AGREEN

CROSS-BORDER ALLIANCE FOR CLIMATE-SMART AND GREEN AGRICULTURE IN THE BLACK SEA BASIN

Subsidy Contract No. BSB 1135

FEASIBILITY STUDY

CLIMATE-SMART AGRICULTURE IN THE BLACK SEA BASIN REGION OF

TURKEY

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Contents

List of abbreviations

AgMIP: The Agricultural Model Inter-comparison and Improvement Project
ARIP: The Agricultural Reform Implementation Project
CA: Conservation Agriculture
CATAK: Protection Program of Agricultural Lands for Environmental Proposes Program
CEA: Controlled Environment Agriculture
CSA: Climate Smart Agriculture
DIS: Direct Income Support
EU: European Union
FAO: The Food and Agriculture Organization
FRS: Farmer Registration System
GAP: Good Agricultural Practices
GDP: Gross Domestic Product
GHG: Greenhouse Gas
GIS: Geographical information system
GPS: Global Positioning System
IFOAM: Federation of Organic Farming Movement
IPA: The Instrument for Pre-Accession Assistance
IPARD: The Instrument for Pre-Accession Assistance Rural Development
IPCC: The Intergovernmental Panel on Climate Change
OF: Organic Farming
RAP: Representative Agricultural Pathway
RIA: Regional Integrated Assessment
SOC: Soil Organic Carbon
UNFCCC: The Framework Convention for Combating Climate Change

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AGREEN Community for climate-smart agriculture

Black Sea CROSS BORDER COOPERATION

1. General Description

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Target audience:

- Development Partners
- International Policy Research Organisations
- International Research Institutions
- National Agricultural Extension Representatives
- NGOs Operating at Farmer Level

Category: Report

1.1 Definitions and Acronyms

Introducing Climate-Smart Agriculture (FAO, http://www.fao.org/climate-smart-agriculture-sourcebook/concept/module-a1-introducing-csa/a1-overview/en/?type=111)

Reviewing the above reference of FAO on Climate Smart Agriculture (CSA), the following information or data are suggested to collect in a feasibility study to guide how to implement CSA for crop production in a specific region.

The agriculture sectors need to overcome three intertwined challenges:

- sustainably increase agricultural productivity to meet global demand;
- adapt to the impacts of climate change; and
- contribute to reducing the accumulation of greenhouse gases in the atmosphere.

FAO has developed and promoted the concept of climate-smart agriculture. Climate-smart agriculture has three objectives:

- sustainably increase agricultural productivity and the incomes of agricultural producers;
- strengthen the capacities of agricultural communities to adapt to the impacts of climate change; and,
- where possible, reduce and/or remove greenhouse gas emissions.

Climate-smart agriculture is an approach for transforming and reorienting agricultural production systems and food value chains so that they support sustainable development and can **ensure food security under climate change**.

1.2 Abstract

The agriculture sectors need to overcome three intertwined challenges: sustainably increase agricultural productivity to meet global demand; adapt to the impacts of climate change; and contribute to reducing the accumulation of greenhouse gases in the atmosphere. FAO has developed and promoted the concept of CSA to achieve these goals.

Climate change projections show that the average temperature of Turkey will increase up to 3 and 6 °C for optimistic and pessimistic scenarios, respectively, coupling with the decrease in the amount of average and maximum annual precipitation up to 60 mm and 250-300 mm respectively. In Turkey, excluding the Black Sea region, decreases in spring and summer precipitation coupling with the increase in temperature and evapotranspiration will lead to decreases in yield/cultivated area of summer crops like sunflower, corn, rice, bean, chickpea, lentil, sugar beet, cotton, vegetables and fruits beside alfalfa and pastures. It is predicted that climate change will cause decreases in the yield of some strategically important crops for Turkey. Shortage of forage crops, oilseed crops and legumes will increase with climate change and become more problematic in the medium and long term.

Although adaptation studies in agroproduction against climate change have been started for the solution, the small and economically weak agricultural enterprises, their insufficient capacity, and the fragmented and scattered lands make the solution difficult. Solving these problems will facilitate the implementation of CSA. The SWOT analysis proves that Turkey has a potential to overcome these challenges.

For the adaptation to climate change, varieties resistant to extreme climatic conditions should be preferred/improved by using local genetic resources, organic carbon content of the soil should be increased, a new crop rotation/diversification plan should be made within the scope of direct sowing/cover crop concept, sowing dates should be adjusted to benefit from the precipitation effectively, escape from the drought and diseases/pest. For the mitigation of climate change: Organic farming, good agricultural practices, precision farming and climate smart agriculture should be encouraged and supported. For the technological and mechanical infrastructure required by these systems, farmers should be supported financially and technically by the government. For the resilience of the farmers against the adverse impact of climate change: farmers should be provided with financial support for production and insurance, and low or interest-free credit opportunities should be created.

Trakya region is suggested for the CSA studies of AGREEN. Summer crops such as sunflower, corn, fodder crops, legumes under rainfed and smart irrigation, under altered crop rotations, under traditional and direct sowing conditions may be studied. The decided adaptation, mitigation and resilience practices combined with the above crop models can be theoretically simulated or experimentally studied considering available time and research facilities of the partner institutions.

2. Introduction

2.1 The agricultural sector in Turkey

The impact and consequences of climate change affect our lives noticeably, causing epidemic diseases, drought, erosion, desertification, displacement of climatic zones, increase in severe weather events, sea level rise, damage to life species and deterioration of human health. This situation affects socio-economic sectors and ecological systems directly or indirectly, causing undesirable consequences. The effects of climate change on agricultural activities are of particular importance due to the relationship between production and nutrition, i.e. food security.

In the international arena, joint efforts against climate change attract attention. The Framework Convention for Combating Climate Change (UNFCCC), which entered into force in 1994 under the umbrella of the United Nations, the Kyoto Protocol, which entered into force in 2004, and the Paris Agreement, which entered into force in 2016, are the most important focal points of this struggle.

Turkey is located in the Mediterranean basin which is expected to be affected by the climate change mostly in the world. It is projected that the drought will be felt in the wider region and increase the number of very hot days will increase.

The sustainability of agro-production and food security depend on the mitigation and adaptation of the impacts of climate change. While the efforts to prevent climate change continue, the current situation of the agricultural sector should be examined well and strategies should be evaluated accordingly in order to achieve success in the adaptation of agricultural production to climate change within the concept of "climate smart agriculture (CSA)". The current situation of the agricultural sector will be examined in terms of cultivated land resources, the share of employment, export and import of agro production, raw material for industry, foreign currency return and agricultural policy.

Cultivated land resources of Turkey

Turkey has influential geo-political status because its location serves as a natural bridge between Europe and Asia. Turkey has a total area of 76.9 million ha. The land use of typea are summarized in Table 1.

Table 1. Land use of Turkey’s territory (TUIK,2020, https://www.tuik.gov.tr/).

Land use type	Area (million ha)	Area (%)
Agriculture	23.1	30.0
Forest	21.5	28.0
Meadow and pasture	14.5	18.9
Water body and others	17.8	23.1
Total area of Turkey (million ha)	**76.9**	**100.0**

Table 2 shows the variation of crops grown on agricultural land by years. The table reveals that the total cultivated land decreased by 4.86 million ha (%16.8) from 27.78 million ha in 1990 to 23.10 million ha in 2020.

Table 2. The variation of crops grown on agricultural land by years (TUIK, 2020, https://www.tuik.gov.tr/)

Agricultural land	1990		2000		2020	
	Area (million ha)	Area (%)	Area (million ha)	Area (%)	Area (million ha)	Area (%)
Field crops	18.80	67.67	17.94	67.49	15.39	66.62
Fallow	5.32	19.15	5.04	18.96	3.39	14.68
Vegetable	0.63	2.27	0.93	3.50	0.79	3.42
Fruits, herbs etc.	3.03	10.91	2.67	10.05	3.52	15.24
Ornamental plants		0.00		0.00	0.005	0.02
Total	**27.78**	**100.00**	**26.58**	**100.00**	**23.10**	**100.00**

In Turkey, 24.5% of the total land consists of the land capability classes of 1st, 2nd and 3rd, which is called absolute farmland. The share of agricultural land in absolute farmland is 90%. Technically and economically total irrigable land is 8.5 million ha. As of now, the total land under irrigation throughout the country has reached 6.6 million ha, irrigable lands, which corresponds to 70% of the total irrigable and 28.57% of the total agricultural land. Dry farming is carried out in the remaining 71.43%, which totally depends on fluctuating climatic conditions (Anonymous, 2018)

As seen from Table 2, a considerable amount of the non-irrigated land is not cultivated and left fallow every year. The reason for this is to increase soil fertility by accumulating two years of rainfall in the soil. This practice is generally carried out in places where the average annual precipitation is below 400 mm. With today's technology, products can be obtained every year by planting suitable crops in places with more rainfall. As a result of the contribution of the "Narrowing Fallow Lands Project" initiated by the Ministry of Agriculture and Rural Affairs in 1983, the fallow land, which was 8.2 million hectares in 1980, was reduced to 3.39 million hectares (Yavuz, 2005). **This implies that resilience of agroproduction to unfavourable climatic conditions can be improved by carefully adapting CSA .**

As for the pattern of agricultural products in Turkey, 75% of the cultivated fields are cereals (wheat, barley, corn, rice, etc.), 8.5% legumes (lentils, beans, broad beans, chickpeas, etc.), 7.7% oil seeds (sunflower, sesame, canola, poppy, etc.), 7.2% ındustrial crops (cotton, tobacco sugar beet, etc.) and 1.6% tuber plants (potatoes, onions, garlic, etc. (TUIK,2020, https://www.tuik.gov.tr/).

As of 2016, Turkey is the world's largest producer of hazelnuts, cherries, figs, apricots, and pomegranates; the second-largest producer of quinces and watermelons; the third-largest producer of cucumbers, green peppers, lentils and pistachios; the fourth-largest producer of apples, tomatoes, eggplants, and olives; the fifth-largest producer of tea, chickpeas and sugar beet; the sixth-largest producer of almonds and onions; the seventh-largest producer of lemons, grapefruit, and cotton; and the eighth-largest producer of barley. In the year 1989, the total production of wheat was 16.2 million tonnes, and barley 3.44 million tonnes (Muminjanov and Karagoz, 2018).

Agriculture has a very important role in the national economy, providing 19.2% of total employment (Figure 1), 3.1% of all exports ($5.32 billion) (Table 3), and 6.5% of GDP ($47.35 billion) (Table 4) in 2020. Turkey has been the world's eight largest agricultural producer since 2008 (TUIK,2020, https://www.tuik.gov.tr/).

Figure 1. The share of employment in the economic sectors in Turkey by years (TUIK,2020, https://www.tuik.gov.tr/).

Although employment in agriculture has fluctuated over the years, the trend is downward slightly. However, this rate is still very high compared to developed and developing countries.

Table 3. Share of agricultural product in total export and import of Turkey (TUIK: https://www.tuik.gov.tr/).

Year	Total export ($billion)	Agricultural product export		Total import ($billion)	Agricultural product import	
		$billion	% in total		$billion	% in total
2000	27.80	1.66	6.0	54.50	1.50	2.8
2005	73.50	3.33	4.5	116.80	2.80	2.4
2010	113.00	5.09	4.5	185.50	8.16	4.4
2013	151.60	5.91	3.9	251.40	7.29	2.9
2015	143.90	6.13	4.3	207.20	7.25	3.5
2017	157.00	5.74	3.7	233.80	9.04	3.9
2018	167.90	6.04	3.6	223.04	9.33	4.2
2019	180.83	5.35	3.0	210.35	9.00	4.3
2020	169.67	5.32	3.1	219.51	9.40	4.3

Over the last 20 years, the agricultural product export rates have fluctuated while the ratios in total export decreased steadily. However, the import rates and ratios in total import have continuously increased.

Land fragmentation is one of the most serious problem in Turkey, nearly 80% of agricultural holdings were under 10 ha and 57% of these were fragmented into four or more non-contiguous plots (TUIK,2020, https://www.tuik.gov.tr/).

Table 4. Contribution of agriculture to GDP of Turkey by years (TUIK: https://www.tuik.gov.tr/).

Years	Contribution of agriculture to GDP by years	
	Billion $	%
2011	63.74	7.5
2012	60.96	7.3
2013	55.35	6.9
2014	52.68	6.6
2015	59.47	6.8
2016	53.35	6.4
2017	51.86	6.3
2018	46.04	6.2
2019	48.87	6.4
2020	47.35	6.5

Land use change and decrease of cultivated land, land degradation and desertification, loss of biodiversity due to climate change and drought, lack of crop rotation, agricultural soils with low organic matter content, erosion, intensive chemical use, limited irrigation areas and excess irrigation water application by traditional irrigation methods are among the widespread problems of Turkish agriculture.

2.2 Climate change and impact on Turkey

Turkish Republic Ministry of Agriculture and Forestry General Directorate of Water Management (SYGM) forecasted climate change in Turkey within the scope of “Impact of Climate Change on Water Resources” Project (SYGM, 2016). In this Project, it is envisaged to run a regional climate model with the outputs of three global models selected from the CMIP5 archive (HadGEM2-ES, MPI-ESM-MR and CNRM-CM5-1) under two different scenarios (RCP4.5: optimistic and RCP8.5: pessimist) with 10x10 km^2 resolution between the years 2015 and 2100. In the project, estimates were made for 8 different climate parameters including average annual precipitation and temperature in addition to 17 different climate indices including heavy rainfall and drought. Changes in average temperature and precipitation among climate parameters will be briefly given here.

Projection for the average temperature of Turkey

According to all three models and both scenarios, the increase continues throughout the projection period (Figure 2, Table 5):

- HadGEM2-ES model: forecasted 3.5 °C for RCP4.5 scenario and approximately 6 °C for RCP8.5 scenario.
- MPI-ESM-MR model: predicted approximately 2 °C for RCP4.5 scenario and approximately 4.5 °C for RCP8.5 scenario.
- CNRM-CM5.1 model: projected approximately 2.4 °C for RCP4.5 scenario and approximately 4.1 °C for RCP8.5 scenario.

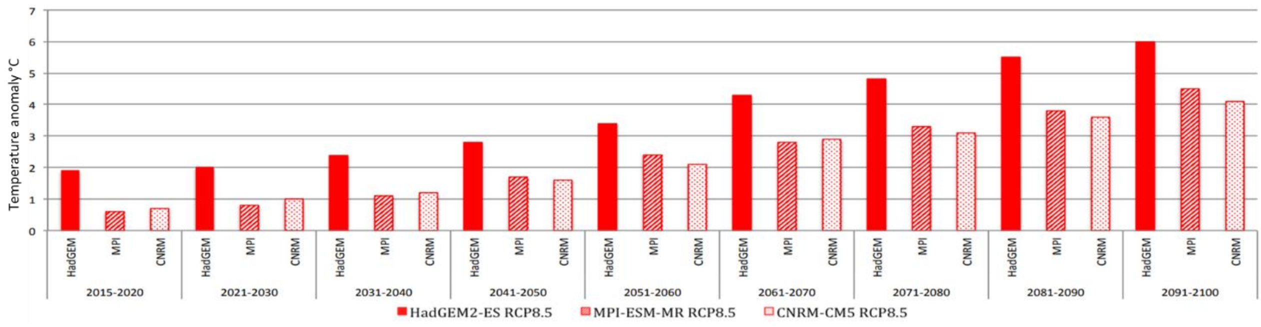

Figure 2. Temperature anomaly (SYGM, 2016).

Table 5. Projection in the average temperature according to HadGEM2-ES, MPI-ESM-MR and CNRM-CM5-1 model under RCP4.5 and RCP8.5 scenarios between the periods of 2015-2040, 2041-2070 an 2071-2100 (SYGM, 2016).

Scenario	Period	Projection for the average temperature of Turkey
RCP4.5	**2015-2040**	In all three models, an increase of 1-2 °C in average annual temperatures is expected in temperatures. According to HadGEM models, except for the southeast area, it is expected to increase around 2 °C in winter temperatures throughout Turkey.
	2041-2070	The temperatures continue to increase linearly. According to the HadGEM model, annual average temperatures will increase of up to 3 °C, while the highest increases will be in the summer months. As one of the common outputs of all 3 models, temperature increases are expected to occur mostly in the east of the country.
	2071-2100	In the last projection period, it is predicted that the annual average temperature increases may be up to 4 °C. Considering the summer and winter seasons, it is expected that the highest temperature increases will be experienced especially in the east and southeast of the country.
RCP8.5	**2015-2040**	According to all three models, an increase between 1 and 2.5 °C is expected in temperature in Turkey, more east and southeast.
	2041-2070	It is predicted that from the 2040s, there may be an increase of 3 to 5 degrees, especially in the summer period temperatures. Temperature increases in the Marmara and Black Sea Regions are expected to be less than in other regions.
	2071-2100	The average annual temperature in Turkey in general will experience an increase of at least 3.5 °C, regionally may reach up to 6-7 ° C degrees, most of the country is estimated to rise again to experience the east and south.

Projection in the average precipitation of Turkey

- According to both scenarios, in Turkey, it is expected to decrease in the amount of precipitation in the years 2015-2100.
- From 2050 onwards, more pronounced reductions up to 250-300 mm are predicted (average 60 mm).
- Negative rainfall anomalies stand out, especially in the Aegean and Mediterranean coasts, and in the Southeast and East regions.
- Increases in total precipitation and extreme rainfall events are expected in the east of the Black Sea.

- Significant reduction in snow-covered areas and amount of snowfall is predicted.

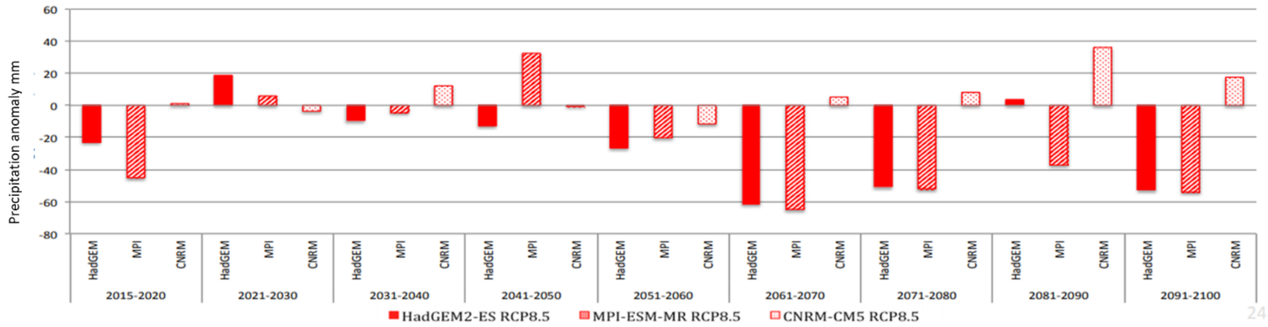

Figure 3. Precipitation anomaly (SYGM, 2016).

Table 6. Projection in the average precipitation according to HadGEM2-ES, MPI-ESM-MR and CNRM-CM5-1 model under RCP4.5 and RCP8.5 scenarios between the periods of 2015-2040, 2041-2070 and 2071-2100 (SYGM, 2016).

Scenario	Period	Projection in the average precipitation
RCP4.5	2015-2040	Locality is very high in total annual precipitation. When winter season anomalies are examined, according to the MPI model, decreases in precipitation in the west, south and southeast and significant increases in the black sea coastal regions in the north are observed. According to HadGEM, the expected decrease in total annual rainfall is around 50-100 mm in Turkey. No significant change is expected in the spring precipitation.
	2041-2070	In the same regions, it is predicted that the annual total precipitation decreases will be more severe and may reach up to 200 mm regionally.
	2071-2100	Negative anomalies in the east and southeast will spread to wider areas compared to the previous period and the expected decreases may increase further and exceed 250 mm. On the other hand, annual total precipitation increases of more than 75 mm are expected in the coastal parts of the Marmara Region and the Black Sea Region.
RCP8.5	2015-2040	Similar to the optimistic scenario; according to the MPI model, there will be decreases in annual total precipitation and winter precipitation in the west, south and southeast, and increases in the black sea coasts in the north.
	2041-2070	Except for the Black Sea Region, decreases between 75 and 250 mm in total annual precipitation is expected. From the 2040s, sparing precipitation will decreased about 50 mm.
	2071-2100	In the last 30 year projection period, there will be an increase of more than 300 mm in the eastern black sea, especially in winter season precipitation and annual total precipitation. On the other hand, in the west and south, it is estimated that the decreases in annual total rainfall may intensify and reach 350 mm.

Climate indices

Number of average frozen days in a year: Except for the Central and Southern Anatolian Region, the number of frozen days in a year will be almost diminished (Figure 4).

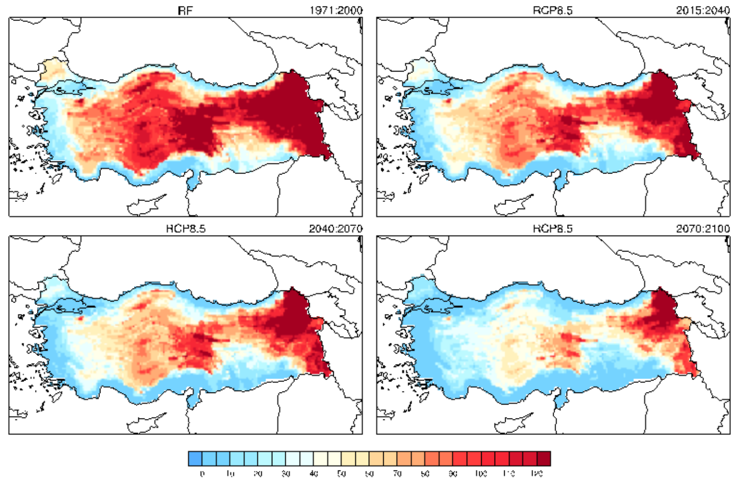

Figure 4. The yearly average number of frozen days in 30-year periods projected for RCP8.5 scenario of the MPI-ESM-MR Model(SYGM, 2016).

Hot days (days with the maximum temperature reaches to 25 °C): The number of hot days will change from 35 days to 112 days in a year. Changes in temperature extremes will increase the intensity and frequency of heat waves. Especially when the city heat island effect is added, it will cause an increase in health problems associated with heat waves in megacities where the population is very dense. Depending on the increase in temperature, the growing season of the plant gets longer. However, the decrease in precipitation and the increase in the amount of potential evaporation cause significant decreases in soil moisture (SYGM, 2016).

Number of consecutive dry days: The average number of consecutive dry days will increase from 83 days to 95 days. The southern Turkey, particularly south eastern part of the country, will be severely affected while the Black sea region will not be affected (Figure 5.) (SYGM, 2016).

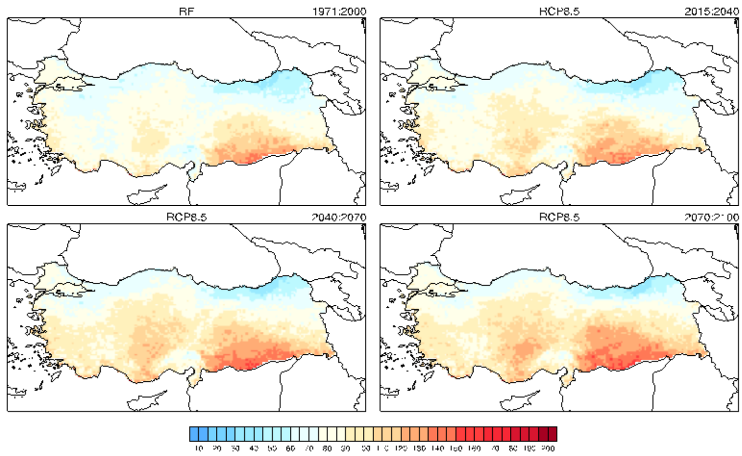

Figure 5. Number of consecutive dry days (HadGEM2-ES) RCP8.5 (SYGM, 2016).

Number of heavy rainy days and frequency: Especially in the Black Sea coastline, Mediterranean coastline and south eastern Anatolia, increases in the frequency and intensity of heavy rainfall are expected (SYGM, 2016).

Wind and radiation: Potential increases are expected in both wind and solar energy from renewable energy sources. In the RCP8.5 scenario in wind energy, there may be an increase of around 16% in Maramara and Aegean regions (SYGM, 2016).

Impact of climate change on agriculture in Turkey

Agriculture in Turkey is an important sector socioeconomically. However, it is largely vulnerable to climate change. In the decision making process of agricultural policy for the future for sustainable agriculture, both in determining appropriate crop selection and in promotion of agricultural production basins, climate change projections must be considered.

Decrease in suitability for agricultural production. In Turkey, excluding the Black Sea region, decreases in spring and summer precipitation coupling with the increase in temperature and evapotranspiration will lead to decreases in yield/cultivated area of summer crops like sunflower, corn, rice, bean, chickpea, lentil, sugar beet, cotton, vegetables and fruits beside alfalfa and pastures. Accordingly, the amount of irrigation water needed could be doubled compared to today. Even with irrigation, it is expected that there will be a decrease in the yield of summer plants, as the plants will be exposed to higher and extreme temperatures during the flowering and grain filling period (Kadioglu et al., 2017).

The rapid increase in heat waves, decreases in precipitation (especially snowfall) together with the increase in evapotranspiration rate will constrain water resources. This restriction would enormously increase the water stress in the competing sectors of the agriculture, tourism, industry and household in summer when water is most needed (Kadioglu et al., 2017).

Changes in planting and harvest time: Beside increases in temperature and decreases in precipitation, prolongation of the crop growing season, decreases in the number of frozen days, soil water deficit in the crop growing season, increases in the frequency and severity of the flood events will adversely affect the crop production and biodiversity. At the same time, drier periods cause prolongation of the fire season and pose a serious risk for agriculture.

Changes in precipitation regime, heavy rainfall and associated floods may delay planting and harvest times. On the contrary, the early warming of the weather may cause the sowing and planting dates to be brought forward as the last frost date is brought forward. For example, 1-3 degrees of warming in the country means that warm season cereals such as corn, rice and summer crops are put into production earlier. Thus, it may be possible to protect from summer heat and evaporation rate (Akinerdem, 2014; Ozturk, 2005; Kadioglu et al., 2017).

Many studies have been carried out in order to determine how the yield and phenological periods have changed in the face of increasing air temperature as a result of climate change. Especially the increasing temperatures in winter and spring shifts the plant development phases (phenological period) in field crops and orchards earlier; this causes frost damage in early blooming fruit trees and a decrease in the quality of products (Turkoglu et al., 2016; Kadioglu et al., 2017)

More diseases and pests: If the cold winters can no longer control them, some diseases and pests can survive or even multiply more and more every year, causing epidemics. As temperatures and humidity conditions change, new diseases and pests can cause damage in areas previously unseen. For example, previously unseen Septoria leaf spot in wheat in Central Anatolia and yellow dwarf virus diseases are seen now. In addition, it is a common situation that excessive rainfall causes an increase in rust and powdery mildew diseases in plants.

Even in today's somewhat severe weather conditions, it is seen that the yield and quality of agricultural production decrease, prices rise excessively and exports decrease. For example, even if only by heavy rainfall in some years has leaded many problems, caused cracking in cherries and largest cherry exporter Turkey experienced great difficulties in finding cherry to exports. On the other hand, sometimes frost causes losses up to 95% in hazelnut and apricot production. The hail, whose frequency and intensity has increased recently, decreases the quality and quantity of products and shortens the storage period. Sometimes the amount of straw decreases significantly as the grains are short due to the low amount of rainfall. In other words, even today, when the negative effects of global climate change are not fully felt, small changes in weather conditions affect agricultural production, producers and consumers very often and negatively (Kadioglu et al., 2017).

Water shortage for irrigation: Climate change will increase the water requirement in agriculture and cause a decrease in surface and underground water resources. Despite technological advances in plant cultivation, fertilization and irrigation, climate is still the most important factor in agricultural production. Therefore, the biggest problem of Turkey's agriculture is irrigation. Vulnerability of agricultural production to climate change will be decreased and sustainability will be ensured when the irrigation problem is solved. The variety of agricultural products increases. In Turkey, where 71.43% of the agricultural production is under rainfed conditions, irrigation water losses of up to 60% should be reduced to an acceptable level and thus more area should be open to irrigation for food security.

It is predicted that climate change will cause decreases in the yield of some strategically important crops for Turkey, by 8.18% in wheat, 2.24% in barley, 9.11% in corn, 4.53% in in cotton and 12.89% in sunflower by the year 2050 (Dellal et al 2011).

2.3 SWOT analysis of the climate-smart agriculture in Turkey

Strengths

- There are well-established organizations, such as Ministry with a strong organizational structure, all over the country, even at the district level: The Ministry of Environment and Urbanization has broad authority in all matters related to climate change and the Ministry of Agriculture and Forestry has broad authority in controlling climate change impact on agriculture and drought management.
- Turkey has a sufficient number of qualified human resources in the disciplines relevant to the climate change.
- Communication and technological infrastructure is sufficient enough.
- Climate Change Action Plan 2011-2023 is prepared by The Ministry of Environment and Urbanization for many sectors such as agriculture, land use and forestry, industry, transport and energy.
- Agricultural Drought Fighting Strategy and The Action Plan has been prepared by the Ministry of Agriculture and Forestry and is implemented on a provincial basis.
- Recently, plans are made based on the basin integrity: Alongside 26 river basins, 30 agricultural production basins have been created, management plans, conservation action plans and drought management plans have been prepared and implemented at the basin scale.
- State financing for basin investments has increased in recent years. Financial support are made on basin and crop basis.

Weakness

- There is a lack of basin level data information system.
- There is no national drought early warning and monitoring information infrastructure and management system.
- There are difficulties in accessing agricultural, climate/climate change, drought and meteorological data.

- Data on the effects of past droughts are not sufficient.
- Despite the well-structured organization, there are difficulties in coordination.
- There are gaps in the legislation.
- A complete coordination between basin-based sectoral investment policies and deficiencies in policies and strategies regarding basin management could not be achieved.
- There are insufficient stakeholder participation and local ownership.
- There are deficiencies in the criteria and methods of prioritizing watershed projects and activities.
- The high-level plans that will form the basis for the coordinated execution of watershed studies have not been completed.
- Units working on climate change are not sufficient in most of the relevant and responsible institutions.
- Agricultural enterprises are small and their lands are fragmented.
- The number of high-resolution and detailed R&D on climate change and drought is still very limited.
- Traditional production techniques are common in agricultural production.
- Farmers are not familiar with CSA it is a new topic for researchers.
- Water management is carried out in the form of crisis management in dry periods, rather than risk management based on threshold values to be determined according to the severity of drought and future measures based on these.

Opportunities

- Climate change is the most trendy topic on the agenda.
- Social awareness is increasing on climate change and related issues.
- Along with climate change, awareness of natural resources and environmental protection has increased in society.
- Modern irrigation water saving systems are known among farmers, they are accessible and supported by the government.
- Converting traditional irrigation systems to modern irrigation systems saving water is the top priority agenda of the Ministry of Agriculture and Forestry. Such systems are supported by the Ministry.
- Within the scope of the Program for Improving Efficiency of Water Use in Agriculture, after the determination of agricultural supports in line with the crop pattern on the basis of agricultural basins, necessary precautions have been initiated taking into account the existing water resources.
- Access to information and the opportunity to benefit from developing information technologies (GIS, digital agriculture, etc.) have increased.
- Political interest and support on climate change related subjects increased
- Participatory approach is developing in institutions.
- Stakeholders other than public institutions (NGOs, scientific organizations, etc.) have started to take an active role in integrated watershed management.
- Support for R&D studies on climate change, its impact and adaptation activities has recently increased.
- Farmers are highly anticipating action on climate change, due to resent losses incurred by climate change, especially extreme climate events. It is the best time to involve farmers in actions against climate change.
- There are 3 agricultural research institutes in the region specialized in climate change and agriculture.

- The region occupies a strategically important position between Europe and Asia.
- The region is an area of attraction within the country, as it is an industrial production, intensive agriculture and logistics centre.
- Compared to the farmers in the other parts of Turkey, farmers in the target region of AGREEN has more land asset, are more innovative and have more modernized agricultural equipment.
- One of Turkey's most powerful agricultural faculties are located in the region.
- Turkey has a rich genetic material in terms of developing resistant or tolerant varieties against droughts and extreme climate events,

Threats

- Turkey is located in the Mediterranean Basin which is estimated to be the most affected by global climate change.
- Long-term droughts and sudden excessive rainfalls as a results of climate change; inappropriate agricultural techniques, severe erosion, overgrazing, very low soil organic matter content, intense agrochemical (pesticide, chemical fertilizer) use, land use beyond their capacities, land use change due to issues such as urbanization, population growth, migration accelerate the degradation of agricultural lands, reduce yield potential and threaten food security in Turkey and in the region.
- When land is degraded, soil carbon can be released into the atmosphere, along with nitrous oxide, making land degradation one of the biggest contributors to climate change, as agriculture generates roughly a quarter of all anthropogenic greenhouse gas emissions.
- Surface water resources have been polluted.
- Groundwater resources are used far above their renewable potential.
- With the unplanned use of water, ecological flow cannot be achieved, as well as pollution, river and wetland ecosystems deteriorate.

3. Research methodology

3.1 Background analysis

Early researches on agriculture focused on economic impacts only, however, present assessments are multi-dimensional that consider agricultural system performance in economic, environmental and social dimensions and the inevitable tradeoffs among those dimensions (Antle 2011; Antle et al. 2014).

The climate change that have been experienced in recent years has made it necessary that the search for sustainable systems must also consider vulnerability to climate change, which may include increasing frequency and magnitude of climate extremes. The recent calls for "climate smart" agriculture recognize that climate adaptation, mitigation and resilience must be integrated into the broader agenda of developing sustainable agricultural systems.

The motivation for this approach is the fact that conventional field experiments and ex post assessments are not appropriate tools to evaluate agricultural system performance in changing and uncertain climatic conditions and future socio-economic conditions. The approach should combine the available data, including observational data from field experiments and from the previous research and surveys of actual farming system performance, with biophysical and economic models and future climate and socio-economic scenarios.

In these models, simulation experiments can be conducted to explore the performance of agricultural systems under the range of conditions considered relevant by stakeholders and scientists. The approach based on the Regional Integrated Assessment (RIA) methods developed by the Agricultural Model Inter-comparison and Improvement Project (AgMIP) for climate impact assessment (Antle et al. 2015; AgMIP 2015) may be adopted in the case of Black Sea Basin.

In this context, an overview of the AgMIP methods for technology impact assessment, and discuss how they can be used for CSA assessments of vulnerability, resilience and adaptive capacity will be discussed. Then, some key feature of the farming system in Trakya Region of Turkey and available data to be used in the assessment will be provided.

AgMIP Regional Integrated Assessment Methods

AgMIP has developed a methodology for RIA of climate change impact, adaptation, mitigation and vulnerability, and thus provides a framework for CSA assessment. The approach is designed to quantify indicators of system performance deemed to be relevant by both stakeholders and scientists, and then conduct simulation experiments to evaluate how system performance responds to climate and other changes, including system changes for climate adaptation and mitigation. These methods can be used in various ways to support technology development, e.g., to facilitate the targeting of agricultural interventions to farm types, for design and impact assessment of context specific safety-net, food security or market oriented intervention packages (Antle et al., 2018).

A number of key indicators relevant to the evaluation of CSA are identified to assess impact, vulnerability, mitigation and adaptation. These indicators (Antle et al., 2018):

- Physical quantities and value of principal agricultural products,
- Net value of single agricultural commodities,
- Average income,
- The headcount poverty rate in the population,

- Food security indicators, including capability to buy an adequate diet, per-capita food consumption, calories and other nutrient intake, dietary diversity indicators, and impacts on children such as stunting or mortality.
- Environmental indicators, including soil fertility, soil erosion, and indicators of greenhouse gas emissions and mitigation,
- Vulnerability, defined as the proportion of households that may be adversely affected by climate change. Losses can be measured in economic terms or in other dimensions of well-being such as health,
- Resilience, defined as the capability of a system to minimize the magnitude of adverse impacts or enhance positive effects towards greater adaptive capacity

Appropriate indicators can be chosen among the above list for the investigations. For regional integrated assessments, AgMIP identified four "core" research questions as illustrated in Figure 6 (Antle et al., 2018):

Core Question 1: What is the sensitivity of current agricultural production systems to climate change? This question addresses the isolated impacts of a change in climate assuming that the production system does not change from its current state. It is useful as a baseline for comparison with other combinations of technology and states of the world.

Core Question 2: What are the effects of adaptation in the current state of the world? This question is one often raised by stakeholders: what is the value of adapting today's agricultural systems to climate changes that may be occurring now and in the near future?

Core Question 3: What is the impact of climate change on future agricultural production systems? This question evaluates the isolated role of climate impacts on a future production system, which will differ from the current production system due to development in the agricultural sector not directly motivated by climate changes.

Core Question 4: What are the benefits of climate change adaptations? This question analyses the benefit of potential adaptation options in the production system of the future, which may offset climate vulnerabilities or enhance positive effects identified in Core Question 3 above.

Following the four core climate impact assessment questions discussed above, the model can be set up with appropriate combinations of parameters to represent the corresponding technologies, climates, and socio-economic conditions.

For analysis of adaptations, individual or set of CSA activities are used to assess how the existing system could be changed. The individual and combine impact of CSA adaptation activities can be simulated by productivity and socio-economic models. In the assessments, **vulnerability** and **resilience** are quantified.

Quantifying Vulnerability: Impacts of climate change are quantified as gains and losses in economic wellbeing (e.g., farm income or per capita income) or other metrics of well-being (e.g., changes in health or environmental quality). In this framework, some or all individuals may gain or lose from a change, and we say the losers are vulnerable to loss from climate change. Figure 7 illustrates this idea with two loss distributions. The area under the distribution on the positive side of zero is the proportion of losers and is the measure of vulnerability. The solid distribution in Fig.7 represents a system for which the average loss is positive and there are more losers than gainers. Note, however, that even in this case there are some gainers.

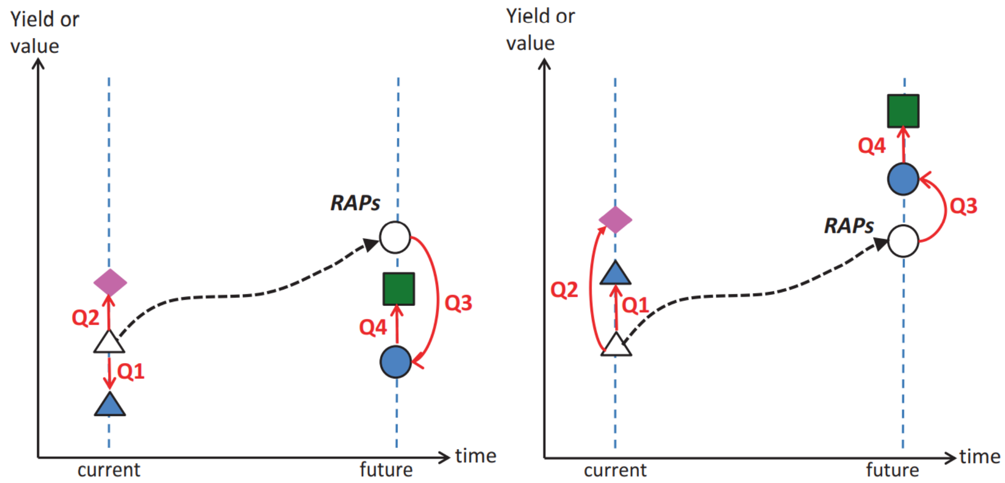

Figure 6. Overview of core climate assessment questions and the production system states that are simulated. The dashed black line represents the evolution of the production system in response to development in the agricultural sector that would occur without climate change, or independently of climate change, as defined by a Representative Agricultural Pathway (RAP). Arrows illustrate effects associated with the four core questions described in the text (Source: adapted from Antle et al. 2015).

The goal of analysis for CSA is to improve the performance of farming systems. In the context of vulnerability analysis, this means reducing the number of losers (the vulnerable) and increasing the gainers from any perturbation of the system, be it climate change or any other change.

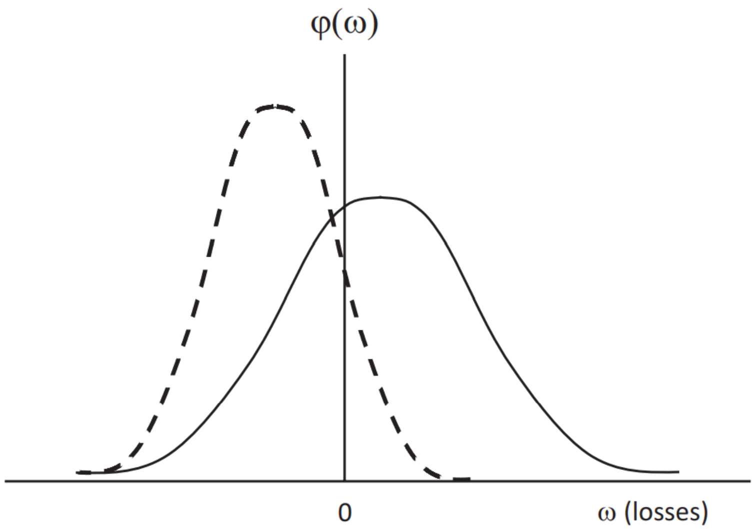

Figure 7. Vulnerability Assessment Using the Distribution of Losses Associated with Climate Change. The area under the distribution on the positive side of zero is the proportion of losers and a measure of vulnerability. Here the solid distribution represents a system for which the average loss is positive and there are more losers than gainers. The dashed distribution represents a system with more gainers than losers. The goal of climate adaptation is to shift the distribution leftward (Antle et al., 2018).

Quantifying Resilience: Resilience to climate change can be defined more broadly as the capacity to cope with change and minimize losses from change and enhance possible benefits of change, and thus can incorporate longer-term responses through adaptation (Malone 2009).

The capacity to withstand disruptions refers to the properties of a given system's performance, and is most relevant to analysis of relatively short-term events such as a storm or drought where it can be expected that the system will return to its normal state. In contrast, the capability to adapt or respond by making purposeful changes in a system seems most relevant to longer-term permanent changes in climate, and can include adaptations that are designed to improve the capability to withstand shocks or disruptions.

Figure 8 provides a stylized graphical representation of how resilience can be quantified for a temporary disruption as well as for a permanent change, over a specified time horizon from time t1 to time t2. In the analysis of a temporary disruption, the system provides a value V1 before the disruption occurs at t1. The disruption lowers the system performance to V2, and the system then recovers along some path from V2 back to V1 (the path is shown as linear in Figure 8, but more generally may be nonlinear). Suppose we are comparing two different systems, one more resilient than the other. The heavy dashed line in Figure 8 indicates the system with the most rapid recovery possible, and thus Lossmin equals area (A+D) and its resilience is 100%. The less resilient system recovers along the path indicated by the lighter dashed line, so the loss is area (A+B+D+E), and the system resilience is calculated as 100 (A+D)/(A+B+D+E)<100%.

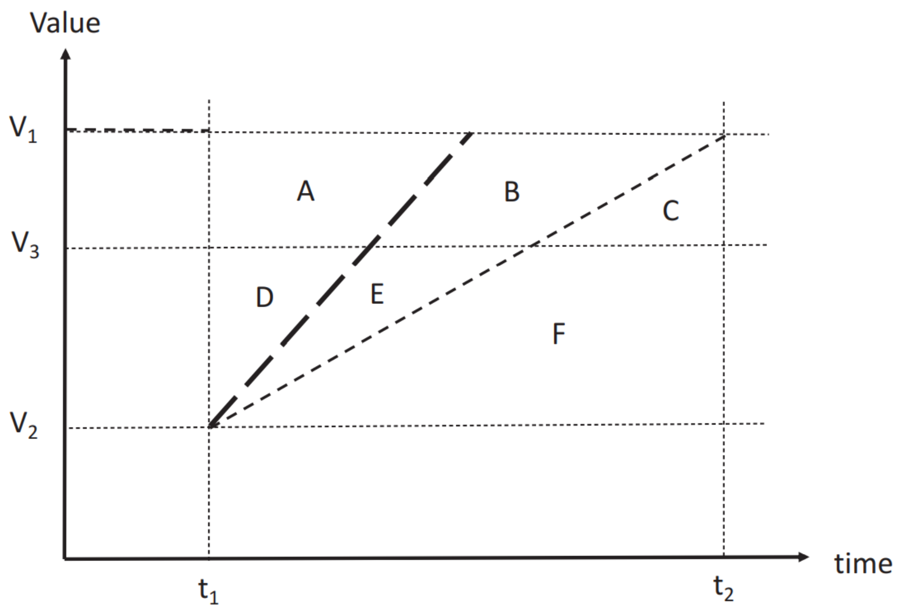

Figure 8. Analysis of Resilience to Temporary Disruptions and Long-term Change. See the text for explanation

The analysis of resilience to a long-term change in climate is somewhat different than the case of a temporary disturbance in several respects. In response to long term changes we expect systems to be adapted to climate change to some degree. There are three types of adaptations that can be expected to occur and can overlap at different scales. First, there are the kinds of changes in management that farmers can undertake within the existing system, such as changes in planting dates and reallocation of land and other resources among existing crops activities, or reallocation of their time among farm and non-farm activities. These types of adaptations have been called "autonomous or incremental adaptations." Second, there are adaptations that require investments external to the farm, such as investments in research and development of new technologies, such as improved crop varieties, or diversification and risk management options, sometimes referred to as "planned or systems adaptations." Third, transformational adaptation requires more fundamental changes in production systems, institutional arrangements, priorities for investment, and norms and behaviour (Kates et al. 2012).

As we discussed above, the analysis of climate impact and adaptation must be carried out under future socio-economic conditions defined by a RAP. By definition, the RAP represents changes in socio-economic conditions that would occur without climate change. Therefore, any changes in crop or livestock systems and productivity described in a RAP cannot be a climate adaptation. Changes defined as a climate adaptation must, by definition, be changes that would occur in response to changes in climate, given any other changes that would have occurred regardless of climate change. The "simulation experiments" carried out for a climate adaptation analysis are designed to show the effect of climate adaptation holding all else constant, including any changes in productivity that would have occurred without climate change.

3.2 Data sources

The required data for the assessment of impact, vulnerability, mitigation and adaptation depends on the indicator relevant to the evaluation of CSA. In case of Thrace region of Turkey (target region of AGREEN) the data required for each indicators and source of data are summaries below.

Climate data: past and present climate data (from 1971-to present) is available, obtained from General Directorate of Meteorology during the implementation of CCGS/042 project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme. The data covers all relevant parameters such as temperature, precipitation, and etc.

Climate change data: climate change data forecasted up to 2100 using 3 global climate models selected from the CMIP5 archive for the RCP 4.5 and RCP 8.5 scenarios with 10 km^2 resolution in 10 year intervals obtained from the Ministry of Agriculture and Forestry, General Directorate of Water Management and from CCGS/042 project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme. The data set covers temperature (min., max, average), precipitation (min., max, average), wind velocity (min., max, average) radiation (min., max, average) parameters including 11 extreme climate event such as flood, drought, number of freezing days, number of hot days, length of growing period, etc.

Agricultural system: The relevant data may be obtained from Ministry of Agriculture and Forestry reports, academic research papers and completed project reports. CCGS/042 project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme.

Regional plans: Regional Environmental Settlement Plans by the Ministry of Environment and Urbanization, reports by TR21 Trakya Development Agency; future scenarios from the scientific research will be the source of data.

Physical quantities and value of principal agricultural products: The data of land and water resources of the region, land asset of the farmers, principal agricultural crops and their yields and prices are available in the Turkish Statistical Institute reports, Ministry of Agriculture and Forestry reports, academic research papers and completed project reports.

Net value of single agricultural commodities: The required data is available in Provincial Commodity Exchange reports. Interviews with farmers may be required for more detailed information.

Average income: It is available in the Turkish Statistical Institute reports (TUIK). Interviews with farmers may be required for more detailed information

The headcount poverty rate in the population: If this is necessary it may be obtained from the Turkish Statistical Institute reports and Interviews with farmers.

Environmental indicators, including soil fertility, soil erosion, and indicators of greenhouse gas emissions and mitigation: Soil, soil fertility, organic matter contents and soil erosion data are available in the project report completed recently (Integrated land Use Management Modelling of Black Sea Estuaries, ILMM-BSE/211 project of JOP Black Sea Basin 2007-2013 and CCGS/042 project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme). Indicators of greenhouse gas emissions and mitigation data may be obtained from the scientific literature.

Vulnerability/adverse effect of climate change, losses in economic terms or in other dimensions of well-being such as health: The impact of climate change on main crops of the Thrace Region, wheat and sunflower, on water resources both quality and quantity, were simulated under different scenario until 2100 with 10 year intervals within the scope of CCGS/042 project of Capacity Building in the Field of Climate Change in Turkey Grant Scheme. The vulnerability can be simulated using the impact data by the aid of available models.

Resilience, defined as the capability of a system to minimize the magnitude of adverse impacts or enhance positive effects towards greater adaptive capacity: The positive impact of adaptive strategies of CSA can be partly obtained from the R&D project results and partly from the experimental study that will be carried out in AGREEN Project. In this case, country specific adaptive practices of CSA should be decided. CSA adaptive practices may be related to soil management, water/irrigation management, crop management, agricultural system management, financial management, agricultural policy management.

3.3 Research limitations

Theoretical and physical tools and methods are available to assess the decided adaptation, mitigation and resilience practices combined with the crop models. However, the time is limited and research facilities of the partner institutions may not be sufficient for experimental studies; the available physical and socioeconomic data for present and future and their quality may not be at the desired level for the theoretical studies.

4. State of art of organic farming and sustainable agricultural practices in Turkey

4.1 Country-specific conditions for sustainable agriculture implementation

Efforts to solve agricultural environmental problems in the world constitute the first step of sustainable agriculture systems based on protecting human health and natural resources. Organic farming (OF) and good agricultural practices (GAP) that emerged in this context are accepted as the most common sustainable farming systems today. According to the International Federation of Organic Farming Movement (IFOAM), OF is expressed as a production system that protects human health and maintains the ecosystem. This system is based on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs that have negative effects (Anonymous, 2009). In GAP, although chemical input applications are in question, these practices are applied in a way that does not harm human health and the environment (Hasdemir, 2011). In the prevention of environmental problems in the world, the development of sustainable agriculture systems is considered as a priority target (Eryilmaz et al, 2019).

Organic farming is a sustainable agriculture system focused on human and environment, based on the protection of ecological diversity. OF in Turkey started in the Aegean region in line with the demands of European importers in middle of the 1980s, then spread to other provinces. Although farmers has led to organic farming movement in developed countries, European private companies have played an active role in adopting organic farming in Turkey (Demiryurek, 2011).

In 1991, the European Union (EU) imposed an obligation on countries that export organic products to EU countries to implement EU’s OF legislation. In Turkey, "Regulation on the Production of Plant and Animal Products Using Ecological Methods" was published for the first time in 1994 (Official Gazette, 1994). The legislation has subsequently been amended several times in order to adapt to EU legislation. Currently, the certification of organic agricultural products in Turkey are executed in line with the "Regulation on Organic Farming Principles and Practices" published on 18.08.2010. The purpose of the regulation is to determine the principles and procedures regarding the protection of ecological balance, the conduct of organic agriculture activities, the regulation, development and dissemination of organic production and marketing (Official Gazette, 2010).

Good agricultural practices have emerged in the context of the commitments of food processing and retail firms, farmers, agricultural workers and consumers on food production, quality and safety, and the environmental sustainability of agriculture in the medium and long term food safety, food quality, production efficiency, meeting specific goals of environmental gains (Icel, 2007). GAP have emerged in the context of commitments on food quality and safety and environmental sustainability of agriculture in the medium and long term (Icel, 2007). In good agricultural practices, it is aimed to minimize the environmental damage caused by agricultural activities by reducing the use of chemical fertilizers and pesticides within a certain program (Eryilmaz et al, 2019).

Good agricultural practices in Turkey is one of the sustainable agriculture systems implemented towards the end of the 2000s. Legal regulations on good agricultural practices started with the "Regulation on Good Agricultural Practices", which was first published on 08.09.2004. According to the regulation, the purpose of GAP is the realization of a production model that does not harm human and animal health, adopts an environmentally friendly agricultural production, ensures traceability and sustainability in agriculture, and aims to protect natural resources and food safety (Official Gazette, 2004b). The regulation determines the rules and conditions of standards regarding good agricultural practices, the way of certification, the duties and responsibilities of individuals and organizations. GLOBALGAP protocol, the certification related to the required standards for GAP, allows the international trade of GAP in in developing countries such as Turkey (Eryilmaz et al, 2019).

Turkey encourages OF and farmers in GAP and provide financial support to promote these practices. OF and GAP are made support payments since 2005 and 2009, respectively. In addition, support payments are made to OF and GAP within the scope of CATAK Program (Protection Program of Agricultural Lands for Environmental Proposes) in order to protect the soil and water quality, sustain natural resources, prevent erosion and protect the areas for reducing the negative effects of agriculture. In a study conducted in Goksu Delta, it was determined that the most effective factor for paddy producers to make good agricultural practices is CATAK support (Polat an Dellal, 2016, Eryilmaz et al, 2019). In European countries, it is stated that the supports provided independently of production have a protective effect on the agricultural sector (Meijl et al., 2006, Eryilmaz et al, 2019).

4.2 National capacities

Despite its natural resources such as uncontaminated soil and water and its appropriate ecology, Turkey also has problems restricting the development of OF such as the small scale of agricultural enterprises, fragmented and dispersed land increases the certification cost of the individual producer. For this reason, small producers mostly produce within the group by contracting with intermediary merchants, processors or marketing companies. In this model, while the control and certification fee per producer decreases, serious problems are experienced regarding the validity of the contract or the ownership of the certificate. In this system, which does not include purchase and sale guarantees due to commercial concerns, the producers who do not have an individual certificate have problems while marketing their remaining product and cannot market their product as organic product without the permission of the certificate holder. This situation causes the product to be sold conventionally under cost. In addition, the inadequate organization of producers in organic agriculture and problems in accessing alternative markets cause small producers to give up organic production.

As in the rest of the world, the support provided to producers has been of great importance in the adoption and directing the producers to organic agriculture in our country.

Although the increase in OF production continues over the years, due to the mentioned problems, the target of 3% in terms of production area envisaged in the Ninth Development Plan (2007-2013) has not been reached yet. As of 2016, the share of OF in total agricultural areas has reached approximately 2%.

“Organic Agriculture Strategic Plan” and “National Organic Agriculture Action Plan” were prepared with the contributions of all relevant stakeholders in order to develop and spread organic agriculture.

Within an 11-year period between 2005 and 2016 the number of producers, production area (ha) and production increased 4.71, 2.57 and 5.85 folds, respectively (Table 6)

Good agricultural practices based on control-certification within the framework of the country's legislation started in Turkey with the Regulation on GAP published in 2004. After the authorization of the control and certification bodies, GAP, which started with 651 producers in 5.360 ha and in 18 provinces in 2007, showed a significant improvement in 10-year period between 2007 and 2016 and reached 5.027.892 tons of production in 64 province with 55.609 producers (Table 7).

Table 7 Organic farming and good agricultural practices in Turkey (Anonymous, 2016)

Year	Organic Farming			Good Agriculture Practices		
	Numbre of producers	Production area (ha)	Production (ton)	Number of producers	Production area (ha)	Production (ton)
2002	12.428	89.827				
2003	14.798	113.621				
2004	12.751	209.573				
2005	14.401	203.811	422.934			
2006	14.256	192.789	458.095			
2007	16.276	174.283	568.128	651	5.360	149.693
2008	14.926	166.883	530.225	822	6.023	168.190
2009	35.565	501.641	983.715	6.020	170.280	2.709.132
2010	42.097	510.033	1.343.737	4.540	78.174	1.902.072
2011	42.460	614.618	1.659.543	3.042	49.963	1.717.222
2012	54.635	702.909	1.750.127	3.676	83.717	1.538.556
2013	60.797	769.014	1.620.387	8.170	9.809	1.599.636
2014	71.472	842.216	1.642.235	21.332	214.770	4.151.661
2015	69.967	515.268	1.829.291	39.740	346.569	3.271.239
2016	67.878	523.778	2.473.600	55.609	474.107	5.027.892

4.3 Existing policies and instruments for funding

The agricultural sector is one of the most important sectors due to reasons such as employment, contribution to national income and foreign trade, meeting the food needs of the growing population and providing raw materials to the industry. For this reason, various agricultural policies have been developed to ensure productivity and continuity in the agricultural sector (Sayin et al., 2015; Yildiz, 2017, Yuceer et al. 2020). Because the applied agricultural policies are aimed at the economy of the countries and the solution of the problems of the agricultural sector in the relevant country, the determining factors in agricultural support policies are different according to countries (Dogan and Gurler, 2015, Yuceer et al. 2020). While some countries develop policies on food safety of agricultural products, some countries implement agricultural policies to increase the contribution of the sector to the country's economy (Arslan and Solak, 2019; Yuceer et al., 2020).

In Turkey after the 2000s, a number of changes have been made in agricultural policy tools and hence practices that bring about these changes has led to a series of changes in agriculture (Yuceer et al. 2020). The reason for the extensive changes made to agricultural policy in Turkey is external and internal dynamics that occur in 2000s.

External dynamics that led to the gradual removal of past policy instruments and their replacement with new systems are obligations arising from the World Trade Organization (WTO) Agriculture Agreement, the full membership negotiations carried out with the European Union (EU), the letters of intent presented to and agreements made with the International Monetary Fund (IMF) and the World Bank (WB) (Guresinli, 2015 Ataseven et al.2020, Yuceer et al. 2020).

Internal dynamics effective in the formation of national agricultural policies have been shaped under the influence of external dynamics such as EU, WTO, WB, IMF. The internal dynamics affecting national agricultural policies are the financial burden on the budget caused by the supports within the country, the current account deficit and the increasing external debt, the ongoing structural problems in the country's agricultural sector and political instabilities (Ataseven, 2020; Koc et al.2015; Yuceer et al. 2020). On the other hand, climate change, environmental problems and social, cultural and economic changes occurred in rural areas have also played an important role in the determining agricultural policies (Ataseven et al.2020).

“Agricultural Reform Implementation Project-ARIP, 2001-2008” within the scope of "Economic Reform Loan" to fulfil the commitments given to the IMF and the financial support of the WB, has led to the biggest change in agricultural policies (Ataseven et al., 2020; Tan vd., 2010; Yuceer et al. 2020) While it was aimed to create a harmonious and competitive agricultural structure within the framework of this agreement, it was also emphasized that the pressure created by the agricultural sector on the budget should be reduced (Tan et al., 2010; Yüceer et al. 2020).

The Agricultural Reform Implementation Project (ARIP) has 3 main components. These are (Yavuz, 2005; Yuceer et al. 2020):

- Direct Income Support (DIS),
- The gradual removal of price supports and credit supports that mostly cause to increase the incomes of large-scale enterprises,
- The privatization of state-owned enterprises in the agricultural sector and reducing government intervention in the processing and marketing of agricultural products.

As a result; within the scope of ARIP, input subsidies, price supports, credit supports were removed and Direct Income Support (DIS) was introduced in order to provide support in a single item (Tan et al., 2010; Aktas and Tan., 2007; Yuceer et al. 2020). Direct Income Support is cultivated area based payments regardless of the price of the product or the amount of the product produced. It has also replaced interventions that distort the market by including payments that are related to production to a certain extent (i.e., price, input and loan) (Ataseven et al., 2020; Ataseven, 2016; Ateş et al., 2017, Yuceer et al. 2020). The most important contribution of DIS is the Farmer Registration System (FRS), which is a prerequisite for the implementation of the system (Ataseven, 2016, Ataseven et al.2020, Yuceer et al. 2020).

After the year 2000, "Agricultural Strategy Document (2006-2010)" was the first document which was prepared in 2004 at the national level as an important step in relation to agriculture. This document n is considered as another important development in the history of agricultural policy of Turkey apart from the ARIP project. Considering also the EU harmonization efforts, the Agricultural Strategy Document aimed to create a highly competitive sustainable agricultural sector, which deals with the social, environmental, economic and international developments as a whole with the principle of efficient use of resources, enables producers' organization, provides easy access to marketing opportunities for producers by improving the agricultural marketing infrastructures (Koc et al.2015, Yuceer et al. 2020).

Following the Agriculture Strategy Document, the "Agriculture Law" No. 5488, which determines the purpose, scope and subjects of agricultural policies, entered into force on April 25, 2006. The law also defined the objectives and principles of agricultural support policies and support programs and established the basis of support (Anonymous, 2006; Demirdogen ve Olhan, 2014; Yuceer et al. 2020).

Among the developments that significantly affected the agricultural markets in the analysed period, enacting the Sugar Law in 2001, the Organic Agriculture Law in 2004, the Agricultural Insurance Law in 2005, the Seed Law in 2006 and the Biosafety Law in 2010 can be listed (Demirdogen and Olhan, 2014, Yuceer et al. 2020).

On the other hand, rural development policies in Turkey with a new approach began to be carried out since the 2000s, rural development model based on the project that would strengthen agriculture-industry integration in the countryside became widespread. The main reason for this approach is the change in the nature of agricultural subsidies, diversification in agricultural support instruments, multi-functionality given to rural areas and agriculture, institutionalization in regional policies and the positive effects of the EU harmonization process. In this direction, policy documents were published for the first time under the name of National Rural Development Strategy and Rural Development Plan during the Ninth Development Plan period (2007-2013) for rural development (Anonymous, 2015, Yuceer et al. 2020).

Deficiency payments support was first initiated in 2002 for seeds, olive oil and cotton, followed by tea (2004), cereals and paddy (2005) and legumes (2008). The deficiency payments support is applied when the production costs of producers are above the market price without affecting the prices paid by consumers. The difference between the market price and the target price calculated based on production and marketing costs (http://www.tek.org.tr, March 2021). With this support, the government aimed to change the crop pattern by following the ecological conditions and to increase the production of crops with shortage while reducing the excess supply in some products (Anonymous, 2020).

Since the mid-2000s, some rural development policy frameworks have emerged as part of the road towards the EU acquis. Thus, it was aimed to determine the needs of the country in the field of rural development in the pre-access period.

Within the scope of the European Union Instrument for Pre-Accession Assistance (IPA), grant support has been given to investments since 2011 by the Instrument for Pre-Accession Assistance Rural Development (IPARD). In this context, the first period of the IPARD program was completed in 2013 and the second period in 2020 (Anonymous, 2020).

In 2009, "Turkey Agricultural Basin Production and Support Model " was implemented by the Ministry of Agriculture and Forestry. In this context; Turkey is divided into 30 agricultural basins, whose climate, geographical conditions and ecology are similar; where crops can be grown in the most economical way, that are in manageable size, and production plans were aimed to be made in these basins (Dogan and Gurler, 2015; Oguz et al., 2012; Yuceer et al. 2020). According to this model, in which basin a crop would be grown in the most efficient way, that crop would be supported in that basin only. Therefore, with the basin-based support model, there is no crop with or without support premium for the first time, a situation similar to the previous supports has emerged since it is possible to support any crop in any basin (Olhan, 2012).

With the National Agriculture Project launched in 2017, it is aimed to guarantee sustainable agricultural production and food security, to increase the welfare of farmers, to gain more place in the global competitive environment and to leave a more liveable country to the next generations. The National Agriculture Project has been categorized under two main headings: Support Model for Domestic Production in Livestock and Basin Based Support Model (Anonymous, 2018).

In this model, 941 agricultural basins are designated in Turkey, an ecological and economical crop support map was created for 21 strategic crops with supply shortages, important for human and animal nutrition and health. These crops are sunflower for oil, rye, safflower, wheat, olive oil, barley, hazelnuts, oats, lentils, corn, chickpeas, rice, triticale, dried beans, potatoes, canola, soybean, cotton, onion (dry), fodder crops and tea.

In Turkey with a very rich climatic diversity, the Agricultural Basin Based Support Model provides priority support of the most economically advantageous or least disadvantaged products in a region, taking into account the principle of comparative advantage between regions. It is particularly important in terms of evaluating the production potential of the agricultural basin (Tan et al., 2015). In 2020, the number of agricultural basins were increased to 945 and crop patterns to be supported within the Basin Based Support Model were determined (Anonymous, 2020a). The most important contribution of the model to the Turkish agricultural economy is the determination of agricultural basins and the creation of a healthy agricultural inventory, demand-based production planning, support of production on basin basis, and efficient and rational distribution of supports (Eroglu et al, 2018).

In the Agriculture Law, it is foreseen that the amount of resources to be allocated to agriculture from the budget should not be less than 1% of the Gross National Product (Semerci, 2019). However, no such source has been allocated since the enactment of the Law until today (Yuceer et al. 2020)

Instruments for Support

Agricultural Support Instruments may be classified into:

- Direct income support payments,
- Premium support (deficiency payments),
- The alternative crop support,
- Rural development support,
- Crop insurance support,
- Environmentally Purposed Agricultural Land Protection (CATAK) Program supports, and
- Many other support tools such as rural development supports.

Direct Income Support Payments (DIS)

DIS payments is made over the unit payment amount (TL per da, da = 1000 m^2) determined each year over the lands cultivated for agricultural production. Payment amounts can be determined at different levels to facilitate the producers' compliance with the agricultural policy objectives. In parallel with the development of the farmer registration system (FRS), payments is made to farmers growing certain crops.

Premium Support (Deficiency Payments)

Premium supports are currently implemented on a product basis in Turkey. It was initially applied within the scope of products with a lack of supply in the market, and as of 2018, oilseed plants, grains, legumes, grain corn, olive oil, hazelnuts, fresh tea, lentils and chickpeas in basins where groundwater are insufficient and/or water constraints are determined by the state are under support. Premium payment supports are given to the farmers in the form of direct government payments within an annual program (Russo, 2007; Bal, 2019).

Premium supports payments encourage local production, reduce imports, increase exports, and ensure that products reach the targeted production level in order to reduce investment risks. It is aimed to use the resources effectively and to increase the quality of the supported products. Premium supports make it easier for products to adapt to world market prices, enabling consumers to buy products at more reasonable prices (Yavuz et al., 2016; Bal, 2019).

Alternative Crop Support

It was developed in order to restrict the production of crops (like tobacco) that are produced more than needed and to prevent waste of resources. As stated in Article 19 of the Agriculture Law No. 5488, support is provided to farmers to prevent income losses that may arise as a result of planting alternative crops on their land. The amount of support to be made to each farmer is found by multiplying the land allocated by the farmer for alternative crops and the amount to be paid per unit. Additional payments can be made to farmers to finance their necessary investments during the production, processing and marketing of alternative products. With alternative product support, it is aimed to replace the crops that are short in supply like, corn, sunflower, soybean, forage crops, lentils, wheat, chickpea and cotton with the crops that are excess in demand like sugar beets, nuts and tobacco. Farmers' registration to the Farmer Registration System (FRS) is the prerequisite for the payments under Alternative Product Supports (Erdinc and Erdinc, 2001; Bal, 2019).

Rural Development Support

The main purpose of rural development supports is to use the agricultural areas efficiently and effectively, to increase the income level of the farmers, to improve the social structure, to encourage entrepreneurship, to improve the technologies and mechanization in rural areas. With this aim, part of the costs of investment projects in this field are covered by the public. Principles such as sustainability, target audience, use of appropriate technology, and dissemination of modern systems must be followed for a project to be supported (Bal, 2019).

There are many support programs in the field of rural development. The most common one is IPA Rural development (IPARAD) support. The purpose of IPARD support is to ensure the application of the experience gained on subjects such as plant and animal health by ensuring sustainable development within the framework of the common agricultural policy with the EU.

Agricultural Insurance Supports

Agricultural insurances have been supported by governments in order to guarantee farmers' agricultural production tools and products against various risks (unpredictable changes in weather conditions, inefficiency or insufficient yield, etc.) and to minimize the risks they may encounter. Agricultural insurance principles have been laid down in order to compensate farmers' losses as a result of the risks specified within the framework of the Agricultural Insurance Law No.5363 and to provide premium support. It supports the farmer by paying a portion of the state insurance premium to obtain insurance. The first agricultural insurance policy that was applied in receipt of government support in Turkey June 1, 2006. The amount of agricultural insurance premium paid by the state was determined as 50% in terms of products in 2014. State Supported Agricultural Insurance was implemented in 81 provinces and 958 districts between 2006-2017. In total, 123 billion TL of agricultural assets were insured and 3.42 billion TL of state premium support was provided. 3.99 billion TL compensation was paid. New products with the title of District Based Drought Yield Insurance were included in the Multiple Risk Insurance applied in 7 different branches in 2017 and 2018 (Bal, 2019).

Environmentally Purposed Agricultural Land Protection (CATAK)

CATAK Program aims to protect the quality of soil and water, which are the main resources of agricultural production, to reduce the negative effects on the environment due to agricultural production, to ensure the sustainability and balance of natural resources, to direct renewable energy resources in this sector and to develop these resources. Environmental protection is ensured by conserving natural vegetation cover and biodiversity and controlling soil erosion in the target area. CATAK Support is calculated on a unit area with the agreements made between the relevant Ministry and the farmers (Bal, 2019).

Support payments are made for 3 years in three different categories within the scope of the program (Hasdemir and Hasdemir, 2016).

Category 1: These are applications based on soil cultivation. 45 TL/da is supported on issues such as preventing landslides and increasing the productivity of the soil.

Category 2: Conservation of soil and water infrastructure and prevention of erosion. 60 TL/da is supported for issues such as appropriate agricultural activities and agricultural struggle, determination of the most accurate irrigation system.

Category 3: Environmental farming methods and cultural practices. 135 TL/da is supported for application and fertilization with appropriate methods to protect the environment. Organic Farming and Good Agricultural Practices are considered in this category.

Area Based Supports

Area Based Supports are Hazelnut Field Based Income Support, Good Agricultural Practices Support, Diesel, Fertilizer and Soil Analysis Support, Organic Farming Support, Small Family Business Support for Crop Production and Alternative Product Support. Support for Small Family Business Producing Plants is 100 TL per da, Area-Based Income Support for Hazelnut Producers is 170 TL per da.

Soil Analysis is 40 TL per sample while OF Support is in 4 categories. Production in the first category is 100 TL per da, the second category is 70 TL per da, the third category is 30 TL per da, the fourth category is 10 TL per da.

Total agricultural support and their ration in GDP between 2002 and 2007 are given in Table 8. The rate of support given to agriculture in GDP has always remained below the committed ratio of 1%.

4.4 Domestic and international markets for climate smart agriculture

Global climate change, regional economic and political crises and epidemics have a significant impact on agriculture and food markets. There is a process in which technological developments come to the fore in the management and administration of the agricultural sector.

In this direction, FAO determined 15 major global trends that are expected to shape and affect the present and future of the world agriculture and food sector (FAO 2017). These trends are:

Table 8 Total agricultural support and their ration in GDP (TUIK: https://www.tuik.gov.tr/).

Years	Support Amount (Billion $)	Ratio in GDP (%)
2002	1.589	0.63
2003	2.020	0.64
2004	2.153	0.53
2005	2.750	0.55
2006	3.294	0.6
2007	4.340	0.64
2008	4.577	0.59
2009	3.075	0.48
2010	3.959	0.51
2011	4.224	0.51
2012	4.258	0.49
2013	4.751	0.5
2014	4.210	0.45
2015	3.670	0.43
2016	3.799	0.44
2017	3.498	0.42

- Population growth, urbanization and aging,
- Global economic growth, investments, trade and food prices,
- Competition for access to natural resources,
- Climate change,
- Agricultural productivity and innovation,
- Transboundary diseases and pests,
- Conflicts, crises and natural disasters,
- Poverty, inequality and food insecurity,
- Nutrition and health,
- Structural changes and employment,
- Migration and its impact on agriculture,
- Changing food systems,
- Food loss and waste,
- Management mechanisms for food safety,
- Development economics, and
- Biofuels.

In addition, 10 subject areas and challenges to be faced today and in the future in order to eliminate hunger, food waste and unsustainable issues and food insecurity indicated by these trends have also been identified (FAO 2017). These are listed as follows:

- Increasing agricultural productivity sustainably in order to meet the increasing demand,
- Creating a foundation for sustainable natural resources,
- Addressing climate change and intensification of natural hazards
- Preventing cross-border diseases and pests,
- Eliminating extreme poverty and reduce inequality,
- Ending hunger and eliminating all kinds of malnutrition,
- Developing income generating opportunities in rural areas and addressing the root causes of migration,
- Gaining resilience to prolonged crises, disasters and conflicts,
- Making food systems more effective, inclusive and flexible,and
- Meting the national and international management needs in a harmonious and effective manner.

The subject area and challenges are in line with the scope of CSA and general objective of AGREEN project.

In 2018, Republic of Turkey Ministry of Development prepared "Competitive Agriculture and Food Production Expertise Commission Report" for the 11th (2019-2023) Development Plan (Anonymous, 2018: https://www.sbb.gov.tr/wp-content/uploads/2020/04/Tarim_ve_GidadaRekabetciUretimOzelIhtisasKomisyonuRaporu.pdf). (FAO 2017). This section has made extensive use of this report.

The world population, with an average increase of approximately 1.2% in the last ten-year period, reached to 7.8 billion whereas Turkey's population became about 83.7 million. The world population will reach 9.1 billion by 2050 with an increase of 34% and the problem of feeding the world population will be one of the priority policy areas of all countries and international organizations. The increase in income of the increasing urban population will change the traditional food demand based on basic food and this will create significant changes in the global agriculture and food production capacity and habits (FAO, 2017).

The agriculture sector in Turkey, with the exception of 2016, generally grown in recent years and has contributed significantly to the national economy. In 2020, the share of agriculture in GDP was 6.5% and its share in employment was 19.8% (TUIK, 2020).

In recent years, global agricultural production has reached significant levels. In 2016, world grain production exceeded 2.1 billion tons while oilseed production exceeded 570 million tons. Between 2000 and 2016, soybean with an increase of 108% and corn with an increase of 79% stand out among the products whose production increased the most. The production of wheat, which can be produced by many countries around the world, increased by 28 % in the same period (FAO, 2018). Due to its food, feed and industrial use, oilseeds have been even more important. Oilseed consumption is expected to increase by 18% and grain and rice consumption by 8 % in the next decade (Anonymous, 2018).

Global agricultural growth rate slows down, but the agricultural growth of developing countries continues to increase. For this reason, the share of developing countries in the world foreign trade of agricultural products, which reached 1.4 trillion dollars from 457 billion dollars between the years of 2001-2016, increased from 32% to 53% (Anonymous, 2018). This data shows that developing countries like Turkey, which is agro strategically prominent, will become increasingly important in the future of agriculture and food industry.

In the management of agricultural operations, manual work is replaced with, in sequence, mechanical systems, hydraulic or pneumatic machines, electronic-GPS-satellite-information communication, and cyber-physical systems. In the current period, the "Fourth Industrial Revolution", which is a new industrial vision on a global scale, is taking place. In the Fourth Industrial Revolution, there are machines, products, systems, processes that are more widespread and in communication with each other with the mobile internet, and digital and information technologies are used at the highest level. It is aimed to increase productivity, quality and added value in agriculture with smart technologies. With Agriculture 4.0, a significant competitive advantage will be achieved by working less but smarter, obtaining more and better quality products with less resources. Turkey should improve the technology used in the agricultural production system, use this technology at the highest level and thus should be in a position to compete in the international arena with no delay (Anonymous, 2018).

Although the misuse of agricultural land has increased, crop production is increasing with the increase in yield. Turkey obtains approximately 160 million tons plant production including forage crops from about 23.1 million hectares of arable land. Despite the shrinkage in fallow land, the cultivated area (devoted for field crops) has decreased to 15.6 million hectares. There is a decrease in cultivated areas and an increase in planted areas (devoted for orchards and vegetables). In fruit and vegetable products where Turkey is self-sufficient, it is necessary to plan the production of the quality desired by the market and to reduce the losses, and to improve the production of oil seeds and legumes, where the amount of imports has increased.

Turkey also experienced significant changes in the foreign trade of agricultural and food products. Turkey's share in the global food and agricultural exports increased from 0.8% to 1.2%. As of 2016, exports of agricultural products were 16.9 billion dollars and imports were 15.6 billion dollars. Due to the developments in the domestic market prices of agricultural and food products in 2017, periodic changes were made in customs taxes. As a result of these developments, as of 2017, exports of agricultural products were 17.6 billion dollars and imports were 18.3 billion dollars, and the ratio of exports to imports declined to 96 percent. However, a foreign trade surplus of 4.3 billion dollars in foodstuffs still continues (TUIK, 2018; Anonymous, 2018).

In the Eleventh Development Plan period (2019-2023), the crop production sector aims at important developments in production and export with the vision of a highly competitive and well organized crop production sector that provides environmentally, socially and economically sustainable, sufficient and reliable food. Within the framework of the 2023 vision, a target of 150 billion dollars agricultural income and 40 billion dollars export of agricultural products has been set for the agricultural sector. In order to achieve these goals, substantial transformation is expected in the plant production sector in the management, structural condition, supply and demand areas of the system.

As for the domestic and international markets for CSA, because CSA is a new concept, data on the global CSA market size is very limited while there is no data on domestic CSA market size.

A report by Grand View Research (https://www.grandviewresearch.com/industry-analysis/smart-agriculture-farming-market) entitled with "Smart Agriculture Market Size, Share & Trends Analysis Report 2018 – 2025" discusses the smart agriculture market size in general.

Smart farming was defined as an integrated approach to manage farming activities, such as preserving resources and optimizing yields, with the implementation of IoT and information communication technologies. Smart farming entails real-time data on the conditions of soil, air, and crops. It aims at ensuring profitability and sustainability of the farm yield while protecting the environment.

Based on agriculture types, the smart farming market has been segmented into precision farming, smart greenhouse, livestock monitoring, and others. The others segment includes fish farming and horticulture.

The market estimates and forecasts of the smart greenhouse segment include vertical farming. Smart greenhouse enables farmers to cultivate crops with minimal human intervention. Climatic conditions such as soil moisture, temperature, and humidity are continuously monitored and any variation observed in them triggers an automated action.

The global smart agriculture market size was valued at USD 5.79 billion in 2016. Increasing automation of commercial greenhouses and growing implementation of the Controlled Environment Agriculture (CEA) concept in greenhouses, in a bid to obtain higher yield and maintain optimum growing conditions, are the key factors driving demand over the projected period.

De Pinto et al. (2020) analysed climate smart agriculture and global food-crop production in a research paper. They used two scenarios: Business As Usual Scenario (BAU) and Climate Smart Agriculture Scenario. BAU scenario reflects the use of current practices and technologies throughout the 2010–2050 period and assumes that agriculture is developing under climate change conditions.

CSA scenarios were constructed by assuming that farmers who are currently using a particular set of practices to grow maize, wheat, and rice are offered a portfolio of alternatives from which to choose (i.e. the four CSA practices considered). Their analysis focuses on four major categories of agricultural practices: no-till, integrated soil fertility management, nitrogen use efficiency and alternate wetting and dry. They have been shown to have positive impacts on yields and GHG mitigation across a wide range of conditions, but they all require specific modifications and adjustments on the ground. As a consequence, the modelling work presented is a stylized representation of a range of many technologies and practices that would be identified using the CSA approach. The results were discussed in terms of (https://www.grandviewresearch.com/industry-analysis/smart-agriculture-farming-market):

- Price and production,
- Greenhouse gas emission,

- Other effects related to emissions,
- Adaptation and resilience, and
- Effects of adoption rates and production costs.

Price and production: Price and production projections for the BAU scenario indicate that global production of maize, wheat, and rice in 2050 will increase by 47% (36–58%), 42% (40–44%), and 19% (18–20%) respectively, compared to 2010. Prices are projected to increase by 80% (56–103%), 35% (24–46%), and 52% (44–60%) respectively. Therefore, despite the impact of climate change, production of these three main cereals is projected to increase. After economic growth and changing incomes and diets are considered, by 2050 according to BAU projections there will be 47 million (45–48) fewer undernourished children and 385 million (361–410) fewer people at risk of hunger.

Compared to BAU, by 2050 CSA practices are estimated to increase global production of maize by an additional 4% (1–9%); wheat production is also estimated to increase by about 4% (1–9%). CSA practices appear to have the largest effect on rice, for which production is projected to increase by about 9% (4–16%).

Prices are still projected to increase but compared to BAU their growth is reduced by 8% (3-17%) for maize, by 11% (3-25%) for wheat, and by 27% (13–42%) for rice. As a result, the population at risk of hunger decreases more than what is projected by the BAU scenario. The number of people at risk of hunger is reduced by an additional 34 million (10–69 million) by 2050.

Greenhouse gas emission: Global GHG emissions decrease under CSA scenarios, but there are important distinctions between the practices. The reduction in GHG emissions is estimated to be equivalent to 44 Mt CO_2 e yr^{-1} 101 Mt CO_2 e yr^{-1}. It is important to note that the effects on emissions vary from country to country.

Adaptation and resilience: The effects on production, prices, soil, and land use suggest that CSA practices are a form of adaptation to new climate conditions and make crop-production more resilient. A comparison with a scenario in which the effects of climate change on future crop production are removed show that the production gains obtained from CSA practices can offset the negative impacts of climate change on maize and rice production and slow down consequent increases in prices. CSA practices are also successful in reducing the price of wheat which, despite an increase in production, is projected to increase in the BAU scenario.

Effects of adoption rates and production costs

Social and cost barriers significantly affect the results with an overall reduction in benefits. Compared to BAU, yearly production for the three crops increases on average by 60 Mt and GHG yearly emissions are reduced on average by 13 Mt CO2e.

De Pinto et al. (2020) concluded that that widespread adoption of CSA practices can increase production and lower world prices of wheat, maize, and rice under future unfavourable climatic conditions. The reduction in prices is projected to make food products more accessible to millions of people thereby lowering the number of people at risk of hunger and that of undernourished children. These gains can be obtained while improving soil fertility and with a reduction in GHG emissions. Taken all together, results suggest that CSA practice can deliver benefits across its three foundational pillars on a planetary scale. CSA with its multi-objective approach may provide a useful framework for decision-making ranging from the farm to the policy level. However, for this to occur significant investments must be made (https://www.grandviewresearch.com/industry-analysis/smart-agriculture-farming-market).

4.5 Benefits of Climate Smart and Green Agriculture practices

Economic aspects of green agriculture

Organic farming standards applied in Turkey have been harmonized with international standards. Organic farming, which is an important part of the agricultural development in Turkey, is a continuous upward trend in recent years. Due to the increase in the number of producers and production in recent years has shown great improvement. The number of organic farming producers has increased 4.17 folds in the 10 years from 2007 to 2016, and the production area has increased 3 times. In good agricultural practices, the number of producers increased by 85 while the area increased by 88 times between the same years (Table 9) (Eryilmaz et al, 2019).

In sustainable agriculture systems, soil fertility decreases for a certain period of time with the restriction of chemical inputs or transition to organic agriculture. Demirci et al. (2002) found in their study that the yield of some organic products (seedless raisins, olives, cotton, barley and wheat) is 5-20% lower than conventional products, and their selling prices are 10-15% higher. In the research, it was stated that the price advantage in organic products does not always compensate for the yield losses, the net profit loss due to low yield and high unit cost is 25-60%. In addition, during the transition to organic agriculture, products produced in lesser amounts are sold at the same prices as conventional products, since they do not qualify as organic products (Eryilmaz et al, 2019).

There is no such transition period in good agricultural practices. However, restrictions on the use of chemical inputs cause loss of yield and, accordingly, income in good agricultural practices. In a study conducted by Eryılmaz and Kılıc (2018), it was determined that the gross profit obtained with good agricultural practices is 8.6% lower than conventional agriculture. And 54.02% of this decrease in gross profit can only be met with financial support given to good agriculture (Eryilmaz et al, 2019).

Turkey began organic farming in line with external demand, but also in the domestic market have shown improvement over time, however, the weight is still producing for foreign markets. The main reasons for the inadequate development of the domestic market are low income, high product prices, lack of marketing strategies and consumer unconsciousness (Ayla and Altıntas, 2017; Eryilmaz et al, 2019).

In 2019, organic products produced in Turkey and export values are given in Table 9. Approximately 95% of organic product exports, in terms of amount and value, are wheat and wheat products, fruit and fruit products, grape and grape products, fig and fig products, hazelnut and hazelnut products and apricot and apricot products (Ministry of Agriculture and Forestry official website, March 2021). Approximately half of the organic product produced in Turkey are exported to the United States. This is followed by Germany, France and China (Eryilmaz et al, 2019).

Turkey's import of organic products is limited to 3880 tons. The most important imported organic products are soybeans, dates, flax seeds, dried fruits and coconut

Table 9. Organic products produced in Turkey and export values are given (Eryilmaz et al, 2019)

Name of the product	Produced amount		Value	
	tons	%	$	%
Wheat and wheat products	31.195	41,10	11.913.987	5,86
Fruit and fruit products	16.734	22,05	65.242.625	32,12
Grape and grape products	9.536	12,56	27.895.276	13,73

Fig and fig products	6.896	9,08	40.306.275	19,84
Hazelnut and hazelnut products	4.441	5,85	31.964.563	15,74
Apricot and apricot products	3.744	4,93	14.727.473	7,25
Vegetable and vegetable products	1.147	1,51	1.694.271	0,83
Others	850	1,12	2.198.961	1,08
Corn	815	1,07	2.983.475	1,47
Olive and olive products	178	0,23	394.232	0,19
Spices	138	0,18	1.850.384	0,91
Pistachio	86	0,11	1.566.455	0,77
Total	**75.759,34**		**202.737.976,94**	

The number of organic markets established with the contributions of local governments and non-governmental organizations is increasing. The organic market established in 2006 in Istanbul Sisli Town with the contributions of municipalities and non-governmental organizations, made a significant contribution to the increase of domestic consumption in order to facilitate the access of consumers living in metropolitan cities to organic foods, especially fruits and vegetables. Organic markets in different provinces, more than 20 in number, are developing day by day. However, it will be beneficial to develop a mechanism for effective control of organic markets in order to maintain consumer confidence in organic agriculture certification and to maintain the system in an appropriate way (Anonymous, 2018)

Social aspects of sustainable agriculture

Social benefits of OF and GAP to sustainable rural development can discussed into three ways:

First, employment diversity and women's employment in rural areas increase. Organic agriculture and good agricultural practices increase the demand for the workforce due to the substitution of organic inputs with chemical inputs and the implementation of agriculture within the framework of certain rules. Especially, weed control and similar work done by hand to a large extent leads to higher labour usage in organic agriculture. Most of these works including preparation for the markets are done by women. Therefore, sustainable agriculture makes a significant contribution to the sustainability of small agricultural enterprises (Eryilmaz et al, 2019).

Second, producers sell their organic product in local organic markets. These markets are places where cultural interaction between producers and consumers is ensured, local cultures are preserved and promoted to wider environments (Ayan et al., 2017a,b; Boz and Rasulov, 2018).

Third, ecological tourism opportunities arise in the enterprises that practice organic farming and good agricultural practices. Especially people living in big cities in developed countries tend to change their environment at regular intervals in order to get rid of the problems brought by urban life and working life. Ecological tourism which is developed to meet this need provides an opportunity to introduce village life to wider audiences through their farms that practice organic farming and good agricultural practices (Boz et al., 2018).

Environmental aspects of sustainable agriculture

In addition to chemical fertilizers used in high doses in order to obtain higher yields, pesticides used to control diseases and pests pollute agricultural soils and water resources and negatively affect biodiversity. Decrease in organic matter and weakening of vegetation increase soil loss with erosion and cause land degradation. Good agricultural practices limit the use of fertilizers and pesticides while organic agriculture eliminates the use of chemicals. Therefore, both activities ensure the environmental sustainability of agricultural production, prevent erosion and land degradation and preserve the biodiversity.

In Turkey, between the years 2002-2016, nitrogen fertilizers were used mostly whereas potassium fertilizers are used least. While the use of nitrogenous fertilizers was 45.11 kg/ha in 2002, it increased by 77.28% and reached 79.97 kg/ha in 2016. Between the same years, the use of phosphorus and potassium fertilizers increased by 87.28% and 80.14%, respectively.

Total pesticide uses in Turkey increased by %54 from 27.9 tons to 43.0 tons between the years 2002 and 2016. t is noteworthy that the most used pesticide type is fungicide since 2008 (Table 10).

Table 10. Pesticide uses in Turkey (active substance) (Anonymous, 2106)

Years	Pesticide use (1000 ton)			
	Insecticide	Herbicide	Fungicide	Total
2002	13.1	6.3	8.5	27.9
2003	11.9	9.9	11.3	33.1
2004	13.8	8.7	6.4	28.8
2005	16.3	11.7	12.6	40.6
2006	8.5	8.2	10.7	27.4
2007	22.0	6.7	16.7	45.4
2008	10.0	6.2	17.9	34.0
2009	11.5	6.0	17.4	34.8
2010	8.2	7.5	17.6	33.2
2011	7.2	7.4	18.1	32.7
2012	8.1	7.4	15.5	31.0
2013	8.6	7.3	16.3	32.2
2014	9.1	7.8	16.7	33.6
2015	9.7	7.8	16.0	33.5
2016	12.5	10.0	20.5	43.0

Wrong practices in chemical fertilizers and pesticides use create chemical residues in agricultural products and drinking water, threatening the whole environment, especially human health. As a result of improper fertilization, environmental problems such as salinization, heavy metal accumulation, nutrient imbalance, deterioration of microorganism activity, nitrate accumulation, release of nitrogen and sulphur-containing gases into the air, and thinning of the ozone layer occur (Sonmez et al., 2008).

4.6 Challenges before the implementation of CSA practices

Crop residues-benefits, conflicts and trade-offs

Crop residue is defined as the portions of crops remaining such as stems, leaves and roots, some fallen grain, and often some weeds in the field after the grain has been harvested. Crop residues may have a direct monetary value to the farmer for livestock feed as well as a value for soil and yield improvement that varies widely according to the environment. Additional uses may include erosion control, industrial products or building materials. Farmers can place a value on the residues according to theses using purposes. Depending on the areas of use, crop residues can be difficult for the farmer to estimate in monetary terms (Anderson and Siddique, 2015). These might include reducing or controlling wind and water erosion or incorporating into the soil to improve or maintain soil fertility (Bessam and Mrabet 2003; Lal 2010) which presumably increase or maintain crop yield in the longer term.

Crop residue retention is one of the components of conservation agriculture (CA), along with zero or minimum mechanical disturbance and crop rotation, (Verhulst et al. 2010; Kassam et al. 2012; Serraj and Siddique 2012, Anderson and Siddique, 2015) and is assumed to have value in both erosion control and in building soil organic carbon (SOC) (Prasad and Power 1991; Farooq and Siddique 2015, Anderson and Siddique, 2015).

Where use of residues for animal feed is customary (Saud et al. 2011) as in Turkey experiencing lack in fodder, there may be a trade-off between the value for grazing and the value for soil improvement or soil protection (Magnan et al. 2011; Mrabet et al. 2012; Scott et al. 2013; Valbuena et al. 2012, Anderson and Siddique, 2015). The adoption of zero tillage, and the presumed desirability of returning crop residues to the soil, has renewed focus on the value of residues for purposes other than animal feed. It has been inferred that CA should be a fixed system (FAO 2011) but it has also been suggested that there is scope to adapt it to fit various farming systems (Anderson and Siddique, 2015).

Anderson and Siddique (2015) overviewed the role and value of crop residues in dryland agriculture in aspects of biological evidence for soil and crop yield improvement, soil water, soil organic matter, crop yield, the value of crop residues, animal feed, controlling soil erosion and carbon sequestration:

Biological evidence for soil and crop yield improvement: In theory, increased water infiltration and reduced soil evaporation will lead to increased crop yield which, in the absence of other limiting factors, will lead to increased return of organic matter.

Soil water: Storage of limited rainfall in the soil during the fallow period after the harvest may be crucial for the soil moisture annealing, germination and emergence of the seed in the early stages of the next cropping season. Crop residues can help this in the ways of increased water infiltration (Hamblin et al., 1987; Marley and Littler 1989; Radford et al., 1992; Malinda 1995; Thomas et al., 1995; Schwilch et al. 2013) and reduced soil surface evaporation (Smika 1983; Sommer et al. 2012).

Soil organic matter: There are scientific evidences (Mrabet et al. 2012 and Loss et al. 2015) that no-till systems with stubble retention increase soil organic matter in comparison to the conventional tillage. However, residue retention in Australian rainfed crops suggests no increase even after 10 or more years unless annual rainfall exceeds about 500 mm (summarized by Chan et al. 2003). This is possibly due to the lower crop yields and residues that are produced under lower rainfall conditions, or to the likelihood that soil temperatures are higher in the low rainfall areas leading to destruction of soil organic matter (Hamza and Anderson 2010).

The increase of organic matter in the soil improves the physical properties of the soil and accelerates the infiltration of rainwater into the soil. In addition, by increasing the water holding capacity of the soils, it prevents the infiltration of water below the root zone and therefore crops benefited from the rainwater effectively. Climate change forecast in Turkey suggest that rainfall characteristic will change, i.e., the number of consecutive dry days will increase and very heavy rainfall will occur at one time. Under these conditions, the increase of soil organic matter provides maximum benefit from this irregular rainfall and prevents soil erosion to a significant extent.

Crop yield: Although there are research results showing that residue affects the plant yield negatively (Scott et al., 2010), it is stated that it generally increases (Pannell et al. ,2013, Ward and Siddique, 2015, Schwilch et al., 2013).

Farooq et al. (2011) found that the impact of conservation agriculture (including both zero tillage and residue retention) on crop yields was mostly positive, especially at lower rainfall, but suggested that where the yield of conservation agriculture crops did not exceed those of conventional systems, factors such as weeds and diseases may have been responsible.

The apparent lack of a robust relationship, or set of relationships, between soil organic matter percentage and crop yield may be due to some other factor or factors limiting yield such as water or nutrient availability. In general, there is some level of agreement that soil organic matter and crop yields are more or less linearly related up to about 2% organic carbon (Howard and Howard 1990; Janzen et al. 1992) but less agreement that a critical level exists across soil types and environments (Loveland and Webb 2003). However, the variability in these relationships suggests that the slope of the increase below 2% organic carbon is quite wide (Anderson and Siddique, 2015).

Considering the above given information, it seems likely that local climatic, edaphic and technological situations should be accounted for when attempting to extrapolate experimental evidence to commercial farms (Anderson and Siddique, 2015).

The value of crop residues:

Potentially competing uses of crop residue include livestock grazing versus soil protection and fertility improvement; soil improvement versus harvest and sale off-farm; burning to facilitate sowing operations of the succeeding crop (with additional fertilizer to replace lost nutrients) versus return to the soil. One of the constraints in valuing crop residues is the difficulty of comparing cases where a direct monetary return can be obtained for the residue itself with cases where the return only comes via animal production or survival, or through preservation of the soil resource (Anderson and Siddique, 2015).

Animal feed: In Turkey, it is common that the straw is sold in 20 kg package for livestock feeding. An advertisement is seen in Figure 9 that a package of wheat straw is 15 TL (approximately 1.5 €).

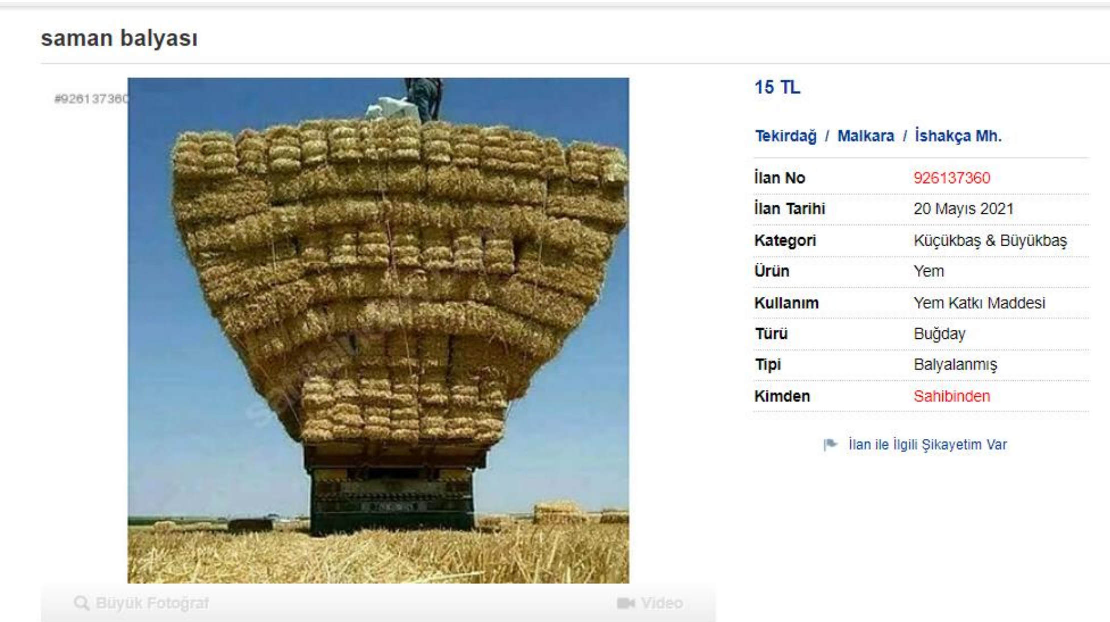

Figure 9. An internet advertisement of wheat straw for livestock feed in Turkey (https://www.sahibinden.com/ilan/hayvanlar-alemi-yem-mama-kucukbas-buyukbas-saman-balyasi-926137360/detay.).

In eastern Mediterranean countries, nomadic herders pay crop producers between US $ 20 and $ 60/ha for grazing rights depending on whether the land is irrigated or rainfed, and the crop residue is barley or wheat. The value in the market place will be decided by supply and demand for any given situation but the cost of nutrients removed by grazing or other means needs to be taken into account. (Anderson and Siddique, 2015).

Controlling soil erosion: The value of erosion control is more difficult to assess. The effectiveness of residue cover for reducing soil loss by wind or water erosion has been asserted, measured or modelled in a range of rainfed environments (Lyles and Allison 1976; Findlater et al. 1990; Hansen et al. 2012) but the amount of soil lost and its relevance to crop yield is not clear.

Erosion is one of the most important ecological problem threatening the world's natural resources. While about 25 billion t of soil are eroded into the seas every year by surface runoff. 6 million ha of productive agricultural land is deserted in the world due to this reason to an extent that can not be recovered (Kocaman et al, 2005).

Turkey is particularly vulnerable to erosion due to its geographic position, climate, topography and soil conditions. While human factors are the leading drivers of erosion in Turkey; the geographical position, topography and climate exacerbate erosion and obstruct control activities. Various minerals and organic matter transported by erosion sweeps away the productivity of soil along. Sediment transportation causes dams to be filled up long before their economic lifetime, thus leading to floods and overflows that claim human and material losses. Land degradation caused by intense erosion may also lead to substantial decrease in agricultural husbandry, exacerbating, in return, rural emigrations. Combating erosion is a must to ensure soil conservation, natural resources management and food security (https://www.tarimorman.gov.tr/CEM/Belgeler/yay%C4%B1nlar/yay%C4%B1nlar%202017/FAAL%20ING%201000%20AD.pdf).

The latest statistical records show that 63.3% of the total and 72.1% of the cultivated land in Turkey is experiencing water erosion problems (Dagdeviren, 1997). According to the sediment measurement from 26 basins all over Turkey, the magnitude of the average eroded soil into the seas, lakes, and dams is around 500 Million t per year (Kocaman et al., 2005). This means that 600 t of soil are carried from each 1 km^2 area per year in Turkey, which is 6, 17, and 22 times greater than that in North America, Europe, and Africa, respectively (Kocaman et al., 2005). 1/50 of the eroded soil in the world occurs in Turkey (Kocaman et al., 2005).

Improving soil physical condition to increase water intake during heavy rainfall events by increasing its organic matter and keeping the soil surface covered are the key factors to control erosion. Crop residue facilitates to take both of these measures.

Carbon sequestration: A further value of retaining crop residues lies in carbon sequestration for the purpose of reducing atmospheric carbon dioxide. Various values have been placed on soil carbon sequestration ranging from about US $ 25 to US $ 150/t (Antle et al. 2002: Belcher 2003). Given the relatively small amount of crop residue from dryland cereal crops, say 1–15 t/ha/year, it would take a long time to sequester each t of carbon. The potential for carbon sequestration in current cropping systems in Victoria, Australia has recently been questioned (Robertson and Nash, 2013).

In long term trials in northern Syria comparing zero-tillage with stubble retention and conventionally-tilled treatments, Loss et al. (2015) measured carbon sequestration rates associated with increased soil organic matter in the range of 0.27 to 0.30 Mg C/ha/year and they postulated that this rather modest increase was probably due to low to moderate crop productivity and a reasonable initial soil organic matter content of about 1.3% (Anderson and Siddique, 2015).

Rotations and other diversification options

Crop rotation: Cropping systems are increasingly simplified, with fewer and fewer crop species grown in rotation from year to year. But diverse rotations provide higher crop yields compared with continuous monoculture, in particular in years with low precipitation and high temperatures. Swedish, Polish and Italian researchers found this by analysing cereal yield data collected for decades from long-term agricultural field experiments from southern to northern Europe. Diversifying crop rotations emerges as an adaptation to a forthcoming warmer and drier climate (https://www.slu.se/en/ew-news/2020/11/crop-rotation-a-promising-way-to-improve-food-security-under-a-changing-climate/)

Global demand for food is predicted to increase by 50-70% in the coming forty years, according to FAO. Although yields continue to increase in many regions, they either never improved, stagnated or even collapsed across about one third of the growing area of major staple crops. Soil exhaustion, pest build-up and climate change play key roles for this worrying trend. We have lost 5.5% of global wheat production due to climate change alone between 1980 and 2008. We need to adapt our crop production systems to better cope especially with rising temperatures and more frequent and prolonged droughts, such as in 2018 in northern and central Europe. Crop rotation or diversification has been suggested as a general strategy to sustain yields and reduce risks of yield losses from adverse climatic conditions, through improved soil fertility, enhanced beneficial soil biota and suppressed build-up of weeds, pests and diseases. “But the trend in major cropping systems worldwide is that we grow cereals in shorter and shorter rotations, and in some places even in continuous monoculture”. For instance, in Thrace region of Turkey, wheat-sunflower rotation is practiced widely (https://www.slu.se/en/ew-news/2020/11/crop-rotation-a-promising-way-to-improve-food-security-under-a-changing-climate/).

Swedish, Polish and Italian researchers tested whether diversified crop rotations works as climate change adaptation strategy. They merged unique yield information in their countries from seven long-term agricultural experiments, thus spanning northern to southern Europe. The experiments were established as far back as in 1958. In each experiment, cereals grown in monoculture had every year since been compared with the yields from diverse crop rotations. By matching these yield time series with meteorological data from each location, the team could explore yield outcomes in, for instance, dry and hot, or wet and cold years. Growing multiple crop species in a year-to-year rotation always gave higher yields compared with a continuous monoculture. The average yield gain with rotation was 860 and 390 kg/ha in autumn- and spring-sown cereals, respectively. In spring cereals the benefit of a diverse rotation increased without plateauing over time since the beginning of the experiments, reaching a gain of 500 kg/ha after 50-60 years. The benefit of a diverse rotation was stronger in hot and dry years, a condition that is predicted to become more frequent with climate change. In extremely dry (less than 143 mm total rain) and warm growing seasons (more than 17 °C in daily average temperature), the average yield gain was 800 kg/ha for spring sown cereals in fields with crop rotation. For autumn sown cereals the average yield gain was 1100 kg/ha during dry years, while heat lowered the harvest to the same extent for both monocultures and crop rotation. Therefore, they concluded that diversified rotations emerge as a promising way to improve food security under a changing climate (https://www.slu.se/en/ew-news/2020/11/crop-rotation-a-promising-way-to-improve-food-security-under-a-changing-climate/).

Teixeira et al. (2018) develop a catchment-scale assessment to investigate the effects of tactical adaptations (choice of genotype and sowing date) on yield and underlying crop-soil factors of rotations. Based on locally surveyed data, a silage-maize followed by catch-crop-wheat rotation was simulated with the APSIM model for the RCP 8.5 emission scenario, two time periods (1985–2004 and 2080–2100) and six climate models across the Kaituna catchment in New Zealand. Results showed that direction and magnitude of climate change impacts, and the response to adaptation, varied spatially and were affected by rotation carryover effects due to agronomical (e.g. timing of sowing and harvesting) and soil (e.g. residual nitrogen, N) aspects. For example, by adapting maize to early-sowing dates under a warmer climate, there was an advance in catch crop establishment which enhanced residual soil N uptake. This dynamics, however, differed with local environment and choice of short- or long-cycle maize genotypes. Adaptation was insufficient to neutralize rotation yield losses in lowland but consistently enhanced yield gains in highlands, where other constraints limited arable cropping. The positive responses to adaptation were mainly due to increases in solar radiation interception across the entire growth season. These results provide deeper insights on the dynamics of climate change impacts for crop rotation systems. Such knowledge can be used to develop improved regional impact assessments for situations where multi-crop rotations better represent predominant agricultural systems.

Crop diversification: Crop diversification could be an effective adaptation option under extreme temperature, frequent and intensive flood, cyclone and other natural disasters due to climate change became acute and expecting to be severe in future as it protects natural biodiversity, strengthening the ability of the agroecosystem to respond to these stresses, minimizing environmental pollution, reducing the risk of total crop failure, reducing incidence of insect pests, diseases and weed problems and secure food supply opportunities and also providing producers with alternative means of generating income. It provides better conditions for food security and enables farmers to grow surplus products for sale at market and thus obtain increased income to meet other needs related to household well-being. Farmers needs to gain knowledge and skills in affected areas about crop-production techniques, integrated farming systems (including crop rotation and intercropping), and climate resilient production techniques. It can be implemented in a variety of forms and at a variety of scales, allowing farmers to choose a strategy that both increases resilience and provides economic benefits. Crop diversification can improve resilience in a variety of ways: by engendering a greater ability to suppress pest outbreaks and dampen pathogen transmission, which may worsen under future climate scenarios, as well as by buffering crop production from the effects of greater climate variability and extreme events. Such benefits point toward the obvious value of adopting crop diversification to improve resilience, yet adoption has been slow (Lakhran et al. 2017).

Considering the climate change projection in Turkey and Thrace region, drought and heat resistant alternative legumes, forage crops and oil crops should be included in the rotation.

Weeds and their management under clime change

Climate is the principal determinant of vegetation distribution from regional to global levels among global change stressors. Change in atmospheric CO_2, rainfall and temperature will affect weed species distribution, and prevalence within weed and crop communities in contrast to crops. Weeds are troublesome invaders, ecological opportunists and resilient plants with far more genetic diversity. Weed populations include individuals with the ability to adapt and flourish in different types of habitats. Any factor which increases environmental stress on crops may make them more vulnerable to attack by insects and plant pathogens and less competitive with weeds. The geographical and seasonal distribution of pests likely will change as the climate changes. The physiological plasticity of weeds and their greater intra specific genetic variation compared with most crops could provide weeds with a competitive advantage in a changing environment events such as cyclones, flooding, drought and fires (from high temperature) will become more common and weeds will be the first to gain a stronghold after these events (Amare, 2016).

Effectiveness of weed management is also hypothesized to change along with environmental conditions. Weeds that are under moisture stress can respond by thickening their leaf cuticles, slowing down vegetative growth and flowering rapidly. Drought stressed weeds are more difficult to control with post-emergent herbicides than plants that are actively growing for example, systemic herbicides that are translocate within the weed need active plant growth stage to be effective. Pre-emergent herbicides or herbicides absorbed by plant roots need soil moisture and actively growing roots to reach their target sites. Occurrence of drought has the potential to reduce the effectiveness of pre-emergent herbicides. Overall; there are strong empirical reasons for expecting climate and/or rising CO_2 to alter weed management. Adaptation strategies are available, but the cost of implementing such strategies (e.g. new herbicides, higher chemical concentrations, new bio control agents) is unclear (Amare, 2016).

There are several ways to manage weeds: chemical control, mechanical control, competitive species and biological control.

In general, different scholar at different time suggests their own idea on the possible effects of climate change on chemical weed control methods. These are (Amare, 2016):

- Greater root to shoot ratio leading to subsequent dilution effect on glyphosate when grown at elevated CO_2,
- Decreased stomatal aperture or number, cuticle thickening, development or increased leaf pubescence with subsequent reductions in herbicide entry into the leaf.
- Altered transpiration leading to reduced uptake of soil herbicides,
- Changes to the wetting and drying of soil profiles affecting microbial activity and herbicide degradation,
- Increased temperatures affecting the efficacy and selectivity of herbicides.
- Increased growth rate implying narrower temporal windows in which to apply herbicides before crop yield losses from weed competition and before weed set.
- High temperatures, low relative humidity and unsuitable wind conditions reducing the window of spraying opportunity.

Of course, all of the above ideas should be taken into account in chemical control, but it is inevitable to apply precision farming techniques that reduce chemical use.

Tillage is regarded as a global mechanical method of weed control in agronomic systems. Under heavy frequent rainfall carrying out of tillage and other mechanical weed control methods will very difficult due to logging of soil and under condition undertaking of cultivation will help to reduce soil moisture which may decrease the growth of crop plant and make less competitive with weeds. Elevated CO_2 could lead to further below ground carbon storage with subsequent increases in the growth of roots or rhizomes particularly in perennial weeds (Rogers et al.,1994). Consequently, mechanical tillage may lead to additional plant propagation in a higher CO_2 environment, with increased asexual reproduction from below ground structures and negative effects on weed control (Ziska et al., 2004; Amare, 2016).

In the process of climate change, competitive selection of species and varieties may be the most effective method in combating weeds.

Biological control involves the introduction of host-specific agents, usually insects or fungi, for the control of a weed species. The biological control agents have evolved to feed only on the target plant (Medd et al., 2001; Darren et al., 2010). Most bio-control systems perform best under a stable environment. However, in addition to the forecast increase in mean temperatures, a CO_2 and shift in rainfall distribution climate variability is expected to increase. Extreme weather events such as droughts, flood and even unseasonal frosts are predicted to occur more frequently. While many species have mechanisms to cope with extremes, they require time to acclimatize and/or enter the resistant state. The relative vulnerability of the host plants, and biocontrol agents to extremes of temperature, desiccation or flooding will determine whether the drought or flood will be followed by a weed or pest outbreak (Gerard et al., 2010). Moreover, according to (Gerard et al., 2010). increases in CO_2, changes in water availability and increases in temperature will alter plant phenology, growth and distribution, all of which will have flow on effects on the plant herbivores and those that prey on them. Aspects of plant life cycle events controlled by temperature, such as the timing and duration of seed germination, bud burst, and flowering, are likely to change with warmer temperatures, subject to photoperiod and water availability (Amare, 2016).

The direct impacts of climate change will be either on the biology of the biological control agent and/or on the ability of the host plant to tolerates or compensate for the presence of the herbivore or plant pathogen. Increased temperature would be expected to increase the rate of life cycles of both the biological control agents and the weeds. Increased water stress will affect the host plant’s development, and through this, the development of biological control agents, so they might be less effective in drier situations. Increase in greenhouse gases will also affect the herbivore plant relationship so impacts at both the spatial and temporal scales are possible (Darren et al., 2010). Changes in temperature can influence production of plant defense compounds against plant herbivores. It is known that levels of many insect-resistance allelochemicals increase during drought (Gerard et al., 2010).

Availability of appropriate scale machinery

The lower amount of rainfall, prolonged spell of rain or drought, together with increase in temperature due to climate change, will negatively affect agriculture. Through implementation of conservation agriculture, climate smart agriculture and precision farming, these effects can be mitigated. However, in their implementation, new machinery, equipment, infrastructure and technology may be needed different from those used in traditional agriculture. Most small-scale farmers may not be able to afford this and may not have sufficient technical capacity.

Conservation agriculture: Selection of appropriate machinery is important to minimize detrimental effects or to correct existing anomalies. Tools and equipment used in conservation agriculture are (Sundaram et al., 2019):

- Minimum tillage equipment,
- Direct seeding equipment, and
- Cover crop and weed management equipment.

Climate smart agriculture: There is a need for smart machines as well as climate, soil, water and plant data capacity development for data management. In order for the technology to be effectively promoted, there is a need for (Zwane, 2019: https://www.intechopen.com/books/climate-change-and-agriculture/capacity-development-for-scaling-up-climate-smart-agriculture-innovations)

- Policy financial support and the willingness of farmers to adopt such technologies on conditions the benefits outweigh the costs of implementing it, and
- Advisors accommodated in institutions and to train the advisors in climate-smart principles to enable them to be ahead of their farmers with knowledge in climate change and climate smart in agriculture.

Precision farming: The following tools and trained advisors farmers are needed in order to implement precision farming (http://www.journalcra.com/sites/default/files/Download%20366.pdf).

- Global positioning system (GPS),
- Geographical information system (GIS),
- Grid sampling,
- Variable rate technology,
- Yield monitors,
- Yield maps,
- Remote sensors for soil mapping, wasteland mapping, water stress, insect detection, nutrient stress,
- Auto-guidance systems,
- Proximate sensors,
- Computer hardware and software in order to analyses the data collected by other precision agriculture technology components and to make it available in usable formats such as maps, graphs, charts or reports, computer support.

Market saturation and global competition

It is predicted that climate change will significantly affect agricultural production. For instance, studies in cereal products, which are very important for world food supply security, predict that each °C increase in global average temperature will reduce global average land yields by 6% in wheat, 7.4% in corn, 3.2% in rice and 3.1% in soybeans. Model results foresee a 25-50% yield loss around 2050 for a 3 °C temperature increase. Moreover, it is predicted that the annual yield variability in grains will also increase (Karapınar, et al., 2020).

Economic models based on the results of climate models estimate that the price increases caused by climate change will reach 84% on product basis (Nelson et al., 2011; IPCC, 2014). Increases in food prices create significant impoverishing effects in both rural and urban areas, even in the absence of climate stress, and cause food insecurity at the local level.

Climate change is thought to affect products that Turkey is competitive in global markets. Regional concentration of these export products increases supply risks. In this context, regional production and export revenue risks are analysed by exemplifying major export products, namely hazelnuts, raisins, and apricots by Karapınar, et al. (2020).

In the process of climate change, all regions in Turkey will not be affected at the same rate. Considering the increases in average temperature and decreases in precipitation, the target region of AGREEN, the Thrace region, has been and will be among the least affected regions (Konukcu et al., 2019).

Considering the cultivation areas and average yield of important agricultural products in the last 20 years in the Thrace region, it is understood that the region has not been affected muchby the climate change. This is because there is no significant drought during the development period of wheat and canola. Although the development period of sunflower shifts into a slightly more arid period compared to wheat and canola, planting it on time before it is late eliminates the effect of drought. However, summer crop such as corn, fruit and vegetables and others with limited cultivation areas are mostly affected (Konukcu et al., 2019)..

Although it is not a serious problem in general, extreme climatic events can cause significant losses in Thracian agriculture from time to time. Lying in wheat due to excessive rainfall and the increase of diseases and pests related to it, damages caused by more frequent hail events, untimely and irregular frost events and damage to fruits especially due to heat waves can be given as examples (Konukcu et al., 2019)..

Using these climate change data of Thrace region, modeld estimated that the yield of wheat will not change in the short and medium term while it will increase up to 60% in long term compared to the present yield data. In sunflower, while the yield does not change in the short term, yield loss of up to 15-20% is predicted in the medium and long term (Konukcu et al., 2019).

Although the rates change, there will be significant crop losses in the yield of summer crop due to the decrease of the share to be allocated for irrigation with the increase of competition for water in the summer period due to the decrease in water resources, decrease in the summer precipitation both in Turkey and in Thrace. It is clear that this situation will cause serious problems in our country, which has a deficit for oilseed and legume plants.

As a result, with the climate change process, the cultivation areas of summer plants will shrink in dry farming areas or significant yield losses will be experienced; It can be predicted that the production of winter oilseeds, legumes or other plants will increase. In this case, it may be possible to decrease the sunflower cultivation areas and increase the canola cultivation areas in Thrace.

5. Climate-smart agricultural practices and crop models in Turkey

CSA is a new concept in Turkey and the target region of AGREEN, and the following six practices are not directly performed for CSA, but serve it.

- Use of smart irrigation technology to save water and mitigate the adverse effect of climate change,
- Residue management
  - minimum tillage and direct seeding and
  - ban of burning residue
- Shifting or adjusting planting dates
- Agricultural insurances
  - Crop production insurance:
  - Village based drought yield insurance:
- Environmentally Purposed Agricultural Land Protection (CATAK) Project
- National Drought Management Strategy Document and Action Plan

Use of smart irrigation technology to save water and mitigate the adverse effect of climate change

Smart irrigation technologies and their application areas are increasing day by day in Turkey in order to reduce the negative effects of climate change and drought on agricultural production to ensure the sustainability of quality and yield, as well as to ensure optimum use of limited water resources. For modern smart Irrigation infrastructure investments, the government provides long term loans to farmers with no interest or low interest rates or some of them as grants. Although irrigated farming areas are very limited and dry farming is generally practiced in the Trakya region, smart irrigation technologies have become common in recent years in the second crop corn and in newly establishment orchards such as walnuts and apple. Deficit or supplementary irrigation is also applied in sunflower in drought years. The total irrigation area of Trakya region is about 20 000 ha, 50% of which is under smart irrigation practices.

In recent years, Volnat Agriculture Forestry Food and Livestock Industry and Trade Inc., who has been making significant investments in walnut cultivation, irrigates approximately 300 ha of walnut orchards in Thrace with the smart drip irrigation system. One of the similar best practice in this context is Cevizli Bahce Agriculure Inc. in Edirne Province of Trakya region, who planted 120 ha walnut equipped with smart drip irrigation system.

Figure 10. A general view from Volnat Agriculture, Forest Food, Livestock Industry and Trade Inc. Walnut planting area and smart irrigation unit.

Figure 11. News on Turkish national TV canal about walnut farming as a best practice (Cevizli Bahce).

Figure 12. A general view from Cevizli Bahce Agriculture Inc. walnut planting area (https://cevizlibahce.com.tr/)

Residue management

Considering the practices in Trakya region, residue management can be examined under two headings: minimum tillage and direct seeding and ban of burning residue

Minimum tillage and direct seeding: In this context, direct seeding is practiced in summer corn as second crop for silage after harvesting wheat, barley, vetch or pea in about 3.000 ha area in Trakya region for the last 10 years to keep soil water, increase organic matter, decrease cost of seeding and use time effectively. Ekmen Agriculture Inc. has the machine of direct sowing and the farmers purchase the direct sowing services from it. In the region there are 10 direct sowing machine with disc which is imported from Brazil. The local company (Irtem Farm Machinery Inc.) has also started to manufacture pneumatic direct sowing machine. While the direct sowing of maize is increasing day by day, it has not been successful in sunflower due to its rooting system (Personnel communication with Irfan Ekmen, owner of Emen Farming Inc.) (Figure 13).

Figure 13. Direct sowing of summer corn as second crop for silage after wheat harvest in Trakya region (Photos were obtained from Ekmen Farming Inc.'s owner, Agricultural Engineer Irfan Ekmen.)

Ban of burning residue: Following the harvest, the remaining stubble after the straw of the product is collected is burned by the farmers on the grounds that it causes difficulties in preparing the seed bed for planting and its disposal is costly.

Stubble burning is prohibited legally due to environmental and fire safety reasons, but it also serves the CSA as it increases organic matter in the soil, prevents erosion, increases water infiltration into the soil, increases the water holding capacity of soils and prevents damage to soil organisms.

Shifting or adjusting planting dates

Although drought and climatic changes, especially felt in recent years, have not yet caused a significant change in Thrace agricultural production, shifts in seasonal climate have caused some changes in the management of diseases and pests. For instance, in order to prevent yellow dwarf disease, which is seen in wheat due to the changing climatic conditions in Thrace and has caused quality and yield losses up to 33% in recent years, the planting time has been shifted from October towards November.

Figure 14. Yellow dwarf disease seen in Trakya Region (https://www.tarimbilgisi.com/haber/tarim-ve-ciftci/bugdayda-sari-cucelik-virus-hastaliklari-ve-mucadele-yontemleri//: adopted from the interview by Tarım Bilgi Bankası with Prof. Dr.Havva lbağı).

On the other hand, farmers are aware of the fact that they have to determine the planting dates of sunflower very carefully in order not to be affected by prolonged summer droughts in Trakya region.

Agricultural insurances

Agricultural insurance is a very important instrument in increasing the resilience of small and medium size economically weak agricultural enterprises against the negative effects of climate change.

Crop production insurance: The coverage of agricultural insurance related to climate change to for all agricultural products are amount of loss caused by hail, storm, tornado, fire, flood, and quality loss caused by hail in fresh fruit, fresh vegetables and cut flowers. In addition, the scope of the coverage can be expanded upon request. In crop insurance, 50% of the premium written in the protocol is covered by the State. In fruit products, if frost coverage is taken in addition to the full package coverage, 2/3 of the premium is covered by the State only for frost coverage.

Village based drought yield insurance: Loss of yield caused by the risks of drought, frost, hot wind and heat wave, excessive humidity, excessive precipitation occurring throughout the village in wheat, barley, rye, oat, triticale, chickpea, red lentil and green lentil produced under rainfed conditions is covered by village based drought yield insurance. In this type of insurance, 60% of the premium written in the protocol is covered by the State.

Apart from these two insurances, there is also a greenhouse insurance, but since greenhouses are not very common in the region, no details are given here.

Environmentally Purposed Agricultural Land Protection (CATAK) Project

CATAK Program aims to protect the quality of soil and water, which are the main resources of agricultural production, to reduce the negative effects on the environment due to agricultural production, to ensure the sustainability and balance of natural resources, to direct renewable energy resources in this sector and to develop these resources. Environmental protection is ensured by conserving natural vegetation cover and biodiversity and controlling soil erosion in the target area. CATAK Support is calculated on a unit area with the agreements made between the relevant Ministry and the farmers (Bal, 2019). The detail of CATAK is given under paragraph 4.3. Existing policies and instruments for funding.

CATAK is developed for environmentally purposes but it contributes to the first and third objective of CSA, i.e. sustainably increase agricultural productivity and the incomes of agricultural producers, and where possible, reduce and/or remove greenhouse gas emissions.

National Drought Management Strategy Document and Action Plan

The purposes of this strategy document are to determine a result-oriented and supported policy with concrete targets, define the targets together with the responsible institutions, inform the public about the drought, encourage and support the public sector, private sector, non-governmental organizations and scientific institutions to act with a coordinated and participatory approach for watershed-based sustainable drought management.

The scope of this strategy document is to draft legislation on drought management, determine the functions of responsible institutions and investigate how these institutions can work in a coordinated manner, raise the awareness of the society on drought and ensure the management of droughts at the basin scale.

Based on this document, drought commissions were established in each province and action plans were prepared for pre, during and after drought.

6. Conclusions

Located in the Mediterranean climate zone, Turkey experiences mild drought every 5-6 years and severe drought every 15-16 years, and it is estimated that it will be affected by climate change to a great extent.

The impact and consequences of climate change affect our lives noticeably, causing epidemic diseases, drought, erosion, desertification, displacement of climatic zones, increase in severe weather events, sea level rise, damage to life species and deterioration of human health. This situation affects socio-economic sectors and ecological systems directly or indirectly, causing undesirable consequences. The effects of climate change on agricultural activities are of particular importance due to the relationship between production and nutrition, i.e. food security.

The agriculture sectors need to overcome three intertwined challenges: sustainably increase agricultural productivity to meet global demand; adapt to the impacts of climate change; and contribute to reducing the accumulation of greenhouse gases in the atmosphere. FAO has developed and promoted the concept of CSA to achieve these goals.

Within the scope of AGREEN Project, the feasibility of the state of art and potential of climate-smart agriculture in Turkey has been completed and presented in this document.

The following conclusions may be drawn from the feasibility study in Turkey:

- **Climate change:** Climate change projections show that the average temperature of Turkey will increase up to 3 and 6 °C for optimistic and pessimistic scenarios, respectively, coupling with the decrease in the amount of average and maximum annual precipitation up to 60 mm and 250-300 mm respectively. Negative rainfall anomalies stand out, especially in the Aegean and Mediterranean coasts, and in the Southeast and East regions. Increases in total precipitation and extreme rainfall events are expected in the Black Sea region. Marmara region and Trakya will be relatively less affected. Significant reduction in snow-covered areas and amount of snowfall is predicted. The number of frozen days in a year will be almost diminished. The number of Hot days, days with the maximum temperature reaches to 25 °C, will change from 35 days to 112 days in a year. The average number of consecutive dry days will increase from 83 days to 95 days.
- **Decrease in suitability for agricultural production.** In Turkey, excluding the Black Sea region, decreases in spring and summer precipitation coupling with the increase in temperature and evapotranspiration will lead to decreases in yield/cultivated area of summer crops like sunflower, corn, rice, bean, chickpea, lentil, sugar beet, cotton, vegetables and fruits beside alfalfa and pastures. Accordingly, the amount of irrigation water needed could be doubled compared to today. Even with irrigation, it is expected that there will be a decrease in the yield of summer plants, as the plants will be exposed to higher and extreme temperatures during the flowering and grain filling period. Beside increases in temperature and decreases in precipitation, prolongation of the crop growing season, decreases in the number of frozen days, soil water deficit in the crop growing season, increases in the frequency and severity of the flood events will adversely affect the crop production and biodiversity. Changes in precipitation regime, heavy rainfall and associated floods may delay planting and harvest times. On the contrary, the early warming of the weather may cause the sowing and planting dates to be brought forward as the last frost date is brought forward. If the cold winters can no longer control them, some diseases and pests can survive or even multiply more and

more every year, causing epidemics. As temperatures and humidity conditions change, new diseases and pests can cause damage in areas previously unseen. Even in today's somewhat severe weather conditions (hale, heatwave, heavy rainfall, frost), it is seen that the yield and quality of agricultural production decrease, prices rise excessively and exports decrease.

- **Food availability**: It is predicted that climate change will cause decreases in the yield of some strategically important crops for Turkey, by 8.18% in wheat, 2.24% in barley, 9.11% in corn, 4.53% in in cotton and 12.89% in sunflower by the year 2050. Shortage of forage crops, oilseed crops and legumes will increase with climate change and become more problematic in the medium and long term.
- **Current challenges**: Although adaptation studies have been started for the solution of agricultural problems in Turkey, against climate change and especially against drought, the small and economically weak agricultural enterprises, their insufficient capacity to apply modern agricultural techniques to manage land and water resources sustainably, and the fragmented and scattered lands make the solution difficult. Solving these problems will facilitate the implementation of CSA. The SWOT analysis proves that Turkey has a potential to overcome these challenges.
- **Solution**: In order to ensure food security against climate change, first, land consolidation should be done to strengthen small and medium-sized agricultural enterprises, land use change and wrong land use should be prevented, irrigation systems should be modernized for effective use of water resources, and production-supporting-marketing planning should be done individually for 30 agricultural basins determined by the Ministry of Agriculture and Forestry. Then, adaptation, mitigation and resilience to climate change activities may be applied within the concept of CSA. **For the adaptation to climate change**: varieties resistant to extreme climatic conditions should be preferred and/or resistant varieties should be improved by using local genetic resources, organic carbon content of the soil should be increased, a new crop rotation/diversification plan should be made within the scope of direct sowing/cover crop concept, sowing dates should be adjusted to benefit from the precipitation effectively, escape from the drought and diseases/pest. **For the mitigation of climate change**: Organic farming, good agricultural practices, precision farming and climate smart agriculture should be encouraged and supported. For the technological and mechanical infrastructure required by these systems, farmers should be supported financially and technically by the government. **For the resilience of the farmers against the adverse impact of climate change**: As currently practiced, farmers should be provided with financial support for production and insurance, and long-term and low-interest/interest-free credit opportunities should be created.
- **As for the AGREEN**: **Study area:** Trakya region and Black Sea region in Turkey falls into the coverage of BSB Cross Border Cooperation area. Trakya Region, occupying only 2.5% of surface of Turkey, is one of the most prominent centres. Its share in industrial production is 35% and in agroproduction is 11%. The region produces 11% of wheat, %45 of sunflower and 47% of rice in Turkey. It is a key region in terms of food security due to the high yield per unit area. Data for climate impact assessment is sufficiently available for this region in comparison to Black Sea region of Turkey. Moreover, in Balck Sea region, precipitation is expected to increase and agroproduction will not be much affected. Therefore, Trakya region is suggested for the CSA studies of AGREEN. **Crop type and crop model:** Winter crops in Trakya region will be affected minimally and positively whereas summer crops will be significantly and negatively affected by the climate change. Therefore, summer crops such as sunflower, corn, fodder crops,

legumes under rainfed and smart irrigation, under altered crop rotations including winter crops, under traditional and direct sowing conditions may be studied. The decided adaptation, mitigation and resilience practices combined with the above crop models can be theoretically simulated or experimentally studied considering available time and research facilities of the partner institutions.

- **Research limitations:** Theoretical and physical tools and methods are available to assess the decided adaptation, mitigation and resilience practices combined with the crop models. However, the time is limited and research facilities of the partner institutions may not be sufficient for experimental studies; the available physical and socioeconomic data for present and future and their quality may not be at the desired level for the theoretical studies.

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