



Sustainable Agriculture Soil and Water



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Acronyms & Abbreviations

ÇEM	General Directorate of Combating Desertification and Erosion
ÇMUSEP	National Strategy and Action Plan to Combat Desertification
DSI	State Hydraulic Works
EEA	European Union Environment Agency
FAO	Food and Agriculture Organization
GAP	Southeast Anatolia Project
GMO	Genetically Modified Organisms
IPCC	Intergovernmental Panel on Climate Change
MGM	General Directorate of Meteorology
OECD	Organisation for Economic Development and Cooperation
SKD	World Business Council for Sustainable Development - WBCSD
SDG	Sustainable Development Goals
SOC	Soil Organic Carbon
STOK	Strategic Focus Commission
TAGEM	General Directorate of Agricultural Research and Policies
TSKB	Industrial Development Bank of Turkey
TURKSTAT	Turkey Statistical Institute
TTGV	Technology Development Foundation of Turkey
UN	United Nations
UNDP	United Nations Development Program
WRI	World Resources Institute
WWF	World Wildlife Fund

*We would like to express
our deep gratitude to all our
participants who devoted their
valuable time in performing
this study and sincerely shared
with us their opinions that were
valuable in the future outlook
of our ecosystem and in the
formation of local knowledge.*

For all your inquiries about our research, feel free to contact
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Introduction

Technology Development Foundation of Turkey is an organization that aims at using and disseminating technology as a tool that facilitates life, by supporting the technology development and innovation activities of the private sector in harmony with the ecosystem. As a long-term strategic goal, it has adopted the objective to carry out the entire process together with the stakeholders and enrich the technological innovation ecosystem based on common benefit, to identify the common problems and requirements of the real sector in Turkey, explore and implement the technology-supported solutions.

In this context, the studies on the agricultural innovation ecosystem were initiated with the discussion report on the “Opportunities for Innovation in the Agricultural Ecosystem”, published in January 2021. It was with this report that agriculture and food ecosystems were explored from the perspective of R&D, technology, and innovation. It is critically important and a top priority how soil and water are used, as one of the most important resources for sustainable economic development in the agricultural and food ecosystem.

While the demand for soil and water is on the rise, the constant decrease in usable soil and water assets has made the development of the most efficient and sustainable use methods for these resources a vital necessity. Therefore, this study focuses on **Soil and Water** issues as a follow-up of the STOK-Agriculture study.

Study Method

This study aims to ensure that the basic requirements of the ecosystem are understood and to emphasize the fact that sustainable use of soil and water resources is the inevitable and unique solution;

- **Interviews were made with the stakeholders** based on the basic principles of the qualitative research pattern,
- **The findings obtained were synthesized with internal competencies,**
- **Basic problems with soil and water in Turkey were identified,**
- **Solution options were offered.**

Interviews were conducted in the fields of soil science and plant nutrition, agricultural structures, and irrigation, with the participation of;

- **Academics,**
- **Experts and researchers employed at public institutions,**
- **Researchers with active participation in the field,**
- **TTGV STOK Agriculture Team,**
- Via mostly online and partly face-to-face sessions in the second quarter of 2021.
- **The main findings and themes derived through qualitative sorting, classification, and evaluation of the information obtained from the interviews were also supported by the complementary literature research in the report.**

The report consists of seven chapters. The title **“Water”** discusses the areas of problem in agricultural irrigation in Turkey with special emphasis on the water assets both in the world and in Turkey. The title **“Soil”** addresses the soil-related problem areas in Turkey as well as introduces the findings and assessments regarding the asset and use of soil as an important living element¹ of the ecosystem. The chapter **“Soil & Water Relationship”** mentions briefly the changes caused to each other due to their utilization based on the interactions of these two assets which cannot be considered separately from each other. The following part of the study touches on **“Sustainability”** discussions concerning the soil and water resources. Once the considerations mentioned up until this chapter is discussed under the title **“Technology”** along with the information as to what solutions the technology will deliver, the propositions synthesized in line with the findings reached are included in the chapters **“Review”** and **“Conclusion”**.

1. Soil can be defined as a living being since it is called an ecosystem in which millions of living creatures inhabit and interact. Detailed information about the vitality and significance of soil can be found in the “Info Box: 4 Soil Vitality and Significance”.

Preamble

Reports from the Intergovernmental Panel on Climate Change (IPCC) indicate that the climate crisis may have devastating consequences on the life of living organisms on a global scale in the coming decades and will reshape the life of living creatures. Upon the emergence of the climate crisis, it is better understood that temperature and drought will surely affect broader regions as it intensifies over time and as a result of the interaction of other ecosystem parameters with each other, which can be noticed owing the long-term research, all living things will struggle at various levels to accommodate to these changes. As a result of these changes, **the sufficiency of soil and water resources**, which are the fundamental and limited assets of the ecosystem, becomes more critical. Strategic and effective use of world resources as well as the identification of the problems in practice today and the corrective actions planned for the future have become the main concerns.

Although the EU's transition to a sustainable food system as a collective and organized positioning against climate change has already started in many areas, it will be almost impossible to prevent environmental degradation unless the sustainability of agricultural production and food systems is compatible with climate change. Urgently, it is required to;

- reduce the dependence on pesticides/herbicides and chemicals,
- reduce over-fertilization and excessive water consumption,
- increase organic agriculture,
- increase animal welfare and
- stop the loss of biodiversity.
- Among the 17 ecosystem processes, as identified problematic all over the world by the United Nations (UN) and expected to improve by 2030, there are also those targets related to soil and water resources. The **soil and water-related goals and sub-goals**, among the sustainable development goals as given in Figure 1, **constitute the primary focus of this report**.



*“Everything else
can wait, but not
agriculture”*

*Shri Jawaharlal
Nehru*



Figure 1: Sustainable Development Goals

Role of Agriculture in Sustainable Development

The human relationship with soil and water happens to be the most decisive ecosystem relationship which, on the one hand, improves agriculture thanks to its ability to establish superiority over other species in the ecosystem and to manage these species to meet their needs while, on the other, it allows other economic and social activities are carried out by relying on the outputs of agriculture and enables the human civilization to be established and settled deeply in the world.

Anthropological data indicate that the agricultural revolution can date back 10,000 years ago in Gobekli-tepe and 12,000 years in Boncuklu Tarla- Mardin. In this period, which is such a short glimpse in time compared to the 4.5 billion-year-old world, **the agriculture that enabled the people to play a dominant role in the ecosystem will continue to be the main activity of the communities in the future as long as the people need to feed due to their current anatomical structure, although they may change with the new technologies.**

The most basic sustainability prerequisite for the natural ecosystem is the conservation of biodiversity. For this reason, if we can organize our human activities in a way that could create such conditions where we can preserve biodiversity, we can achieve a sustainable life, as well. Any forms of life other than that would be unsustainable alternatives. **Since human interaction with soil, water, light, and climate affect the entire ecosystem and the chain of living organisms directly, these relationships must, first of all, be harmonized with the ecosystem.** Hence, the second one of the chain of reports, it is aimed to reveal the relations of people with soil and water in Turkey along with problem and opportunity options, in the light of the available data.

Soil, water, air, light, and climate combine in mutual interaction to form a five-point ecosystem helix and the kinesis of this helix with the substance forms a habitat for the living, which in turn leads to the development of the ecosystem. The evolution of the ecosystem takes place in a way that can be defined by this spiral relationship of the five-point helix. In its natural course, the changes occurring within the ecosystem manifest themselves in the form of low deviations over a long period of time and so, it takes over hundreds and sometimes thousands of years for those changes to be realized. Human activities against nature, which became widespread and intensified in the 20th century, accelerated the rate of transformation. The increase in problems related to global climate change and its impacts is an important indicator of this acceleration. **Unless radical and widespread measures are taken, this five-point spiral relationship is predicted to change faster in the coming decades,**

the equilibrium of the entire ecosystem together with its living and non-living assets will be disrupted and biodiversity will become impoverished due to the disappearance of numerous species. Among the activities aimed at slowing down this negative change, “good agricultural practices” seems to be one of the most ethical measures.

The first steps in good agricultural practices are,

- **To determine the status of soil, water, climate, labor, and other resources in a simple manner by constantly monitoring the change of these resources according to time,**
- **To meet the agricultural requirements by using ecosystem-compatible techniques.**

The change in ecosystem balance reveals its effect firstly in the form of tiny changes in climatic conditions. This is followed by minor changes in the local flora and then by hard-to-notice fauna changes. All of these changes affect the quality of habitat and the carbon sequestration capacity of the soil directly. As an important disruptor, **improper cultivation methods limit the ability of the soil ecosystem to “rejuvenate itself”** as it leads to mega droughts and large-scale floods, as worsened due to climate change. It is claimed that, while the agricultural lands in the world,

- was once 4.564.120.000 ha (1970),
- now reduced down to 42.078.500 ha and
- These lands are no longer suitable for agricultural use due to urbanization, industrialization, mining, and misuse of fields (2).

Not only do the agricultural lands shrink, but also soil health and quality deteriorate. According to FAO, the world’s soils are becoming infertile and biodiversity is being damaged day by day due to various reasons such as **soil pollution, poor agricultural practices, and urban structuring, particularly the salinity, erosion, lack of nutrients, and organic matter in the soil.**

Looking into the agricultural land change in Turkey, it is seen that farmlands reached a level of 28 million hectares from 1928 to 1980 owing to the population growth and intensive migration influx. However, it is stated that **qualified agricultural lands** are reduced to 24 million hectares (3) since,

- **they are used for other purposes,**
- **the soil has become unproductive day by day and lost its vitality**

According to the data of TurkStat (see. Figure 2), all agricultural lands of our country are 37.7 million hectares as of 2019.

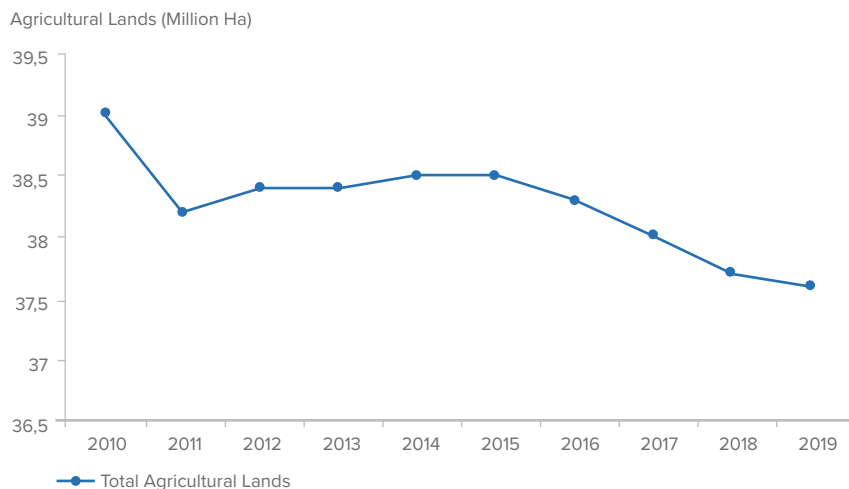


Figure 2: Changes in Turkey's Agricultural Lands (TurkStat, 2020)
(TÜİK, 2020)

The distribution of these lands is listed as follows,

- Cultivated area 15,4 Mha²,
- Meadows and pastures 14.6 Mha,
- Fallow land is 3.4 Mha,
- Orchards and other plant areas 3.3 Mha,
- Vegetable gardens 0,79 Mha,
- Ornamental plants 5 thousand hectares (4).

Arable agricultural land in Turkey is 49.1% of the country's entire land (World Bank 2018 statistics). According to the data from the Ministry of Environment, Urbanization, and Climate Change, the agricultural land in Turkey decreased to 37 Mha and the agricultural land per capita decreased to as low as 0.4 hectares (Figure 3).

2. Mha: Million hectares

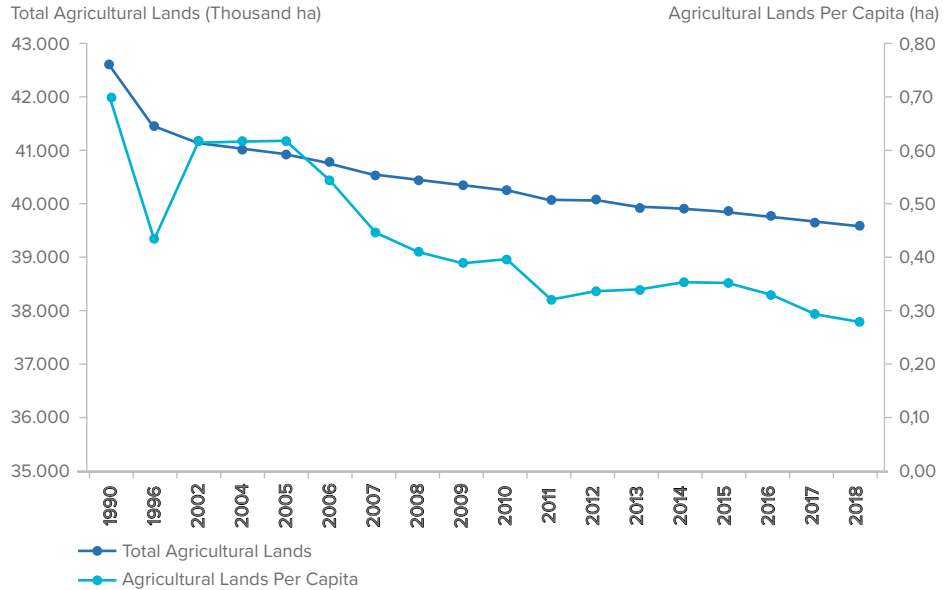


Figure 3: Total Agricultural Land of Turkey, Ministry of Environment, Urbanization and Climate Change Environmental Indicators

When the data related to agriculture are examined, it is observed that there are some differences in the classification and definition of agricultural lands.

- **Agricultural land,**
- **Arable agricultural land,**
- **Absolute agricultural land,**
- **Meadow, pastures**

It appears that there is no clear definition or classification about the location and amount of the above-listed lands, compared to the agricultural lands in total or it is seen that they are taken differently in different sources.³ Hence, **it seems a prerequisite to;**

- Avoid misleading consequences caused by uncertain data,
- Make agricultural plans and policies in a common language that everyone will understand in the same way

3. According to Soil Protection and Land Use Law No. 5403, Agricultural land defines the lands whose soil, topography, and other ecological properties are suitable for plant, animal, and aquaculture production and which are used for this purpose or can be transformed into suitable lands for agricultural production. On the other hand, absolute agricultural land is defined as "In crop production, it refers to the lands where the combination of physical, chemical and biological properties of the soil are not restrictive for cultivation in regional average, with no or very little topographical limitations, having national, regional or local importance, currently used in agricultural production or suitable for use to that end."

- **Create a unique and up-to-date “Handbook of Agricultural Terms” and include it in the digital environment** to create basin agricultural models according to simple data.

Even if there are differences in definition and classification, it is understood from the available data that the soils that form the basis of the food production source in our country are losing value and decreasing in quantity and quality day by day.

Therefore, **it is imperative to develop appropriate methods for the sustainable and efficient use of the soil in Turkey and to implement them immediately.** The soil in Turkey, where the agricultural production is intense and export volume is large, loses its health as it degrades due to,

- **Product cultivation is incompatible with land and basin’s nutritiousness,**
- **Tilling and cultivation are incompatible with the land’s topography,**
- **Excessive use of fertilizer and herbicides/pesticides,**
- **Overgrazing,**
- **Natural erosion,**

This process, which can be described as **the slow death of the soil**, not only jeopardizes the agricultural ecosystem, human health, and the survival of the species, but also makes the sustainability of resources difficult. The difficulty of sustainability in soil and water resources makes it necessary to,

- **Establish “Turkey Soil-Water Data Network”,**
- **Protect the “biodiversity” in an absolute manner,**
- **“Initiate the sample applications that will minimize land destruction and**
- **Determine the working principles that will disseminate the sample applications, through the international conventions to which Turkey is a party.**

Not only the use and management of soil but also effective management of water resources is important for the survival of a sustainable ecosystem. Various sources mention that approximately 70% - while others suggest 69%- of the freshwater is used in agriculture in the world as of 2021. **In our country, 74% of water resources are used for agricultural purposes (6).** According to the data of DSI, the share of agricultural irrigation in total water use in our country in 2020 was estimated at 77% with 44.25 billion cubic meters (7). **Although different rates are expressed in agricultural water use in various sources, it is seen that the rate of water used by Turkey in the unit of agricultural land is, in any case, above the world’s average.**

“ In our country, 74% of water resources are used for agricultural purposes. ”

To give an example, **the Konya Basin**, which has an important place in the agricultural sector, faces the risk of drought due to,

- **Excessive consumption of agricultural water,**
- **Planting the products with high water (e.g. as corn, sugar beet, and clover) and moderate water consumption (e.g. sunflower), which are not suitable for the structure of the ecosystem),**
- **Increase in the number of fields cultivating these products.**

This creates intense pressure on water resources and makes **the irrigation systems and methods** relying on the most efficient use of water resources, even more important.

The optimum use of water in agriculture is one of the most remedial attempts.

With the global climate crisis, there are opinions that the main effects of climate change will be observed from 2040 onwards (8). In these years, it is predicted that precipitation in Turkey will decrease by around 10-15%. Therefore, the main actors of the agricultural ecosystem are anticipating the draft of the water law. In addition to the amounts of water used in agricultural irrigation, it is believed that the low rainfall and drought effects caused by climate change will make the management of water resources even more difficult. In many sources, there are even estimations about the possibility of water-sharing wars in the future. This makes it even more important **how water resources are used by countries in industry, agriculture, and other sectors; how the use of water should be planned and managed, as well as the water assets in our country, the problems in agricultural irrigation, and effective irrigation systems and methods.**

1.1. Water Assets

Looking at the status of water resources globally, three-quarters of the Earth's surface is covered with water, it is known that

- 97.5% is **salt water**,
- 2.5% is **fresh water**.

It is stated that water suitable for human use corresponds to a total of 35 million km³ of fresh water with only 2.5% (13).

It is known that;

- 1.2% of fresh water is suitable for use on earth (14),
- While most of the remaining fresh water is found in soil, underground, and glaciers (Antarctica and Greenland).

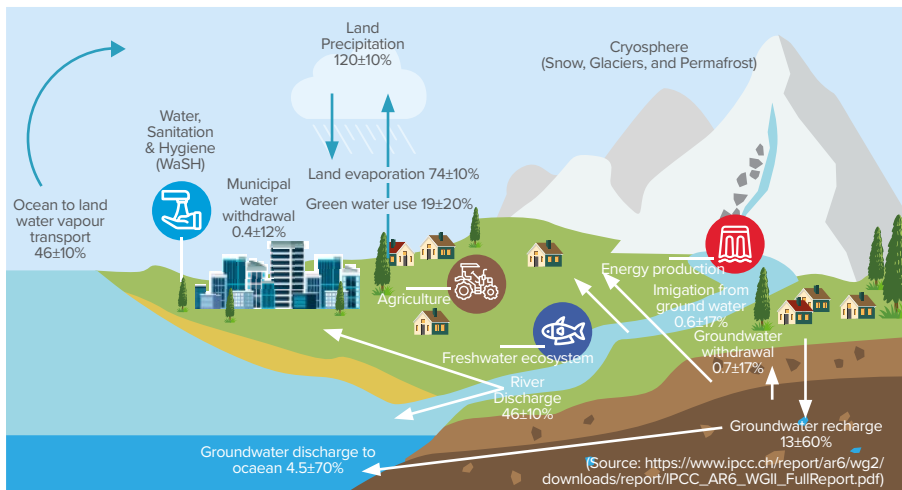


Figure 4: Water cycle

Clean water sources that can be accessed in lakes, reservoirs, rivers and streams, corresponds to 0.1% of the total water potential (15).

“If we consider all the water in the globe as a 5-liter bottle, the amount of fresh water suitable for the ecosystem and human use is only equivalent to one tablespoon” (16). The fact that;

- The fact that freshwater resources are so limited,
- The rate of self-renewal of the ecosystem is gradually decreasing,
- Increasing continuation of human intervention,

“Imagine all water on earth as 5-liter bottle, the amount of fresh water suitable for the ecosystem and human use can only correspond to a tablespoon” (16).

makes it even more important how the existing water resources should be used effectively and sustainably. It is anticipated that **we may experience “water scarcity on a global scale” shortly soon**. Studies show that the amount of water resources has remained the same over the past 50 years, but **water use has tripled** (16).

The water cycle of the ecosystem has no problems apart from human use. The vast majority of water resources are used by people and we need to emphasize that we encounter the problems caused by,

- 1. by both excessive consumption of and pollution with the chemicals, especially in agriculture,**
- 2. and by industrial consumption, energy generation, and household consumption and high-dose pollution with solid and liquid chemicals**

According to the 2017 DSI data, it is stated that annual water consumption in Turkey is,

- **7 billion m³ of water (13%) in industry,**
- **7 billion m³ (13%) in drinking and domestic use,**
- **40 billion m³ (74%)^{e4} in agricultural irrigation,**
- **With a total of 54 billion m³ of water annually.**

Annual water use in total is nearly half the annual usable water which is 112 billion m³ in total (17). There are different data and rates related to water use in the agricultural sector in our country. Table 1 contains information on the percentages of total annual water assets used in agricultural irrigation in some countries. According to the table created based on the data published by FAO according to the estimated calculations, it is seen that the use of agricultural water in other countries, except for India and Mexico, is less than in Turkey. Turkey ranks third among OECD countries, as it uses the natural groundwater reserves formed over several years agricultural irrigation (18).

Agricultural Water Absorption in Total Water Absorption	
India	%90,41 (2018)
Austria	%2,20 (2018)
China	%64,4 (2018)
Japan	%67,72 (2018)
Mexico	%75,72 (2018)
Russia	%28,76 (2018)
Brazil	%58,14 (2018)
USA	%39,66 (2018)
France	%10,9 (2018)
The Netherlands	%3,71 (2018)

Table 1: Agricultural Water Use in Some Countries (FAO Aquastat)

4. According to the FAO's Aquastat statistics, water use in agriculture in Turkey is given as 87.12% of total water use.

According to the 2017 data of DSI, of the total water consumed

- 72.2% is supplied from surface waters,
- 27.8% is supplied from groundwater (17).

Considering that the **total amount of water consumed in our country has increased by 40% within the last 20 years**; it is predicted that the amount of water used will triple compared to today, in the next 25 years (17) due to;

- **Increased demand for water in agricultural production,**
- Ongoing asymmetric developments in the industrial sector,
- The rapid growth of urban population,
- Unexpected unplanned migration influx from abroad

According to Figure 5, total water use is predicted to be 112 billion m³ by 2023. **With this prediction, it will be fair to propose that current annual usable water resources in total will come to the verge of depletion.**

With the current habit in water usage, it is predicted that the highest consumer will be the agricultural sector with 72 billion m³ in 2023. Assuming that the approximately 50% increase that occurred in water usage between 2004 and 2016 will continue, the current population and economic growth rates are expected to put tremendous pressure on the usable water resources (14).

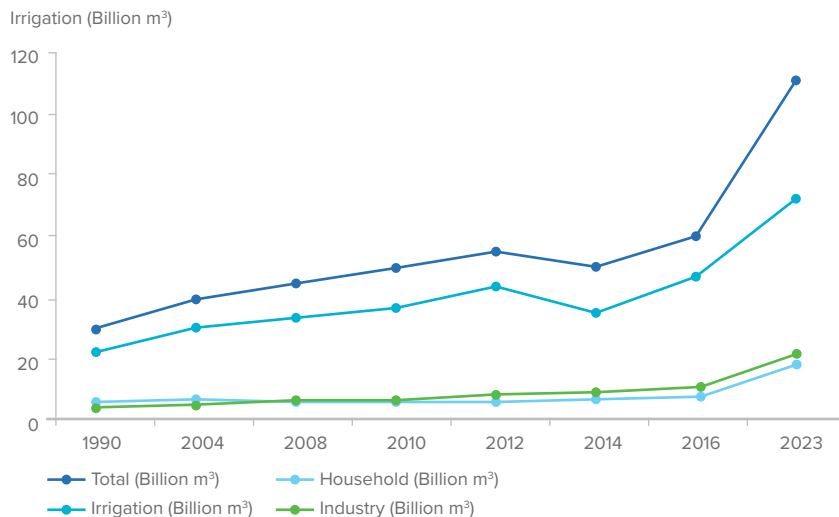


Figure 5: Water Use in Turkey
(TSKB, 2019)

The decrease in the water volume in our lakes and rivers, which are one of the most important sources of agricultural irrigation, is caused mainly due to,

- Reduced precipitation,
- Temperature rise,
- Large-scale use of surface irrigation,
- Expansion of inappropriate cultivation areas with high water consumption.

Given the precipitation data of our country, it can be said that;

- **Total annual precipitation is 450 billion m³,**
- **The average natural flow is 185 billion m³,**
- **Annual usable water in total is 112 billion m³ and**
- **The annual amount of usable water per capita is approximately 1.350 m³**

(1,347 m³ according to DSI 2020 data)

According to the data, it is predicted that our country is **not water-rich** and will be **among the countries suffering from severe water stress** by 2040, **based on the water stress indicator** given in Info Box 1.

Info Box 1

Water Stress

The concept of water stress defines the situation where the annual use of fresh water per capita falls to 1.700 m³ and below. The water assets of the countries are classified by the severity of the consumption pressure on the resources, according to the thresholds assigned by the Falkenmark Indicator given in Figure 4.

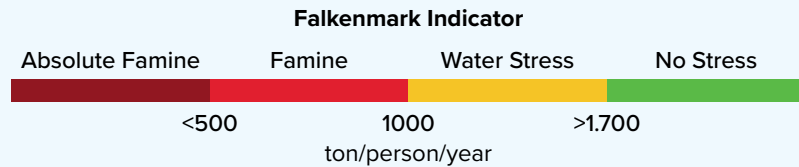


Figure 6: Falkenmark Indicator, Water Stress

Source: (20) "What is the Water Status in Turkey? What is Water Stress? ", (2021), <https://barajdoluluk.com/turkiyede-su-durumu-nedir-su-stresi-nedir/> Accessed on March 01,

In the world water stress map (Figure-7), it is emphasized that Turkey will be one of the countries that will suffer from water scarcity and will be affected the most by global climate change by 2040.

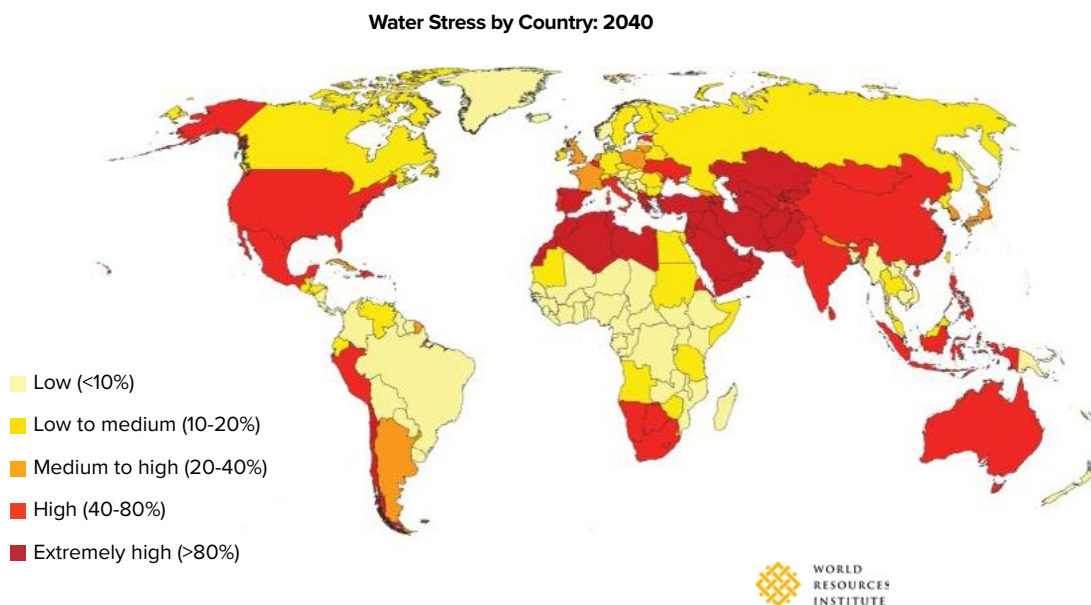


Figure 7: Water Stress Values of Countries, World Resources Institute, 2015

In this study conducted based on 167 countries, water stress values predicted based on the datasets are adapted to the countries for the years 2020, 2030, and 2040.

In this study that lays out the general water stress levels of the countries, as well as the stress level scores by industry, agricultural sectors, and domestic use, Turkey ranks 27th among the 33 countries to suffer from water stress most severely. According to the data of NASA, which gives out important findings related to water stress and drought, our country has had the driest period of the last five years with the least rainfall in the second half of 2020. It is stated that Istanbul, a world city, has reached the lowest water storage levels in the last 15 years (21). Figure 10 shows groundwater storage and groundwater wetness percentiles as of 11 January 2021. **As can be seen in the figure, existing groundwater is at serious risk and our country is facing a drought.** When the groundwater decreases, the amount of moisture in the soil decreases, too. Water requirements of soils, either due to drought or decreased groundwater levels, will increase even more. **The decrease in groundwater, together with drought, will create a devastatingly synergistic impact on the future of agricultural production.**



Info Box 2

Water Footprint

Defined as one of the basic indicators measuring the amount of water required for the production of goods and services that we consume. **Water footprint** is very important in revealing the use of water, directly and/or indirectly. As a multidimensional indicator, the water footprint also shows the **type of water, when, and where it is used.**

- **Green water indicates the total rainwater used in production,**
- **Blue water is the total surface and groundwater used in production,**
- **Grey water refers to the water consumed to make the wastewater reusable.**

The water footprint helps us to understand for what purposes and how the limited freshwater resources are consumed (23). The purpose of estimating the water footprint is to demonstrate the relationship of human activities and products with the water and to produce a scale in an attempt to reduce drought and pollution in a way to ensure the sustainability of water. **Agricultural production in Turkey is the activity with the highest water footprint.**

According to the climate, soil, and water characteristics of our basins; the implementation of advanced techniques to be developed in the areas listed below will directly affect the water footprint positively and support the equilibrium of “conservation and use” in water resources (24);

- **Soil cultivation and improvement,**
- **Irrigation,**
- **Product selection and diversification,**
- **Seed improvement,**
- **Anti-pest control,**
- **Prevention of harvest losses.**

The Data concerning the water footprint is presented in a report prepared by the WWF and the Ministry of Forest Water Affairs in 2014. According to this study, Figure 8 shows the ranking in **the water footprint as follows;**

- **Agricultural 89%,**
- **Household 7%,**
- **Industrial 4% .**

Looking at the detail of the water footprint in the agricultural sector as shown in Figure 8, water footprint stems from,

- **Agricultural production by 92%,**
- **Animal grazing by 8%**

The largest share of the water footprint caused by vegetable production is distributed as follows;

- 38% in cereals,
- 32% in forage plants,
- 13% in fruits,
- 5% in oil plants,
- 2% in vegetables and legumes.

The fact that there was a 20% increase in the water footprint in the 2005-2011 period, along with the change in consumption habits and the increase in production, is **clear proof that there is a need for radical innovations in the way to manage our water assets in Turkey as well as in the economic, social and environmental sustainability aspects (23).**

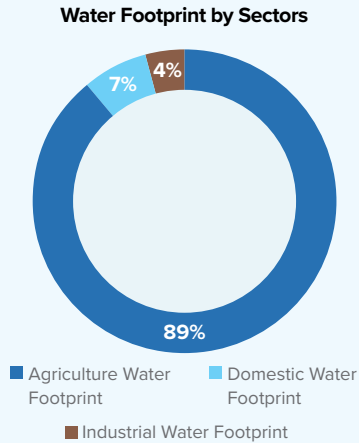


Figure 8: Water Footprint by Sectors, WWF, Turkey's Water Footprint Report, 2014

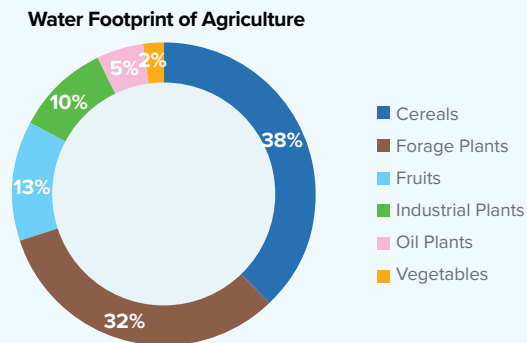


Figure 9: Water Footprint of Agriculture, WWF, Turkey's Water Footprint Report, 2014

Source:

(23) Hoekstra, A. Y., Chapagain, A. K., Aldaya, M. M., & Mekonnen, M. M. (2011). The water footprint assessment manual: Setting the global standard. Routledge.

(24) CENGİZLER, I., AYDIN, M., ÖZPOLAT, E., DERELİ, H., DUMAN, S., & KARLI, A. G. R. G. O. (2020). Research Dynamics.

(25) WWF, (2014), Turkey's Water Footprint Report, https://wwftr.awsassets.panda.org/downloads/su_ayak_iz_raporweb.pdf?2720/trkiyeninsuayakiziraporu, Accessed on: March 11, 2022.

Although there are roller coaster rides on an annual basis, the precipitation in the first half of 2022 in Turkey was at a level that would reduce the water stress of 2021 to a certain extent, as a relatively short-term positive development.

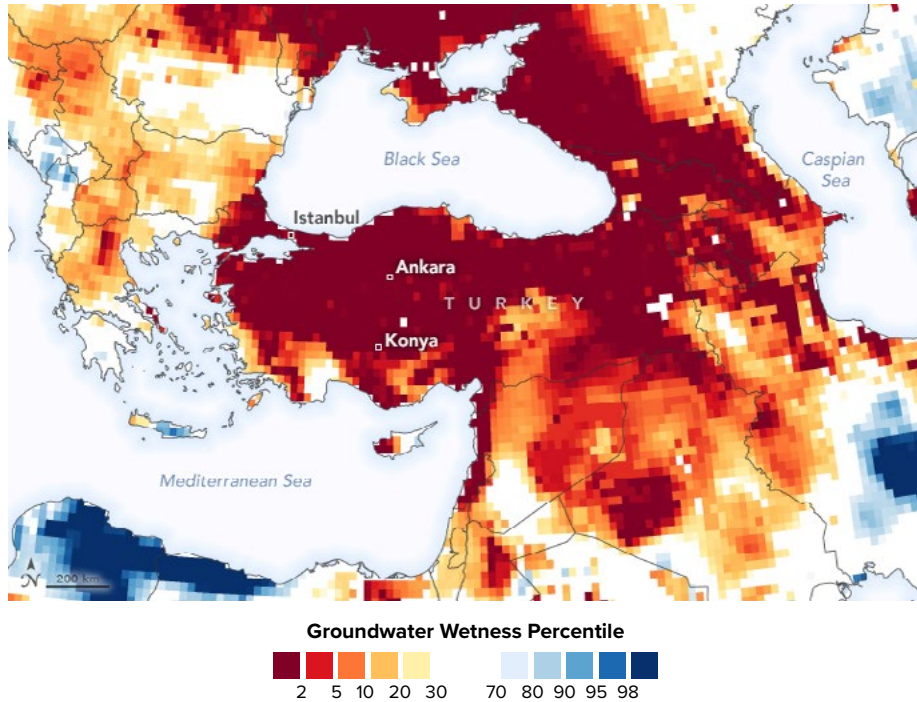


Figure 10: Groundwater Storage, NASA, 2021

The assessments regarding the water stress scores of the countries also point to the consequences likely to be caused by potential problems in the future. In this sense, it is predicted that the countries that will suffer severe water stress will be vulnerable in the sectors where they are highly dependent on water, and their economic growth will be affected drastically (22).

Info Box 2 gives the **sectoral distribution of the water footprint** indicating the consumption of each unit of water used in production and **its breakdowns in agricultural use**. The agricultural sector is **the leading sector in terms of the sectoral water footprint** in our country.

Considering the amounts of water withdrawal by sectors in Turkey, it is stated that the amount of water withdrawal from agricultural sources increased as follows,

- from 43.78 m³/year between 2008-2012
- to 50.05 m³/year between 2013-2017 (15).

It is emphasized that also the use of non-agricultural, industrial, and urban water increased, but this increase is lower than that in the agricultural water withdrawal

and the share of agricultural water withdrawal in total water withdrawal soared as high as 84%. **Low-loss irrigation systems have a role in facilitating water management and agricultural production will reduce the intense pressure on water resources as well as improve the quality of the soil.**

1.2. Agricultural Irrigation Systems and Methods

Agricultural irrigation is a practice against the natural process, outside its normal course. For this reason, irrigation should be done in moderation as much as needed by the product, by paying attention to the characteristics of soil and climate. In the natural process, plants develop to the extent permitted by soil, water, and climate and become members of the system. The fact that individuals try to produce agricultural products in any quantity and quality they wish to have, -not as much as afforded by the natural process - can be regarded as an indication that they try to alter the characteristics of soil, water, and plant however they fancy. Therefore, intervention in soil and water should be designed and implemented in such a way that will minimize the extent of this damage, to perform agriculture compatible with the ecosystem.

Plants need different amounts of water at different times of the year for their development and each plant has different water requirements. Not to mention the fact that water consumption of the same plant varies in different climates and soil conditions, as well. **The whole process of transferring the water from its source to the area of irrigation and bringing it right to the stem cell of the plant is defined as the “Irrigation System”.** The classification of the main irrigation systems used today is given in Figure 11.

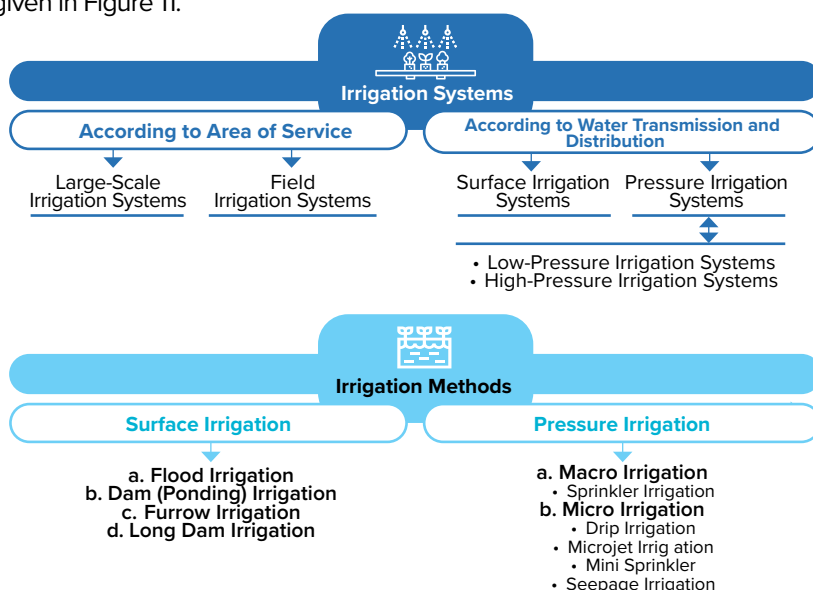


Figure 11: Classification of Irrigation Methods, GAP Regional Development Administration, 2012:21.

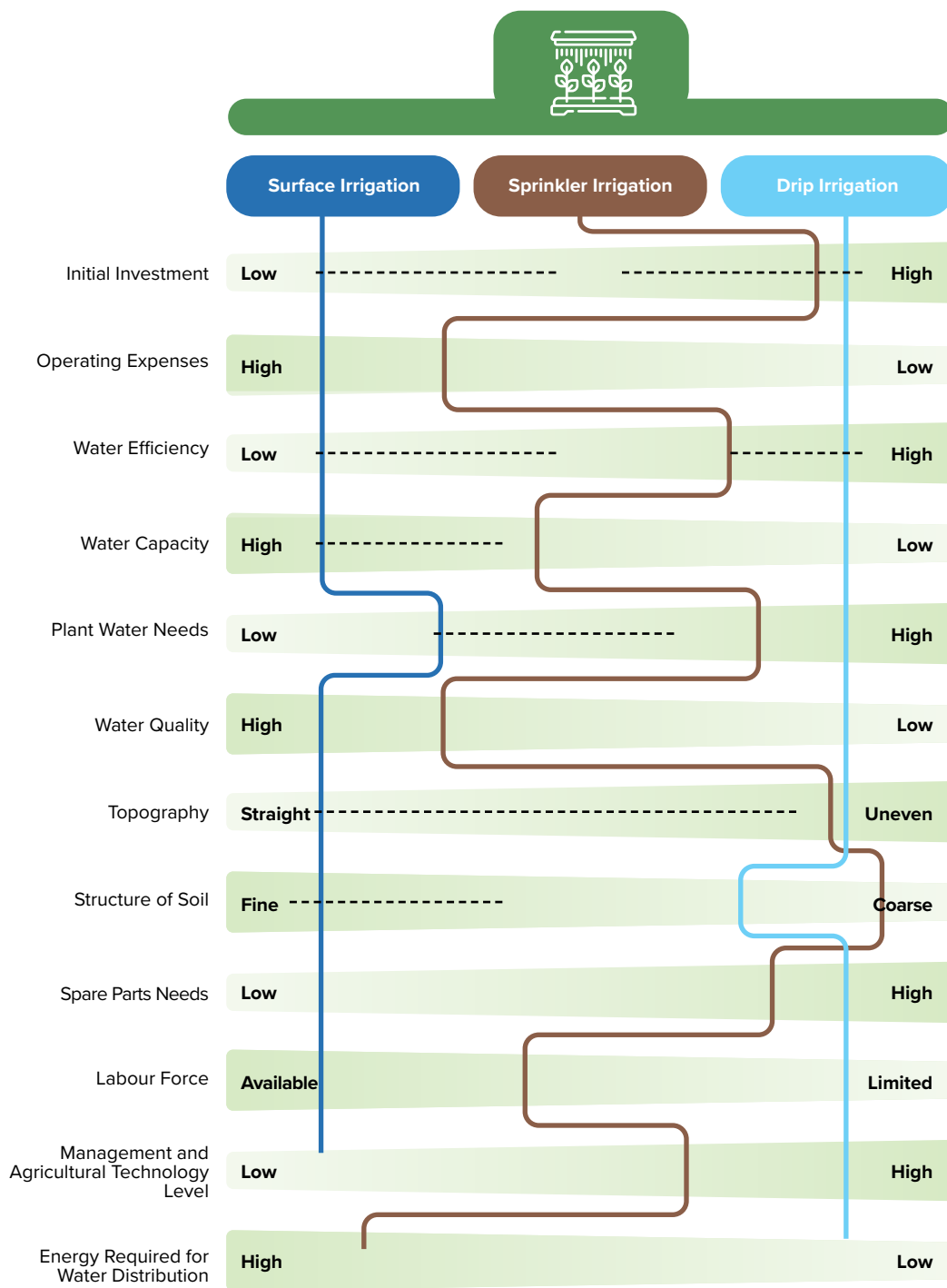


Figure 12: Factors in the Selection of Irrigation Methods, GAP Regional Development Administration, 2012:23

“Irrigation Method”, on the otherhand, refers to how the water is taken from the source for agricultural irrigation will be transferred to the plant’s root. In flood irrigation, table (ponding) irrigation, furrow irrigation, and long table irrigation methods, which are referred to as surface irrigation, the water moves along as determined by the slantof the land before it reaches the plant. Unlike surface irrigation methods, in pressure irrigation methods, the water taken from the source is transmitted to the plant root utilizing pressurized pipes (26).

In the graph given in Figure 12 comparing the selection characteristics of irrigation methods, it is seen that the initial investment costs and water use efficiencies of drip and sprinkler methods are high and the amount of energy spent is lower. The advantages of high water efficiency⁵ and low operating energy necessitated the use of pressure systems in agriculture. Surface irrigation, offering the only advantage of low investment cost, should not be preferred because other aspects are disadvantageous. It should be required to make it an obligation to use pressure irrigation methods with advanced technology, which have already been used widely in global agriculture, in all agricultural basins, and also introduce incentive systems.

The cost and investment costs of innovation in this field should be supported by appropriate financing structures; inappropriate water loss should be prevented and the reserves of surface and ground waters should be restored.

On the other hand, rainwater reservation is also considered an option to support water scarcity. Rainwater harvesting is outlined in Info Box 3.

5. It refers to the ratio of the amount of water required to be stored in the stem cell of the plant to the amount of water needed at the beginning of the field, but it varies according to the irrigation method used.



Info Box 3

Rainwater Harvesting and Irrigation Water Quality

Rainwater harvesting is defined as an effective water management model which is

- capable of storing a significant portion of the nearby rainfall,
- used as drinking, service, garden irrigation, and livestock water,
- used in raising the groundwater level,
- used in a small-scale but widely.

Remarkable early examples of rainwater collection and storage include the storage networks that involved large cisterns built in Crete in circa 2600-1100 BC. Today, it began to be used as a method that provides small-scale but widespread water collection and storage possibilities in every developed or underdeveloped country. In China, New Zealand, Brazil, India, Thailand, Singapore, Europe, and especially Germany, water-supplying rainwater collection networks were built using structures with large roof surfaces, for also use in non-agricultural purposes, as well.

There are even states in India that impose rainwater harvesting in an effort to prevent the depletion of groundwater.

In rainwater harvesting, the water collected from the rainfall is collected with different methods, stored in reservoirs, and put to use in times of low rainfall. The following illustrations summarize the benefits of rainwater harvesting.

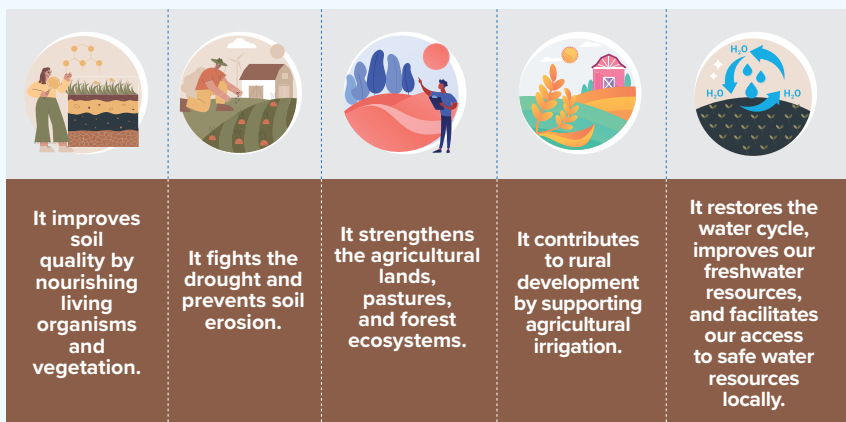


Figure 13: Benefits of Rainwater Harvesting

Irrigation water quality is determined by the total amounts of salt and the types of salt available in the water. Salt is the combination of two element ions. One has a positive charge (e.g. sodium) and the other a negative charge (e.g. chloride).

The concentration and composition of water-soluble salts determine the quality for various purposes (human and animal drinking, crop irrigation, etc.). Therefore, the quality of water is an important component in terms of the sustainable use of water for irrigated farming, especially when the ongoing salinity is expected to be a problem in the lands used in irrigated agriculture.

The development of standards for agricultural water quality is still ongoing. In many countries, there are quite many irrigation water classifications that are different but close to each other in terms of size. FAO strives to make these standards a unique international standard. California Salinity classification is known for its high-quality requirements in agricultural water as well as its standards for the use of wastewater.

Among these classification measures, the most important ones are the salts and their amounts in water. Waters used in plant irrigation according to the total salt concentration values in ppm given in the California salinity classification are described as follows;

1. 0-175 ppm- the best,
2. 175-525 ppm- good,
3. 525-1400 ppm- acceptable,
4. 1400-2100 ppm- suspicious,
5. >2100 ppm- harmful.

In addition to the fact that agricultural water is salt-free or slightly salty, it is also required that;

- pH range should be between 6.5-8.4,
- it is not charged with nitrogen and phosphorus,
- it contains the elements such as copper, zinc, lead, cadmium, aluminium, and arsenic, only to the extent permitted by the standards,
- it has a low biological oxygen requirement,
- It must be free from bacteria and parasites.

Source:

(27)WWF, (2020), To Improve Water Cycle Rainwater Harvesting, https://wwwfr.awsassets.panda.org/downloads/ysh_web_ekim_2020_1.pdf?10340/Su-Dongusunu-lylestirmek-lcn-Yagmur-Suyu-Hasadi Erişim Tarihi: 24 Mart 2022.

(28) Rainwater Harvest, https://tr.wikipedia.org/wiki/Ya_%C4%9Fmur_suyu_hasad%C4%B1 Accessed on: March 16, 2022.

(29) Irrigation Water Quality, <http://agrilifeextension.tamu.edu/wp-content/uploads/2019/04/EL5417-irrigation-water-quality.pdf>

(30) <https://link.springer.com/content/pdf/10.1007/978-3-319-96190-3.pdf>

1.3. Problems in Agricultural Irrigation

Figure 14 formed relying on the interviews with our agricultural stakeholders and the complementary research of our STOK study group points to the interaction and cause-effect relationships oriented toward agricultural irrigation.

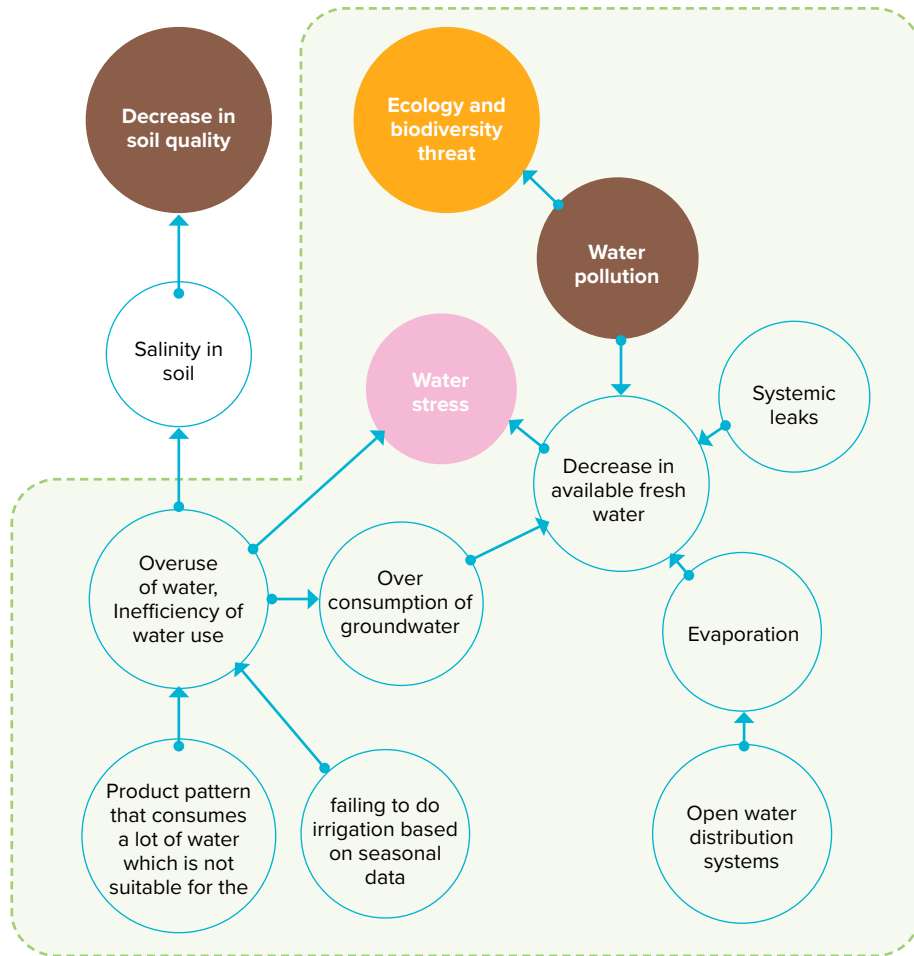


Figure 14: Water Problem Model

In addition, **the problem areas related to agricultural irrigation** in our country are laid out in detail as follows:

- It is stated that **there is a need for a long-term “Turkish Agricultural Master Plan” suitable for the water potential of the basins in Turkey,**

- **Even the products with high water consumption can be planted in those regions imposing water constraints**, due to short-term economic expectations where product cultivation is performed in an unplanned way.
- It is stated that the practices introduced so that the producers can give up the products that consume plenty of water in the regions with water stress failed to serve the purpose, so **it would be a good practice to necessitate switching from the products consuming lots of water to those products suitable for the conditions of the basin, with the support of financing**. It is stated that dissuasive measures alone will not suffice to prevent the cultivation of products that consume excessive water in zones with water scarcity.
- It is stated that **the number of illegally drilled wells to access groundwater resources increased, causing uncontrolled use of water as well as public damage, due to the lack of plans for product patterns suitable for the basin's climate and water potential as well as the disruptions** in the support for appropriate models.
- It is also stated that the **inter-basin water transfer practices proposed as a solution to prevent irresponsible practices** that almost caused the depletion of water resources are yet another mistake in water management. The transfer of water from the basins, which are considered relatively sufficient for themselves, to the basins where the water is insufficient **causes both the water risk for the basin from which the water is withdrawn and the disruption in the equilibrium of the living ecosystem due to the decreasing water in that particular region**. It is stated that there is not a single example where a country ever succeeded with solutions, such as the transfer of water from other basins to the bigger cities. That's because it leads to the continuation of available water resources with the existing water usage habits, rather than giving up improper water use methods.
- It is stated that the **vast majority of water distribution systems are made up of traditionally exposed systems with high evaporation and water leaks**. It is stated that 28% of the irrigation canals built by DSI are pipe systems, and 72% are exposed canals, in both of which there is a high water loss due to evaporation. Since there is no clear and up-to-date data on irrigation facilities other than the inventory of DSI, there is no possibility to make out an accurate evaluation (15).
- It is stated that **groundwater is widely used in agricultural irrigation. The use of groundwater causes a significant increase in input costs** due to **energy consumption** by irrigation units and producers as well as the infrastructures for water piping and electrical wiring.
- Not only has **excessive use of water in agriculture** become a threat to living

organisms but it also depletes the water resources rapidly. **Water levels in all groundwater resources of Turkey have decreased dramatically.** For example, flock mortality was observed in the waterfowls across the region in the summer months of 2021 due to the use of freshwater resources for irrigation, which is supposed to feed the Salt Lake (Tuz Gölü); the dams constructed on the streams feeding the wetlands and the drainage channels and newly-drilled water wells.

- The beverage and bottled water sector is another factor that leads to a dramatic decrease in the level of groundwater. Domestic and foreign brands have a high production of soft drinks in Turkey, and the need for quality water is relatively higher than in any sector. For instance, water can be extracted from 500 meters in the Ergene Basin today while it was possible to get it from 20-60 meters only.
- In addition, the water and soil loss suffered by the basin due to industrial and urban waste released into the Ergene river tributaries was documented by the studies conducted in the region by our universities and the Ministry of Environment (61). Organic compounds, resins, dyes, nitrates, mercury, chromium, copper, cadmium, arsenic, phosphorus compounds, and disease-causing microorganisms released with polluted wastewater both pollute our clean waters, and these contaminations are transferred to fertile agricultural soils.
- **One of the ongoing problems in agriculture is that irrigation does not rely on a schedule and the water retention capacity of soil is impaired due to old-school irrigation.** Continued surface irrigation reduces the groundwater and disrupts the structure of the soil **by directly causing the soil to salinate. Therefore, soil, product type, irrigation methods, and climate should be considered as the basic parameters of the most efficient agricultural model of each basin as interdependent variables.** When the product is exposed to excessive water, salt water is formed by the water that goes deep down in the soil and melts away the rocks at the bottom comes to the surface. This salt to which the cultivated plant is exposed also causes the organic matter in the soil to deteriorate and diminish. In Turkey, the problem of salinization especially in the Harran Plain, which has increased over the years due to the high groundwater formed following agricultural irrigation, has increased throughout the region in general. This has become a threat to plant cultivation. The salinization problem in the Harran Plain is stated to increase from the south all the way to the north. The results of the analysis of salinity data starting from the south of the plain, which was conducted via the Geographic Information System, revealed that the saline-stricken areas, which were 11.430 ha in total in 2000, increased by around 55% within 10 years, reaching 17.767 hectares in 2009. It is stated that there was a remarkable decrease in the areas affected by salt following the drainage works initiated in the Harran Plain in 2011, however, no up-to-date data is

available on the extent of the net area, due to the lack of new mapping studies (30).

- Traditional surface irrigation methods are preferred by the majority of producers, in lieu of pressure irrigation techniques such as sprinkling, drip, microjet, mini sprinkler, and seepage irrigation. **It is stated that water loss occurs by approximately 35%-60% in surface irrigation techniques** (15). 2012 data from the GAP Regional Development Department indicate that approximately 94% of Turkey's total agricultural lands is irrigated with traditional furrow, table, and flooding methods, and the remaining 6% uses pressured sprinkler and drip irrigation methods. According to the data from DSI for 2021, and according to the irrigation methods applied in the irrigations operated by DSI, it is emphasized that 60% (1,133,550 ha) of the total area of 1,882,391 ha is irrigated by surface irrigation methods; 23% (431,116 ha) by sprinkler method; 17% (317,725 ha) are irrigated by drip irrigation method.⁶ (26).
- "Irrigation efficiency" is around 40% on traditional surface irrigation methods. With the widespread use of modern irrigation technologies, it is stated that this rate can increase up to 70% in sprinkling and 90% in drip irrigation (15). According to DSI data, water saving can be achieved by 35% in sprinkler irrigation and 65% in drip irrigation (31). In the Agricultural Irrigation Sector Policy Document, the water loss in drip irrigation occurs between 5% - 25% (15).
- In traditional surface irrigation methods, 30 liters of water/second is supplied to 8 ha of irrigation area, while in modern pressure irrigation techniques, sprinkling, and drip irrigation methods, it is underlined that an average of 10 liters of water/second can be given to 8 hectares. Thus, **with the water we normally spend on surface irrigation, we can manage to irrigate three times the land, should we adopt contemporary irrigation techniques** (31).
- **It is stated that pressure irrigation methods** aimed at using the water efficiently and most effectively **can be misapplied by the producers sticking to old habits**. For example, it is emphasized that producers continue to irrigate the soil in drip irrigation "until water is soaked" as in the case of surface irrigation, or the frequency of irrigation is increased.
- For the drip irrigation technique to be applied as broadly as possible in Turkish agriculture, the relevant public institutions are required to establish a private investment incentive policy, support the producer and lead the recovery of our water resources. Especially, **subsurface drip irrigation will make very valuable contributions to the economical management of water** as it reduces the amount of evaporation to almost zero, thanks to its characteristics that deliver the water right down to the root, rather than the fact that the root moves to the water.

6. Data were accessed from DSI.

2.1. Soil Assets Cultivation Methods

Soil, in its broadest sense, constitutes the main reservoir of the ecosystem's material assets, all elements, all living and non-living, as well as the habitat with biodiversity in its richest form. A high number of different living organisms rely on soil for survival, and they eventually decompose and turn to the soil at the end of their lives.

According to the Specialization Commission Report on Sustainable Use of Soil and Water (2018),

- With a surface area of 78 Mha, Turkey has 24 Mha of farmlands.
- However, only 8.5 Mha of those lands can be irrigated economically (31).
- It is stated that agricultural lands decreased by 4,720,000 ha between 1990-2020 (2).
- Along with meadows and pastures, 37 million 802 thousand hectares (48% of the total share) of our country are used for agricultural activities (33).

Not only **can the soils of Turkey** afford to **meet its own needs** in terms of the quantity, variety, and product quality of the crops that can be grown and harvested, but **it also has the capacity to export on significant scales to many countries on the three continents to which it is connected terrestrially**. It is possible to increase this capacity by making the lands, which are not yet considered economical, available for agriculture in the future.

It helps to obtain more efficient and quality products with the use of healthy and quality soil, less water, and fewer nutrients. Products obtained from healthy soils have a higher rate of meeting human needs and have a higher nutrient content. Therefore, **it is required to refrain from all sorts of actions that can degrade soil assets**. Below are given the factors that threaten the soil health and quality, under the title “the factors that degrade soil assets”.

The Factors Degrading Our Soil Assets:

1. Climate change,
2. Impoverishment by crop harvest (soil components transferred to the product),
3. Chemical pollution (agricultural, urban, industrial, mining and radiation),
4. Erosion (water and wind),

“

“We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect”

*Aldo Leopold,
1887-1948*

5. Improper cultivation and fertilization techniques (practices against the requirements of soil and product),
6. Large-scale and long-term cultivation of the same type of product,
7. Deforestation,
8. Degradation of biodiversity,
9. Loss of land due to urbanization and industrialization of agricultural lands,
10. Loss of land due to mining.

The imbalance between agricultural production and the demand for food, which was worsened by the temperature rise in the geography surrounding our country, has already started to manifest itself. As a result of severe droughts, increased evaporation due to heat waves, and water consumption by the plant, the soil loses its moisture and becomes barren, leading to a decrease in the yield.

Climate change causes changes in the moisture and water-holding capacity of the soil. The more the water holding capacity of the soil changes, the more the yield and quality of the product will be affected. It is particularly stated that soil moisture in the Southeast of our country decreases significantly in late spring and in summer months, which in turn brings about decreases in the yield and quality of the products grown.

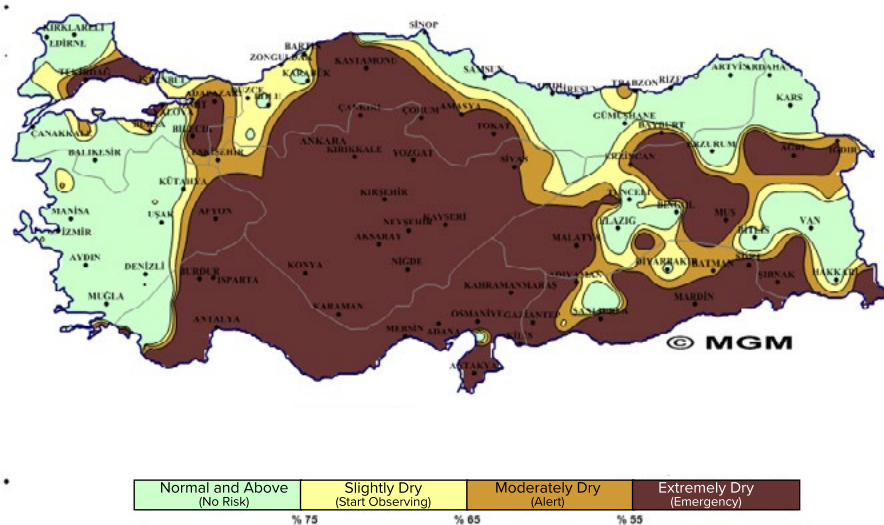


Figure 15: MGM, Drought Map, October 2021

Figure 15, the meteorological drought map for October 2021, published by MGM, indicates the continued risk of drought that affects agricultural production adversely. Increased risk of drought and desertification causes loss of crops in agricultural production and makes it difficult to cultivate such products that are not drought-tolerant. 22.5% of Turkey's lands are highly vulnerable to desertification while 50.9% are moderately vulnerable. It is therefore necessary to produce and disseminate essential solution proposals to preserve and enhance soil viability (Info Box 4).

Some basic applications to protect and improve soil viability are given in Figure 16.

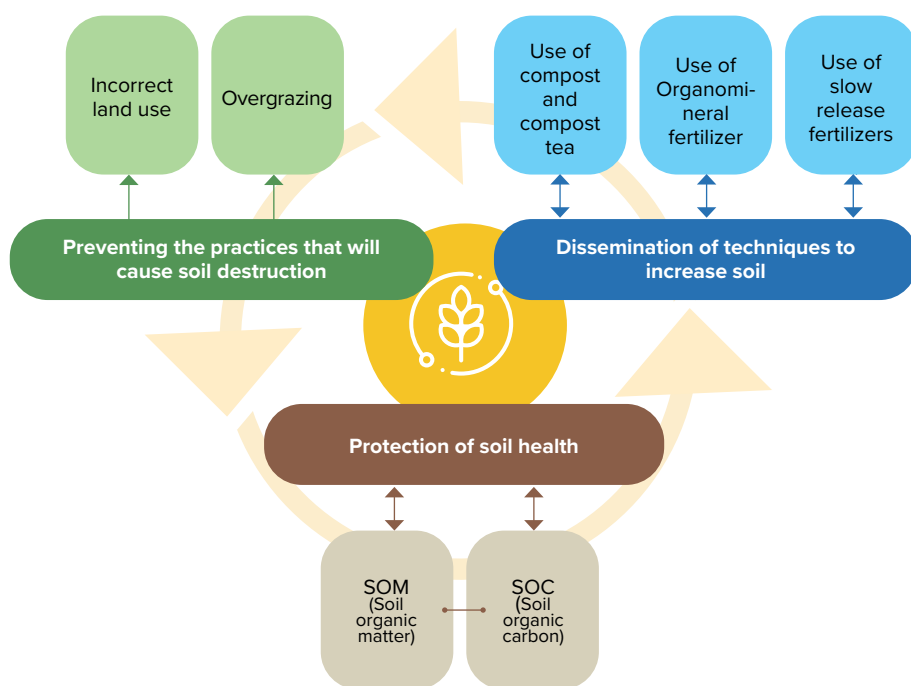


Figure 16: Basic Practices for the Protection of Soil Vitality



Info Box 4

Soil Vitality and Significance

Soil is a living part of the natural environment. Together with the climate, it determines the distribution of living species on the earth and creates an environment to feed and inhabit for a wide variety of organism populations. It controls the flow of water and chemicals between the atmosphere and the earth and acts as both a source and a reservoir for the gases in the atmosphere.

Soil, along with plant and animal life that it supports, is an amazing and complex natural system (NRCS).

Healthy soil is part of the biosphere, which serves as a habitat for numerous species, from microorganisms to mammals. The composition of ideal soil suitable for the growth of plants includes 45% mineral, 25% air, 25% water, and 5% organic matter.

Type of Organism	kg/ha (from surface to around 8" deep)
Bacteria	4371,32
Fungi	2914,21
Algae	100,88
Protozoa	100,88
Nematodes	50,44
Earthworms	498,78
Insects/Anthropods	930,31
Toplam 8966,82	

It is a living ecosystem that provides material transfer with the soil, water, and atmosphere in which fungi/algae, bacteria, microorganisms, earthworms, meso and microfauna can exist. **The measure of soil viability is the amount and diversity of living things hosted by it and the richness of the organic matter produced by these organisms through vital activities.** Of these creatures, earthworms are defined, in some sources, as “engineers of the ecosystem” or “environmental fighters” (34).

Table 2: Average Vitality Data in Agricultural Soil

Organisms and their functions in healthy soil

Bacteria: Small single-celled organisms. They are decomposers that consume simple carbon compounds such as root secretions and fresh plant garbage.

Fungi: Soil particles are single or multicellular organisms that can live between roots and rocks, and do not photosynthesize, and consume other organisms. Many plants depend on fungi to get nutrients from the soil. They convert hard-to-digest organic matter into forms that other organisms can use. It retains the

water in the soil and enriches it with minerals by forming a living composite called mycorrhizae using tiny soil particles and roots of plants. The plant responds to the fungus by providing it with sugar. Mushrooms exploit insects and small worms. Their spores penetrate the pests and destroy them.

They help in processes such as the suppression of plant diseases. Mushroom spores are used as a pest control spray in crops.

Protozoa: They are single-celled organisms that feed on bacteria. They eat other protozoa, soluble organic matter, and sometimes mushrooms. It allows the minerals in the food to be released while they eat the bacteria. They release the excess nitrogen into the soil, which can be used especially by other members of the plant and food network.

Nematodes: They are tiny worms (about 1 mm long). Although some damage the plant, the majority help to control plant diseases and improve the nutrient cycle by releasing the nitrogen available in the bacteria and fungi into the soil.

Arthropods: They are insects. A thousand different species of arthropods can dwell in a hundred hectares of vegetable soil. They eat mushrooms, little worms, and other arthropods. They ventilate and stir the soil as they feed. They regulate the size of the population in other soil organisms. It breaks down organic matters, increases microbial activity by mixing the microbes with food, and keeps the pests under control. It mineralizes plant nutrients.

The main ecosystem processes of healthy soil are:

1. **Carbon Cycle:** a process in which plants convert atmospheric carbon dioxide into sugar with sunlight.
2. **Biocommunity Dynamics:** interaction of animals, plants, and other organisms living in the soil.
3. **Water Cycle:** Retention, seepage, and availability of water.
4. **Food Cycle:** Processes in which the soil water is nourished with the food chain continuously, moves to the plants as it dissolves in water, and goes deep down from plants to the organisms.

Soil Food Network comprises;

- Plant shoots and roots,
- Organic matter is waste and residues of plants and animals as well as the microbes, bacteria, fungi, nematodes, arthropods, protozoa, birds, and animals.

Activities improving the soil health:

- Not to cultivate the soil or to cultivate limitedly on a protective scale,
- Not to cultivate the soil when it is wet,
- To keep cover crops in unplanted soil,

- To take turns in using different and variable products,
- To grow perennial plant species,
- To use green and animal manure,
- To keep product residues in the field,
- To use cover plants to increase the roots that live continuously in the soil,
- To increase the biodiversity of plants, animals, and microorganisms,
- To fight against the pests in a versatile way,
- To minimize the vehicle traffic on the soil,
- To maintain the moisture of the soil with sawdust/chips, mulch, and cover plants.

Activities that deteriorate the soil health;

- Aggressive cultivation every year,
- Keeping the weeds under control by using sprays or tillage,
- Annual or seasonal fallow,
- Single-type crop,
- Annual crops,
- Excessive use of inorganic fertilizer,
- Excessive removal of crop residues,
- Overgrazing on the same land,
- Broad-spectrum fungicides and insecticides,
- Non-selective weed sprays.

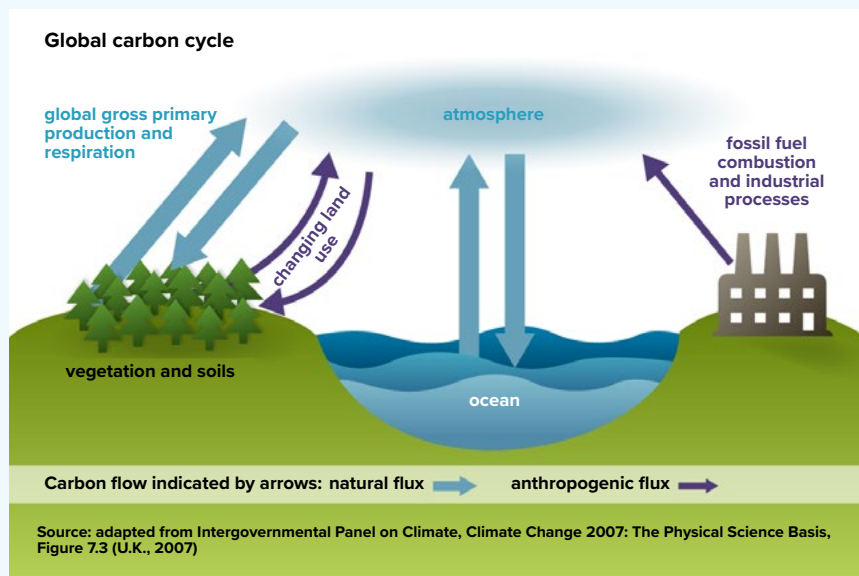


Figure 17: Carbon Cycle

Practices such as continuous cultivation of the soil, use of chemical fertilizers in soil, and excessive and intensive use of pesticides reduce the amount of organic matter in the soil and endanger soil viability as well as the nutrient network. When the soil loses its vitality, food production, and biodiversity decrease, making sustainability difficult. For this reason, it **is very important to disseminate the practices aimed at preserving the soil viability in all of the activities related to changing nature, especially agriculture.**

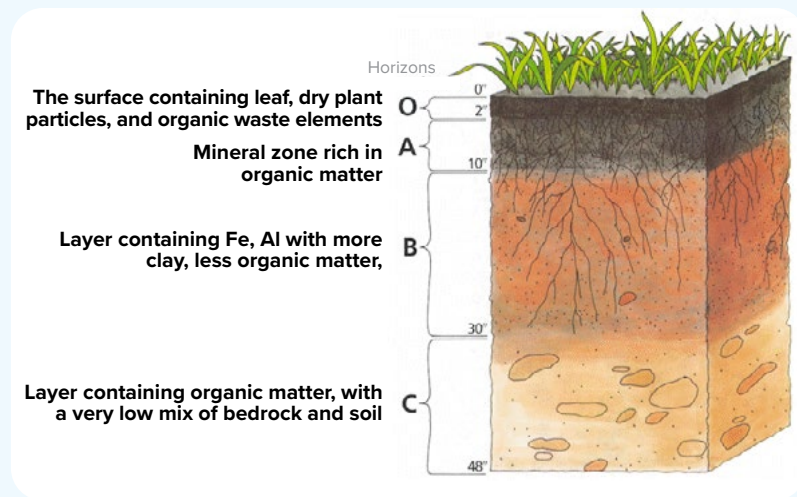


Figure 18: Soil Layers

References:

(34) European Environment Agency, (2019), EEA Indicators: Land and Soil in Europe. <https://www.eea.europa.eu/tr/publications/aca-isaretler-2019-avrupa2019da-arazi> Accessed: 13 April 2022.

(35) "Toprak Son Nefesini Veriyor", (2021) <https://www.bugday.org/blog/toprak-son-nefesini-veriyor/> Accessed on: April 25, 2022.

(36) Tema Foundation, "What is Soil?" <https://topraktema.org/toprak-nedir> Accessed on: March 10, 2022.

<https://pikeconservation.org/soil-profile/>

<http://depo.cografyahocasi.com/Rustu-ilgar/Pedoloji-toprak-cografyasi.pdf>

The first 10-15 cm layer of soil is of vital importance for soil and plant health. For this reason, this layer in particular needs to be well preserved. **Especially, the chemicals used in the soil damage this very special layer and disrupt its structure.** In order to reduce this damage, it will be required to:

- Use the chemical fertilizers and pesticides in accordance with the phenological period of the cultivated product in a minimum amount as verified scientifically,
- Establish the industrial campuses away from agricultural basins, equipped with an environmentally friendly filters, treatment, and solid waste storage facilities,
- Develop the biological control of pests,
- Improve the product to encourage its self-defense system.

Therefore, it will be possible to prevent the pollutants in the soil great extent, which are caused by irrigation water, rainwater and air, if the above-listed measures are taken collectively.

It is stated that a significant part of Turkey's lands are "exhausted" and not rich in organic matter. **The techniques that will enhance soil health should be disseminated in these lands. It is therefore imperative that the producers acquire a more comprehensive knowledge and analysis of the soil health, apart from and beyond the general assessments as regards the physical and chemical characteristics of the soil.** Only then can the producer develop an ability to monitor and implement effectively in the following subjects,

- **Interpretation of the laboratory analysis results of the soil,**
- **The requirements of the product,**
- **The sufficiency of the macro and microelements in the soil,**
- **Nutrients that need to be added to the soil,**
- **How, how much and when these nutrients should be given, briefly the systematics of implementation, etc.**

Currently, it is stated that **the producer;**

- **is dependent on application prescriptions issued by the supplier, the application systematics of the nutrients and regulatory additives required by the soil,**
- **is lack of interpretation and decision-making,**
- **has a relatively low and superficial knowledge,**
- **does not consider it necessary to get a soil analysis done,**
- **is more apt to decisions making based on existing habits and trends.**

It is stated that the majority of producers **get a soil analysis done only if they**

receive support, otherwise, they make their own decisions with the guidance of dealers who provide agriculture. input, rather than making these decisions based on soil analysis. This causes the decision-making widely to be caused on beliefs and habits, rather than based on the requirements, data, and analysis of the soil.

2.2. Soil-Related Problems

Problem areas and solution proposals on the resources and utilization of soil are summed up in Figure 19 in light of interviews and complementary readings.



Figure 19: Soil Problem Model

The problem areas mentioned in relation to our country's soils are outlined in detail below:

- Failure to introduce **“Basin Agricultural Planning”** deemed necessary specifically to each basin and prepare the **“Basin Agricultural Incentive Budgets”** accordingly.
- Planting the products unsuitable for climate and soil conditions in the basins causes a change in the need for irrigation and soil quality. The farmers should be provided with proper training for a gradual reduction in inappropriate product cultivation as per the “Basin Agricultural Planning” and the **water and soil should be protected by providing strong funding so that the agriculture of other suitable products, rather than those unsuitable ones, can be disseminated across the basin.**
- Reliability problems can sometimes be experienced in laboratories that perform soil analysis. Since the producers receive different reports for the same soil sample, from different laboratories, or even from the same laboratory from time to time; they lose their confidence in laboratory analysis, which causes the producers to walk away from getting a soil analysis done.
- **Measurement accuracies should be improved by introducing more common measurement comparison experiments between soil analysis laboratories; soil analyses should be repeated annually for field crops and every three years for perennial crops, it must be encouraged with financial incentives, and the producer should be advised on taking samples from the soil.**
- In addition to soil composition analysis, **also the institutions and laboratories performing soil pollution analysis** should initially be improved in quality and then increased **in numbers to suffice each agricultural basin.**
- **Soil pollution is a major problem area.** It is required to research the methods to prevent soil pollution caused by Cr, Cd, Cu, Zn, biologically active compositions, pitch, oil radioactive substances, asbestos and hazardous gases, ph change, and heavy metal accumulation as well as the storage methods for these substances.
- In this regard, the environmental pollution in Ezine, Çanakkale, which took place from past to present and discussed, can be given as an example. The rapid and unplanned urbanization and the increase in industrial settlements in our country, especially within the last 30 years, have led to the abandonment of agricultural lands and the pollution of the environment and soil (61).
- **The soils in Turkey, in which chemical fertilizers and drugs are widely used, have a specific pollution problem.** The most important purchase criterion of the consumer markets in the export products is not the product's price, but the amount of chemical pollution. The consumer tries to secure this aspect by inspecting the production on-site. If the existing misapplications, such as the use of excessive chemical fertilizer and



Info Box 5

Soil and Water Analysis

Maintaining the soil fertility first requires the identification of the characteristics of soil in the best way and therefore, physical, chemical, and biological properties of the soils must be determined through analysis. Soil analysis in agriculture is performed for the following purposes,

- Determining the number of nutrients in the soil and its ability to provide plants with nutrients,
- Determining the type and amount of fertilizer to be applied,
- Identifying the source of nutritional disorders in the soil,
- Determining the soil pollution,
- Diagnosis and rehabilitation of saline, sodium areas,
- Land survey, genesis (formation) and classification,
- Variety of the plant to grow in the soil,
- Drainage problem and solution. (63)

The **Directorates of Research Institute** affiliated with the Ministry of Agriculture and Forestry **perform soil analysis** for water saturation, grain structure distribution, clay, salt, pH, electrical conductivity, lime, nitrogen, phosphorus, potassium, magnesium, organic matter, iron, manganese, zinc and copper properties. **Standard irrigation water** includes the analysis for pH, EC, Ca, Ca+Mg, Na, K, B, CO₃, HCO₃, Cl, and SO₄. However, in addition to these analyses in the soil, **biological pollutant and persistent pollutant analyses will also be required.** For instance,

- **Sewerage water can be used in agricultural irrigation** and disease-causing microorganisms in water **cause general pollution** as they are transferred into the soil, product, water, and atmosphere.
- **Agricultural plastics and plastic waste dumped in agricultural lands mix with** soil and irrigation water, causing microplastic and nanoplastic **permanent particle pollution** in soil and water. **Detailed analyses are needed for permanent particle pollution.**

Source:

Ozturk, Elif. (2021), Soil Analysis and Interpretation, Directorate of Black Sea Agricultural Research Institute. Available at: https://arastirma.tarimorman.gov.tr/ktae/Belgeler/BGT/Toprak_Analizleri_ve_Yorumlanmasi.pdf

herbicide/pesticide, are continued; it will be difficult to grow agricultural products in these soils, and the volume of export will decrease. **Our soils not treated with any chemical fertilizers and herbicides/pesticides are in much better condition, but the destruction caused by techniques such as furrow, ponding, and flood irrigation continues in these soils.**

- **Quick-release fertilizers** are washed away and transmitted due to excessive rainfall or agricultural irrigation, polluting the surface and groundwater resources and affecting the agricultural product quality. Besides, it is considered that these water sources contaminated with nitrate and nitrite have a contributing effect to the increase in the formation of mucilage in the Sea of Marmara. **Slow-release fertilizers are thought to be more sustainable and beneficial.**
- It is stated that there is a **salinity problem in patches** in Turkey's soils, including the GAP region where the water is so abundant. In some soils with excessive irrigation, the groundwater level rises, the salts in the deeper layers of the soil dissolve and rise to the surface and as the water evaporates, it is transferred to the soil surface. It is known that closed basins are also prone to salinization, and impermeable layers that prevent the passage of groundwater are more prone to salinization, especially in terms of topography (37). The formation and increase of salinity (sodium and boron) in the soil affect the plant's development due to the direct effect of the poison. Moreover, upon the increase in salinity, the water retention capacity of the soil decreases, and the water intake of the plant reduces. It is stated that the lands suffering alkalinity (aridity) problems constitute 2% of the surface area of our country, 5.48% of the total cultivated soils, and 17% of the economically irrigable land; 74% of the total arid fields are salines, 25.5% are saline-alkaline and 0.5% are alkaline soils (38).

Soil properties	Area (ha)	According to Problem Areas (%)
Lightly saline	614.617	41%
Saline	505.603	33%
Alkaline	8.461	0,5%
Lightly Saline-Alkaline	125.863	8%
Saline-Alkaline	264.958	17,5%
TOTAL	1.518.722	100%

Table 3: Salinity of Soils

- The salt coming from the bottom as it breaks up with water in saline soils reduces the water withdrawal of plants from the soil and causes



physiological drought by disrupting the osmotic pressure⁷ balance of the natural soil solution. (38). Therefore, the plant develops poorly and yields decrease.

- Carbon, as the main building block of living organisms, plays a major role in improving the organic structure of the soil, connecting the carbon in the atmosphere to the soil, reducing the greenhouse effect, and forming the molecular backbone of the sugars, which are the energy source of almost every living creature. It is stated that low-carbon soils in our country are generally found in hot and dry climatic regions whereas high-carbon soils are found in cool and rainy climatic regions (60).

Soil is grouped as very low, low, moderate, good, and high carbon soils in terms of organic carbon content.

Organic carbon content	Area (ha)	Area (%)
Very Low	14.216.623,774	18,040
Low	55.572.605,257	70,519
Moderate	7.703.539,206	9,775
Good	437.678,010	0,555
High	5,788	0,000
Unclassified	874.351,846	1,110
Total	78.804.803,881	100,000

Table 4: Organic Carbon Distribution (%) of Soils in Turkey, TAGEM; 2018: 26

According to Table 4, 88.5% of our soils are classified as very low and low carbon in terms of organic carbon. In general, it is emphasized that the ratio of organic matter may be around 5% in healthy soil, however, it may increase up to 10% in soils with high organic matter. It is stated that this ratio will decrease below 1% in the soils used extensively through continuous cultivation and will impair the health of the soil (39).

It is stated that microorganisms, bacteria, and fungi would stand out in terms of soil health and plant nutrition, and various research has been conducted on rhizobium and mycorrhiza, especially by agricultural research institutes in Turkey, but there are some challenges and disruptions experienced regarding the transfer of the results of this study to the producers.

*I tilled its belly
with a pickaxe
and fork,*

*I tore apart its
face with nails
and hands*

*But still, it
welcomed me
with roses,*

*My Faithful
Beloved Is The
Black Earth.*

*Aşık Veysel
Şatıroğlu,
1894-1973*

7. Osmotic Pressure: It is the pressure that allows plants to take up the water and nutrients they need, through their roots.



3

Soil and Water Relationship

Soil is a living ecosystem in which millions of various bacteria, fungi, viruses, microorganisms, and organic residues coexist in contact with water in an inorganic matrix. This system is of vital importance for the food, fiber, and energy supply, directly and indirectly, for all living things on earth as well as for many functions that enrich the ecological, socio-economic and cultural life. The interaction between water and soil is given in Figure 20 in its most basic form.

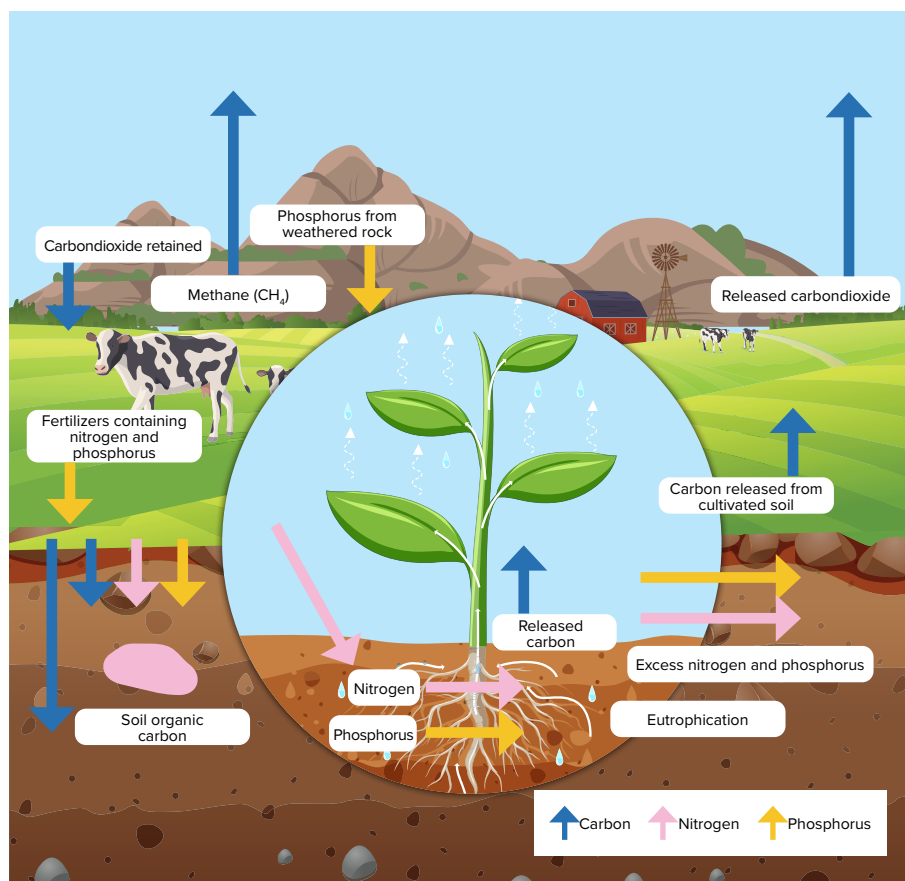


Figure 20: Water and Soil Relationship

The health and quality of soil, which is vital for all living things, plays a key role in both improving the negative effects of climate change and in obtaining productive crops. Soil health and quality are often mistaken. Soil quality is a parameter that expresses the results of the use of the soil as a whole, while soil health refers to the viability of the soil. Losing the health of the soil reduces its efficiency and it takes a long time to recover.

The activities of soil-inhabiting organisms (worms, bacteria, viruses, fungi, and other microorganisms) and biological balance make the soil healthy and fertile. Therefore, there is a linear relationship between healthy soil, fertility, and soil quality.

The better the characteristics of the soil are known, the better its interaction with water can be known, and thus appropriate decisions can be taken for the management of the soil. The texture and layers of the soil determine its permeability, infiltration, and water retaining capacity.

The relation of soil with water is considered highly productive for agriculture, if;

- **It includes particles of various sizes,**
- **the air gaps between the particles are tiny, plenty, and evenly distributed.**

As the main habitat, the soil retains a significant amount of water in it, playing a crucial role in the large water cycle between the earth and the atmosphere, both as a **water trap (retainer)** and **evaporation surface**. Therefore, water contaminated with heavy metals and chemicals should not be used as agricultural water as it will carry their pollution to clean soil and from there to the food chain.

On the other hand, the fact that clean water passes through contaminated soils by washing the contaminants leads to the contamination of both surface and underground waters and other soils using these waters.

Soil and water resources need to be addressed in a holistic approach. Sustainable agricultural production efficiency can be achieved only by preserving the viability of soil and water.

Giving the plant more water than it needs impairs the structure of the soil and increases the risk of soil salinity. When there is a salt content between 100-150 mg (0.10-0.15%) in 100 g of soil, it is stated that this does not have a toxic effect on the growth of the plant, but the soils with salinity beyond this range will hinder the growth of plants (40).



Info Box 6

Soil Salinity

Although several types of salt are found in soil, the most common are carbonates, sulfates, chlorides, nitrates, and borates. The most dangerous salt type for plant development is stated to be Sodium Carbonate (Na_2CO_3). It is said that this salt species, which can be found in various forms in soils, has a high water solubility, and can disrupt the pH balance of the soil and it can therefore cause toxic effects to the plants grown in the soil (40). The use of proper irrigation techniques, responsible irrigation and the application of agricultural techniques suitable for the basin will surely be beneficial in reducing the soil salinity and alkalinity.

Nature's ability to renew itself in the face of external interventions and damages it sustains is very limited. Therefore, the conservation of resources and every step to be taken to this end count for the sustainability of the ecosystem.

Sustainability in agriculture describes a form of production in which the resources are preserved and used optimally in the long term, environmentally friendly agricultural technologies and inputs are used, and also the soil, water and biodiversity are conserved. This mode of production relies on disseminating the practices that maintain the balance of the ecosystem in many ways, including the use of water resources, the processes applied to the soil, etc.

Agricultural sustainability is based on the idea to secure the ability to meet the needs of future generations while meeting the needs of today. Therefore, long-term management of both human-made and natural resources is equally important as short-term financial gain. Management of human resources must consider the social responsibilities such as the working and living conditions of both present and future producers, the needs of rural communities, and consumers' health and safety.

The management of lands and natural resources should stipulate to preserve and improve the quality of these assets, to use them in a way that will enable them to survive in the future as the components of the ecosystem. Another aspect regarding the management is to ensure that the procedures to eliminate the concerns about animal welfare are implemented at the farms involving livestock breeding.

Comprehension of sustainability requires probing into the agricultural ecosystems and food systems from a holistic perspective. Agricultural ecosystems can be taken, in the broadest sense, to include individual fields, farms, and economic regions, etc. The Food systems that include distribution and food consumption components, in addition to the agricultural ecosystems, range similarly from the farmers to the local community and all the way to the global population. The system perspective provides our agricultural production and distribution businesses with a comprehensive view of how they affect the human communities and the natural environment on the one hand and provides us with tools to assess the impact of human society and institutions on agriculture and environmental sustainability, on the other.

Research on different types of natural and social systems indicates that those who are highly resilient, self-adaptive, and highly diverse are more resilient and have a better chance of survival. Resilience is critical because the majority of agricultural ecosystems confront such conditions that are often highly unlikely to predict and barely stable in the long run (climate, pest populations, political and financial reasons, etc.). Adaptability is an important component of resilience, as it is not always possible or desirable for an agricultural ecosystem to regain the formation and function it had before a radical degradation. **The systems**

that can accommodate themselves to changing conditions can survive by reshaping themselves. The most fundamental basis for the adaptability of an ecosystem to new conditions is rich biodiversity. The richer biodiversity, the more likely it will be to establish cross-symbiotic life links for the sustainability of the ecosystem and find tools/processes for new forms of structuring.

A sustainable agricultural ecosystem and food system approach also means versatile efforts in research, education, and action. Farmers, laborers, retailers, consumers, policymakers, and other people interested in our agriculture and food systems, especially researchers from various disciplines, play a major role in Turkey's progress towards agricultural sustainability that can be more comprehensive and consistent.

Sustainable agriculture in today's conditions is a complex set of activities, which have to be modelled better according to the specific processes in every country, but the modelling of which has just begun and is still underway. **It is a complex process that countless living communities, from humans to bacteria, carry out on soil based on climate, air, water, and auxiliary equipment.**

Intervening in the course of the natural ecosystem, but keeping it at such a level that will not prevent the system from self-survival is only possible by analyzing this complex chain of relationships properly and updating this analysis constantly over time. In general terms, sustainable agriculture is a process whose components are environmental-social-economic sustainability. **Scientific insight into what constitutes environmental, social, and economic sustainability is constantly evolving and influenced by contemporary issues, perspectives, and values.** For example, the ability of agriculture to adapt itself to climate change was not regarded as a critical issue until recently, but its importance was understood by a wide range of communities today. Furthermore, the details of what constitutes a sustainable system (e.g., soil types, climate, labor costs) may vary from one set of conditions to another or from one cultural and ideological perspective to another, and this sounds like the definition of a "sustainable" characteristic. Therefore, it will be a good practice to take the agricultural systems as a process **ranging from the unsustainable to the sustainable one, rather than take it as a dilemma between sustainable -unsustainable**, and to construct the new agricultural systems accordingly (9).

Agricultural ecosystems cannot be sustainable in the long term without the knowledge, technical competence, and skilled workforce needed to manage them effectively. Given the ever-changing and local nature of agriculture, sustainability requires diverse and adaptive knowledge that uses both formal, experimental science and farmers' local knowledge. Social institutions supporting the education of both farmers and scientists promoting innovation and encouraging farmer-researcher partnerships can boost agricultural productivity, as well as long-term sustainability.

Social equality questions are frequently raised in sustainable agriculture discussions. In most industrialized countries, farm labor wages are so low that agricultural sectors rely on migrant labor from poor countries, heavily. Labour migration from poor countries leaves the farmers vulnerable to changing immigration policies and forces the social services of governments. The suspicious legal status of most of these workers also results in low wages and living standards in general, lack of job security, lack of opportunities to move towards social comfort, and their exclusion from job security protections, which are accepted as standards in other industries. Therefore,

Some of the alternative ways to improve labor equality and social justice are:

- Gathering the resources from several farmers to provide better accommodation,
- Sharing the labor between farms having different crops, in an attempt to equalize the seasonality of work opportunities,
- Equality shared in farm profits,
- Guiding the workers to acquire and operate their own farms,
- Working on innovative ways to provide cost-effective products,
- Health insurance,
- Education opportunities for the workers.

Increased consolidation of food producers, marketers, and farm input suppliers has paved the way for farmers to lose their power to negotiate better prices for inputs and crops. This means that the farmer's profit margins are shrinking and many farmers are left with very few resources to improve the environment and working conditions.

Clustering in production, processing, or marketing cooperatives is a way for farmers to increase their relative economic power. **Performing some value-increasing operations on the farm, producing higher-value specialty products, creating direct marketing opportunities without any brokers, and looking for niche markets** before selling their products are other ways for farmers to get a larger share of the economic value of what they produce.

Due to these economic pressures on farmers, many rural communities became even poorer as farms and related local agricultural enterprises have gone bankrupt. **Economic development policies and tax structures that promote more versatile agricultural production on family farms can provide a basis for more appropriate rural economies. Consumers can also play a role within the limits of the market structure; they send strong messages to the producers, retailers, and others in the system through their purchases, about what they think is important, including environmental quality and social equity.**

Last but not least, some of the same economic pressures that damage the

sustainability on the farm caused social equity concerns for the consumers in low-income communities, who often have little access to healthy food, while the conventional supermarkets are forced to move to more paying neighborhoods.

Food production and marketing regulations, including the use of fresh local farm products in community and home gardens, farmers' markets, school food programs, and local food cooperatives, in order to support the community's food safety, represent the efforts to address these concerns. What's more, an approach to food systems also takes into account the effects of farming practices on the safety and nutritional qualities of final food products delivered to the consumers, for example by minimizing or eliminating the toxic residues (10), (11), (12). Social, economic, and environmental sustainability are such components closely related to truly sustainable agriculture. For example, some farmers facing poverty are forced to increase their yield by overusing natural resources to increase soil fertility in order to earn their living, although they are aware of the fact that environmental degradation will damage their source of income in the long run. Societies can develop more sustainable agricultural systems only by creating such policies that integrate social, environmental, and economic interests.

I. UN Sustainable Development Goals

In 1987, the UN Brundtland Commission defined sustainable development as **“development that meets the needs of the present without compromising the ability of future generations to meet their own needs”** (41).

- The United Nations Sustainable Development Goals consist of objectives that emphasize the need for simultaneous cooperation by underlining the economic, social, and environmental aspects of sustainable development. These goals are important as they argue that the ecosystem needs to adapt to changing conditions. The Development Goals discussed in this study and corresponding to the subjects of water and soil are summarized as follows.
- Objective 3.9: To reduce the deaths and diseases caused by hazardous chemicals, air, water, and soil pollution, and their contamination, remarkably by 2030.
- SDG 6: To secure accessible water and wastewater services and sustainable water management for everybody.
- Objective 6.3: To reduce pollution worldwide by 2030, eliminate unnecessary rubbish storage, and minimize the release of hazardous chemicals and substances.
- Objective 6.5: To implement integrated water resources management at all levels by 2030, also including cross-border cooperation, where appropriate.

- Objective 6.6: To protect and restore aquatic ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes, by 2020.
- Objective 12.4: To ensure environmentally sound management of chemicals and all wastes throughout their life cycle according to international frameworks adopted, by 2020 and to significantly reduce the release of these wastes to air, water and soil in order to minimize their harmful effects on human health and the environment.
- Objective 13: To take urgent action against climate change and its impacts: One of the economic activities most vulnerable to climate change is the agricultural sector. The biggest indicator of this is the production losses caused by sudden and extreme weather conditions. In addition, this goal is important as it emphasizes monitoring, measuring, and reducing the greenhouse gas emissions caused by agriculture.
- Objective 15.1: To ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services, especially the forests, wetlands, mountains, and arid areas, in line with the obligations imposed by international agreements, by 2020 (water management).
- Objective 15.3: To fight desertification by 2020; restore degraded lands and soils, including those soils affected by desertification, drought, and floods; and strive to achieve a world free from land degradation.
- Objective 15.5: To take urgent and significant measures to reduce the degradation of natural habitats, halt the loss of biodiversity, and protect the endangered species, and prevent their complete extinction, by 2020.
- Objective 15.8: To take measures preventing the entry of invasive noninhabitant species into the soil and water ecosystems, to reduce their impact remarkably, and to contain or eliminate the invasive species of high priority, by 2020. (an example of the impact on biodiversity is that water creatures and flamingos are almost on the brink of extinction due to the use of freshwater resources supplying the salt lake, for the purposes of agricultural irrigation).

2. EU Green Deal

With European Green Deal's Farm-to-Fork Strategy, important targets are set for the establishment of a healthy, fair, and environmentally friendly food system and the dissemination of sustainable agriculture. This strategy document states that necessary measures should be taken to reduce the use of chemicals and pesticides by 50% and the use of more dangerous chemicals by 50%, by 2030. It is emphasized that it is important to replace chemical fertilizers with biological, organic, etc. fertilizers, and it is noted that essential measures should be taken in this respect.

Green Deal Action Plan, which is based on the idea that Turkey becomes a sustainable and resource-efficient country and published by the Ministry of Trade in 2021, is also addressed in this chapter since it is part of sustainability discussions.

Green Deal Action Plan published by the Ministry of Trade in 2021, also involves the actions to be implemented in order to achieve the objectives determined under the titles of carbon border arrangements, a green and cyclical economy, green financing, clean, economic, and safe energy supply, sustainable agriculture, sustainable smart transportation and the fight against climate change. It is expressed that increasing food demand and climate change put some pressure on soil and water resources, agricultural production, and producer. In order to protect the environment and biodiversity for the development of such plant and animal species suitable for the changing climate, the objectives of the action plan for sustainable agriculture were determined. According to these objectives, it required to:

- Make the decisions in line with the EU's targets for the reduction of pesticides and antimicrobials and carry out the studies aimed at reducing the use of pesticides,
- Develop and disseminate the biological and biotechnical control methods within the framework of the studies to be carried out for the reduction of pesticides,
- Encourage the work by considering the policies and practices of the EU to reduce the use of chemical fertilizers,
- Improve organic agriculture production, conduct studies to this end, and perform mutual initiatives in the field of organic agriculture with the EU,
- Conduct land consolidation activities,
- Develop crop production by utilizing geothermal resources within geothermal greenhouse zones and support the greenhouses and production facilities using renewable energy in this context,
- Carry out studies on the reuse of waste generated as a result of agricultural production and conduct R&D activities,
- Carry out activities to raise awareness of the consumers in an effort to ensure the recycling of food waste,
- Perform awareness-raising activities on "Farm to Fork" and "Biodiversity Strategies" as specified by the European Commission.

Fulfilling these targets will contribute positively to the harmonious functioning of ecosystem actors and result in increases in agricultural productivity. These goals constitute both opportunity and crisis areas for Turkey. Moreover, a serious source of finance is needed to ensure the transition targeted with strategic plans.

3. Biodiversity Strategy

Another important aspect of the future of agriculture is Biodiversity, which means that the plant species grown on the soils of our country increase the fauna diversity, reshaping the consumption habits in general. It is known that the lands of our country are home to more than 3500 endemic species. This number is considerably higher than the number of endemic plant species grown in continental Europe. During the pandemic period, the importance of biodiversity was apprehended and it was noticed that consumers need to consume a wide range of products for healthy living. It is believed that the future of every consumer in a society depends on agricultural production, so agriculture is a “giant production arena”. A biodiversity strategy framework was drawn up by the European Union with a view to ensuring the improvement of all ecosystems of the world and the protection of biodiversity. Info Box 7 lists basic commitments of the biodiversity strategy regarding agricultural production.



Info Box 7

Biodiversity

The 2030 Biodiversity Strategy is a strategy document based on organizing Europe's biodiversity by 2030 for the benefit of humans, the climate, and the planet.

EU Nature Restoration Plan: Basic Commitments by 2030 (regarding the Agriculture):

- By 2030, some of the ecosystems that are damaged and in need of improvement in terms of carbon quantity must be recovered.
- The use of chemical pesticides will be reduced by 50% and the use of more dangerous pesticides will be reduced by 50%.
- At least 10% of agricultural lands will be restored to possess high biodiversity characteristics.
- Organic farming methods should be applied in at least 25% of agricultural lands and agroecological practices should be widely disseminated.
- At least three billion new trees will be planted within the EU.
- Significant progress must be made in the improvement of contaminated soil areas
- At least 25,000 km of free-flowing rivers will be rehabilitated.
- Nutrient loss due to the use of fertilizer [excess or inappropriate fertilizer] It should be reduced by 50% and fertilizer use should be reduced by at least 20%.

Source: (42) AKIB, (2020), EU 2030 Biodiversity Strategy, 20 May 2020 Brussels, <https://surdurulebilirlik.adasoportal.com/Assets/Dosyalar/46ae20ae-add6-4f72-95d9-58a664d0425a.pdf> Accessed on: April 28, 2022.

4. Soil Organic Carbon

It is seen that the technologies and agricultural techniques that will be developed with the research to be conducted on the carbon sequestration capacities of the soil, which is one of the largest carbon storages, stand before us as a subject of very serious study. Info Box 8 outlines the data on the importance of soil organic carbon and the current status of Turkey's soils in terms of the amount of organic carbon.



Info Box 8

Importance of Soil Organic Carbon

Soil Organic Carbon (SOC) refers to the carbon formed in soil organic matter (38). SOC penetrates the soil through the decomposition of plant and animal residues, living, and dead microorganisms. If most of the carbon in the soil is stored as organic carbon, the amount of carbon in the atmosphere will decrease and help to reduce global warming. This process is called **soil carbon binding**, which is **the storage of carbon in the soil**.

Each soil contains different amounts of organic carbon depending on the use and cultivation method. Conservation of organic carbon in soils can be achieved via sustainable soil management, such as balanced fertilization, mulching, reduced tillage, tillage-free agriculture, and the application of appropriate irrigation techniques in agricultural lands (30).

Soil organic matter, as the main source of soil organic carbon, is important as it reveals the productivity and efficiency of the soil ecosystem.

It is stated that the amount of organic matter in Turkey's soils is quite low, especially in the Central Anatolia and South-eastern Anatolia regions, the soils are extremely poor in organic matter; and the Mediterranean, the Black Sea, and Eastern Anatolia are comparatively richer.

In general, it is known that the amount of organic matter in Turkey varies between 0.5% and 6%.

The amount of organic carbon in the soil is vital since it plays a major role in securing the proper functioning of the ecosystem. Therefore, the technologies and agricultural techniques to be developed for carbon sequestration in soil are very important research topics. In order to make use of this relationship between soil and carbon, it will be required to carry out studies that will contribute to increasing the amount of organic carbon in the soil.

Organic Carbon Status of Soils in Turkey

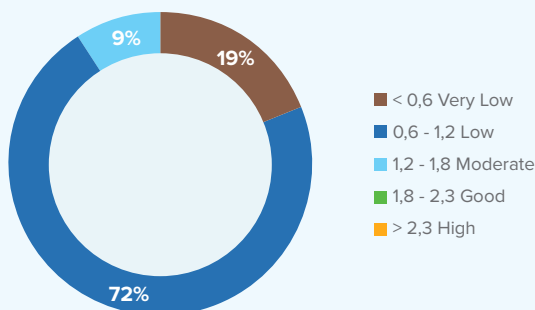


Figure 21: Organic Carbon Status of Soils in Turkey, TAGEM, 2018:26

Soil Organic Carbon is affected negatively by these variables because it is sensitive to soil temperature and humidity.

Source:

(30)) "Salinity in Our Soils", (2021), <https://www.hortiturkey.com/yazilar/topraklarimizdaki-tuzluluk> Accessed on: June 3, 2022.

(38) CMUSEP, (2019), National Strategy and Action Plan for Combating Desertification 2019-2030, General Directorate of Combating Desertification and Erosion Publications, Ankara. [http://cmusep.com.gov.tr/Uploads/Documents/COLLESMEYLE %20M%C3%9CCADELE%20EYLEM%20PLANI% 202019-2030.pdf](http://cmusep.com.gov.tr/Uploads/Documents/COLLESMEYLE%20M%C3%9CCADELE%20EYLEM%20PLANI%202019-2030.pdf) Accessed on: March 9, 2022.

5. Microplastics ve Nanoplastics

Discussions on soil health will highly likely include references to microplastic and nanoplastic pollution in the agricultural soil ecosystem. Microplastic pollution is considered anthropogenic because it is human-induced pollution. The fact that micro and nanoplastics are found so widely and worryingly, not only in water but also in the depths of the soil, proves that this pollution created by human hands can be carried and spread unexpectedly even to very distant points due to the effect of natural processes (55).



Info Box 9

Microplastics ve Nanoplastics

Although there are a good many studies in the international literature on microplastics, there are a total of 26 studies in the national literature. Of these studies, 1 is related to microplastic pollution in agricultural production and 25 are related to microplastic pollution in aquatic ecosystems. Hardly any study is available on microplastic pollution in freshwater resources. There is no academic thesis study completed on nanoplastics.

In addition to the intensive presence of microplastics in soil and water resources, recent studies point out that the food consumed by the mother is transferred also to the baby through breast milk, and even infants are exposed to much more microplastics, compared to adults (56). However, the detection of microplastics in infants' feces also (57) and the lack of significant evidence on the adverse effects of exposure to microplastic pollution on individuals, in the long run, indicate how worrying this issue has become.

Comprehensive research should be conducted on the transition (effects on human health) of micro and nanoplastics found in air, soil, and water into agricultural products, humans, and all other living things.

Source:

(56) Zhang, J., Wang, L., Trasande, L., & Kannan, K. (2021). Occurrence of polyethylene terephthalate and polycarbonate microplastics in infant and adult feces. *Environmental Science & Technology Letters*, 8(11), 989-994.

(57) Mohamed Nor, N. H., Kooi, M., Diepens, N. J., & Koelmans, A. A. (2021). Lifetime accumulation of microplastic in children and adults. *Environmental science & technology*, 55(8), 5084-5096.

As a result of the rapidly increasing use of plastics in agricultural production, microplastic pollution in soils is higher than it is in the oceans (52). It has been found that microplastic residues are also transferred to agricultural products such as lettuce, broccoli, potatoes, carrots, apples, and pears grown on soils contaminated with microplastic waste (53).

Agriculture is one of the oldest and major means of livelihood of our country. In order to consolidate agriculture in Turkey, **the big picture of agriculture should first be taken before anything else begins. We can develop this only after creating associated databases concerning our agricultural assets and activities.** We can decide on what type of new technologies will be applied, areas of application, and the priorities thereof, only if we can manage to create these databases.

Access to information and data in the field of agriculture urgently in need of new strategies and policies is the first step for both producers and professionals working in this field so that they can do what they do. **It is stated that technology-oriented farmers engaged in agricultural production and professionals working in agriculture have difficulties accessing up-to-date data and starting new studies with these data.**

The fact that access to detailed data can still be offered by the institutes only disrupts the study of researchers and experts working in this field. Although various data are shared publicly on the websites of various units under the Ministry of Agriculture and through meteorological resources, these data are stated to be limited, and timely access to comprehensive data by the researchers creates poses some problems. On the other hand, the fact that the resolutions of the data shared by MGM are not of good quality disrupts the access to data by the researchers who produce information in this field.

The production of synthetic information about the processes that are unpredictable for us in the 20th century can now be performed successfully, thanks to the big data and the data science that processes and organizes it, and the trends of highly complicated and chaotic processes can be identified through mathematical models and data evaluation algorithms. Owing to the use of these means, it seems evident that data analysis methods in the agricultural sector will have a directly positive effect on decision-making mechanisms, enabling that the right projections are made in water and soil management, and the right decisions are taken.

With a system to be created with a special emphasis on processing satellite images that will produce data for all products grown in our country, both product yields and the sustainable use of our soil and water resources can be monitored. It is believed that the establishment of an **Agricultural Monitoring Project** that will allow for the fusion of our own data is important for us as a country. With this system, it will be possible to identify the types of products grown in all agricultural blocks in our country, monitor the development of the products in different phenological periods, and **estimate the total volume of national production precisely for each product. These analyses will also produce remarkable arguments to work out the most suitable products for agricultural basins and perform basin product planning.**

The establishment of this technological infrastructure and database requires agronomist confirmation in the cultivation areas. It also necessitates so much technical data such as the sun's angle of incidence, angle of view of the sensor, etc. in the satellite images taken. For this reason, **qualified researchers such as image processing specialists, computer and electronic engineers, and agronomists will also be needed.**

As emphasized in the **National Water Plan (2019-2023)** published by the Ministry of Agriculture and Forestry, the following are the issues mentioned as the major problems encountered in producing and sharing water-related data in our country (17);

- **The institutions in charge of agricultural matters and conducting the studies in this respect are organized in different structures that are not properly associated with each other,**
- **Most of the water-related data are not maintained on the basis of basins,**
- **Problems encountered in data generation and sharing between the institutions,**
- **Standardization problems in the data produced,**
- **Briefly, the lack of effective data management.**

It is seen that there is **not an appropriate database for the information containing up-to-date, real-time, and spatial analysis** in relation to the data regarding the water resources in our country. It is mentioned that there is not a regular data breakdown by years and also the **data already produced are not maintained on a basin basis in a way to include the coordinates** (17).

It is also expressed that the **coverage of the observation and monitoring stations in our country is not sufficient** and therefore, **international sources have to be consulted in order to have access to comprehensive meteorological data. Agriculture is defined as “a factory without a roof”. In this factory without a roof, you always have to be prepared for natural and climatic conditions.** Therefore, necessary measures should be taken against the negative effects of the elements, such as hail, frost, excessive rainfall, drought, and excessive heat, on agriculture. It will be a good practice for us to focus on such technologies that will predict and mitigate these adverse effects.

It is stated that there are some deficiencies experienced in tracking and maintaining the hydrological, hydro morphological, hydrogeological, biological, and ecological parameters that should be monitored regarding the water, as specified in the Water Framework Directive in which all water-related issues are combined by the European Union.

It is emphasized that the **National Water Information System**, which was put in place by the **Ministry of Agriculture and Forestry and General Directorate**

of Water Management in order to ensure the creation of data that will meet the requirements of the users with a view to supporting the preparation of the **National Water Policy** with a special emphasis on the holistic assessment of the water data in terms of the components such as basin-based and quantity, quality use, flood, and drought, etc., **is not actively available for use and there are some deficiencies in the collection of data locally.** Uploading the data to this system through real-time monitoring stations and sharing such data will contribute to eliminating the uncertainty about the data.

New irrigation systems and technologies are needed so that water is used more efficiently in agriculture. In our country, **various projects are carried out in an attempt to ensure that irrigation is done optimally,** such as the integration and development of mobile irrigation systems and drip irrigation systems, etc. **It is stated that irrigation can be done much more efficiently if these projects are disseminated.**

New technologies, infrastructural studies, and innovation studies regarding the treatment and reuse of wastewater in irrigation can be developed.

All sorts of smart machines and equipment as well as necessary technological tools need development in agricultural production. Smart agricultural machinery can be developed in collaboration with agricultural machinery engineers, and electronic, computer, and mechanical engineers within the technology development regions where the research and development activities are carried out intensively by taking references from good practice examples overseas. In this way, **intelligent harvesting, cultivation, spraying, fertilization, and seed planting machines can be manufactured.** These machines can be used for yield mapping, soil cultivation at different depths based on soil characteristics, sight-and-spray and variable-rate spraying, variable-rate fertilization, and seeding. Our industrial sectors are technologically far ahead of our agricultural sector. **“Turkey Agricultural Technologies Specialization Center”** can be established **to enhance agriculture by transferring the technologically advanced level in the industry to agriculture.** In this center that could be established in one of our fertile agricultural basins, the researchers and experts will get the chance to work in all engineering and newly-emerging disciplines of science.

We propose the establishment of three basic research implementation and education institutes;

- 1. Firstly, an institute related to agricultural techniques and production processes in accordance with the characteristics of Turkey,**
- 2. Secondly, an institute on agricultural machinery, infrastructure facilities, monitoring, and support systems,**
- 3. Thirdly, an institute that delivers higher education by combining the**

experimental training to be conducted on production-scale fields around the campus, with the theoretical training and laboratory studies offered on the campus, and trains “Agriculture and Food Experts” for Turkey.

Monitoring agricultural products is a new practice we get to see in our country. It is particularly thought that the **use of unmanned aerial vehicle technologies, which we are pioneering, in agriculture will be at a much more advanced level in the coming years.** It is stated that the number of scientific research and publications using multispectral cameras and thermal images is very little and that **irrigation planning with drones** is a quite new research area. It is believed that these technologies will become very important in boosting agricultural production and increasing productivity in the near future.

The design and manufacture of Biosensors, which began to be used extensively in agriculture, is another technological innovation that Turkey should take a close interest. In this area where China, the USA, Korea, and India are in the lead, the biosensors ensure the measurement of certain parameters with biological factors. The investments to be made in biodefense and biosensors can be used not only in soil but also in many areas of agriculture. For example, **biosensors are needed even for strategic purposes that necessitate the country’s self-defense against a possible biological attack.** Various detection and analysis methods can be developed in **identifying the GMO products**, along with with the striking developments in biotechnology and genetics.

Thanks to the Internet of Things (IoT technology), **the sensors to be installed on agricultural lands will render it possible to monitor what is going on in agricultural lands.** This technology, which was previously used in various sectors, can now be used for the agricultural sector. Among the important technologies that can be used in agriculture are artificial intelligence and machine learning. **Artificial intelligence and machine learning technologies can also be integrated for agricultural production and monitoring and developments in agricultural production can be predicted with these technologies.** Therefore, these technologies are very important research topics.

Technological solutions to be developed in areas where earnings or profits are very low, e.g. in agriculture, should be rational and available to the producer. Furthermore, it is necessary to develop and disseminate technologies affordable to the producer and accessible to everybody.

As can be seen in Figure 20, the data is closely related to soil and water analyses as well as it ensures quality control and traceability. Soil and water analyses allow the determination of the actions to be taken and the predictability regarding climate change, and also help to ensure irrigation efficiency by providing an advantage in the optimal use of water resources. On the other hand, the aspect of agricultural technologies proposes a solution to both the data and the predictability derived from soil and water analyses.

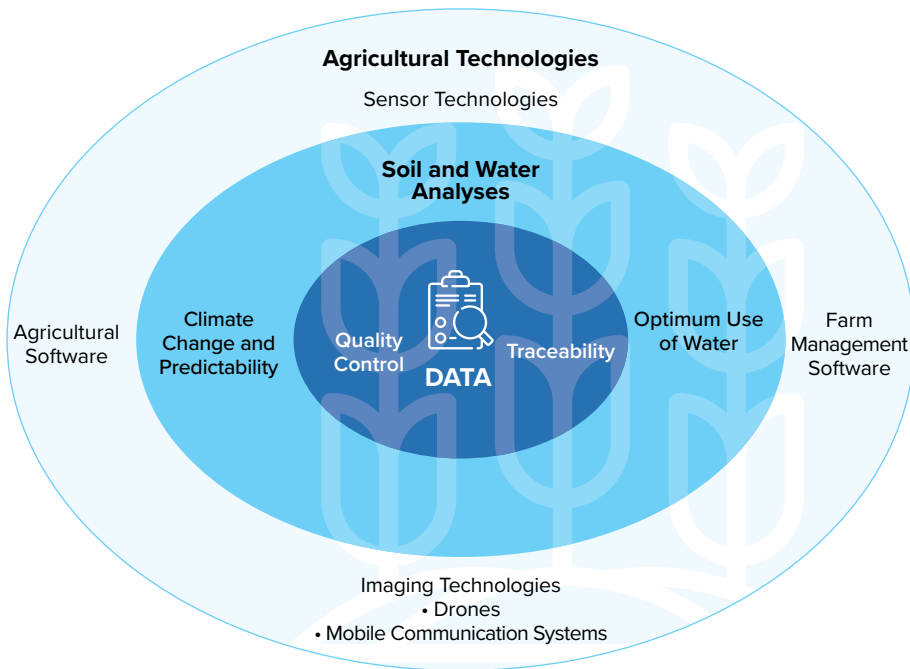


Figure 22: Relationship between Data, Soil and Water Analysis and Agricultural Technologies.

TTGV Hit Agricultural Technologies study was used.

Available at: <https://www.ttg.v.org.tr/tur/images/publications/606f3e795d263.pdf>

5.1. Areas of R&D and Innovation on Soil and Water

These areas include the following:

- Research for sustainable soil ecology,
- Techniques and technologies for the protection, monitoring, and enhancement of soil health,
- Research for soil microbiology and soil biology genetics,
- Investigating the long-term effects (>10 years) of different fertilization and soil improvement practices,
- Developing no-till farming techniques,
- Research on the presence of micro and nano-plastics in the soil and its transfer to the plant,

- Research on microorganism pollution (especially those with the potential to cause disease in agricultural products),
- Development of fertilizers for unsuitable soils (e.g. saline),
- Use of microorganisms for fertilizer production and microbial fertilizers,
- Detection, reproduction of functional soil organisms; releasing them into the soil, and investigating their effects
- Research on carbon sequestration and carbon emissions in soil,
- Technologies for bringing the carbon to the ground,
- Biological methods for soil improvement,
- Development of preventive/restorative agricultural techniques,
- Development of techniques and technologies to increase the water retention capacity of the soil,
- Development of technologies and creation of data sets to figure out the water stress of plants (especially with remote detection),
- Technologies to create irrigation programs,
 - Establishing the databases by measuring water intake/ consumption of plants under different soil and climatic conditions,
 - Using artificial intelligence to make decisions by combining and analyzing the data from different sources,
- Our country should design and use its own agricultural satellite in order to perform data-based yield estimates,
- Establishing an integrated agricultural monitoring and data sharing system,
 - Recording and integration of remote detection data with plant, soil, geography, and meteorology databases (created with calibrated data),
 - Establishment of a center to evaluate remote-detection data and images for agriculture,
- Creating databases by working out the water footprints for the life cycle of agricultural and industrial products,
- Modelling how Turkey will be affected by climate change and predicting Turkey's future freshwater status by means of climate analysis,
- The importance of multispectral and thermal images in remote detection (Satellite, UAV/Drone, manned vehicles, etc.) is increasing. Especially the detection of water stress, using thermal images,

- Although the resolution of the cameras of commercial satellites is low, it is sufficient for the analysis of the regions and the agricultural areas of the basins. However, it is not adequate to make decisions based on sensitive analysis on the field scale. So, the development of manned systems or IHA/Drone providing high camera resolution,
- Remote detection and especially obtaining the images from satellites are not enough. It will be necessary to develop the technologies so that the images can be processed, improved, and interpreted by agronomists,
- Use of a closed system for water conveyance and irrigation, instead of an exposed system,
- Adoption of pressure irrigation with the sprinkler and drip systems based on data-based irrigation programs, instead of flood irrigation,
- Encouraging pressure-protected sprinkling, surface drip irrigation, and sub-surface drip irrigation methods on the field (water usage efficiency highest first).



6

Review

This part of the report involves the assessments of the problem areas and solutions, based on the interviews and additional readings within the scope of the study. In this context, an overall evaluation was presented with a reference to the sustainability of soil and water resources, data analytics and analysis, irrigation, soil, soil analysis, soil health and quality, fertilizer, compost, chemical sprays, microplastic and nanoplastic pollution, hydroponic agriculture, human resource, and producer aspects.

6.1. Sustainability of Soil and Water Resources

Not only is the sustainability of soil and water assets decisive for the sustainability of agriculture and therefore food, but it also has a decisive effect on ecological sustainability. The relationship between soil and water sustainability, which is mutual and interactive, is given in Figure 23.

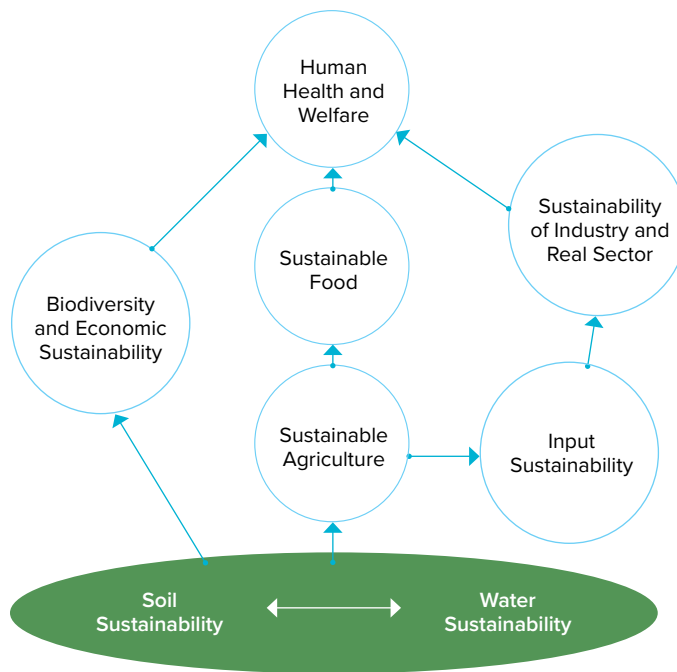


Figure 23: Sustainability Relationship between Soil and Water

6.2. Data Analytics and Analysis

In our country, agricultural data cannot be kept systematically and in real-time. For this reason, **agricultural activities in our country are determined based on the data published by international organizations, rather than the national databases in Turkey.** In addition to deficiencies such as **data quality, data diversity, data verifiability, and data frequency**, in terms of the recorded data, there are also some other obstacles in accessing such data by the researchers and professionals interested in data analysis. From this point of view, a **common and important problem in agriculture and other areas in our country is the problem related to the management of data and information.** While it makes it impossible to make evidence and data-based decision-making, strategy, and policy-making, it also disrupts and negatively affects the efforts of specialist researchers and professionals in producing the necessary information for the system. **Today's technologies make it highly possible to collect, store, analyze and share appropriate, real-time, verifiable, namely quality data.** In our history, the institutions such as the **Central Statistical Committee in the Ottoman Empire, the Central Statistical Office, and the State Statistical Institute in the Republic of Turkey** were authorized to regulate the state's decision-making and policy-making processes based on **data quality, data diversity, data verifiability, and data frequency** so that reliable data can be accessed.

Today, we have reliable institutions in Turkey, which contribute to the inventory of our land, water, surface, and underground assets, but **the expectation is that the “Turkey Agriculture Big Database” will be created.** To create this database,

- Appropriate infrastructures should be established in an effort to disseminate the use of **“lean data”⁸ analytics methods and formats** in our institutions,
- The data currently used and collected largely based on the declaration should be **verified and sorted**,
- In the light of these data, our assets should be determined under data titles such as **“Turkey Soil Inventory”, “Turkey Water Inventory”, “Turkey Farm Animals Inventory”, “Turkey Product Inventory”,** etc. in a format that will be updated constantly,
- **Our assets under these titles should be associated according to agricultural basins**,
- In order to create a **“Basin-Based Agricultural Production Plan”,** a

8. Lean data describes the objective, uninterpreted data that is not altered with deceptive opinions and policies.

production model and plan should be prepared for each basin according to the current and future potentials of the agricultural production forces of each basin,”

- **“Agricultural Congresses” should be held** in each basin, where the agricultural stakeholders from all segments are represented,
- **“Basin-Based Agricultural Production Plan” should be discussed in these congresses,**
- **“Turkey Agriculture Master Plan”,** which has not been created yet, should be drawn up once the decisions taken have been assessed.

When this structure is put in place, unfavorable economic surprises and external dependency can be minimized as it can be adapted constantly to the change in agricultural conditions.

It is impossible to make decisions and develop the right strategy and policy without reliance on lean data analysis and synthesis. This also negatively affects the efforts of officials and researchers working on the data to produce information. **With today’s technologies, it is possible to readily collect, store, analyze and share proper, real-time, verifiable data.** The production of a large database in agriculture and sharing the same with long-term projections, the implementation of **an agricultural master plan based on this database will not only consolidate the agricultural economy but also ensure early systematic identification of possible problems related to the agriculture and produce some clues to the solutions.**

It is required that;

- Our country’s soil assets be observed systematically, **making the data collection for this purpose a continuous practice as a rule,**
- **Collection and classification systems be improved to increase the quality** of existing data on soil,
- **Scientific research on monitoring the soil assets be given top priority,**
- **Access to the database** created with particular attention to the cyber security rules be **made available to researchers and officials, and synthesized findings and results be shared with everyone,**
- **Decisions no longer be made using unreliable data,**
- Some sort of **“soil governance structure”** in which all stakeholders and/or representatives participate, be established for the data-based management of soil.

6.3. Irrigation

It is stated that our country is expected to be among the countries that will be affected by the climate crisis extremely, it will suffer from water scarcity especially in the periods to come, and the drought has already manifested itself in the agricultural lands in the past few years. **All kinds of innovations in the light of the sciences related to soil, plant, food, climate, and ecology, which are aimed to improve agricultural irrigation using three-quarters of our freshwater resources, will make a highly positive contribution to both agricultural production and water management in Turkey in general.** It is evident that the measures listed below will have a fundamental role in the basic understanding and resolution of the water problem so that our resources can be used effectively:

1. **It is necessary to make central planning based on the geography, climate, and soil characteristics of the products to be planted in each basin.**
2. **Transition to drought- and climate-tolerant crop cultivation should be financed by means of grants and incentives.**
3. **The products in need of high water intake in the areas suffering water scarcity should no longer be supported, deterrent measures must be taken to that end.**
4. **The producers who turn towards products suitable for the conditions of the basin, but with lower economic returns should be provided with sufficient financial support.**
5. **Optimal irrigation programs should be established** in accordance with the water consumption of the plant in different phenological periods, the temperature and humidity of air and soil as well as the evaporation mechanisms within the basin.
6. The water should be conveyed to **the farm field in closed systems**, and the open canals and canal systems should be discontinued immediately and completely.
7. **The most appropriate pressurized and efficient irrigation methods for the product should be determined and used.**
8. It is seen that **a future stock exchange is established for the future management and financing of water** due to the approaching danger of water scarcity as a result of climate change and inappropriate water consumption and similar solutions are sought after. Making water a market product, which is a very basic human right and resource, should be handled very carefully and meticulously. As the drought increases and water scarcity begins with climate change, which is felt day by day, such attempts will increase even more.

9. Due to the fact that agricultural lands and urban areas are intertwined day by day and three-quarters of fresh water are used in irrigation, water partnership studies will gain importance in near future since the agricultural producers and urban residents use the same resources.
10. It is required to carry out studies in our country, on the feasibility of the examples of practices regarding the efficient use and storage of water, **such as storing the unused water under the ground and using it for agricultural irrigation, as in some other countries.**
11. **It is necessary to take various measures against the uncontrolled use of groundwater resources, monitor the use of groundwater, and impose usage restrictions for each basin.** It is believed that these restrictions will be more effective as long as the opinions of the farmers' associations are obtained in each basin. Otherwise, the number of informal wells will increase rapidly and the restrictions will not serve the purpose. The producers should be involved in the process of taking restrictive decisions.

6.4. Soil

Apparently, not only will our existing water resources be affected by the drought, but also some changes will occur in the existing physical, biological, and chemical structures of our arable soils. With global warming and inevitable drought, carbon sequestration properties of our soils already tend to diminish. Recent studies emphasize that our soils will emit more carbon due to global warming and that the soils especially at high latitudes will be affected much more by this situation.

It is stated that the soils in our country are insufficient in terms of parameters such as health and quality as well as the amount of organic matter content (organic components). **As in the entire world, arable lands in our country, too, are decreasing day by day.** Excessive manipulation of the soil, such as unnecessary or use of pesticides and chemical fertilizers (or excessive use when needed), salinity and aridity of soil due to excessive irrigation, etc. affect the soil health, water retention capacity, pollute our ground and surface water resources and damage all creatures within the entire ecosystem.

Contaminated groundwater requires challenging and expensive measures as it can only be treated and cleansed by means of treatment facilities on site. **Incorrectly applied chemical fertilizers and sprays (pesticides/herbicides) mean that water is totally wasted 'beyond repair.'** Therefore, in order to prevent the producer from using excess fertilizer blindly, some measures can be taken;

- Provide training in fertilization of the product and soil in a way that will supply the nutrients required, develop variable rate fertilization technologies and support the farmer for widespread use, and thus ensure the most accurate use of fertilizers,
- Encourage and disseminate soil analysis by means of support,
- Impose a “fertilizer quota” according to the size of the land and the expected product amount.

The findings and statements indicating that the lands of our country are not as efficient and rich in organic matter as thought are another way to express the extent of the destruction caused by inaccurate agricultural, industrial, and urbanization practices adopted on our lands.

The introduction of GAP region with salinity following the irrigation through the dams is another indicator of the extent to which we are culturally and technologically unprepared as we embrace the new technical facilities. Before the GAP, the water was not so abundant across the region and it would be used prudently. The groundwater level was not high, either. However, after the GAP, the region met with salinity, which was worsened when the new water resources are combined with the old-school agricultural culture (unaware of what the excess water could do to the soil). This is a very typical example of our fundamental shortages, which are still prevalent in our agriculture. Before initiating a new technological application in a production or life process,

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The knowledge produced with accurate soil analysis will form the basis for the decision-making processes of the producers and agricultural entrepreneurs on the practices they will adopt during the production season.

- Positive and negative consequences of innovation should be investigated beforehand,
- Actions need to be determined for the harmony and transformation of the old and new ones,
- Innovation should be tested in pilot-scale applications,
- Lessons should be taken from successful and unsuccessful practices in other countries,
- The methods should be determined to disseminate the new technological practice.

6.5. Soil Analysis

The findings obtained in our study show that **soil analysis laboratories in our country need accreditation, calibration, and perform uniform tests on the same samples. It is stated that consistent and repeatable results cannot be obtained** at different laboratories, or even in the same laboratory from time to time, in the analysis of samples taken from the same soil. It is stated that soil analyses are

not repeatable and their reliability is low. On the other hand, ongoing discussions about the absence of an obligation of accreditation for the soil laboratories is a paradox while the fertilizer laboratories are obliged to have one. **Accreditation of soil analysis laboratories** and meeting the calibration requirements are thought to produce solutions to these problems. **The lack of trust in the results of the analysis caused even the conscious producers to have some reservations about the analyses.**

Also, **organic analyses should be performed additionally in order to determine the soil's quality and therefore innovation activities should be encouraged for the technologies that will support these analyses.** Our country is not a country of poor soil, however, the vast majority of our lands are considered poor due to both natural conditions and the organic matters they contain as well as the faulty methods applied to the soil. Currently, the average amount of organic matter in our soils should be 4%, but there are some regions in the range of 1-2% and other regions in the vicinity of 0.5-1%.

6.6. Soil Health/Quality

It is mentioned that the soils in our country lack health, quality, and organic matter content. The soil becomes salinized due to interventions such as unnecessary spraying and chemical fertilization (or excessive use when needed), excessive cultivation, irrigation more than needed, etc. Soil health and quality are affected and the living creatures within the ecosystem chain are damaged.

Soil health and fertile soil are usually mistaken. **Soil health** can be defined as the quality of harmony shown by living creatures coexisting in the soil. If the creatures such as worms, arthropods, fungi, bacteria, etc. can reproduce with the vital activities they create, then the soil will be considered healthy. Healthy soil is the favorable soil type that can be turned into fertile soil.

It is also stated that there is confusion about the concepts of soil health and soil quality. **The concept of soil quality** is seen as an indicator reflecting the ability of soil to perform its function, displaying the soil's reaction and resistance against natural or human effects or the usage results of the soil. **Soil health**, on the other hand, is a concept that refers to the vitality qualities of the soil as well as the creatures in the soil. **Improving the degraded soil and restoring its structural properties is a long and challenging process that can take at least 5-6 years.** Some examples of the general practices for the protection of soil health and quality are;

- **The soil can be provided with bacteria, fungi, water retaining, and organic matters that will improve water permeability.**
- **Applications that increase the amount of organic matter in the soil can be performed, e.g. green fertilization, organomineral, compost, and less**

tillage. (Such applications help the product to get chemical fertilizer from the soil better, reducing fertilizer consumption and costs.)

- **Trap (bait) and companion plants can be used.**
- **No-plothing or low-tilling cultivation can be adopted.** (Direct seeding, no-plow farming, and sowing into stubble conserves the organic matter, and contributes positively to carbon emissions, in addition to labor and fuel saving.)
- **Production of microbial fertilizer culture, microbial fertilization,** and microbiological applications can be adopted, (For example, the application of Mycorrhiza fungal culture that establishes a common life by connecting with plant roots in the form of a network).
- **Slow-release fertilizer can be used.** (It protects the soil indirectly as it causes less water contamination.)

6.7. Fertilizer

In our country, the producers mostly use ready-made chemical fertilizers containing various elements in an attempt to increase production efficiency. **However, it is evident that the producers do not have a decent culture, such as identifying the type and amount of fertilizer by comparing the element composition of the cultivated soil with the elements needed by the crop, that they refrain from getting a soil analysis done to learn the number of nutrients and that they do not make the decisions on fertilization by comparing the requirements of the product and the results of the analyses.** It is also stated that producers get the soil analysis done only when they are given incentives for that matter. Since soil analysis is not widely performed and the elements needed by the soil are not identified, phosphorus fertilizer can be thrown unnecessarily into the soil with high **phosphorus content and potassium fertilizer can be thrown into the soil containing potassium.** This approach causes the soil to become contaminated with excessive build-up of elements.

Our participants mentioned that the producer has a strong perception that if he does not use chemical fertilizer, the product yield will decrease and he will earn less. But in fact, the usage rates of chemical fertilizers can be reduced with the application of compost fertilizer.

6.8. Compost

Compared to chemical fertilizers, compost is a much healthier and more sustainable natural fertilizer. However, **it is stated that the producers are not familiar enough with compost and are more inclined to use the chemical fertilizers they buy from the dealers, rather than make their own compost.** In this regard, it is thought that the production of compost on the pilot farms



Info Box 10

Compost and Slow-Release Fertilizer

Compost

- Compost is a hummus-like, nutritious, and also possibly biopesticidal product formed through the decomposition of organic waste by means of microorganisms in an oxygenated environment (44).
- Compost may differ in terms of organic matter and minerals, depending on the type of waste used in the fertilizer. Not only is composting organic waste an environmental solution but also it is seen as a highly beneficial solution as it improves the soil, reduces pollution, minimizes dependence on fertilizer and reduces the risk of soil erosion.
- The production and use of compost are valuable as it reduces the negative effects of chemical fertilizer, and it is a type of fertilizer that can be made by the producer on the farm. However, it is stated that this method is not widely used among Turkish producers.

Source:

(44) Ağaçayak, T.; Öztürk, L. (2017), Strategies for the Reduction of Greenhouse Gas Emissions Arising from the Agricultural Sector in Turkey, Istanbul Policies Center, Sabanci University.

(45) Öztürk, M. (2017), Compost Production from Manure and Waste, Ministry of Environment and Urbanization.

Slow-Release Fertilizer

Slow-release fertilizers are liquid and solid fertilizers that can nourish the plant for a longer period of time as they dissolve slowly, depending on the water solubility of the nutrient content and the ambient conditions in which the plant is grown (46). The most important benefit of slow-release fertilizers, unlike conventional fertilizers, is that they are very unlikely to mix in and contaminate the groundwater sources. It is stated that it will be sufficient to use slow-release fertilizers at a lower dose, compared to other fertilizers. It is therefore deemed as a solution compatible with the environment and water resources, compared to classical fertilizers.

Source:

(46) AKALIN, G. O. Controlled and Slow-Release Fertilizer Systems. Science and Mathematics, 99.

to be selected in each basin with the guidance of an expert may contribute to the revival of the collective work culture, encouraging the widespread use of compost as a more suitable fertilizer for sustainable and healthy soil.

It is believed that the most accessible, curable, and sustainable one for our soils is the application of compost. Not only is compost a **biopesticide** due to the amount of organic matter it contains, but also it is a **soil activator**. **Compost is a functional and environmentally friendly application, as it can be produced by the farmer with the right formulation and raw materials available, without the need for large facilities.**

The use of compost is crucial for Turkey both in terms of reducing the dependency on the use of chemical fertilizers, improving the soil health, increasing the soil's organic matter and water retention capacity, and providing further protection for the soil and therefore the producer against the droughts that will increase as a result of climate change.

Since both aerobic and worm-derived compost (vermicompost) can be produced with the resources available on the producer's land, it is a cost-effective solution even when it is small-scale. Hence, **providing the producer with technical information about the benefits and production methods of compost and developing a compost recipe using the formulation created according to the raw materials found in the producer's hands** will ensure widespread and effective compost production.

However, in cases beyond the producer's own capabilities, **compost-making centers can be established** in the regions or villages. Commonly seen in developed economies, compost centers (bio-coal can be produced, as well) can be operated by local governments, cooperatives, or producers' associations. High process/output quality can be achieved with the adoption of professional management procedures as well as the applications such as creating a recipe according to the requirements, keeping the records of materials brought in, and contributing to the producers in proportion to the materials they bring in.

The Producers/regions capable of performing both animal breeding and plant cultivation all in the same place and at the same time will be more advantageous owing to the potential to transform the production waste and use it for another good purpose.

The fact that the production facilities and the materials are close to each other and that the animal-derived materials go from the separator directly to the bio-reactor will be a factor that reduces costs.

6.9. Chemicals (Herbicides & Pesticides)

It is emphasized that the producers could get poisoned and even lose their lives at times over the years due to the intensive utilization of chemicals. The reports of the National Poison Center, and Ministry of Health in Turkey claim that the number of cases of poisoning with agricultural herbicides and pesticides increased from 7303 in 2014 up to 8945 in 2018. It was found that chemical poisoning has increased 15 folds in the last 30 years on a global scale, 44% of the world's farmers are exposed to chemical poisoning every year, and what's worse, **approximately 20,000 farmers die every year.** This is due to the significant increase in the use of herbicides and pesticides within the last 30 years (an 82% increase in the use of chemicals from 1990 to 2017 globally) and the producers who are unaware of the practices of personal sterilization during and after the use of sprays although they have knowledge of the chemical sprays (43). All of the foregoing tells us that we have to find other methods for pest control. Although the banning of herbicides and pesticides is another story, which will take some time, **producers are liable to take steps to cut down on the use of chemicals and restore the balance of the ecosystem,** as stipulated in the European Green Deal Action Plan.

6.10. Microplastics ve Nanoplastics in Pollution

Our farmlands are exposed to a number of pollutants, from heavy metals to organic pollutants and microplastics. Of these pollutants, **microplastics** that have been discovered only recently and discussed in the studies have **begun to be seen seriously in both water resources and soil.** The Studies in the international literature on the contamination of microplastics and nanoplastics have a long background. However, it is seen that this issue has just begun to be addressed in Turkey. **The Studies started on the microplastics found in our water resources, but it is seen that studies on microplastics in the soil are yet to cover more ground.** It is stated that researchers may encounter various technical obstacles in establishing the necessary equipment infrastructure to detect microplastics and nanoplastics. According to the results of international studies, the situation is extremely worrying, and it is considered quite important to initiate studies on microplastic and nanoplastic pollution in the soil as soon as possible in Turkey.

6.II. Soil and Carbon Relationship

Agricultural lands are described as “open-air factories” with inputs and outputs. For this reason, **storing the carbon in the soil as far as possible in the form of organic compounds will reduce the amount of carbon in the atmosphere and enrich the nutritional value of the soil.** As the amount of organic carbon in the soil increases, carbon dioxide which is one of the greenhouse gases will decrease, which in turn will affect climate change favorably. In addition, the surge of organic carbon levels in the soil will stimulate plant formation, encourage the photosynthesis cycle and contribute to the functioning of the ecosystem. Therefore, the technologies to be developed for carbon sequestration in soil are critically important.

6.I2. Hydroponic Agriculture

It is seen that the health and quality of our country's lands deteriorate day by day as a result of concepts far from sustainable agriculture. There are different opinions on hydroponic farming practices, which are sort of seen as solutions to such degradation.

It is also believed by some that Hydroponic agriculture,

- will not suffice to feed the world population which has been increasing day by day,
- is not sustainable because it is costly,
- however, although there are some who suggest it is somehow an intervention in nature,
- some believe that hydroponic agriculture is much more profitable and efficient than conventional agriculture,
- it is an agricultural production technique that is affected by the elements the least, since it allows for production throughout the year, and
- it reduces the labor and pesticide costs significantly.

It is seen that hydroponic agriculture is becoming increasingly more popular in our country and there are successful examples of young entrepreneurs in particular. Through hydroponic agriculture, the products such as micro greens, tomatoes, and strawberries are grown, and **it is known that hydroponic culture**

greenhouses were built on a large scale and became widespread, especially in our cities such as Antalya, Mersin, Izmir, Manisa, and Yalova.

It is also stated that hydroponic agriculture should be included in the curriculum as part of the education and it is an important method that can be used during basic agricultural practices and food literacy education.

6.13. Human Resource and Producer

- As in many areas, our country is in need of qualified human resources in agriculture, especially in terms of water and soil. It is stated that the knowledge and formations of the employees in this field are insufficient and therefore the data collection, recording, and interpretation processes are not consistent. It is thought that while there are several graduates, the number of qualified researchers, experts, and professionals is only a few; the diploma is a direct indication of the qualification and that is related to the increasing question marks regarding the quality of studies offered at the agricultural faculties. **It is stated that the number of students who prefer agricultural faculties has been decreasing every year and the students who study agriculture** anyhow struggle following graduation. It is rather paradoxical that the **departments of agricultural structures and irrigation, soil science, and plant nutrition at the agricultural faculties**, which we will need more in the fight against global warming and increasing drought that makes itself felt increasing, **cannot find students and eventually these departments are bound to shut down.**
- The fact that the research institutions engaged in agricultural activities, as well as the researchers and experts working at these institutions, develop their communication networks by establishing international relations with the institutions and specialists of other countries is one of the critical requirements for success in the field of research and to be able to follow up the developments in the world in real-time. **When planned and executed properly, even short-term overseas education programs are believed to improve the social networks, experience, and quality of scientists both quantitatively and qualitatively.**
- **It is mentioned that there is a lack of connectivity between the knowledge produced at the academy and those applied in the field.** It is observed that there are various shortages in reflecting the knowledge acquired at the universities and research institutes onto agricultural production. In order to eliminate this drawback, there is a need for an infrastructure that should serve as a bridge with the producers and

involve the expert with both theoretical and practical knowledge. Since there is no such infrastructure, it is stated that the producers, engineers, and experts actively involved in the field cannot have access to such information. **There are some countries where agricultural knowledge is disseminated through the field offices within the universities where the knowledge is actually produced.** On the other hand, **it is seen that universities in our country do not have agricultural innovation** centers and there is no such environment where the knowledge produced at the university is shared with the producer.

- While on the one hand the study methods in universities and institutes are changed in a manner to strengthen the connections with the field, the establishment of **Local Agricultural Application and Training Centers**, where the producers can notice they will be more successful in agriculture as they learn and apply new techniques, on the other hand, may seem to be a major step for a radical solution. These centers can teach the following subjects,
 - **Protection of soil health,**
 - **Clean and efficient use of water,**
 - **Pests and control methods,**
 - **Soil enrichment,**
 - **Cultivation with plant diversity,**
 - **Green fertilizer production techniques,**
 - **Basic principles of adaptation to climate change,**
 - **At these centers, also field practices related to the training can be performed.** Local Information Transfer Centers, which will be established in cooperation with the public and universities through the selected centers, can be a solution so that these studies can gain wide popularity.
- In the information age, when the production of new information keeps on increasing day by day, it can also be disseminated in order **to raise awareness of the producers and introduce them to the new knowledge produced continuously, and make the up-to-date information a guide of application for all producers.**
- It is stated that **the producers tend to rely mainly on the dealers that sell farming inputs as part of the solutions to the problems** and they keep away from the institutions, organizations, and authorities, apart from those agencies. The main reason for this is thought that the dealers are instantly available on the field, they produce practical solutions to the problems encountered during the production and they work closely with the farmers. It is stated that the experts and field staff working in this field, apart from the dealers have a high workload. For this reason, **it becomes difficult for the producers on the field and the agricultural experts to**

come together on the field, and therefore the relationship between them weakens. The producers of our country are in need of specialists with high knowledge of technological application, who will come down on the field frequently, as well as accessible and autonomous institutions where these people are employed.

- **Both new and domestic knowledge can be produced and the knowledge can be disseminated through an integrated mechanism where human resources capable of conveying the knowledge to be needed by the producers can be trained by the researchers** working in this field. It is emphasized **that interfaces and mechanisms** should be established by taking into account the technological means and facilities of our age, **with a view to further extending the agricultural publications and scientific knowledge discovered** in agricultural studies and projects, **especially** those conducted by **TAGEM institutes and universities**. To this end, the **“Farm Advisor and Extension System” widely implemented across the USA, which is given in Info Box 11, can be examined.**
- It should be investigated which methods can best be used to transfer information to the producers of our country on soil health and efficient use of water, and the success of the selected method should be measured at regular intervals after the application starts and improvements should be made in the method.
- **Cooperatives specializing in soil and water can be established and sample practices can be implemented at these cooperatives in order to improve soil health and use the water efficiently in agricultural irrigation.**
- In order to make use of the plant and animal waste and to produce fertilizer using high organic matter content, compost production centers can be established, where the compost can be distributed to the producer in proportion to the amount of waste they supply.
- Through the field days organized with the lead farmers, an environment can be created where **both the technological practices are displayed and the information about soil health and efficient use of water is shared.**
- Based on the widespread belief that “The farmer’s mind is in his eyes”, it **is considered extremely important and necessary to provide producers with on-site demonstrations.**
- As stated by our participants, **the establishment of strong and well-attended unions of producers for various crops** will ultimately provide both the producers and public institutions with long-term benefits. These unions and cooperatives will train their members who are producers on sustainable agricultural techniques, efficient use of water resources and improvement of soil health and support them on the field.



Info Box 11

Agricultural Extension System

Agricultural Extension System is a mechanism implemented in various forms in countries with developed agriculture, especially in the USA, which aims at transferring the knowledge obtained through non-formal education to the farmers engaged in agricultural production and living in both rural and urban areas throughout the country. It is a system operated both in the field of research and in the field of application together with the producer.

Farm Advisors who are trained in a master-apprentice relationship, holding a master's and doctoral degree are assigned to each region and relay information to the farmers mutually. This system is implemented widely and effectively in the U.S. successfully and transfers the information obtained by the universities and research institutes to the farmers on a regular basis. Figure 24 shows the major actors in the Agricultural Extension System in Turkey and the nature of the relationship between these actors.

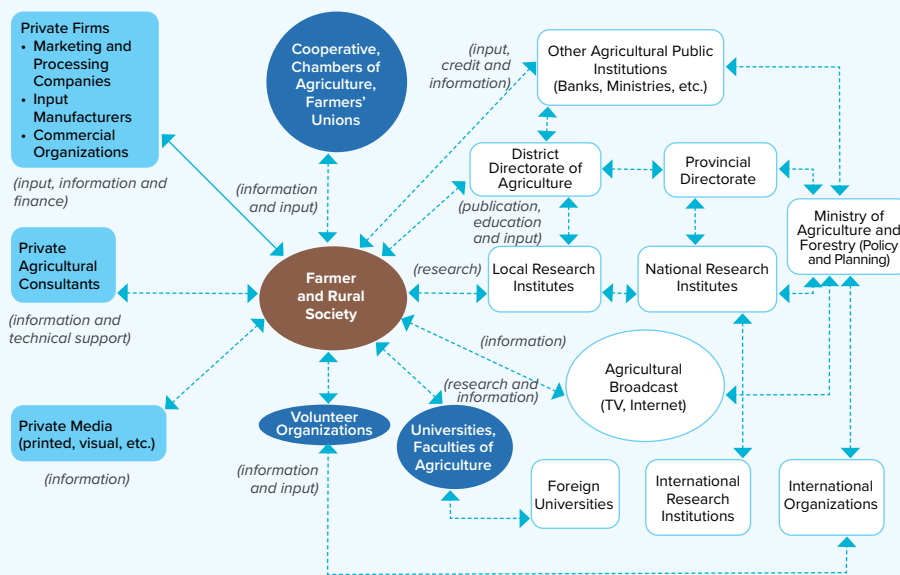


Figure 24: Major Actors in the Agricultural Extension System in Turkey

Source:

(48) <https://nifa.usda.gov/about-nifa/how-we-work/extension> Accessed on:

(49) Savran, F., K. Demiryurek, O.N. Ozcatlbaz, A. Aysegul and I. Boz, 2011. The agricultural extension system and practices in Turkey. Sci. Res. Essays, 6: 1831-1838.

- It is stated that it is difficult for the producers of our country to part with the traditional concept of agriculture, so consciousness and awareness of the producers should be raised in order for the new generation technologies and techniques to become widespread. When we look at the demographic structure of our agricultural labor force,

It is believed;

- Since the average age of the population involved in agriculture is over 50 years and above, they refrain from adapting to the next-generation technological developments,
- The producers have different levels of awareness in different regions, and
- Interregional cultural differences, prevent producers from coming together and cooperating.

To persuade the producers who keep away from sustainable agriculture and next-generation production techniques and technologies, and to break down the resistance in this respect, it will be required to,

- Provide training widely and at certain intervals,
- Perform demonstrations through the lead farmers,
- Use effective means of communication.

On the other hand, **local governments need to play a more effective role in the fields of agricultural production and consumption with a comprehensive sense of responsibility, including addressing the technological solutions in the future, in an effort to resolve the lack of communication between the central government and producers.**



7

Conclusion

In order to satisfy the increasing demand for natural resources such as soil and water, it is now an undeniable requirement to use these resources efficiently and sustainably.

“ Efficient and sustainable use of resources has become a necessity. ”

Global climate changes, and pollution in soil, water, and air are important indicators of this change. Unless measures are taken, it is evident that the balance of the entire ecosystem, along with all living and non-living beings, will gradually change. **We are now in a period in which those failing to manage the risks will have to deal with the crises. Our country, together with the world, entered a period requiring tough decisions about the sustainability of soil and water assets.** Soil and water issues have long been discussed by the world's agricultural and environmental stakeholders. It will be required to develop and implement such policies as,

1. Protecting the soil, water, and air
2. Adapting to climate change
3. Stopping asymmetric industrial development
4. Slowing down population growth and unplanned urbanization
5. Protecting the natural (wild) ecosystem and biodiversity
6. Recognizing that the human is only an advantaged member of the ecosystem cluster, not the master.

Monitoring the results to be derived from these policies and updating the policies and practices when necessary based on the results appear to be the only way for us to observe patiently and carefully. Above all, the existence of humans, which is clearly associated with agriculture, food, soil, air, and water, will be threatened unless positive results are obtained from these practices.

Climate change also affects the condition of soil resources, soil health, quality, and carbon sequestration capacity directly. Inappropriate cultivation systems significantly limit the ability of the soil ecosystem to “rebuild itself”. It is required to use the water resources in the most efficient way, to protect the soil assets and improve their health. In this context, **the approach to adaptation to climate change has not yet been reflected in the agricultural policies.**

Before deciding upon the methods of implementation and setting the general approach policies, central and local authorities should communicate adequately with the community, especially the producers and institutions representing the producers, and then they need to make sure that the community is advised of such methods and policies. **It will**

be highly beneficial to carry out the studies, which will be conducted in order to increase awareness within the entire value chain from farmer to consumer, by taking into account the characteristics of the culture, sociology, and human resources of our country and to implement the solutions in cooperation with the professionals of social behavior psychology.

The practices should be carried out with such policies with improved audit and sanction aspects, and a holistic approach should be taken by improving the decisions planned to be implemented by looking into the results of the impact analysis of the policies in force.



Study Team

Fusun Özüğür



Fusun Özüğür graduated from the Department of Sociology, Hacettepe University in 2018. Özüğür who began her master's degree in the Department of Sociology, Hacettepe University in the same year received her MSc in this field. She started her professional career as an intern sociologist at the Ministry of Family and Social Services in 2017. Employed as an Assistant Specialist in TTGV Ecosystem Programs Coordinatorship since June 2021, Özüğür is involved in the studies on the agricultural ecosystem within the scope of Strategy and Foresight Activities. Carrying on her studies on the integration of immigrant and asylum-seeking children in her academic life, Özüğür is also interested in other sciences such as mass migrations, and climate migration, to name but a few..



Güngör Yıldızbayrak



He was interested in basic sciences such as physics, mathematics, and biology with a passion for learning the unknown fascinating structure of the universe. Since his graduation in 1973 from ITU where he studied on a scholarship by PTT, he has participated intensively in national and international events in Turkey, which focused on improving the innovation, science, and technology. He served in the positions assigned by private and public institutions (e.g. TUBITAK and TTGV). He chose to research and development as a compulsory lifestyle and conducted theoretical and practical specialist studies in electronics, machinery, and material engineering. He strived to share what he learned, with others and guided young people in every aspect of life. Currently, Yıldızbayrak continues to learn and research subatomic particle physics, the evolution of living life, and ecosystem entropy. Employed full-time in an electronic testing laboratory, Yıldızbayrak participates in the studies as a Member of the Board at TTGV, on making the science and technology, management, agriculture, food, public health, and education activities sustainable and compatible with the ecosystem.



Dr. Murat Salih



Dr. Murat Salih received his undergraduate degree from METU Electrical and Electronics Engineering in 1987 and his master's degree in 1989, and his doctorate from the University of Massachusetts at Amherst Electrical and Computer Engineering in 1995 in the USA. Since then, he has been involved in managing the family farm in Kilis and growing several species of crops. He conducts research on soil health, compost making, efficient use of irrigation water, and increasing the carbon sequestration in soil for a sustainable agricultural production and smart agricultural technologies and he also implements them on the family-owned farm. Since February 2021, he has been the co-president of TTGV STOK Agriculture and contributing to the preparation of reports on the issues of priority in agriculture. Since November 2021, he has been consulting at TTGV HIT Agriculture Program. Between 1999-2005, he worked as an R&D manager at Komes Communications company founded by himself, where he developed wireless data transmission technologies, and he served as the lead R&D engineer at Karel Electronics company between 1996-1998. He has articles published in international journals.



F. Yağmur Firat



F. Yağmur Firat started her professional career as a Communication Consultant following her undergraduate studies in the Department of Philosophy METU. Later, she continued her career in clinical research, finance and technology cooperation development and she has been employed at TTGV as part of the Strategy and Foresight Activities since April 2019. Believing in life-long learning and development, Firat completed her MBA studies in January 2019, the Business Analytics Nanodegree program in 2020 and the McKinsey Forward leadership program in 2022, with eligibility for further studies.



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Dr. E. Serdar Gökpınar holds Bachelor's Degree in Mechanical Engineering, Master's Degree in Business Administration and Doctoral Degree in Technology Management. He worked as a researcher, manager of various R&D projects and group coordinator at TUBITAK between 1996 and 2011. He served as Technology Management Manager and Combat Aircraft Director at TUSAS-TAI Between 2012-2018. Currently serving as the Ecosystem Programs Coordinator at TTGV, Gökpınar also continues his academic studies as a researcher in engineering management, R&D, technology and innovation management and as a lecturer at METU.





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