing the efficiency of water use.

8 Efficiency and Productivity

The water shortage problem in the country's agricultural sector, which has led to a crisis in production, cannot be compensated by increasing irrigation efficiency. Instead, it is compensable by accurate agricultural planning and partially increased water productivity. The primary debate in today's world agriculture is to increase productivity (yield per unit of water used). One of the factors affecting productivity is Irrigation. Nevertheless, this issue is not just about Irrigation. In addition to Irrigation, it depends on all inputs, technologies, and services, such as; high-quality seeds, appropriate fertilizers, scientific pruning, timely weeding, disease, pest control, Forecasting, and dealing with meteorological stresses; such as freezing, cold, and heat, proper transportation, warehousing, internal and external marketing, in Agricultural activity. For example, just because of a few hours of frost, the whole crop may be destroyed, or because of poor transport, far from farm to market, a large portion of the crop is lost.

9 Conclusion.

Restricting freshwater resources has become a severe problem in many parts of the country. This restriction has been able to overshadow some regions' balanced economic, political and social development. Unsustainable development and uncontrolled abstraction of surface and groundwater resources have caused the most damage to the Environment. The annual decline of groundwater aquifers, drying of some rivers before reaching the sea or wetlands, an imbalance between water resources and consumption, reducing downstream farmers' access to sufficient water, increased conflicts between upstream and downstream farmers in the catchment area, migration of Villagers on the outskirts of the cities in terms of reduced flow or drying of springs and wells are among the problems faced by more or less many countries in the Middle East, including Iran. Due to limited water resources, one of the common solutions to compensate for water shortages, especially in arid areas in recent decades, is to use tools and methods to increase irrigation efficiency in order to reduce conveyance and distribution losses and water application on the farms, and with the idea that reducing irrigation losses, provide a new water source for the development of irrigated agriculture and increase agricultural production.

Increasing irrigation efficiency to achieve self-sufficiency in agricultural production in Iran is a strategic and one of the permanent provisions of the country's development plans. The Islamic parliament approved Iran in 2016 and has been communicated to the executive bodies as an upstream and binding document. Article 61 of the Law on Permanent Provisions of the Country's Development Plans obliges that in order to maintain production capacity and achieve self-sufficiency in the production of essential agricultural products, to perform Eugenics, improve cultivation, and upgrade irrigation efficiency to at least 60% within fifty years, by implementing on-farm irrigation system, irrigation and drainage networks and using new Irrigation methods.

Applying new technologies in irrigation systems, which are used to increase irrigation efficiency and reduce water losses, can increase farmers' management power and reduce labor, energy, and irrigation management costs. However, what needs to be emphasized in terms of improving productivity and optimizing water consumption, is not only the economic view of farms managed independently by farmers; rather, the sustainable benefits of agriculture, water resources, and the Environment must be the criteria for planning.

Typically, since such investments are generally planned at the farm level, the impact of reducing or eliminating irrigation return water on the catchment area water balance is often overlooked. According to the results of global studies, from the perspective of water accounting at the catchment area scale, irrigation losses are considered as "useful unused water," and therefore, investing in the development of new irrigation systems does not lead to real water saving.

Implementing methods in the law of permanent provisions of the country's development plans to increase irrigation efficiency include an on-farm irrigation system, new irrigation methods, and improved cultivation and Eugenics operations.

According to the capacities of the recent law, it is predicted that by increasing irrigation efficiency to 60%, the saved water resources resulting from the implementation of the law will be provided for the development of newly irrigated lands, which will increase agricultural production and Self-sufficiency in the production of strategic products.

Considering that, according to the type of cultivation with the increase of each hectare of new agricultural lands, a particular volume of water resources in the catchment area will decrease by more evapotranspiration to produce more product. Considering that with well-known existing water consumption and withdrawal of water for agricultural, drinking, and industrial sectors, almost all catchment areas faced environmental problems caused by severe groundwater levels falling, droughts, or depletion of wetlands and rivers, this question is raised that where the return irrigation water was used (including water losses in canals, deep percolation, and drainage from the farms) before increasing irrigation efficiency, and where does the new water withdrawal come. The part of irrigation water that is out of reach of the farmer through deep percolation is one of the nourishment sources of groundwater aquifers and supplies part of the water needed for agriculture in downstream lands. Therefore, the return water of the catchment areas can be evaluated and considered in the balance of resources and consumption.

For example, in the Zayandehrood’s closed catchment area (located in Isfahan province in Iran), the interaction between surface and groundwater sources and the effect of irrigation return water on the feeding of Gavkhooniaquifers and lagoon is quite witnessed. According to estimates, this catchment area's overall water consumption efficiency is about 70%.

Suppose it was possible to mark and track the flow of water. In that case, the researchers could trace the water flow from the point of harvest to the farm, and feeding the groundwater aquifers, or return to the river and reuse it within 300 km of Zayandehrood Dam to Gavkhonilagoon; They could draw and confirm the fact that water in this long route has been harvested several times to irrigate agricultural lands and has returned to the groundwater or Due to irrigation losses, it has returned to the aquifer or river. Therefore, if irrigation losses enter the production cycle one or more times, increasing irrigation efficiency will not affect the water available in the catchment area. By changing the irrigation method, excess water cannot be achieved.

Therefore, with the increase of irrigation efficiency from the current 45% to 60%, emphasized by the law of permanent provisions of the country's development programs in the next five years, there will be no new water source to increase agricultural production. Suppose the development of irrigated agriculture is done with the assumptions mentioned above. In that case, it will lead to more complex environmental problems, further decline of groundwater aquifers, exacerbation of downstream farmers' problems, and instability of the country's water resources.

Given the balance of water resources in the country that which more than 70% of annual renewable water resources are used for agriculture, drinking, and industry (this amount is much higher than the global recommendation of 40% of annual renewable water consumption), based on the priority of urban, industrial and environmental needs, It is necessary that the share of agricultural water in the cycle of using the country's water resources be reduced by applying appropriate measures such as; changing the crop patterns, reducing the cultivation area, and increasing productivity for each unit of water consumption By applying appropriate economic incentives proportionate with the social conditions.

One of the goals of reducing the losses of deep percolation of irrigation water in the farms is to prevent the quality reduction of surface and groundwater resources due to the return of contaminated water and reduce environmental damage. Although at the catchment area scale, return water from agricultural fields or deep percolation into groundwater aquifers is considered useful losses, maintaining water quality and preventing pollution through Irrigation above water requirement is one of the goals of macro water resources management.

Therefore, investment in projects to develop new irrigation methods in order to improve irrigation efficiency should be planned in such a way that the number of water losses that are reduced in conveyance, distribution, and water application on the farm through these investments to be deducted from the total numbers of licenses and permits of abstracting water from the rivers or aquifers.

For instance, the Spanish government pays 60 percent of the investment cost for modern Irrigation (drip and sprinkler) while reducing water harvests by 25 percent. Farmers are promised not to increase their cultivation.[1] In this way, the amount of water returned to the groundwater aquifers or rivers is compensated by reducing the amount of water withdrawn from the primary source, and damage to the Environment and downstream farmers are prevented.

1- Literature Review on Rebound Effect of Water Saving Measures and Analysis of a Spanish Case Study

Therefore, to invest in increasing irrigation efficiency, the objectives of the work must be appropriately defined, and the balance of the catchment area, the sustainability of groundwater aquifers, and the environmental protection of rivers and wetlands must be the primary planning topics of the country's executive bodies. Suppose heavy investments from national credit to increase irrigation efficiency lead to the development of irrigated agriculture and increase water consumption in the country. In that case, the damage to water resources and the Environment is not justifiable and, in some cases, can be irreparable.

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