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CLIMATE IMPACTS ON AGRICULTURE IN TURKEY

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CLIMATE IMPACTS ON AGRICULTURE IN TURKEY

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CLIMATE IMPACTS ON AGRICULTURE IN TURKEY

CONTENT

ABBREVIATIONS

ACS	Alternative Cropping Systems
APSIM	Agricultural Production Systems Simulator
UN	United Nations
CERES	Crop Environment Resource Synthesis
CFS	Committee on World Food Security
CMI	Crop Moisture Index
CropSyst	Cropping Systems Simulation Model
CSA	Climate SMART Agriculture
DSSAT	Decision Support System for Agrotechnology Transfer
EPIC	Environmental Policy Integrated Climate Model
FAO	United Nations Food and Agriculture Organisation
GCF	Green Climate Fund
GDD	Growing Degree-Day
GEF	Global Environment Fund
GTHB	Republic of Turkey Ministry of Agriculture and Forestry
HI	High
ICT	Information Communication Technology
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IPCC	Intergovernmental Panel on Climate Change
KIA	Urban Heat Island
LCA	Life Cycle Assessment
LPJML	Lund-Potsdam-Jena
MGM	Meteorology General Directorate
MIKE	Modelling System For Rivers and Canals
MİGM	Local Administrations General Directorate
MR	Microbial Respiration
NAMA	National Adequate Impact Mitigation Actions
ORG	Organic
PDSI	PALMER Drought Severity Index
PNI	Percentage of Normal Index
POU	Prevalence of Undernourishment
RED	Reduced
REDD	Reducing Emissions from Deforestation and Forest Degradation
SOC	Soil Organic Carbon
SPI	Standardized Precipitation Index
STICS	Simulateur multidiscplinaire pour les Cultures Standard
STK	Civil Society Organization
SWAT	Soil & Water Assessment Tool
SWAZEE	Surface Water Supply Index
SWIM	Soil and Water Integrated Model
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations International Children's Emergency Fund
UUP	National Adaptation Programs
VAM	Vulnerability Analysis and Mapping
WFP	World Food Programme
WHO	World Health Organisation

EXECUTIVE SUMMARY

The agriculture is found at any point where the ecosystems intersect with the society. Although the climate change could be perceived as a meteorological problem at the beginning, it has the potential to affect many environmental elements in natural ecosystems, in particular in nutritive cycles or hydrological cycle. Agriculture and food security could be characterized as the most fragile sectors in terms of climate change. Climate change is a global crisis that could easily affect the vegetative productions. However, this crisis depends on how the food security and crop yield of the country react the climate change. For that reason, taking into account the socio-economic importance of agriculture and food sectors, it is necessary to examine the climate change in the future on product efficiency and food security.

The issues where the effects of climate change as reflected to agricultural sector that could be best seen in our country and in the world could be listed as follows:

- Decrease of yield
- Increase if demand for and cost of irrigation water
- Shifts in planting and harvesting time
- Decrease in product growing availability
- More diseases and hazardous species (Kadıoğlu et al., 2017).

The agriculture is found at any point where the ecosystems intersect with the society. Although the climate change could be perceived as a meteorological problem at the beginning, it has the potential to affect many environmental elements in natural ecosystems, in particular in nutritive cycles or hydrological cycle. The effect of climate change in efficiency in agricultural production, hydraulic balances, input resources and other agricultural system components is felt even today, while the impact in the future is tried to be estimated by means of models and it is tried to make plans so as to have minimum impact on humanity on the basis of countries and regions depending on the outputs of these models.

Because, agriculture and food security sectors are the most fragile sectors in terms of climate change.

Whereas climate change is a global crisis that could easily affect vegetative production, to what extent he countries will be affected from the changes in these conditions depends on the food security as well as on how the agricultural yield reacts to climate change. For that reason, taking into account the socio-economic importance of agriculture and food sectors, it is necessary to examine the climate change in the future on product efficiency and food security. Receiving commitments for examining these impacts, creating the policies and mitigating the climate change through agriculture means having more knowledge on the carbon footprint in agriculture.

It is estimated that by the year 2050, the global population will exceed 9 billion. It is foreseen that population increase will increase greenhouse gas emission in the agricultural sector as in the case in many other sectors.

In addition to being the source of climate change, agriculture is one of the sectors which is affected the most from climate change. As a result of the estimations made in relation to year 2050, it is known that there will be differences in all meteorological parameters including the average temperature and precipitation. These changes will clearly affect the type and place of agricultural production in the world. From grapes in the Europe to pasture lands in Africa and rice in Asia, it is foreseen that all production patterns and livelihoods will become different or, in other words, transform. Under these circumstances, the adaptation for agricultural sectors has a vital importance overall the world. Besides, it is a reality which should never be forgotten that global cooperation, mitigation and adaptation policies against climate change and its impacts are vital not only at regional but at global level in terms of food security of humanity.

In summary, this module evaluates the impacts of climate change on agricultural sector.

1. ADAPTATION OF AGRICULTURAL PRODUCTION SYSTEMS TO CLIMATE CHANGE – WHAT IS THE USE OF MODELS?

In agricultural production systems, it is inevitable to use adaptation models for determining the climate changes. The climate change adaptation impacts which will be determined with models are used for supporting the decision making; thus different characteristics of models, as well as the weaknesses and strengths ensure modelling of the agricultural production to be used. Five different models are used in the adaptation of agricultural production systems:

- Empirical product models
- Regional compliance models
- Biophysical models
- Integrated models
- Decision models

These models basically lead to different results in short and long term. Future works that support the efforts towards adaptation to climate change should therefore rely on integrated evaluation of risks and fragilities (taking into account climate variability and uncertainty).

1.1. Climate Impacts and Adaptation in Agricultural Production Systems

Climate is the most important determinant of agricultural production and efficiency based on time and regional differences. Whereas agriculture provides the basic products required for the continuity of humanity (namely food, feed, fiber or biofuel), it is a vital cycle that integrally handles the use of water and earth, and therefore the whole ecosystem (Foley et al, 2011). An appropriate planning is required for preventing the negative impacts of climate change in agricultural production and adapting the agricultural production to climate change (Howden et al., 2007; Schiermeier et al., 2015)

The 13th foal of 17 Sustainable Development Goals which were ratified by the United Nations in the last 15 years includes “an emergency action plan created for the purposes of struggling against climate change and its impacts” (UN, t.y). In these action plans, it is targeted at planning the strength of plant patterns to be created in agricultural production and the capacities of production systems to adapt climate risks and natural disasters. Whereas adaptation to climate change in agricultural systems, “ending the poverty, ensuring food security and encouraging sustainable agriculture” is the primary goal, the second goals is indicated as “ensuring sustainable food production systems, increasing the production, protecting the ecosystems, and implementing resilient agricultural practices that strengthen the adaptation capacity to climate change”.

1.2. Short and Long Term Adaptation Methods

Despite the existence of different opinions, basically there are two types of adaptation to climate change in terms of agricultural production systems. (O’Brien, 2012; Park et al., 2012; Rickards et al., 2012). These are explained below as type A and type B adaptation strategies.

Type A–Short-term adaptation strategies that rely on local knowledge and experiences.

Type B–Long-term adaptation strategies implemented at national or international level, that require common action of many institutions.

Both types of adaptation strategies are important for mitigating the extreme condition risks of climate (O’Brien et al., 2012).

In cases where the climate impacts are not very extreme, the existing system does not exceed the limits of feasibility and the adaptive capacity is high, type A adaptation strategies will be sufficient. In cases where the effects of climate change is higher and type A adaptation strategies are insufficient, type B adaptation process, which has a higher scale and is of longer term, should be rapidly planned.

1.2.1. Type A Adaptation: Short Termed and Localized

Type A adaptation strategies make change in the product pattern selection on planting dates, thus easily ensuring adaptation to climate change. Even only by changing the date of plantation, the extended growth season could be used. Under conditions where the growth season is extended depending on climate change, it could be possible to increase land efficiency by making plantation for twice, even three times in the same year (Liang et al, 2015). In addition to multi-plantation pattern, shifting to species that are tolerant to str ess factors could be shown as an example of implementation of type A adaptation strategies.

In stockbreeding systems, alternative animal races or species, selection of diets in the nutrition of animals could be shown as examples for type A adaptation strategies in stockbreeding sector (Joyce et al, 2013).

1.2.2. Type B Adaptation: Long Termed and Large Scaled (Regional, National or International)

In cases where the impacts of climate change could not be abolished with type A adaptation strategies and affect the production negatively for long term, it is necessary to shift to type B adaptation strategies (Roggema, et al, 2012). However, type B strategies plan the land use in production regions at a large scale, and this planning also brings together the differentiation of infrastructure investments and therefore new investment costs. At the public levels, supporting the adaptation efforts of farmers by creating and planning the incentive systems or from time to time the subventions and enabling them not to refrain from adaptation by letting them less affected from adaptation strategies, are important. Agricultural industries come to the forefront in the development of new Technologies and growing of new species (Chenu et al., 2017; Rosenzweig et al., 2013). Among the targets determined in type B adaptation strategies are efficient use of water, and all measures required to be taken against becoming out of use due to increasing salinity on lands as a result of floods and droughts. Besides, the selection of climate-resistance product pattern should also be considered as a characteristic that should be taken into account while making planning, as in the case of type A adaptation (Bloomfield et al., 2014; Nicotra et al., 2010).

The characteristics of models used for adaptation of agricultural production systems to climate change are:

- Models could encourage physical and socio-economic systems and their scientific theories.
- Long term estimation capabilities of modelling tools could be used for estimating the climate risks in the future.
- Models could be used for testing the environmental and socio-economic impacts of climate adaptation and ultimately for developing the adaptation strategies (Leclère et al., 2014)

Model based tools have been implemented since 1980s for the impact assessment of climate changes in agriculture (Hoogenboom et al., 2000; Parry, 1990; Holzworth et al., 2015; Reidsma et al., 2015). It is necessary to determine the agricultural adaptation to climate change with biophysical and economic models (Harrison et al, 2016).

1.3. Risk of Maladaptation in Agriculture

If adaptation decisions to be taken against climate change and risks that could occur in agricultural production are taken using wrong projections and inappropriate models, this could lead to undesired consequences. Barnett and O'Neill (2009) refers to this as "incompliance". If short term benefits overweigh the long term costs (social, economic or environmental) or if the management does not take into account the negative external impacts of adaptation, for example if irrigation infrastructure is constructed in order to adapt to increasing water scarcity, possible incompliant consequences, increase in the establishment and operation of infrastructure, increase in water costs and negative impacts on water biodiversity could lead to increasing emissions (Barnett & O'Neill, 2013; Haydu et al., 2010; Yesuf et al., 2009; Stupak, 2017)

Risk factors towards the implementation of models are as follows:

- Arising climate changes and climate events that will develop in parallel, namely the uncertainty of context;
- Uncertainty of input;
- Input uncertainty that occurs in the inputs used in the model
- Uncertainty of parameters used in the model and of regional unconformities (Walker et al., 2013; Holzkämper et al., 2015; Walker et al., 2003)

Besides, errors and uncertainties that will occur in model estimations have an effect gradually on minimized climate projections, impact estimations and finally recommendations given for appropriate adaptation methods (Wilby & Dessai, 2010).

1.4. Adaptation of Climate Change Effects With Agricultural Productions Systems Today

The necessity that the impacts of climate change should be evaluated together with the agricultural production systems constitutes the foundation of dynamic modelling systems required to be used today. When the model approaches implemented are analyzed from the point of impact indicators handled and the adaptation options tested, five model approaches could be mentioned below in relation to the issue:

- Empirical product models
- Regional compliance models
- Biophysical models
- Integrated models
- Decision models

1.4.1. Empirical Product Models

Empirical product models estimate climate-efficiency relationships based on empirical time series and/ or panel data clusters of spatial and temporal variability in efficiency and climate variables. These type of models generally fail to clearly explain the possibilities to adapt. However, since autonomous adaptation progresses continuously, reliance of the models on long term data series is a forwarding factor. Possibly due to the limited capability in modelling the adaptation responds, empirical product model approach is mainly implemented in agricultural climate impact assessments (Lobell et al, 2006). In addition to this, Hobbs et al (2016) developed statistical models of forest biomass productions and implemented these models.

1.4.2. Regional Compliance Models

Regional land or climate compliance approaches are generally used for measuring the biophysical land use potential under current and future climate conditions generally at the regional scale (Brown et al., 2008; Palizaro et al., 2011). These two approaches benefit from the expert opinions and/or empirical area evidences for defining the responds given to different assessment criteria. This is widely applied for modelling the potential distributions of natural species (Zhang et al., 2016; Carpenter et al., 1993). As opposed to the empirical product models which aim at estimating the efficiencies, compliance approaches estimate the possibility of occurrence of a certain species (Carpenter et al., 1993). Similar to empirical product model approach, land compliance assessment approaches generally make it possible to test open management adaptations. However, since this approach determined whether the land is suitable for certain products, the land use status could change. Regional compliance approach could also be implemented to estimate the potential distribution of the pests and invading species according to the existing and future climate conditions (Chapman et al., 2017; Stöckle et al., 2003).

1.4.3. Biophysical Models

Biophysical models stimulate the biophysical processes such as plant growth, nutrient and carbon dynamics, water cycle and water flood based on mechanistic process understanding which is explained in mathematical terms. The model provides for a perfect foundation for not only stimulating the impacts of climate change on various agroecosystem functions, but als testing the adaptation options.

1.4.4. Integrated models

In relation to the integrated models; these are created by integrating the information collected from different sources (e.g. complex mechanical models, database collections and literature studies) with the information obtained (Tendall et al, 2015). It implements the nerve network approach in order to obtain integrated models from the outputs of very complex and compound models developed before. The benefit of implementing integrated model in place of complex compound models is the decreased working period, which increases the feasibility of the model to be implemented on the analysis of the research.

1.4.5. Decision models

It implements the models that take into account the decisions taken by agricultural sector as responds to climate, economic or social conditions. Since the decisions are clearly included in these models, these models are herein called as the decision models. Most of these models simulate the decisions of the sector to adapt against the biophysical and economic stimuli. These models are also called the bio-economic models. In general it relies on a connection between process based biophysical model or an empirical production model and an economic farm optimization model (Berry et al., 2011; Vermeulen et al., 2013).

1.5. Value of Model Based Information for Adaptation Planning

Depending on the level of organization where the adaptation decisions are taken (in other words, farm level or government planning horizon), different types of information is necessary and different types of representations could be needed for transmitting the findings in an efficient way (Vermeulen et al, 2013). Relying on the review of modelling works related to adaptation to climate change in agriculture, compliance of every type of model is handled in order to handle the various climate adaptation challenges. For sufficient irrigation infrastructure planning, it is important to know how the irrigation demands and water Results of climate impact assessments relying on statistical product models, process based biophysical models and regional compliance models could provide this information.

1.6. Integration

The model applications reviewed here demonstrate a great difference in terms of integration levels in relation to the effects taken into account (Table 1). Whereas empirical product models and regional compliance models focus only on efficiency and production potential, biophysical models approaches are implemented in order to estimate the impacts of climate and management changes on wider environmental targets. The number and details of modelling works simulating the effects on different targets with each of five model approaches mainly used in the world, are given in Table 1.

Table 1: *Number of Modelling Works Simulating Each of Five Model Approaches Determined and the Impacts on Different Targets (Vermeulen et al, 2013)*

	Empirical Sowing Model	Regional Compliance Model	Biophysical Model	Integrated Model	Decision Model
Efficiency/ efficiency potential	7	9	62	10	25
Water status	0	0	28	6	4
Water quality	0	0	10	1	1
Flood	0	0	4	1	0
Land loss	0	0	4	0	0
Need for irrigation water	0	2	15	4	4
Natural living area	0	0	2	1	0
Pests, Invading species	0	2	0	0	0
Earth carbon	0	0	1	0	0
Mulch	0	0	1	0	0
Greenhouse gas emissions	0	0	0	1	3
Agricultural economic evaluation	0	0	0	1	23
Sectoral adaptation decisions	0	0	0	0	2

Modelling tools which are used for integrating huge amount of information in the form of decision models, integrated models or compound biophysical models, have a big potential as projection and estimation tools in order to assist the mitigation of incompliance risks.

1.7. Uncertainties

Source of uncertainty which is represented the most is the climate projection uncertainty (63.5% of the studies taken into account among 24 different climate scenarios) (Solomon et al., 2007). Climate scenarios rely on different combinations of emission paths and global/regional climate model simulations. Since these socio-economic assumptions do not develop consistently in every condition, the amount of variable that arises is usually ignored.

More than 23% of other studies where the uncertainties are not taken into account in a clear way used many historical climate data in order to research climate effects and adaptation opportunities (Parry et al, 2007). Only a couple of studies (10%) projected climate change as a single climate projection, affecting the agriculture based on the impact model specification (Metz et al, 2007). Uncertainties in the impact estimations are generally represented and discussed in a good manner in the reviewed studies, the soundness of the adaptation measures is rarely evaluated.

2. EVALUATION OF AGRICULTURAL SECTORS FROM THE POINT OF ADAPTATION AND MITIGATION POLICIES

The agricultural sector demonstrates an increasing development in order to meet the need that increases due to the increase of population in our country and in the world. For that reason, agriculture is at the top of sectors where greenhouse gas emissions are observed at high levels when considered within the framework of climate change.

The greenhouse gas emission in our country was around 210.7 million tons in 1990, and it increased to 496.1 million tons with an increase of 135.4% in 2016. It is considered that this rate is around 150% today. The rate held by agricultural activities is around 10-12%. In the latest analysis conducted, it could be observed that greenhouse gas emissions arising from agriculture was 56.5 million tons and this constitutes around 11.4% of the grand total.

Table 2: *Total Greenhouse Gas Emission By Sectors (CO_2 equivalent), 1990 – 2016 (TÜİK, 2018)*

Year/ (Million tons)	Total	Change compared to year 1990 (%)	Energy	Industrial processes and product use	Agricultural activities	Waste
1990	**210,7**	-	134,3	22,9	42,4	11,1
1991	**218,7**	3,8	139,3	24,9	43,3	11,3
1992	**224,7**	6,6	145,4	24,3	43,4	11,5
1993	**233,4**	10,7	152,7	24,9	44,0	11,8
2013	**439,0**	108,3	308,8	59,8	53,6	16,8
2014	**451,8**	114,4	321,3	60,2	53,7	16,6
2015	**469,9**	123,0	339,7	59,6	53,7	17,0
2016	**496,1**	135,4	361,0	62,4	56,5	16,2

Climate scientists overall the world have evaluated the climate change and the impacts that are caused and could be caused by climate change on agriculture in two forms. One of these is the mitigation policies, which mean the alleviation of negative consequences of climate change. Mitigation policies are currently used synonymously with the mitigation of greenhouse gas emissions. Another method adopted in struggling with the negative impacts of climate change is the adaptation policies. In the evaluation conducted by IPCC in 2001, adaptation is the ability of natural or artificial systems to respond climate changes and their impacts, or to soften these impacts.

These two ways indicated are considered as two inseparable parts for results oriented works performed against climate change.

In 2007, IPCC summarized the exiting mitigation practices for agriculture as follows (Pachauri & Reisinger, 2007):

- Ensuring management of fields and pasture land for increasing the carbon storage of soil
- Restoration of turf soil that is not opened for agriculture and distorted lands
- Rice agriculture techniques developed for reducing CH_4 emissions;

- Stockbreeding animal and fertilized management
- Nitrogenous fertilized application techniques developed for reducing N_2O emissions
- Agricultural practices with shallow earth processing.

All applications mentioned decrease earth erosions and use of fossil fuels, and increase the carbon capacity stored in soil. Besides, these applications also increase the product efficiency that lead to increase in organic substances in soil. However, since the results that will be obtained from mitigation applications change depending on soil types and conditions, it becomes hard to calculate net benefits at large scale (Lal, 2004).

Mitigating the greenhouse gas emissions and overcoming the effects of climate change is possible by protecting and improving the existing condition of forests, wetland areas, sea and coast ecosystems, pasture land, agricultural fields and turf areas, each of which has carbon sequestration and storage capabilities (Dudley et al., 2010; Akalın, 2014). Forests are the widest storage of carbon on the land. Even if they become older, the continue to sequester the carbon in the atmosphere. However, they loose this property over time due to long term effects of climate change added up to deforestation as a result of activities for opening land for agriculture.

Wetland areas, turf areas, seas and coastal ecosystems could be counted among important areas due to their carbon sequestration and storage capacities. They undertake an important task in order to mitigate the greenhouse gas in the atmosphere. In addition to this, saline swamps, mangroves and sea grass beds are also important carbon storages. Today most of these systems are under pressure. It is necessary to increase the number and nature of protection areas and to manage these areas good, and thus decrease the pressure. Otherwise, these areas could no longer be carbon depots and easily turn into source of emission. For that reason, there is a need to add new ones to the wetland areas that are under protection and to protect that are currently under protection with more care. As a matter of act, minor changes that could occur in earth carbon cycle have the potential to create significant impacts at global scale (McCarthy et al, 2011).

Anthropogenic greenhouse gas is released to the atmosphere at an average rate of 10-12% due to agricultural activities. For that reason, agricultural activities have become one of the biggest factors of change in the soil- carbon cycle at global scale. The carbon sequestration capacity of soil could be increased by management systems which add biomass to soil, decrease earth degradation of soil, protect earth and water and develop the efficiency of soil structure and soil fauna. For that reason, agricultural industry provides the unique environment where mitigation practices could be carried out with management changes designed for protecting and restructuring of carbon depots. It could be considered to make changes in the agricultural application systems in order to increase carbon sequestration in areas which are deemed necessary in terms of mitigation policy.

The fact that the effects of climate change and its damages in many areas in the future including the agricultural sector should not prevent policy makers from taking concrete and emergency precautions (FAO, 2009).

Even if the mitigation policies succeed at limiting greenhouse gas emissions as they are effectively implemented and mitigating these emissions gradually, it is known that it will take time for the world to totally get rid of the greenhouse gases that currently exist in the atmosphere. As a matter of fact although the mitigation of global greenhouse gas emissions leads to successful results, it is necessary to adapt to the impacts of climate change.

In the definition made by IPCC in 2001, adaptation means adapting to the new or changing environment against the impacts of climate change. In its broad meaning, it means the reduction of the level of being affected from climate change foreseen in the natural or human systems. No matter how strong the mitigation policies are implemented, it is apparent that the climate will change even in the best scenario. For that reason, there is a mitigation strategy that is required to be implemented after the mitigation policy. The biggest responsibility here belongs to the local managers. Following the researches that will be conducted taking into account the needs and requirements of the region, it is necessary to take immediate steps for the required adaptation strategy. Since uncertainty is a fundamental component of climate, it should not be used as an excuse for non-action.

As a conclusion, if we look at the mitigation and adaptation policies in our country in general terms, the Earth Protection and Land Use Law, which is currently in use, should be developed and updated taking into account the climate change adaptation and mitigation practices. The food security, therefore the agricultural sector will be mostly effected from the climate change. The agricultural sector also appears before us as a sector which provides for raw material to the industries in a simultaneous manner. For that reason, the law in force is very important. However, this law and the affiliated regulation could be effective in ensuring the protection of agricultural lands and mitigating the possible effects of climate change. On the other hand, the weak aspects of the law are shown to be that the law that is currently in force has been in force since 2005 and the climate change mitigation and adaptation policies have not been an agenda in the meantime, and also the law fails to be sufficient to protect the agricultural lands. One of the laws that need to be handled within the scope of climate change is the Agricultural Insurances Law dated 14.06.2005 No. 5363. Climate change will inevitably affect the agriculture. The purpose of this law is the compensation of producer damages due to the risks borne by it due to drought, hail, frost, flood, hurricane and tornado as listed under Article 12 of the Law. Although the climate change is not expressed in the law, it is important that the regulation covers also the extreme climate events.

Agriculture Law No. 5488 dated 18.04.2006 regulate the issues which are closely related to climate change such as protection of environment, development of soil and water resources, protection of biodiversity and ecosystems, and struggling against natural disasters. These laws could be based on the implementation on mitigation and adaptation with action plans and regulations, and the distribution of tasks and works among the institutions.

Another law that is important for Turkey within the context of climate change is the Pasture Law No. 4342 dated 25.02.1998. With some amendments made on the law, which has been subjected to may amendments since to date of adoption to current day, pasture lands were opened to urban transformation and urban development areas.

In our country, laws that are needed to be adopted for protecting agricultural areas and biodiversity should be structured in a more detailed format for climate change mitigation and adaptation policies and those which are currently in force should be revised with certain changes (Algedik et al, 2016).

3. EVALUATION OF IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL SECTOR IN TERMS OF RISK AND BENEFIT

There is a need for earth, water, solar light and temperature for the growth of agricultural crops in general. Climate is a dynamic component that has an effect on all of the components mentioned. For that reason, the risks it created for the agricultural sector is at a very high level due to the uncertainties.

When the past temperature data is examined, it could be observed that the year 2010 was 2.38°C hotter than 12.81°C, which was the normal for year 2000. It is a separate finding that, under the light of the existing meteorological data, all of the hottest 10 years were between 1998 and 2010. Whereas extreme maximum temperature value was seen for long years in 6 stations in 2010, new extreme maximum temperatures were observed in 14 stations and extreme minimum temperature was recorded in 1 station (MGM, 2011). Year 2012 was 1.39°C hotter compared to years 1970-2000 and was the third hottest year with an average of 14.2°C. In 2012, 31 stations broke their maximum temperature records and there were a total of 166 hot air waves where the average maximum daily temperature was above 5°C for more than 5 days during 2012 in 66 center, most of which were more than one (MGM, 2012).

When the temperature data obtained according to the RCP 8.5 scenario provided by IPCC is examined, it could be seen that the annual average temperatures in our country were continuously in an increase trend during 2013 – 2099 period. It was determined that, at the end of the period, the increase would be 3.6°C on average. It could be seen that the warming tendency will particularly be increasing after 2060s. The lowest increase in the data obtained was observed to be 0.9 °C, and the biggest increase was 6.3°C. (MGM, 2013; Pachauri & Reisinger, 2007).

In the precipitation data, it could be seen that the precipitation decreased by 0.13 mm/ day, namely 47 mm/ year for the 2013 – 2099 period. Despite this general tendency of decrease, it is important that the change in precipitation did not follow a regular regime. It could be seen that the highest increase was 0.5 mm/ day (annual appr. 180 mm), and the highest fall was around 150 mm (MGM, 2013).

In almost all of the results obtained, there is an apparent increase of temperature, precipitation regime changes at a certain extent in addition and a decrease of precipitation. As a result of this increase, it was observed that there will be differences in the growth speeds of crops, as well as the blossoming and harvesting periods of the cereals, and that these dates would change from several days to a weak. It should not be forgotten that a global heating at this scale will bring loss

In general since these changes could lead to extension of the growth season and period when there is no frost in the agricultural production of North Europe, as well as to higher temperatures and longer growth seasons, and also sowing of new products and thus could bring benefits, it is expected that the decreases in the precipitation and water existence in the South Europe block as a result of extreme weather conditions could prevent the production of crops. Changes in temperature and growth season could lead to increase and dissemination of some vectoral species, invading weeds or diseases that could affect the crop efficiency. For that reason, it is expected that the crop efficiency will incur change gradually over years together with extreme weather conditions and other factors such as pests and diseases (Batan et al, 2015).

Climate change and differentiation in temperature and precipitation that accompany it are known to cause more precipitation at places where there were no rain, or places which were previously inhabitable to become habitable, some forests to have more appropriate temperatures and lead to increasing rains. In addition to this, changes observed in the moisture and temperatures rates connected with the increasing temperature will affect the metabolism functions of insects, their production capacities, nutrition habits and indirectly their dissemination areas. During the global warming process, the effects of displacement of insects and other pests have started to be observed in the north latitudes. It could be said that there will be positive effects such as different insects relocation to new locations and increase of product for the abandoned region (Canli, 2010).

In the presence of water loss which will be observed together with the increase of temperature, farmer applications should be made such as crop rotation as appropriate, regulation of sowing dates according to temperature and rain order and using crop species that are more suitable to new conditions (such as crops that are resistant against heat and drought) In case of drought, since it is not possible to abolish drought within short period, this negative effect could be overcome by selecting products that are suitable for drought (for example, by sowing wheat that needs less water rather than rice which needs more water). In other words, new plant pattern could be recommended in the region in order to adapt to the new situation. However, it should not be forgotten that global climate change distorts some of human and other living habitats, presenting new habitats in their place.

It is indicated that climate change could have positive and negative impacts on the agricultural sector. A positive effect is estimated to be earlier sowing of the plants and their harvesting at a later period. It is asserted that second crops could be harvested in the central regions of our country, that the citrus farming could extend towards the inner regions and tropical plants could be cultivated on the Mediterranean band (Gonultas et al, 2008).

Integration of climate science to risk management and adaptation planning is among the priorities of sustainable agriculture. Climatic risk assessment and management approach is basically as indicated below taking into account the weather condition monitoring, climate data analysis, crop-weather relations, seasonal estimation and economic modelling.

- Inclusion of modern methods and tools for climate data and analysis, as well as satellite precipitation estimation products based on seasonal estimations and real time data and/or the automatic meteorological measurements (precipitation, temperature, wind etc.) made at local level.
- Assessment of climate impacts using the analysis of climate risks and climate – weather interactions.
- Integration of economic models, risk perception by the farmers.
- Preparation of precaution packages by the farmers and creating technologically fast information networks.

As a result of climatic risk assessment and management approach, uncertainties will be lost in relation to the plant pattern and inputs to be used, and the farmers will be ready to fulfill the management and their decisions (Selvaraju, 2014).

It will not be a realistic approach to think that the continuously changing climate conditions will generally provide benefit to the agricultural sector in our country, which could be a paradise of agriculture under the current conditions. Although some small regions could be positively affected from the changes projected, our country is among the countries that will be hit the most by the changes in temperature and precipitation at large scale.

It is highly important for the sustainability of the sector that all institutions, regardless of whether public or private sector, carry out risk analysis taking into account the regional climate projections and determine their strategies and action plans.

3.1. Agricultural Opportunities and Challenges in the Changing Climate

Opportunities and challenges that could possibly occur in the agricultural sector due to climate change are given in Table and Table 4. The works carried out are collected and presented within the framework of efficiency and biodiversity. The issue of continuity of the potential benefits that could be seen is the common weakness of such types of works. As a matter of fact, uncertainties that arise after exceeding certain threshold values do not give an idea about the continuity of benefits.

It should not be forgotten that climate, atmosphere chemistry, soil physiology and chemistry are dynamic systems that have multiple variables. All these systems have the potential to affect the agricultural sector fundamentally. For that reason, the expectations should not be kept high in risk and, in particular, benefit analysis.

Table 3: *Agricultural Opportunities That Could Arise Depending On Climate Change*

Area	Specific Opportunity	Climate Change Factor	Source:
Efficiency	Increasing number of annual harvests	Longer growth period and higher average temperature	1-4
	Increasing quality	Regional climate change	5
	Remedying the hardness brought by climate change	Increasing atmospheric carbondioxide concentration	6, 7
	Supporting multiannual plant cultivation	Regional climate change	3, 8
	Supporting vegetables sown in early spring	Increasing temperature	7, 9
	Seasonal plant patter change in rainy regions	Regional climate change	10, 11
	Efficiency opportunities	Climate change scenarios, in particular early growing depending on early sowing and temperature	3, 8, 12-14, 19
Plant pattern change depending on regional temperature difference	Increasing corn sowing areas	Regional climate change	4, 5, 15
	Increase of the sowing areas for winter wheat and other cereals	Regional climate change	4, 15, 17
	Opportunities that increase for sowing the pees, bakla, oily seeds, soy bean, sunflower and in general C3 plants	Increasing average temperature and rising atmospheric carbon dioxide concentration	3, 18
1. Uleberg et al (2014); 2. Höglind et al (2013); 3. Fogelfors et al (2009); 4. Eckersten et al (2012); 6. Rötter et al (2011); 7. Olesen, 2005; 8. Rötter et al (2013); 9. Olesen et al (2012); 10. Trnka et al (2011); 11. Peltonen-Sainio et al (2010a); 12. Rötter et al (2012); 13. Kaukoranta and Hakala (2008); 14. Torvanger et al (2004); 15. Elsgaard et al (2012); 16. Thorsen and Höglind (2010); 17. MARCHtila et al (2005); 18. Maracchi et al (2005); 19. Lehtonen (2015)			

Table 4: *Agricultural Hardness That Could Arise Depending On Climate Change*

Area	Specific Hardness	Climate Change Factor	Source:
Productivity	Fewer cold resistant plants: Frost damage	Increasing autumn temperature: Delay in the beginning of autumn	1, 2
	Weaker winter resistance (ice coating and ice burnt) Limited root development: Fungi diseases	Frost – defrosting events that occur more frequently: Decreasing snow coating, precipitation in autumn and winter season	1, 3, 4, 25
	Accelerated phonologic development and low productivity (for plants which are sown in winter)	Early beginning of spring	3, 5-11, 24
	Decreasing protein content (cereals)	Rising atmospheric carbondioxide concentration	12
	Generally decreasing productivity	Increasing amount of precipitation, increasing precipitation before and after sowing, drought at season beginnings, summer droughts and critical timings of droughts Extreme precipitation becoming more frequent	1, 5, 7, 13-15, 22, 23
	Challenging and complex conditions in sowing and harvesting periods	Precipitation increasing in autumn and winter	1, 6, 13, 16, 17, 26, 27
	Decrease in the growth potentials of earth covering plants	Summer droughts	12
Decrease in crops	Saturated soil, root decaying and decreasing oxygen	Extreme precipitation in the growth season	1, 3, 13, 16, 17, 26, 27
	Increasing pests and hazardous weed risk	Softer and wetter conditions: Growth season becoming longer: Increasing carbondioxide concentration	1, 3, 4, 12, 18, 19, 28
Obstacles before benefiting from the extending sowing season	Soil temperature being low for early sowing	Extending growth season, frost effect	1
	Excessive water accumulation in soil	Increasing precipitation in spring and the melting snows causing simultaneous saturation	3, 9, 13
Agricultural approaches	Loss of nitrogen and phosphorus due to earth erosion	Precipitation increasing in autumn, winter and spring: Extreme precipitation	3, 4, 12, 20, 21
	Soil erosion	Extreme precipitation , flood	1, 3, 16
	Soil being plowed hard in spring	Soil freezing in winter	3, 4
	Earth compaction	Hardness to process the soil due to increasing precipitation and forest	1, 16, 23, 26
1. Uleberg et al., (2014); 2. Thorsen ve Höglind, (2010); 3. Fogelfors et al., (2009); 4. MARCHtila et al., (2005); 5. Kristensen et al., (2010); 6. Rötter et al., (2013); 7. Olesen, (2005); 8. Laurilla, (1995); 9. Olesen et al., (2012); 10. Eckersten et al., (2012); 11. Maracchi et al., (2005); 12. Eckersten et al., (2007); 13. Hakala et al (2012); 14. Peltonen-Sainio et al (2010b); 15. Torvanger et al (2004); 16. Jordbruksverket, (2013); 17. Rötter et al., (2012); 18. Gaasland, (2004); 19. Wivstad, (2010); 20. Jeppesen et al., (2010); 21. Eckersten et al., (2001); Jordbruksverket (2017); 22. de Toro et al., (2015); 23. Bastviken et al., (2015); 24. Ozturk et al., (2017); 25. Sharif et al., (2017); 26. Jordbruksverket, (2016a); 27. Jordbruksverket, (2016b); 28. Peltonen-Sainio et al., (2016)1			

[1] See the basic source for the sources given in Table 3 and 4. Wiréhn, 2018.

4. MITIGATION OF GREENHOUSE GAS EMISSIONS ARISING FROM AGRICULTURAL SECTOR

If the agricultural sector is evaluate within the framework of climate change, it is a sum of applications that could function both as a source of greenhouse gas and a carbon swallow area.

Most of the greenhouse gas emissions from agriculture in Turkey come from the subsectors of agriculture soils and fertilization management. Agriculture soils cause various emissions due to mineral fertilizer, animal fertilizer and also vegetative wastes that remain in the soil. Balanced fertilization programs to be carried out according to soil and plant analysis have a key role in mitigating the greenhouse gas emissions arising from agricultural activities.

Due to the fact that mineral fertilizers and pesticides cause greenhouse gas emissions and constitute a risk for health, decreasing their use and providing the minerals needed by soil by means of composting method are among the strategies that could be implemented for improving the soil and also improving carbon sequestration capacity. It should not be forgotten that emissions arising from mineral fertilizers are caused not only after the fertilization processes, but also during the production, transportation and application of the fertilizer.

One of the most effective ways of mitigating the emissions arising from agriculture is to ensure that the organic substance and mineral need is covered from outside by means of composting method from vegetative wastes in the vicinity of agricultural areas. The best method which could be used for improving the physical, chemical and biological characteristics of soil and also for increasing the carbon content, is the composting. Biogas production from organic wastes and composting are the most efficient strategies. Composing the organic wastes released from the biogass process and using the same for agricultural production could ensure a significant degree of emission mitigation. As a matter of fact, the uncontrolled presence of the fertilizer used increases in particular the methane emissions.

The agriculture sector in Turkey corresponds 12 % of the total greenhouse gas emissions as of year 2015. Emission mitigation in agriculture should be taken into account as an important sector among the emission mitigation strategies in our country and in the world with its low cost and easy application fields. In particular, taking measures in the fields of enteric fermentation (47%), agricultural soils (40%), fertilizer method (11%), which cause a high portion of emissions, will ensure mitigation of emissions arising from this sector.

Fertilizer Management:

- Sequestration of methane emissions
- Biogas production
- Composting

Soil Management:

- Performing soil analysis
- Control of mineral fertilizer applications
- Increasing soil carbon sequestration capacity with compost practices
- Using wastes with high carbon rate in the soil.
- Increasing agricultural applications without soil processing

Using the methods listed above, greenhouse gas emissions arising from agriculture have been significantly mitigated in many parts of the world.

4.1. Status of Agricultural Greenhouse Gas Emissions in Europe

In the latest report which was published by European Environment Agency in 2018 that included the greenhouse gas emissions of 28 Member countries (Table 5), whereas the greenhouse gas emissions for year 1990 were around 5650 million tons, the emissions values decreased by 24% in year 2016 to 4300 million tons with the implementation relevant measures and mitigations and adaptation policies. As it could be seen from the table, within the last 26 years when the research was conducted, Germany has decreased greenhouse gas emission by 342.2 million tons, recording the most dramatic fall. This fall was accompanied by 313.8 million tons decrease in United Kingdom. Countries with less emissions such as Lithuania, Leetonia and Romania demonstrated a great success by mitigating more than half of their emissions. Austria, South Cyprus Greek Part, Ireland, Portugal and Spain were unsuccessful in reducing greenhouse emissions, and even they have increase the emissions on the contrary.

Table 5: *Equivalent CO_2 Emissions Observed in 28 European Union Countries between 1990 – 2016 (EEA, 2018)*

	1990 Million Tons	2018 Million Tons	2015-2016 Million Tons	Change 2015-2016 (%)	Change 1990-2016 (%)
Austria	78.7	79.7	0.8	1.0%	1.2%
Belgium	146.7	117.7	0.1	0.1%	-19.7%
Bulgaria	104.0	59.1	-2.7	-4.4%	-43.2%
Croatia	31.9	24.3	0.1	0.5%	-23.8%
Cyprus	5.6	8.8	0.4	5.3%	56.9%
Czech Republic	199.6	130.3	1.9	1.5%	-34.7%
Denmark	70.4	50.5	2.0	4.1%	-28.3%
Estonia	40.4	19.6	1.6	8.7%	-51.4%
Finland	71.3	58.8	3.4	6.1%	-17.6%
France	546.4	458.2	0.1	0.0%	-16.1%
Germany	1251.6	909.4	2.7	0.3%	-27.3%
Greece	103.1	91.6	-3.7	-3.9%	-11.1%
Hungary	93.8	61.5	0.5	0.7%	-34.5%
Ireland	55.5	61.5	2.1	3.6%	10.9%
Italia	518.4	427.9	-5.0	-1.2%	-17.5%
Latvia	26.5	11.3	0.0	-0.2%	-57.3%
Lithuania	48.1	20.1	-0.1	-0.5%	-58.3%
Luxembourg	12.8	10.0	-0.2	-2.4%	-21.6%
Malta	2.1	1.9	-0.3	-14.2%	-9.1%
The Netherlands	221.3	195.2	0.5	0.2%	-11.8%
Poland	467.3	395.8	10.7	2.8%	-15.3%
Portugal	59.9	67.8	-1.8	-2.6%	13.1%
Romania	246.7	112.5	-3.7	-3.2%	-54.4%
Slovakia	74.0	41.0	0.1	0.3%	-44.5%
Slovenia	18.6	17.7	0.9	5.1%	-4.9%
Spain	287.7	324.7	-11.1	-3.3%	12.9%
Sweden	71.5	52.9	-0.9	-1.6%	-26.0%
United Kingdom	796.6	482.8	-25.1	-4.9%	-39.4%
EU-28	5650.4	4292.7	-26.7	-0.6%	-24.0%

When the equivalent CO_2 emissions arising from agriculture are examined in the countries mentioned in the same report (Table 6), the total emissions of these 28 countries were recorded as around 94 million tons in 1990. In the year 2016, emissions demonstrated a fall of 20% to 75 million tons. For that reason, it is possible to say that the effective mitigation and adaptation policies in the agricultural sector are widely implemented in the European Union countries. The country that played the main role in these emission decrease is Germany. It has reduced its greenhouse gas emissions by 40% with 4.1 million tones in the last 26 years. Countries which have less emissions in total but which opted climate friendly agricultural methods in terms of percentage and reached high rates of mitigation are Lithuania and Leetonia. In addition to this, European countries such as Bulgaria, Greece, Czech Republic have accomplished significant emission mitigation rates. However, Spain increased its emissions by 31% in this period, releasing 2.7 million tons CO_2 more to the atmosphere.

Table 6: *Equivalent CO_2 Emissions From Agricultural Sector Observed in 28 European Union Countries between 1990 – 2016 (EEA, 2018)*

Member Country	Equivalent CO_2 (kt)			EU-28 Shares	Change 1990-2016		Change 2015-2016	
	1990	**2015**	**2016**		**kt CO_2**	**%**	**kt CO_2**	**%**
Austria	1 253	808	818	1.1%	-435	-35%	11	1%
Belgium	3 033	2 021	2 177	2.9%	-856	-28%	156	8%
Bulgaria	1 652	465	429	0.6%	-1 224	-74%	-36	-8%
Croatia	835	633	638	0.8%	-197	-24%	5	1%
Cyprus	55	82	79	0.1%	24	43%	-3	-4%
Czech Republic	3 790	1 197	1 213	1.6%	-2 577	-68%	16	1%
Denmark	2 590	1 530	1 547	2.0%	-1 043	-40%	17	1%
Estonia	495	318	272	0.4%	-223	-45%	-46	-14%
Finland	1 863	1 358	1 338	1.8%	-525	-28%	-20	-1%
France	11 357	11 008	11 012	14.6%	-345	-3%	4	0%
Germany	10 270	5 977	6 114	8.1%	-4 156	-40%	137	2%
Greece	2 893	499	431	0.6%	-2 462	-85%	-69	-14%
Hungary	2 656	1 351	1 490	2.0%	-1 166	-44%	139	10%
Ireland	747	530	548	0.7%	-199	-27%	18	3%
Italia	8 352	6 933	7 008	9.3%	-1 344	-16%	75	1%
Latvia	1 588	387	415	0.5%	-1 174	-74%	27	7%
Lithuania	1 483	195	204	0.3%	-1 279	-86%	9	5%
Luxembourg	34	23	23	0.0%	-11	-33%	0	1%
Malta	4	11	12	0.0%	8	196%	1	6%
The Netherlands	9 846	9 016	9 033	12.0%	-813	-8%	17	0%
Poland	8 507	9 303	9 875	13.1%	1 368	16%	572	6%
Portugal	1 679	1 050	1 066	1.4%	-613	-36%	16	2%
Romania	1 994	1 078	1 127	1.5%	-867	-43%	49	5%
Slovakia	146	351	348	0.5%	202	138%	-3	-1%
Slovenia	334	218	217	0.3%	-117	-35%	-1	0%
Spain	8 678	11 312	11 406	15.1%	2 728	31%	94	1%
Sweden	1 766	1 452	1 370	1.8%	-395	-22%	-81	-6%
United Kingdom	5 978	4 745	4 781	6.3%	-1 197	-20%	36	1%
EU-28	**93.880**	**73 851**	**74 991**	**99%**	**-18 889**	**-20%**	**1 140**	**2%**

5. EXAMPLES FROM FOREIGN PRACTICES ON MITIGATION OF EMISSIONS IN AGRICULTURAL SOILS AND SOIL MANAGEMENT

Whereas soil is considered as one of the reasons causing the greenhouse gas emission, at the same time it is defined as one of the heroes that provide mitigation (greenhouse gas emission mitigation). On the other hand, changes that occur in land use include as an example the construction of buildings on agricultural and forestry areas, increase of other agricultural activities and differentiation of agricultural systems. These cause greenhouse gas emission (Matjes, 1996). Connecting the carbon in the atmosphere to soil and mitigating its amount is only possible using correct methods (Houghton, 1999).

In terms of mitigating the emissions arising from soils and supporting mitigation, developing countries which have economies based on agricultural systems assert that food security and struggle against hunger should have priority over emission increase. Developed countries assert that it is necessary to handle mitigation and adaptation together and putting the emphasis on the importance of soil as a carbon swallow, defend that increasing the carbon sequestration capacity is a necessity for mitigation and that the two could not be thought separately.

According to Metz et al (2007) opportunities for mitigating the greenhouse gas emissions in agriculture are divided into three categories based on the following mechanism:

- Mitigation of emissions;
- Increasing the relocations
- Preventing or replacing the emissions

Mitigating the Emissions: The agriculture releases important amount of CO_2, CH_4 to N_2O to the atmosphere. The flows of these gases could be mitigated by more efficient management of carbon and nitrogen flow in agricultural ecosystems. Approaches that mitigate the emissions in the best way depend on the local conditions and thus differ from region to region.

Increasing the relocations: Agricultural ecosystems mostly host huge carbon reserves in the soil organic material. Historically the soil has lost its carbon reserves, however, part of this lost carbon could be recovered by means of developed soil management, and thus the amount of CO_2 in the atmosphere could be mitigated. Many studies around the world have demonstrated that soil carbon could be stored by means of applications that are integrated to local conditions (Nelson et al., 2014; UNFCCC, 2016). Significant amount of vegetative carbon could be stored in agricultural forestry systems or other long term sowings on agricultural lands. Agricultural lands clean the CH_4 off the atmosphere by oxidation, however, this effect of agricultural lands is very little compared to the increase of greenhouse gas emissions from the world.

Preventing or Changing the Emissions: Plants and plant wastes coming from the agricultural lands could be used as a source of fuel direct or after being converted into other fuels such as ethanol or diesel. This process of obtaining bioenergy unfortunately still releases CO_2. The emissions of these bioenergy sources are equal to the emissions caused by fossils. Greenhouse gas emissions could be prevented by agricultural management applications that prevent the sowing of soils on forest areas or under other non-agricultural vegetative cover.

5.1. Agricultural Greenhouse Gas Emission

According to United Nations Intergovernmental Climate Conference 2007 report, the agricultural sector has an impact of 14 % among the impacts caused by humanity on the globe as a result of various activities. Main activities that cause greenhouse gas emission during agricultural activities are:

- Stockbreeding (CH_4)
- Stomach fermentation
- Fertilizer use and management
- Nitrogenous fertilizer use (N_2O) and burning of husks (CH_4, N_2O)
- Paddy production (CH_4).

Numerical distribution of greenhouse gas emissions from agriculture to sub-sectors is shown in Table 7. According to the grand total, enteric fermentation is the most important emission source in agriculture with a rate of 47%, which is followed by agricultural soils with 40%, and fertilizer caused emissions with 11%.

Table 7: *Distribution of Greenhouse Gas Emissions Arising from Agriculture to Sub-Sectors (Ağaçayak & Özdemir, 2017)*

	CO_2	CH_4	N_2O	NMVOC	CO_2 EQUIVALENT
Total (kt)	811	1220	88	420	57424
Enteric fermentation	-	1076	-	-	26888
Fertilizer Management	-	126	11	200	6304
Paddy production	-	8	-	-	200
Agricultural soils	-	-	77	220	22878
Agricultural wastes being burnt outdoors	-	11	0,3	-	343
Urea applications	811	-	-	-	811

5.1.1. Greenhouse Gas Emission from Agricultural Soils and Its Reasons

Soils include carbon stock down to a depth of 1 m. Even small losses in this big pool could have important effects in the atmosphere in the future. In other words, minor changes in the organic carbonic pool in the soil could have dramatic impacts on the CO_2 concentration in the atmosphere. The respond of soil organic carbon to global heating therefore has a critical importance.

5.1.1.1. Soil Emission From Fertilizer Use

Greenhouse emissions occur in two ways in the stockbreeding sector. The first of these is the methane gas that is released as a result of microorganisms decomposing the carbohydrates during the rumination of animals. The second is the methane (CH_4)that occurs as a result of animal fertilizer being decomposed in non-oxygen environment. Emission of methane gas (CH_4), which occurs as a result of animal fertilizer use and management, to the atmosphere arises as the animal fertilizers are left or stored in non-oxygen environment. This changes depending on the characteristics of animal fertilizers, fertilizer storage systems and the ways of use.

N_2O_2 is the third important greenhouse gas in terms of global heating after carbon dioxide and methane. Despite the fact that is constitutes only 320 pieces per billion of the world atmosphere, it has a global heating potential which is around 300 fold more than that of carbon dioxide. N_2O emissions are basically of biogenic origin. N_2O is created as a result of nitrification and denitrification processes arising from ammonium and nitrate, which are the components of N, in soils and oceans overall the world. These nitrogen components are released during the biogeochemical nitrogen cycle, however the most important and controllable one is the one that is released to the atmosphere by human activity. In fact, the amount of these components that enter into biosphere has almost doubled since the beginning of the industrial age (Smith, 2010). The biggest source is the agriculture where mainly the synthetic nitrogenous fertilizers are currently being used. Other main widespread resource is the emission of ammonium coming from farm animal fertilizers as a result of biomass burning and fossil fuel burning of

NO_x. Some N_2Os come directly from two processes in the burning and chemistry industry. nitric acid production and adipic acid production used in nylon production. Measures are being taken for stopping the industrial point sourced emissions of N_2O, however, it is naturally harder to manage the measures taken for limiting or mitigating the agricultural emissions, because, use of N fertilizer increases with the increase of sown areas and need to feed the increasing global population and the current development of biomasses, and in connection with that, N_2O emission increase becomes inevitable.

Applications which mean bringing the fertilizer in contact with soil ensure that nitrogen reaches to soil and thus to plants in a more effective manner and with less loss, thus mitigating N_2O emissions. Methods for mitigating N_2O emissions in the agricultural systems include using fertilizer at an amount that is sufficient for the need of the product, using fertilizer with slow emission or using nitrification inhibitors, applying nitrogen in periods when the loss will be experienced the least, and applying the fertilizer in such a way that the roots of the product could reach better. Using animal fertilizers instead of chemical fertilizers, sowing methods without soil processing, using the wastes of plants for increasing the amount of organic substance are the most important measures for increasing the efficiency of earth.

5.1.1.2. Greenhouse Gas Emissions Arising from Processing of Soil

Soil processing is accepted as the oldest soil management system. In some regions, particularly in old and ancient methods, soil processing is applied as part of agriculture in the form of burning the husk, which method, though legally rejected, is still applied from time to time. In old systems, after a forest area was cleaned with controlled burning, the seed was directly placed in the soil. The pictures in Ancient Egyptian graves represent the farmers using a swing – plough and cow before sowing. In fact, soil processing which is resembled with plough with lugs has become almost synonymous with agriculture (Dick & Durkalski, 1997). Soil processing could be defined as a system of producing crops wherein the soil is left from harvest to planting, other than applying fertilizer.

It is well known that, in today’s world, agricultural techniques such as soilless processing agriculture or mitigated soil processing, have been preferred for many reasons. These are:

- Preventing erosion
- Protecting the moisture content of the soil
- Increasing the organic substance content of the soil.

Studies conducted in recent years demonstrated that zero plowing or, in other words, soilless processing agricultural processes are among the effective measures for mitigating the amount of CO_2 in the atmosphere (Yokus et al, 2009).

Conversion of the plant cover, which we call the flora, into sown agricultural lands for the purposes of food security using conventional soil processing system methods, has lead to a significant decrease in the organic substance content of the soil (Paustian et al, 2000; Lal, 2002). Agricultural methods, which use mechanical soil processing for preparing the seed bed, such as plough or plowing for weed control, could support soil CO_2 loss through various mechanisms and also distort the aggregate structure of the soil (Karlen & Cambardella, 1996; Altı et al., 1999; Soares et al., 2005). Meanwhile, it stimulates the short term microbial activity with increasing ventilation and this leads to release of high CO_2 and other gases to the atmosphere (Bayer et al., 2000). Plant wastes are thus mixed into the soil by this way, the conditions of decomposition in the deep of the soil are generally more available compared to surface. (Kladivko, 2001) Moreover, soil processing may make the soils more prone to erosion and this causes more loss of carbon in the soil.

5.1.2. The Example of Brazil in Soilless Processing Agriculture

In 1972, in the southern region of Brazil (Parana province), a different alternative was launched in order to prevent erosion and misuse of agricultural areas (Denardin and Kochhann, 1993). Basic land management principles which lead to the development of soilless processing systems in Brazil, were directed towards mitigating the precipitation effect and surface flow volume speed. As a consequence, soil processing strategy was detailed under two agricultural practices:

- Failure of the Soil to be Washed
- Keeping the soil closed at all times

This alternative strategy has become rapidly widespread in different states and the area sown without soil processing has increased by folds. The area covered by system with soilless processing increased from the beginning of 90s to the year 1997 by 10 folds, reaching to 1 million hectares. An approximate area of around 20 million hectares, which is covered with soilless processing agriculture (Febrapdp, 2006), makes Brazil the second biggest soilless processing agricultural country of the world. This expansion not only occurs in the traditional soils in the southern region (72%), but also in the areas in central-western region (28%) after the natural cover has been cleaned. Today, the farmers in Amazon Region use the old pasture lands by sowing soya bean and corn without soil processing since it is less costly. In the soil processing systems which show the intensity of effects caused on the soil, the highest CO_2 release was determined in contemporary soil processing systems wherein the soil is abundantly ventilated, and less gas output was determined in other mitigated soil processing systems, and the least CO_2 output took place in soilless processing agricultural systems (Reicosky, 2003). Using the plow for compacting the soil transitively after chisel, disc harrow and subsoiler, was declared to cause sudden decrease in CO_2 output and provided much less CO_2 output at the fourth transition. It was declared that this sudden fall was directly related to the increase in the soil volume weight following the compaction (Sezer, 2014).

5.2. Land Consolidation Practices and Soil Emissions

The topographical structure and sizes of the land are important for efficient operation of agricultural machines agricultural mechanization practices. Efficiencies of the machines increase as the sizes of agricultural land increase. It will be a very accurate approach to make consolidation at a size wherein the agricultural machines could be operated in an efficient way depending on the status of partiality in the enterprises. In other words, in addition to increasing the efficiency, land consolidation practices also have effects towards mitigating the CO_2 emission. Depending on the distance taken by the agricultural machine in agricultural land and the specifications of the machine, it was stated that an average of 7.89 kg carbon equivalent mitigation is reached per minimum 1.90 kg and maximum 20.77 kg per km.

5.3. Land Use Change and Emission Mitigation

Land use change indirectly increases the greenhouse emissions, thus covers the most important activities for which measures should be taken. These activities lead to disappearance or distortion of the biomass on the earth as the forests, swamps and peatlands are converted into agricultural areas or pasture lands. Wetland areas function as a swallow and on the contrary to agricultural lands and those used by humans other than for production purposes (forest, pasture land, agriculture, settlement etc.) they have the feature to store the carbon they receive from the atmosphere. Drying, destroying and destructing these areas cause the carbon emission in the atmosphere to increase. Operation of peatlands, which are a sort of wetland, for their economic values and destruction of rain forests serve to this aim.

5.4. Alternative Plant Pattern Practices and Emission Mitigation

Evidences from our ancestors demonstrate that hominids adapt their diets to climate change. Ardipithecus ramidus and Ar anamensis are C_3 focused consumers. However, when the climate change turned the Easter Africa into savanna 4 million years ago, the surviving species were C_3/C_3 consumers (Australopithecus afarensis and Kenyanthropus platyops). The early Homo. H.sapiens which consumed C_3/C_4 food evolved in a period of 2.5 billion years. Whereas it is a very optimistic approach to expect a different development of humanity within the coming fifty years, it could be possible to adopt by changing the vegetable pattern. Many climate scientists try to find the ways for carrying the specifications of C_4 and CAM plants (process efficiency, tolerance of high temperatures, high productivity and resistance against drought and salinity) to C_3 plants. C_3 and C_4 hybrids have been tried to be used for a period of more than 50 years, however, it was not successful due to chromosome incompliance and hybrid sterility.

C_3/C_4/CAM Plants and Their Characteristics:

When the carbon dioxide level decreases in C_3 plants (for example, stomas are closed on hot days) Rubisco does not enter into cyclical reactions and the Calvin circuit is interrupted. This is called the photorespiration. Many industrial plants are in this group, which is defined as C_3. Mostly the examples of C_3 plants include rice, wheat, barley, rye, apples, quince and tomatoes.

Plants which are classified as C_4 and most known types of which are sugar cane and corn, accumulate CO_2 beforehand. Calvin cycle does not take place in the mesophilic cells of these plants. CO_2 is combined with a component named as PEP, is turned into malate and then transferred into bundle sheath cells. Malate enters into Calvin cycle here and CO_2 is formed. The CO_2 that accumulated here could reach up to 10 folds of the atmosphere. This the photo aspiration is prevented. The suspension of photosynthesis under high light and temperature, us thus prevented.

In CAM plants group (cactus and agave) high temperature and lack of water affect these plants, they need to close their stomas during daytime. The open their stomas at night time in order to prevent photorespiration, they connect CO_2 and malic acid is stored in the vacuoles. At the daytime, they close their stomas (in order to prevent perspiration) and they perform photosynthesis by obtaining CO_2 from malic acid. They perform the C_4 way during night time and Calcin cycle during daytime.

It should be known while creating plant pattern that is adapting to all this climate change that since most of the weeds are C_3 plants, they have more possibility to compete against C_4 plants (e.g. corn, sorghum, sugar cane, tomato etc.). It is considered that the existing herbicide/pesticide formulation will not effectively function against weeds and pests (Ziska et al, 1997).

5.4.1. Canada Example

In a few studies, climate change was associated with soil organic carbon (SOC) and microbial respiration (MR). Saskatchewan is one of the example studies in Canada as a successful application and modelling study. For the research area, the long-year climate data (1971 – 2000) and future climate scenarios (2041 -2070) were simulated to evaluate SOC (soil organic carbon) and MR (microbial respiration) values and changes. Between 1994 – 2013, the nineteen-year field and product information obtained from ACS (Alternative Crossing Systems) alternative plant pattern study, was used in the analysis of EPIC (Environmental Policy Integrated Climate Model). ACS study results of which are given in Table 8 comprises three agricultural input levels (organic (ORG), reduced (RED) and high (HI)) and three different plant patterns. It comprises diverse annual grains (DAG) and diverse single annual and multi-annual grain combinations (DAP).

***Table 8** – Product Information Obtained from ACS (Alternative Cropping System)*

LOW	ORG	Wheat-Wheat-Mustard-Wheat
	RED	Wheat-Wheat-Fallowing-Canola-Wheat
	HI	Fallowing-Wheat-Wheat-Fallowing-Canola-Wheat
DAG	ORG	Wheat-Wheat-Grains-Barley-Mustard
	RED	Canola (Autumn Sowing), Grains-Barley-Wheat
	HI	Canola (Winter Sowing)-Grains-Barley-Wheat
DAP	ORG	Mustard-Wheat-Barley-Clover-Clover-Clover
	RED	Canola-Wheat-Barley-Clover-Clover-Clover
	HI	Canola-Wheat-Barley-Clover-Clover-Clover

As a result of the precipitation and temperature changes that occur as a result of climate change, SOC, namely soil organic carbon amount decreased from 1.3% to 1% at a depth of 0-90 cm (from 132.3 to 130.6 $Mgha^{-1}$), and together with this, the microbial respiration increased by 17% from 1.92 to 2.25 MgCha-1 as a result of temperature increases.

Reduced soil processing and input method affected the product yield and alleviated the impacts of climate change. For that reason, the reduced input systems could create an adaptable strategy for the producers and the policy analysis in Canada Prairies for climatization. However, there is a need to conduct more researches in order to approve these relationships within the context of other relations and case studies (Taras et al, 2019).

5.5. Mitigation of Soil Emission with Organic Agriculture

The basic purpose is to bring modern science with traditional knowledge and transforming the livelihood enterprises into more productive places with less use of inputs. The most important characteristic of organic agriculture is that it has tendency to recycle the nutrition materials and organic carbon which is required for the soil. Therefore, the applications conducted involve direct recycling of animal fertilizer in order to prevent erosion of the productive top soil, efficient composting techniques for product wastes and the mixing of product wastes with the green fertilizer. Improving the soil structure with these methods will help mitigate the greenhouse gas emission. Researches conducted demonstrate that the soil carbon lost could be recovered by improving the soil structure at a rate of 55-60%. Besides, reduction of fossil fuel energy consumption in organic agriculture lead to the soil being exposed to erosion less and increase in the carbon sequestration as it ensured the recycling of the nutrients in the soil (FAO, 2011b).

6. CLIMATE AND AGRICULTURAL ECONOMY

In the 21st century, we face with global warming and climate change, which is an environmental threat that could to loss of protection potential and damage which could not be recovered in soil and water ecosystems. The fact that the economies of the developing countries rely on agricultural production lead the effects of climate change to be felt more. In particular, extreme weather conditions make the agricultural production impossible in the developing countries and therefore cause migration. The United Nations estimate that more than 500 million people are displaced overall the world in connection with the climate change. Despite the fact that very important developments have been recorded on issues such as product types adapted according to different conditions, use of chemicals, fertilization and irrigation systems, the climate condition still have the most important role in the agricultural production.

It is foreseen that, as a result of disasters that are related to climate change such as flood disasters and tropical hurricanes, the livelihood sources will be destroyed and this will have significant impacts on the food security in the long run (Porter et al, 2014). Food, which is the basic need in human life, becomes under risk due to the environmental fragility of natural ecosystems in connection with the global change.

Struggle against climate change is vitally important for the monitoring of sustainable development. The search of sustainable development is an inseparable part of mitigating climate change. Important problems that need to be resolved are that the poorest and most vulnerable ones have low social, economic and environmental resistance.

The environmental change, in particular the climate change, has a disproportional impact on poor people on rural areas where the livelihood sources are directly dependent on the natural resources. The deprivation of soil efficiency and distortion of forest resources, water resources, pasture lands and fishery will increase poverty in many developing countries. Besides, global heating will also affect the agricultural ecologic suitability of the crops

Agricultural production is one of the sectors that are most affected from the climate change. Extreme drought or sudden showers cause the crops to be unfertile, and negatively affect the crop yields. Thus, falls are expected in production in the short and long term as a result of climate change.

6.1. Climate Change and Agricultural Practices

At the top of climate change events that occur in the world is the increasing air temperatures. It is foreseen that this increase in the air temperature will cause significant climate change on the world. Climate change connected with global heating is estimated to affect many coastal regions in negative direction due to the rise in the sea level as a result of melting of glaciers and increasing precipitation. Rise in sea levels will lead to huge changes in the coastal ecosystems, causing new swamps to emerge on low plates close to seas. There will also be increases in the coastal erosions in addition to land losses which will occur as the seas advance over the lands. Taking into account that these negative impacts will lead to decrease in agricultural areas and to forced migrations, it is highly important to be aware of the danger to occur.

When we look at the indicators related to climate change on the earth, the energy production and consumptions are highly striking. In general, CO_2 emissions that cause global warming arise from energy, industrial processes, transportation and other sectors (housing, agriculture and forestry) (Tunc et al, 2007). In the study they have conducted on 43 different sectors related to global heating and greenhouse gas emission, it was determined that, of the total greenhouse gas production, 32% comprised by industrial processes, 30% by energy sector, 16% by transportation, 16 % by other sectors and 6 % by agricultural sector. In addition to its effects that encourage global heating, it also has negative effects on agriculture. It is necessary to increase the current food production by 60% in order to feed the global population which is expected to reach 8 billion in 2030. It is apparent that a high majority of this population rate has been living in the cities and, taking into account that the migration from rural areas to cities has been increasing day by day, there will not be a production potential which will correspond to the increasing consumption speed. Siqueira et al (2001) indicated that, as of the year 2050, there will be a decrease of 3-5°C in the air temperature in Brazil and an increase of 11% in the precipitation and this change will reduce the production of wheat (30%) and corn (16%) and increase soya production (21%). It was also indicated that this change will increase erosion, problems in agricultural processes (soil processing, irrigation, chemical use etc.), aggravate the diseases and make the controls hard, thus affect the efficiency and quality of agricultural products in negative direction, and also that significant amount of food scarcity and hunger will arise. Since on the other hand in cases where other conditions are optimum, the increasing CO_2 concentration in the atmosphere will encourage water use efficiencies and photosynthetic activities of the plants, this will increase their product efficiencies by 10 – 50 %. However, the increasing temperature will have negative impact on the agricultural products in general and there will be an increase in the diseases observed together with the temperature. For that reason, farmers in the arid regions will make more irrigation and use more agricultural chemicals.

If the increasing water need could not be covered particularly in arid and semi-arid regions, this will case important productivity decreases and thus preventing water losses, protecting water reserves and developing new plant species that consume less water are highly important in terms of ensuring productivity and sustainability. Currently 1.1 billion human beings fail to find clean drinking water, 800 million people experience the difficulty of nutrition and it is considered that the food need of the global population will be doubled in the coming several decades. Whereas the productivity will increase at the middle and higher latitudes as a result of climate change, the efficiency will increase further in subtropical regions. As a result of this, a high majority of the rural population will be negatively affected. Malnutrition will become an important factor for contagious diseases. Whereas climate change will aggravate the food problems experienced in the lower attitudes such as India, Asia and Africa, hunger and drought will appear in a significant manner. Due to the migration that has been continuing from rural areas to cities, it is expected that, as of 2025, 61% of the global population will live in the cities. Environmental damage, population increase and food scarcity will cause migrations for people and animals and the migrating living things will encounter various diseases and death (Khasnis and Nettleman, 2005).

6.2. Increase of Agricultural Prices

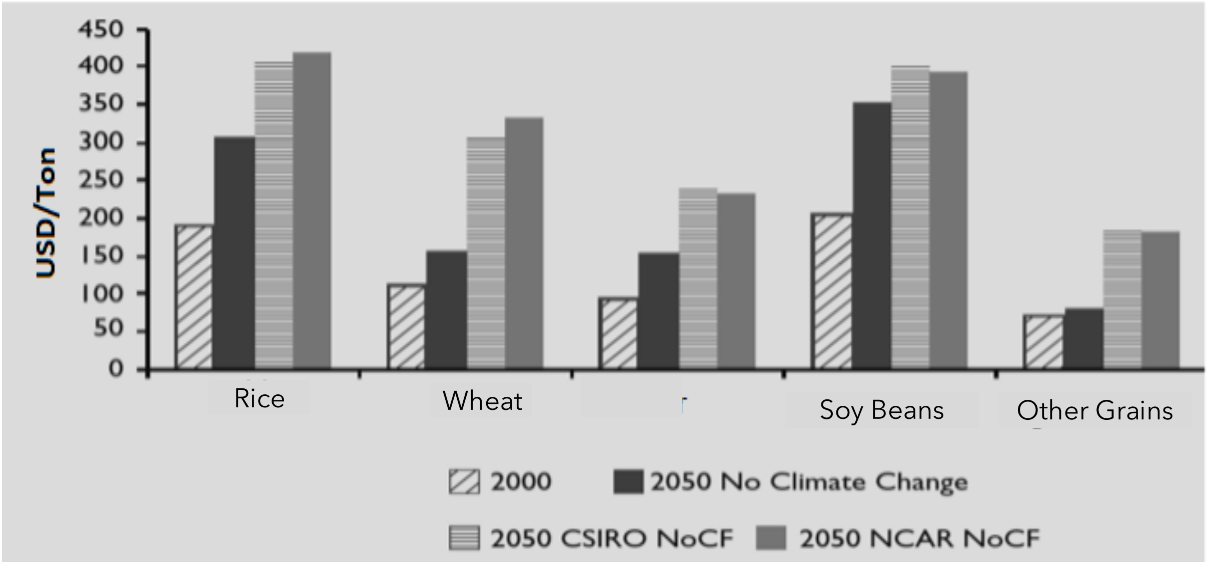
Changes in the agricultural supply arise from the combination of changes in productivity and changes in the sowing areas. In order to explain the effects of climate change on the agriculture, the prices of agricultural products in the national and international markets are an important source. Table 9 shows the trend in global food prices according to the climate change scenarios. In this table, the prices of agricultural products with CO_2 fertilizer and without CO_2 fertilizer are given, taking into account the reflections of CO_2 fertilizer effect on the products. Besides, the food prices in cases where there is no climate change independent of the climate change scenarios, are also given in the table (IFPRI, 2009: 6).

Even in the assumption that no climate change will be experienced as of the year 2050, it is expected that prices of main agricultural products such as wheat, corn and soya bean will increase compared to year 2000 as a result of population increase, increase of per capita average income and the increasing bio-fuel demand. In a future where there is no climate change, it was foreseen that, compared to year 2000, rice prices could increase by 62%, corn prices by 63%, soya price by 72% and grain prices by 39%. When the increases caused by climate change is added to this rise, an additional increase of 32-37% in rice, 52-55% in corn, 94-111% in wheat and 11-14% in soya bean is expected. Taking into account the positive effect of CO_2 fertilizer on production, it is foreseen that the prices expected in 2050 will decrease at a rate of 10%.

Table 9: *Change in the Prices of Some Grain and Animal Products Overall the World (2000 – 2050) (IFPRI, 2009).*

		2050				
AGRICULTURAL PRODUCT	**2000**	**If there is no Climate Change**	**NCAR no CF**	**CSIRO no CF**	**NCAR CF effect (%change from no CF)**	**CSIRO CF effect (%change from no CF)**
Rice (USD/Tons)	**190**	**307**	**421**	**406**	**-17,0**	**-15,1**
Change since 2000		**61,6**	**121,2**	**113,4**		
If there is no climate change 2050			**36,8**	**32**		
Wheat (USD/Tons)	**113**	**158**	**334**	**307**	**-11,4**	**-12,5**
Change since 2000		**39,3**	**194,4**	**170,6**		
If there is no climate change 2050			**111,3**	**94,2**		
Corn (USD/Tons)	**95**	**155**	**235**	**240**	**-11,2**	**-12,6**
Change since 2000		**63,3**	**148**	**153,3**		
If there is no change 2050			**51,9**	**55,1**		
Soy (USD/Tons)	**206**	**354**	**394**	**404**	**-60,6**	**-62,2**
Change since 2000		**72,1**	**91,6**	**96,4**		
If there is no climate change 2050			**11,4**	**14,2**		
Beef (USD/Tons)	**1.925**	**2556**	**3078**	**3073**	**-1,3**	**-1,5**
Change since 2000		**32,8**	**59,8**	**59,6**		
If there is no climate change 2050			**20,4**	**20,2**		
Pork (USD/Tons)	**911**	**1.240**	**1.457**	**1.458**	**-1,3**	**-1,5**
Change since 2000		**36,1**	**60**	**60,1**		
If there is no climate change 2050			**17,5**	**17,6**		
Lamb (USD/Tons)	**2.713**	**3102**	**3462**	**3461**	**-0,7**	**-0,8**
Change since 2000		**14,4**	**27,6**	**27,6**		
If there is no climate change 2050			**11,6**	**11,6**		
Poultry Animals (USD/Tons)	**1.203**	**1.621**	**1.968**	**1.969**	**-1,9**	**-2,1**
Change since 2000		**34,7**	**63,6**	**63,6**		
If there is no climate change 2050			**21,4**	**21,5**		

***Table 10:** Changes Expected in the Prices of Some Grain Products Compared to Models Selected in the World (IFPRI, 2009).*



6.3. Decrease of Productivity in Agricultural Products

Agricultural sector and climate are integrated into one another. The effect of natural factors directly affects the efficiency. Therefore, change of natural resources which are very important for soil and water affect the quality and amounts of agricultural products negatively. Significant changes are observed in the agricultural production depending on the climate change. In particular, in particular it could be seen that strong weather conditions that affect agricultural efficiency such as storms, hot waves and damaging frosts, affect productivity (Buken et al, 2017).

The unpreventable growth in greenhouse gas emissions increase the temperature of the world, leading to seasonal changes such as melting glaciers, drought, more precipitation and extreme weather conditions. The increasing climate change speed threatens the agricultural security everywhere. Agricultural products are very sensitive against climate change. Agricultural productivity is negatively affected from drought. Whereas weeds and pests increase as a result of higher temperatures, these increases decrease the efficiency of the crops. Changes in the precipitation order also increase the crop failure in the short run, and production fall in the long run. Even if there are earnings in some crops in some regions of the world, it is projected that the general effect of climate change will be negative on agriculture and threaten the global food security.

In the year 2005, almost half of the economically active populations in developing countries (2.5 million people) relied on agriculture as livelihood. However today 75% of the poor in the world live in rural areas (World Bank, 2008).

Food Policy Report provides research results that measure the climate change impacts indicated above, evaluate the results of food security and estimate the investments which will compensate the negative results for human wealth. The results of the analysis demonstrate that agriculture and human wealth will be negatively affected from the climate change:

- In developing countries, climate change will cause to efficiency falls for the most important crops.
- In particular, South Asia will have problems due to climate change.
- Climate change will have variable effects in all wet agricultural lands, however, it was observed that significant falls will take place for products on all wet agricultural fields in South Asia.
- Climate change will lead to additional price increases for the most important agricultural products such as rice, wheat, corn and soy bean.
- High feed prices will lead to higher meat prices.
- As a conclusion, climate change will reduce the increase in meat consumption for some amount and will cause a higher decrease in grain consumption.

6.4. Regional Inequalities in Agricultural Economy

There are numerous studies that demonstrate that agricultural production is affected to a significant degree from climate change at both regional and global scale. Therefore, it is possible to indicate that crop production (both for food purposes and industrial purposes) will be affected from regional climate change. Estimations related to such type of effects change depending on the type of crop, region and the climate change adaptation scenarios. On the other hand, it could be seen with scientific researches and observations that, the findings obtained demonstrate difference in geographical terms and therefore the world cities are affected by climate change in different forms and at different levels (Bulkeley, 2013).

Urban areas are 5-6°C hotter on average from the rural areas as a result of concrete buildings and intensity of structures. This is a general situation which we call as Urban Heat Island (UHI), affecting the urban life negatively with the temperatures that increase in summer months in the hot climate regions. Increasing average temperature levels and extreme drought cause the crops to be unfertile and this negatively affects the agricultural economy. It is estimated that the UHI effect will further increase depending on the wind and air circulation that decreases with increasing solarization as a result of climate change, causing many cities to be exposed to deeper UHI effect, heat waves and drought (UN-HABITAT, 2011).

In case that correct adaptation policies could not be implemented in hot regions, the yields of grains that are important for food security, such as wheat, rice and corn, will be negatively affected from local temperatures above 2°C. Climatic differences will negatively affect potentially all dimensions of food security such as access to food, utilization and price stability. Combined with the increasing total demand for food that increased as a result of increasing population, such negative impacts will create higher risks for the food security at both regional and global scale particularly in regions at lower latitudes and create problem for agriculture based economies. In addition to this, it is expected that the efficiency differences and yield fluctuations over years will increase further in many regions. Due to changes in average temperature and precipitation levels on regional basis, increases are observed at global scale in food and grain prices. This demonstrates that the existing markets are highly sensitive against the impacts of regional climate change.

As it was indicated under 5th Review Report of IPCC, there are numerous studies that estimate the potential impacts of climate change on product yield (IPCC, 2014). In many of the studies, it is estimated that climate change will have negative impacts on the product efficiency. IPCC indicates that, relying on the existing researches, there are important findings indicating that wheat and crop production will be negatively affected from the current climate trends in many regions. Moreover, it could be seen that warm regions are more prone to such type of negative impacts. For example, Turkey, which is located in a warm geography, namely the Mediterranean Basin, is among the countries exposed to such type of negative efficiency impacts. According to a study by Dellal et al (2011) which evaluates the economic and biophysical impacts of climate change on the plant production in Turkey, falls between 3.8% - 10.1% are foreseen in crop efficiencies in all regions of the country (Table 11). It is expected that the cotton will be the product which will be least affected from climate change and corn will be the most effected.

Table 11: *Percentage Changes in Corp Yields Compared with Reference Scenario According to HADCM Projections (Dellal et al, 2011).*

	Wheat	Barley	Corn	Cotton	Sunflower
Black Sea	-6.0	-7.0	-7.4	-	-5.0
Marmara	-10.3	-8.5	-7.9	-5.0	-5.9
Aegean	-7.2	-7.2	-11.0	-3.6	-6.6
Mediterranean	-6.5	-6	-10.9	-2.8	-6.8
Central Anatolia	-7.4	-8.2	-12.5	-	-7.3
East Anatolia	-8.3	-8.5	-12.1	-	-7.9
South East Anatolia	-7.2	-7.5	-9.2	-4	-6.3

Together with this, changes to be seen in the precipitation regime cause the decrease of agricultural production and increases in precipitation in arid and semi-arid regions lead to increases in product amounts. Besides, there is a possibility that the amount of production will increase in some products in middle and higher latitudes. Despite these and similar positive effects, it is expected that the general impact of climate change on agriculture will be negative (due to the increase in temperatures (Nelson et al., 2009).

6.5. Costs Reflected to Citizens

Increases that are and could be seen in the frequency and magnitude of natural disasters such as floods and storms due to climate change, could cause that the capital becomes out of use before the expected lifetime. Besides, the global heating with impacts to last for long years, will frequently bring to the agenda the capital investment adjustments (Fankhauser and Tol, 2005). Such an impact could cause capital damages in developed countries which allocate a significant part of their national incomes to fixed capital investments, and lead to deprivation of physical capital.

Similarly, the rise of sea level as a result of climate change could increase the risk of agricultural areas being damaged by increasing the risk of agricultural areas being damaged. The deprivation of agricultural capital means the deprivation of the segment dealing with agriculture to be economically deprived. The production will fall on agricultural areas which are corroded as a result of climate change, and thus there will be increase in costs reflected to the citizens. On the other hand, as a result of distortion of agricultural areas that increase in connection with climate change, country economies will face with significant monetary losses. In this regard, the increase in the intensity of greenhouse gases in the atmosphere and a rapid increase trend in the temperatures parallel to this increase the risk of occurrence of natural disasters.

Countries which are exposed to the negative impacts of agricultural areas that arise as a result of climate change use their resources to avid these damages and to adapt to climate change, which will lead to alternative costs, leading to negative results in economic terms on the citizens who are dealing with agriculture. The alternative costs of resources spent for climate change could be listed as research and development (RD) activities and productive capital investments (Bernauer et al, 2012). These alternative costs create negative impacts on economic growth. Together with this, climate change could affect many sectors in the economy through different aspects.

Since agriculture is mainly an activity that is conducted in connection with climate and weather conditions (Bazzaz & Sombroek, 1996), the impact of climate change on agriculture is more than other sectors. Besides, due to the fact that agriculture is an activity that uses the natural resources, it has impacts on soil and water resources and changes in natural resources also affect the agricultural production. Due to all these characteristics and its structure that is different from other sectors, agriculture is affected more from the effects to be caused by climate change and its impact range is more (Republic of Turkey, Ministry of Environment and Urbanisation, 2012). The agricultural production expected is decreased with the high temperature and the impact of the weeds and pests caused by high temperature.

Changes in agricultural production which could arise with climate change could lead to important reflections in country economy as well as in the economic and social structure of the citizens who make their livelihoods from agriculture (ibid).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7. EVALUATION OF THE CONNECTION OF CLIMATE CHANGE WITH FOOD SUPPLY

Food unsecurity could be considered as the world food supply becoming under threat as a result of the crops being negatively affected under hotter and drier conditions than expected in productive agricultural regions and the decrease of the production amount. The economic consequences caused by the efforts of mitigating the effects of climate change and greenhouse gas emissions in addition to food security, negatively affect the agricultural product prices and the supply chains. If, by the year 2050, CO_2 mitigation policies could be equally implemented between all sectors and regions, it is modelled that the global hunger will have a bigger negative impact than the direct effects of climate change. The negative effects will be more widespread in vulnerable and low income regions such as Sub Saharan Africa and South Asia where the food security problems are acute (Hasegawa, et al.2018).

Paris Agreement which was adopted in 2015 aims at keeping the temperature increase under 2°C until the end of this century. With the Paris Agreement, policies have been determined in order to ensure that countries which are included in the category of developed countries act more diligently in terms of converting significant amount of crops into fuel under the name of biofuel against the risk of decrease in food supply overall the world in the future. When the impacts of climate change on food supply are examined from the point of agricultural production, markets and food security in the studies that were conducted in the previous five-year period, it was determined that the climate change decreased crop productivity overall the world (Nelson et al., 2014; Lotze et al., 2014; Von Lampe et al., 2014). In the study that was conducted in 2018, when 8 different climate models are implemented, even in the best case scenario, it is foreseen that by the year 2050, the crop efficiency will decrease by 17% overall the world and the food prices will increase by 20% (Hasegawa et al, 2018).

In order to ensure food security, it is necessary that the food must be available, accessible, stable and able to be utilized. Measuring the food security is conducted by main and sub-indicators (Agricultural Report, 2017).

Food security calculation method should be reliable, low-cost and time-sensitive, and also enable making comparisons between geographical and cultural differences and be understandable for the policy makers (Nathalie, 2012). According to the Vulnerability Analysis and Mapping (VAM) program of World Food Programme (WFP), methods used for measuring food security are as follows:

- ''Who is unsafe for food or could be affected from this
- Where is food unsecurity happening
- Why is food unsafe
- How many people
- What should be done in order to improve their living standards
- How will their situations change in the future and what are the risks that threaten them''. These questions should be answered (WFP, 2017).

According to The Committee on World Food Security (CFS), the process of monitoring and mapping the food security should be made a part of national food and agriculture knowledge systems and a standard methodology should be used at the country level (CFS, 2017). However, no common standard or criteria has yet been defined that could be used for describing the determinants of food insecurity in different countries (Vineman, 2014). The heterogeneity in global population, difference of governments and the policies, diversity of local economy, labor markets and agriculture, there are certain methods created for defining the food insecurity overall the world. International organizations have conducted studies in order to overcome lack of information about the issue and created combines indexes that bring together the information obtained from food security indicators (Santeramo, 2014). Various economic, political and social variables are used in the calculation of indexes.

Main variables that are used are per capita income, share taken by food expenditures from income, rate of population living under poverty limit, food supply and daily calorie availability. In addition to this, agricultural infrastructure has variables that are specific to indexes such as agricultural infrastructure and RD, widespread anemia among women, and rate of obesity. In recent periods, with the increasing environmental problems and sensitivity, it is to be highlighted that variables such as the availability and quality of water, biodiversity, temperature increase have been included in the food security indexes.

7.1. Nutrition Energy Supply Sufficiency

In the food security measurement, it was found to be appropriate to use calculations which are determined as "sufficient food supply" (Hendriks, 2015). Food security was evaluated using annual food balance sheets and measured depending on covering per capita energy need (Hassan et al, 2017). In this process, focus has been put on developing agricultural production strategies and food safety in ensuring food safety (Coates, 2013). The name of this indicator is dietary energy supply adequacy (consumable nutrient energy supply – nutrient energy need) / nutrient energy need)

This indicator does not take into account the distribution of consumption within the country and provides an idea about the potential food safety. While making calculations for nutrient requirements, with an optimistic approach, only the amount of energy needed for human beings to sustain their lives is used.

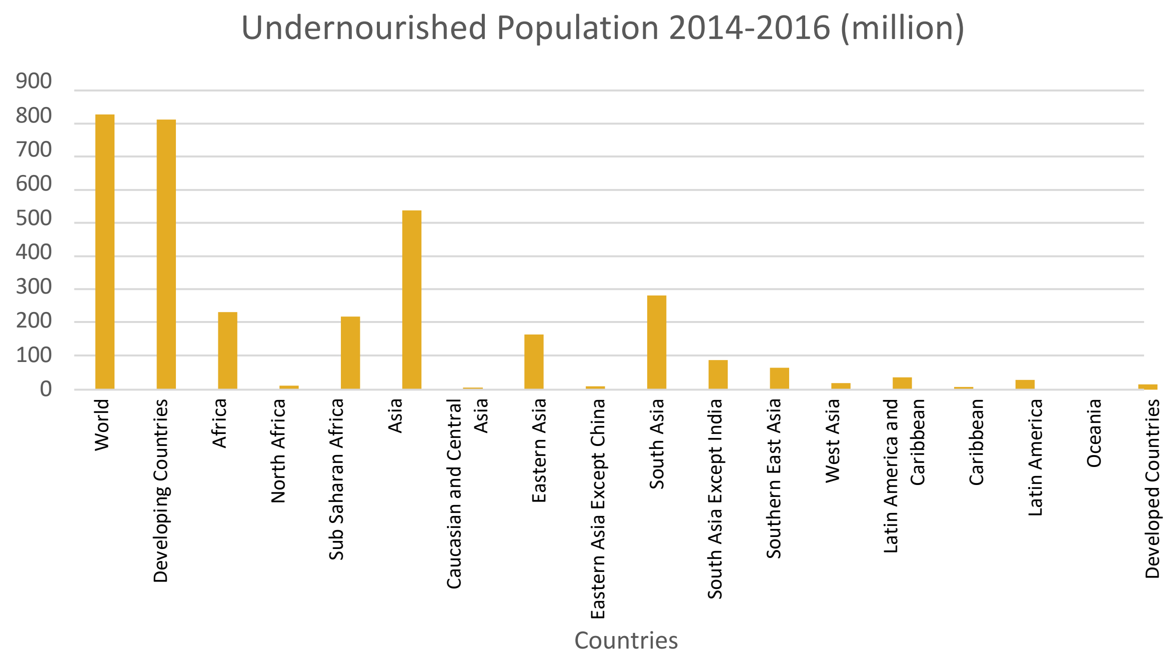
7.2. FAO Food Security Indicators and Methods of Calculation

For the purposes of demonstrating the status of food security, nutrition and hunger overall the world in relation to countries and regions, The State of Food Insecurity in the World (SOFI) report, prepared jointly by FAO, IFAD, UNICEF, WFP and WHO, has been published annually since 1999. The name of this report was changed in 2017 into "The State of Food Security and Nutrition in the World" (Koç et al., 2018).

In 2016, the prevalence of undernutrition has arisen and the progress that was accomplished in the last decade was reversed back to levels in 2012 (FAO, 2017).

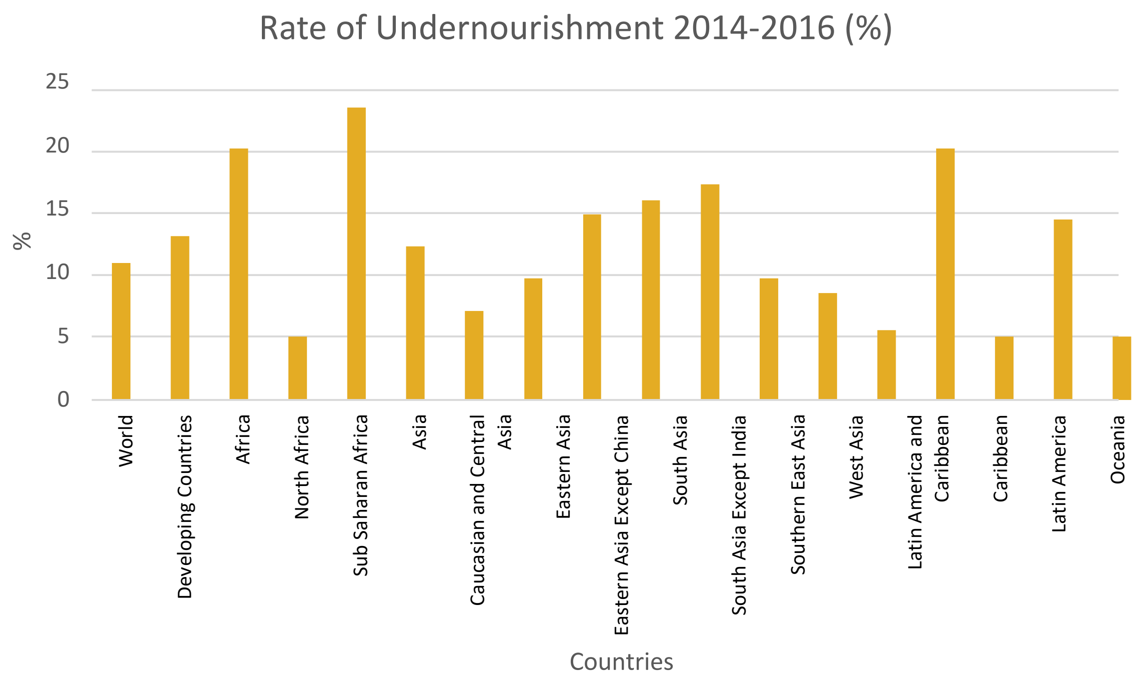
The prevalence of undernutrition was disclosed as 10.8% for years 2015 – 2017 and it was indicated that the number of people with undernutrition was 821 million in 2017 (Figure 1) (FAO, 2018a).

Figure 1: *Global Population With Undernutrition (2014 – 2016) (FAO, 2017)*



Although Prevalence of Undernutrition (POU) is a useful indicator in terms of demonstrating the condition of the countries as of the dimensions of accessibility and availability of food security, it was demonstrated that the values in the index did not reflect the reality for some countries and also these were insufficient in terms of fully representing the food insecurity and there has arisen a need for more comprehensive indicators (Figure 2; Van Wesenbeeck, 2017). Committee on World Food Security (CFS) indicated that FAO should put special emphasis on developing the reliability and actuality of the parameter (CFS, 2017).

Figure 2: *Percentage of Global Undernutrition Rates (2014-2016) (FAO, 2018a)*



Among the human effects of food security are the demographic changes, food waste, dietary change, income and prices, storage conditions, health status and trade models. The effectiveness of adaptation strategies against all these systemic changes is uncertain. The future economic and trade environments and the reactions these will demonstrate towards the changing food supply are tightly connected with these factors. In particular, the decrease in animal food consumption which we could characterize as mitigation of food waste and dietary change, may play a determining role in terms of ensuring food safety.

As it is seen, the impacts of climate change on food safety could be reduced by adaptation. Although it is possible that climate change could reduce agricultural efficiency, it is possible to mitigate the negative consequences to be encountered through various means. Among these solution paths are the efficient investments, powerful adaptation strategies and policies that develop sustainable agricultural preferences and awareness rising which will help providing information to farmers about new efficient technologies. In this regard, whereas initiatives such as "climate smart" food production and distribution systems, technologies and adaptation strategies towards food systems could help adaptation to climate change, these could also meet the climate change mitigation targets.

7.3. Food Supply and Role of Supply Chain in Climate Change

Short term climate shocks and long term climate change causes the distortion of food supply chain. In order to define these distortions, it is necessary to;

- Analysed the types and determinants of gaps in food supply chains against climate shocks and change;
- Evaluate how these fragilities could be conditioned with the rapid transformation of dietary change and food systems;
- Discuss how the actors of supply chain from farmers to workers, distributors to input suppliers invest on mitigating the risks of these shocks and the fragilities;
- Discuss the consequences of food policies and demonstrate the climate smart food supply chains in the developing regions and thus demonstrate the fragility of food supply against climate change.

7.4. Impacts of Short Term Climate Changes on Food Supply Chains

Short term climate shocks increase climate fragility and could show itself in different ways at various points along the supply chain. Points related to energy or food safety, which are considered to negatively affect the life and expected to create climate-shock, are called the "hot points" (Giorgi, 2006). Hot points arise at both food storage points and at processing points and agricultural production points. The security gap at each production and storage stage, in others words abnormal conditions that will occur at the hot points in the supply chain, depend on the type and characteristics of climate shock that will occur at a certain stage. However, other than these hot points being directly outside the supply chain, these will indirectly affect the food supply as a result of affecting the side elements that support agricultural production which we call as secondary supply chains fed by product supply chain.

Short term climate shocks could include floods that occur on highways, abnormal tidal waves or non-seasonal and strong tsunamis. These climate events could slow down or stop the product or input flow along longer supply chains in particular. For example, the production that takes place in a big poultry animal production and processing integrated facility in Thailand relies on the import of grains from the United States of America, and the white meat products produced as a result of production are exported to China and Russia. Stopping of the operation on any of the supply chains could interrupt the production overall the system, or make it harder for people to reach that product by increasing the cost. As it could be seen from this example, the food supply today is carried out in a global manner and weaknesses occur against climate shocks not only in the country where production takes place, but also in all countries in the supply and sales chain (Liverpool- Tasie et al, 2016).

An important point is the increase of fragility of a supply chain with the number and characteristics of the hot points. Besides, the number and characteristics of hot points are the functions of the structure, execution and performance of supply chain structure. We can list these conditioning factors, which are the elements of supply chain transformation as follows.

1) The factor that first determines a hot point in the supply chair is the physical infrastructure that affects the production risk in the supply area. In agricultural field, irrigation, drainage and flood control infrastructure are the most important factors that determine the effect of drought and flood shocks. Unfortunately, the infrastructure that will tolerate climate changes and the hot points that arise in connection with these changes is very low in East and South East Asia and Africa (Rosegrant et al, 2009).

2) The geographical distance that should be taken throughout the supply chain. Side and raw material supply at long distance to the production region and the period and distance of distribution to demand points being long, will increase fragility against climate shocks. Besides, these long supply chains also increase the carbon footprint of food materials which is very important in relation to climate change. Despite this, with the rapid urbanisation and increase of climate fragility in the globalization process in the world, there is a need for longer supply chains.

3) The need for product storage. As the possibility of the product to spoil, or the need for transporting with cold chain or cold storage increase, sensitivity against climate shocks will increase.

4) The strength of physical capital. The physical capital being strong is one of the key elements of fragility of supply chains against climate shocks. An example to this factor is the damage caused in recent years on traditionally weak greenhouses which lack technology and are located at the hot points in the Mediterranean region of our country. Capital/ labor rate has a general trend that increases fragility in food supply chain while shifting from traditional to modern chains.

The reasons for this trend:

- Physical capital and technology replacing the labor force
- Physical capital decreases the costs caused by climate in the supply chain, bigger vehicles and integrated facilities and therefore the transportation periods, and ensures the mitigation of increasing costs of supply chains and hot point fragility.
- The quality competition that increases in the modernization of supply chains increases the need for equipment of the suppliers in order to acquire quality and safety specifications meeting purchaser requirements and standards. The dependence of suppliers and purchasers to "fixed investments" that gradually increases could be encouraged for protecting these assets against climate shocks (e.g. investments under flood control).

5) Position of the production. Sensitivity towards climate change could be mitigated by carrying out production at a point which is less fragile against production. However, when the suppliers want to increase fragility by carrying the product for a longer distance after being produced at certain points, they may be dependent on certain purchasers.

6) Big and sector giant companies could increase or decrease fragility against climate shocks. On one hand, intensifying a process on only one single big company rather than various small companies could make the process more risky. Any production problem which will occur in these big companies could negatively affect the whole market, while the presence of small and various companies could prevent this shortcoming. However, the big companies will have the financing and accordingly the technology to make "threshold investments" required for coping with a climate shock as it was indicated before. In other words, this could both increase and decrease the fragility.

As a conclusion, the determinants of hot points explained above, namely the physical infrastructure for decreasing the production risk in supply regions, geographical length of supply change, the possibility of the product to spoil, intensity and robustness of physical capital create numerous "hot points" in the developing country food chain. Meanwhile, locations and products demonstrate huge differences on the supply chains. These differences mean that solutions towards climate risk should be adapted in the supply chains.

7.5. Impacts of Long Term Climate Change On Transforming Food Supply Chains: Challenges and Strategies

The climate has various possible impacts on agriculture. Transitory weather conditions will affect both the amount of production at land level, as well as the places where the production should be shifted. Together with the changing climate conditions, the companies could make investments on land, processing facilities and equipment in new production regions and complete their adaptation processes.

One of the unexpected results of climate change is the increase of difference between more traditional agricultural communities and more entrepreneur groups. This means that more innovative agricultural producers could overcome some of the negative impacts of adaptation to climate change with policies that provide access to new opportunities.

Similarly, climate change could cause the agricultural workers to migrate from the damaged regions under the worsening conditions. Though being a hard process, migration could make it possible for people who live in regions that suffer from climate change to live in climate regions which are not more fragile.

Even minor changes in temperature could have an important effect that requires adaptation (Di Falco & Veronesi, 2014). Besides, a bit higher temperatures could increase fragility against insects which are necessary for the blossoming of some trees and decrease the cold days, which means that the production will be affected. This could include practices towards mitigating the negative side effects and new species that adapt better to the changing agricultural conditions. Although the developed countries demonstrate efforts in supporting such type of researches and development, in some developing countries, the private sector could seek for suitable technologies for ensuring the usability of inputs.

8. MANAGEMENT OF WATER RESOURCES AGAINST CLIMATE CHANGE FROM THE POINT OF FOOD SECURITY

Water, which is one of the building stones of agriculture, is a key element for the continuity of all life. Whereas irrigation performed in agriculture increases the quality and quantity of agricultural production, it may also cause distortion of the natural balance under conditions when sufficient measures are not taken (Cinar, 2006). Agricultural sector is the number one water consumption sector in many countries including our country. The need for food that arises with population increase, and water which decreased and is expected to decrease further due to climate change have encountered to big problems. As the demand for water resources which has become restricted over time rapidly increases, the amount of water used in agriculture becomes limited and the food safety overall the world becomes endangered. As the global population reached from 2.5 billion in 1950 to 6.5 billion today, the area irrigated was doubled and the water drawn was tripled. If there is no change in the current utilization level and habits, it is expected that the water used in agriculture will be more than 70% in 2050. The amount of water used in agriculture is 7130 km^3 as of 2007 and it is projected that it will be doubled in 2050 and reach to 12000 – 13500 km^3 (Molden, 2007)

The water potential decrease that will occur as a result of climate change combined with the increase in the water demand due to population increase makes it necessary the effective use of water resources. The fact that around 75% of the water resources that are characterized as usable in our country is used in agricultural sector requires that the water saving to be made in agricultural irrigation practices should be saving-oriented. In recent times, there have been studies towards dissemination of drop irrigation systems in agriculture for efficient use of water resources (Cakmak and Gokalp, 2011). In our country, irrigation systems are generally designed as open systems. Accordingly, surface irrigation methods are used in a high portion of irrigation areas. This design form and irrigation methods used increase water losses by evaporation and endanger the environmental sustainability of agricultural areas. For that reason, it is the most important necessity in our country to disseminate the irrigation technologies which will increase the efficiency of water use. As the water is used efficiently in agriculture, vaporization is reduced to a high extent. Besides, using the climate change effectively towards water resources could mitigate at a certain level the negative impacts which have arisen or could arise in the agricultural sector (Korukçu et al., 2007).

8.1. What is Water Resources Management?

The total amount of water is around 1.4 billion km^3 in the world. However, only 2.5% of this comprises fresh water, and the remaining comprises salty waters. Around 68% of fresh water is in frozen condition in the poles. For that reason, their processing and utilization will create significant burden in economic terms. Underground water resources correspond to around 31% of the existing fresh water. However, it was determined that a significant part of these waters are not at an economic utilization depth (UNESCO, 2006). Only 0.3% of the fresh water is found in surface water resources. Unfortunately currently 1.2 billion people in our world try to maintain their lives deprived of sufficient drinking water. Around 2 billion people yearn for healthy water. Annually 7 million people die from diseases related with water. Annually per capital water consumption in the world is around 800 m3 on average (Kanber et al, 2010).

Fresh water resources that are at a very limited amount in the world are the single element that could determine the future of both countries and the humanity. For that reason, having a good organization in every field from the protection of water resources to their operation, from distribution of water to its removal, is one of the most fundamental problems. This integral structure is defined as water resources management. This integral structure includes the protection of forests and pasture land, namely of the nature. In other words, protection of water makes it necessary to protect the whole ecosystem, not only a narrow area. However, it should not be forgotten that water management could be done on the basis of basin in terms of applicability. (Soylu et al., 2006).

The building stone of water management is the development and protection of water basins. For that reason, developing and protecting the water resources and putting these into usage afterwards depends on a disciplined organization and also ensuring sufficient financial conditions. As a matter of fact, taking the water from the source and supplying it to the utilization areas at desired quality and quantity, could be made with big investments such as dams, ponds, water transmission and distribution networks. However, while making the regulations required for water, taking into account the socio-economic conditions in the country and the sectoral developments will help increasing the water supply security.

In today's world, Integrated Water Resource Management applications have been observed since the beginning of 1990s. With this method, the aim is that the ecosystems should not be damaged while developing water resources and sustainable socio-economic and environmental development is ensured. The term "integrated" in the concept refers to the relationship between many objectives indicated below (Yildiz, 2013). In global terms, while creating water management frameworks, there are suggestions that institutions such as the World Bank and IMF should assist the countries with significant incentives and that the countries have no other way to do this (Kilic, 2008).

Whereas there is a significant weight of public sector in water services overall the world, there has been important changes after 1980. After 1980, private sector also started to take place in addition to public in providing the water services. In this process, the efforts to get away from the fact that water services are a public service and to try to impose that it is an "economic commodity", have become apparent. One of the fundamental principles adopted in Dublin Conference, that "the water shall be accepted as an economic commodity", is an evidence of this issue (Salihoğlu, 2006; Kılıç, 2008).

8.2. Water Resources and Food Security Relationship

It is possible to summarize food security with four fundamental factors. These are indicated below:

- Accessibility of food
- Food utilization
- Food sufficiency
- Stability in food system

As it could be understood from this classification, food security could be expressed as the ability of the societies to produce food that could feed them, that they have the economic level to access the food produced, that there exists a sustainable food system, healthy storage methods, quality of the food accessed, its nutritive value and hygiene conditions (FAO, 2008). As a result of changes that could occur as a result of climate change and failure to meet the need for irrigation in particular due to increasing temperatures and decreasing precipitation, food accessibility, sufficiency and stability are under threat with the contribution of the increasing population.

In the studies conducted, there are significant temperature increases observed in particular in the inner regions of our country until the year 2100. It is projected that, in connection with this, precipitation is observed in the form of rain rather than snow and the snow cover melted with a higher speed and mixed to surface waters, and also that the magnitude and frequency of the precipitation within the year will change and shift (Büken & Güner, 2017). Melting of the snow mass together with the precipitation falling more in the form of rain, has the potential that could cause significant problems in the utilization and irrigation waters in regions which provide their urban and agricultural water needs from snow melts at high altitudes throughout the year. This change in the hydrologic cycle could cause severe changes in the quality and quantity of the water resources and affect many climate-dependent sectors, including at first the food production, where water has a vital importance. In addition to this, the increase of summer temperatures caused by climate change in Turkey, decrease of winter precipitation (in particular in western provinces), loss of surface waters, increase of droughts, distortion of soil, erosion, flood and overflows experienced on coasts and other factors directly affect the existence of water resources (UNDP Project Team, Ministry of Environment and Urbanisation, Environmental Management General Directorate, Climate Change Department, Policy and Strategy Development Branch, 2012).

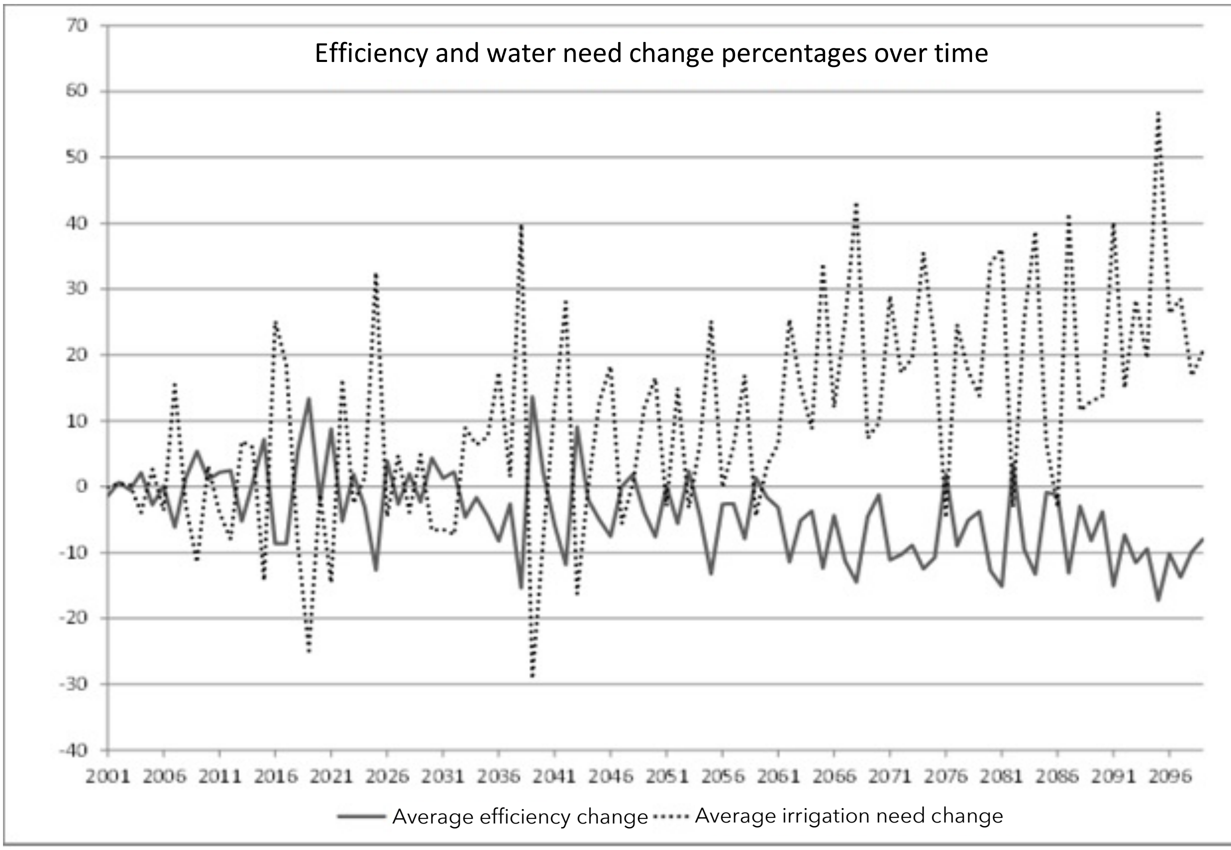
It is foreseen that the most significant impacts of climate change will be on hydrologic cycle and that the climate change in our country will lead to reduction in water resources in the future. For example, it could be seen that there is a decrease in precipitation in the Cukurova Basin and an apparent increase in the temperature, accompanied by a trend of decrease in the flows (Buken, 2016). Besides, it is estimated that 50% of surface waters on Gediz and Buyuk Menderes Basins could disappear in this century and thus extreme water scarcities could occur for water users in agriculture, houses and industry (Apak and Ubay, 2007).

Although human oriented climate change is at the top of the reasons for this situation, the excessive use of water in irrigation is another important factor that should be prevented. More than 70% of the total water used in our country is used for irrigation purposes. The most water loss among the irrigation methods used comprises in surface irrigation method that is most used in our country (water loss between 35% - 60%). Water loss is less in raining and drop irrigation (between 5% and 25%) (Yildiz, 2013). In addition to this, among the fundamental issues that should be coped for adapting to the effects of climate change are the illegal underground water usage, problems arising from the operation of the existing facilities, losses and illegalities in the grids, and occurrence of water pollution due to administrative and institutional problems and delaying of investments (UNDP Project Team, Ministry of Environment and Urbanisation, Environmental Management General Directorate, Climate Change Department, Policy and Strategy Development Branch, 2012)

While yet the first indications of a global crisis is being felt in our country, studies that are being carried out in relation to water management and water safety are on the rise. Figure 3 shows the efficiency and water need changes over time until the year 2100 in percentage according to the projections observed in the studies conducted. While the water needed for irrigation increases, a fall is observed over time in the productivity of the soil (Dudu and Cakmak, 2017).

Food security is a candidate to be one of the biggest problems that both our country and the world should handle in the future in relation to both transportation and quantity taking into account the gradually increasing country population, the soil becoming unproductive and the increasing need for irrigation.

Figure 3: *Productivity and Change in Water Need Percentages Over Time (Dudu and Cakmak, 2017)*



8.3. Country Policies Related to Integrated Management of Water Resources

State Planning Organization (DPT) has defined its objectives and targets in relation to water management as follows in the last development plan published in 2013.

"It is a fundamental objective to protect and develop the amount and quality of water and soil resources, and develop a management system which will ensure sustainable use including by the agricultural sector where the demand is the highest" (pp. 138).

The policies targeted in the same report are as follows:

- The shortcomings and uncertainties in the regulations in relation to water management will be overcome and the duties, authorities and responsibilities of the institutions will be clarified, and cooperation and coordination will be developed between all relevant institutions and organizations related to water management.
- National basin classification system will be developed so as to enable protection and sustainable use of water resources.
- It will be ensured to determine and monitor the underground and surface water quality and amount, create information systems, protect and improve water resources and prevent and control the pollution.
- It will be ensured that all of the water potential of our country will be used in a sustainable manner

in line with the requirements and that the utilization is rated

- Impacts of climate change and all activities in water basins on water amount and quality will be evaluated and relevant measures will be taken for ensuring water saving in basins, struggling against drought and preventing the pollution.
- Measures will be taken to protect the qualified agricultural lands and forest assets, including the natural preserved areas that have special importance. In this scope, struggle against deforestation and erosion will be made efficient, and environmental and social impacts of agricultural activities on soil resources will be monitored and preventive measures will be intensified.
- In order to ensure access to up to date and healthy land information, National Soil Database will be created using the remote detection and geographical information systems, land utilization planning will be conducted and the soil will be efficiently used, including as first the agriculture.
- For the sake of ensuring sustainability in irrigation, various alternatives will be developed such as amount restriction towards underground water resources and different pricing.
- Working processes of irrigation unions will be reviewed and alternatives will be created towards making the system more efficient.

Our country has foreseen the need to adapt water resources management policies within the scope of adaptation to the effects of climate change, and issues such as water management on the basis of basin, water distribution among sectors, water saving, demand management, control of water utilization, extension of observation network and increasing huge volume storage structures are handled as matters of top priority. Taking into consideration the use of the theory of "uncertainty", which has been highly emphasized in recent years in the impacts of global climate change and planning and management of water resources, it is necessary to determine in a more clear and correct manner the changed that could be possibly observed in land use and plant cover for the sake of foreseeing the future status of water resources under the effect of climate change. Within this framework, relevant emphasis should be attached to survey studies conducted in this area using the Geographical Information Systems and Remote Detection Technologies.

9. TURKEY'S POLICIES OF STRUGGLING AGAINST AGRICULTURAL DROUGHT

As the effects of climate change are felt in the Mediterranean countries of which Turkey is a part become felt more, these are accompanied concurrently by the situations of water scarcity as experienced more with the effect of drought arising from natural conditions and from human intervention, and thus these two concepts are frequently confused and used in place of one another. Water scarcity is the lack of water resources to meet long term average needs. Drought is a natural event that negatively affects water resources and production systems and causes severe hydrologic imbalances as a result of the fall of precipitation significantly under the normal levels recorded. In other words, whereas "drought" means a temporary fall in water condition due to low precipitation, "water scarcity" means that the water demand exceeds the capacity of water resources that could be benefited under sustainable conditions. In this sense, it becomes easier for a drought condition to turn into a disasters as a result of interventions caused by human activities on the natural balance. The concept of drought could be expressed in different forms (Bayramin, 2008).

Drought : It is a natural event that negatively affects water resources and production systems and causes severe hydrologic imbalances as a result of the fall of precipitation significantly under the normal levels recorded.

Meteorological Drought: It is expressed as a deviation in precipitation that arises from the normal values pertinent to a certain time period (generally minimum 30 years)

Agricultural Drought: Agricultural drought is the lack of sufficient water in the soil that will meet the needs of the plant.

Hydrologic Drought: Hydrologic drought means the decreases that occur in the hydrologic system such as source levels, surface flow, underground water and soil moisture due to long lasting lack of precipitation.

Drought Management Plan: It means the management plan which includes the measures to be taken before, during and after the drought towards the control of negative impacts of possible drought risks and solution of the drought problem (Turkes, 2014).

Crisis management: This is a provisional form of management which is implemented during the crisis and aims at restoring the situation to normal (National Drought Management Strategy Document and Action Plan, 2007- 2013).

Various studies have been carried out in our country within the framework of drought management. A huge part of these studies have been performed on the axis of agricultural drought. In addition to this, works have also been carried out for meeting the drinking water need of the provinces in case of any drought (opening of underground water wells, making water transfer between basins etc.) The most important feature of drought disaster that separates it from other natural disasters is that it is very hard to definitely determine the start and finishing time. For that reason, it is necessary to develop early warning systems in order to mitigate the damages of drought disaster and take relevant measures in our country. Short, medium and long term measures are taken for struggling against agricultural drought overall the country and action plans are put into force in order to sustainably mitigate the impacts of drought. Turkey Agricultural Drought Struggle Strategy and Action Plan has been implemented between 2008 – 2012 and revised so as to cover 2013 – 2017 years in 2013. It is not sufficient to only struggle against agricultural drought in order to mitigate the damages of drought. Meteorologic, agricultural and hydrologic drought should be considered as a whole and the institutional capacity should be developed in this direction. By this means, sustainable solutions could be developed for each sector affected from drought disaster and socio-economic benefit could be ensured. In this regard, it is necessary to ensure the implementation of measures that complete one another by relevant institutions and organizations.

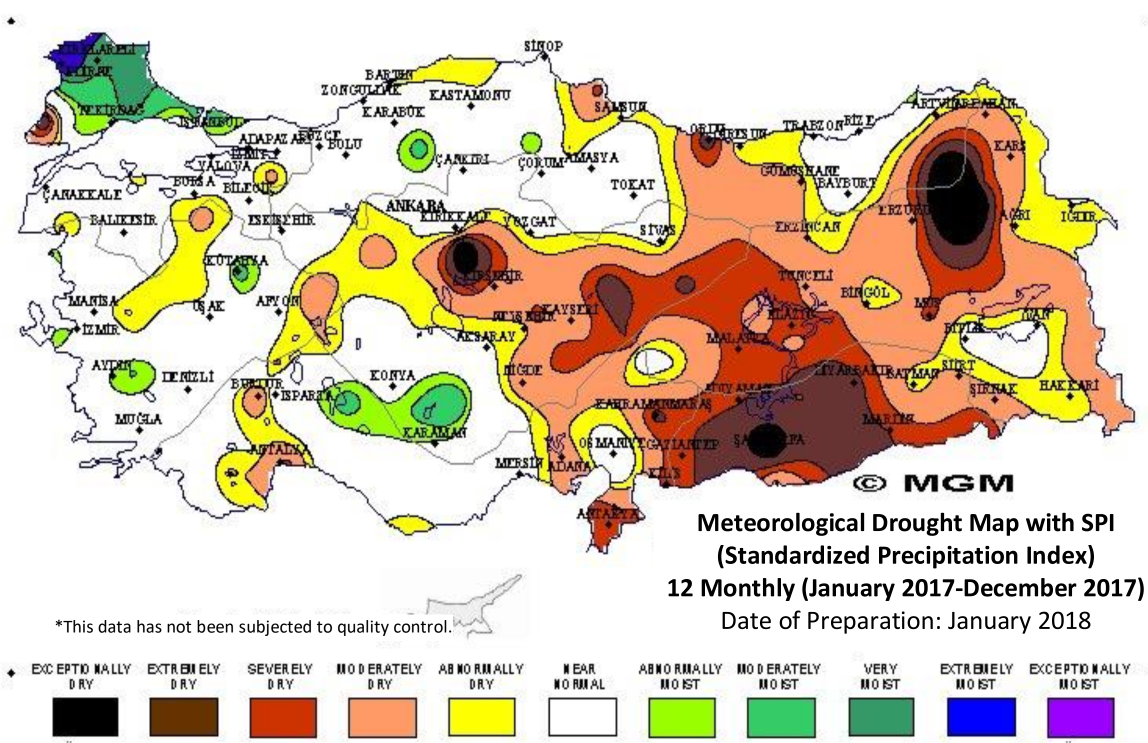
9.1. Indexes Used in the Determination of Drought in the World

- Percent of Normal Index
- Standardized Precipitation Index - SPI
- PALMER Drought Severity Index - PDSI
- Crop Moisture Index - CMI
- Surface Water Supply Index – swazee
- Reclamation Drought Index
- Deciles Method
- Keetch-Byram Drought Index
- Vegetation Condition Index
- Aydeniz Drought Index

9.2. Drought Index Used By Turkey Meteorology Affairs General Directorate

- Standardized Precipitation Index- SPI
- PALMER Drought Severity Index - PDSI
- Percent of Normal Index - PNI
- Aydeniz Method

__Figure 4:__ 2017 Drought Analysis With Standard Precipitation (SPI) Method (MGM, 2018)



Certain changes could be observed on regional basis between two determination methods. The most apparent difference was determined as severe drought in the calculation made with SPI Method in Antakya province and it was calculated at medium severity drought with PNI Method. This is the main reason for using different drought indexes simultaneously. Turkey Anti-Drought Action Plan was prepared based on these calculations and models.

As it could be seen, the risk of occurrence of meteorological droughts in our country in the near future and transformation of these droughts into agricultural and hydrological droughts is increasing (Kurnaz, 2014).

The first step of Turkey's policies for struggling agricultural drought is the action plans which have been prepared since past to now. The purpose of the action plans are:

- Develop an institutional structure that has reached to sufficient capacity;
- Perform the struggle within an integrated and comprehensive plan;
- Carry the agricultural sector to a structure where it is least affected from drought;

9.3. Strategy for Struggling Against Agricultural Drought and Action Plan Activities

Activities included in the Action Plan have been prepared by being grouped under the scope of main development axis and priorities on the basis of the strategy specified above.

1. Drought Risk Estimation and Management

- Crisis management based on agricultural drought estimations will be implemented

2. Providing Sustainable Water Supply

- Potential water retention capacity will be improved
- Water transmission canals will be modernized, and maintenance and renewal investments of water storage and transmission canals will be done on time.
- Measured will be taken towards collecting waste waters and reusing the purified waste waters in agriculture and industry.
- Efficient management of underground waters will be ensured.

3. Effective Management of Agricultural Water Demand

- Agricultural basins will be determined and the most suitable growing areas of agricultural products will be determined taking into account the water assets and water use in agriculture will be decreased.
- Irrigation systems will be modernized.
- Efficient use of underground waters for agricultural purposes will be ensured.
- Vegetative and animal production policies will be implemented taking into account the drought risk.

4. Accelerating Supportive R&D Works and Increasing Education/ Publication Services

- R&D works that will support struggle against drought will be accelerated
- Education and publication services will be increased towards relevant segments including at the top the farmers.

5. Development of Institutional Capacity

- Relevant legal arrangements will be made as necessary for efficient struggling against agricultural drought and institutional structuring will be strengthened;
- Developing the institutional capacity required in struggling against non-forest fires

9.4. Measures Determined Within Action Plan

9.4.1. Works to be Done Before Drought

- Determining the fundamental needs towards institutional and technical capacity in order to ensure drought management.
- Taking into account the characteristics of river basin and land use, determining the drought index and indicators to be used in determining the drought severity
- Drought estimation and creating early warning systems
- Preparation or development of drought maps and drought management plans for each basin
- Preparation and development of legal regulations that regulate the structuring of drought management at basin scale
- Preparing and developing the drought inventory
- Taking the effects of drought into account while preparing or developing the physical plans that foresee the use of various areas in the river basin
- Developing measures that will minimize the negative effect of drought cases to the sectors
- Preparing and developing agricultural product efficiency insurance system
- Training and informing the staff who are assigned in every stage of drought management and the public, and ensuring the participation of the public
- Performing training activities towards using the water economically
- Developing water pricing and prioritization policies so as to regulate the imbalance between water supply and demand that is expected to occur in case of drought.
- Preparing emergency action plans for institutions and organizations to be implemented during drought
- Taking into account the droughts experienced in the basin at the stage of preparing inter-basin water transfer projects
- Installing hydrologic monitoring stations, estimation and monitoring systems
- Encouraging and disseminating rain water harvesting and gray water use
- Shifting to modern irrigation systems which provide for water saving in agricultural irrigation systems
- Opening sufficient number of observation wells in order to monitor the underground water levels in the basins.
- Encouraging the plant species that consume less water
- Ensuring selection of plant pattern suitable for the basin
- Increasing the number of treatment facilities, ensuring their efficient operation and recycling the waste water
- Disseminating the use of waste waters treated with conventional methods by passing through advanced treatment systems and using it for irrigation purposes and modernization of treatment facilities
- Carrying out the activities included in Strategy and Action Plan for Struggling Against Agricultural Drought.
- If possible preventing, or mitigating the illegal use and losses in water transmission and distribution systems
- Ensuring quality and sufficient amount of drinking water supply
- Performing works related to the current status in order to be used in the drought periods in water supply and storage facilities
- Developing middle and long term estimation capacity and performing similar studies
- Increasing animal drinking water ponds
- Disciplining the conditions related to agricultural irrigation subscriptions

9.4.2. Works to be Done During Drought

- Making estimations and warnings for the course of drought

- Implementing Drought Emergency Action Plans prepared by institutions and organizations
- Implementing the operating plans prepared in accordance with the drought condition in the water supply and storage facilities
- Training and informing the staff who are assigned in every stage of drought management and the public, and ensuring the participation of the public
- Health and assistance services
- Carrying out the activities included in Strategy and Action Plan for Struggling Against Agricultural Drought.

9.4.3. Works to be Done After Drought

- Determining the damage on sectors
- Providing relevant support for sectors affected from drought taking into account the dimensions of effects
- Training and informing the staff who are assigned in every stage of drought management and the public, and ensuring the participation of the public
- Preparing After-Drought Improvement Plans related to all institutions, organizations and sectors for improving the severe and destructive damages that could occur after drought
- Reviewing the water supply and storage systems

9.5. Strengths Wherein Conditions Affecting Drought Management Are Systematically Analyzed

- Existence of rooted institutions that have strong organizational structure
- Authority held by the Ministry of Forestry and Water Affairs in relation to drought management
- Our country having human resources who are experts in various disciplines
- The Ministry of Forestry and Water Affairs being the national and international focal point in the fields related to drought
- Having a structure that is dynamic and open to innovations
- Having strong communication and technological infrastructure
- Recently making plans which are based on the basin size
- Starting to make drought management plans at the basin scale
- Basin preservation action plans being ready and river basin management plans being currently prepared
- The increase in recent years experienced in the financing provided by the government to basin investments
- Execution of "Strategy and Action Plan for Struggling Against Agricultural Drought"

9.6. Weaknesses Wherein Conditions Affecting Drought Management Are Systematically Analyzed

- Challenges experienced in accessing the data
- Problems experienced in coordination
- Gaps in the legal regulations
- Insufficiencies in policies and strategies related to basin management and failure to ensure coordination between basin based sectoral investment policies
- Insufficiencies in ensuring participation of stakeholders and local ownership
- Inadequate data information system at the basin basis
- Insufficiencies in the criteria and methods for the prioritization of basin projects and activities
- High level plans which will constitute the basis for performing basin works with coordination being not completed
- Data related to the effects of past droughts being insufficient

- Insufficient number of units working on drought in many relevant and responsible institutions

9.7. Possible Opportunities That Could Occur in Action Plans

- Preparation of Drought Management Plans at Basin Scale
- Increasing awareness among public in the world and in our country on sustainable drought management.
- Supporting modern irrigation systems which provide for water saving in agricultural irrigation systems
- Within the scope of Program for Making Water Use in Agriculture Efficient, launching the works after determining agricultural supports taking into account the existing water opportunities in a way that is compliant with the product pattern on the basis of agricultural basins.
- The climate change being in the agenda
- Increasing the scientific and academic researches in the field of drought management.
- Decreasing the human oriented pressures in upper basins due to migration
- Access to knowledge and opportunity to benefit from the developed information technologies (CBS etc.)
- Raising awareness in the society on protecting the natural resources and environment
- Increasing the contributions and effectiveness of civil society organizations
- Increasing the political interest and support
- The participatory approach being developed in the instutution
- Water basins management becoming important
- Arrangements within the scope of urban transformation law
- Integrated basin management of stakeholders other than public institutions (NGOs, scientific organizations etc.)

9.8. Possible Threats That Could Occur in Action Plans

- Conflict between public targets and targets of the private sector
- Irregular building on river basins and water collection basins of rivers
- Extreme ground and underground water consumption by farmers in the agricultural areas
- Excessive water consumption in cities and rural areas due to lack of training and knowledge, and failure to save water
- The increase experienced in natural environment pollution (air – water – soil) as a result of industrialization negatively affecting global warming and consumable water sources
- Opening the river basins for construction and failure to sufficiently protect the water collection basins of rivers
- Destruction of natural living areas as a result of necessity to create more settlement areas as required by population increase and fast industrialization
- Increase in urban population as a result of migration of agricultural population to cities
- Opening the agricultural lands to the use of different sectors
- Decrease in aquifers, decrease in source flow rates, decrease in river flows – drying out, water withdrawal on lake and swamp areas
- Distortion of water quality in water resources
- Failure to ensure ecologic flow with unplanned use of water, distortion of river and wet area ecosystems (GTHB 2018).

Turkey has been continuing developing policies for struggling against drought with its action plans and it has been acting actively with 2018 – 2022 action plan.

10. SUB ELEMENTS FOR AGRICULTURE

The land plays an important role in global greenhouse gas cycles. The greenhouse gases that are released from the land or kept at the land are carbon dioxide (CO_2), methane (CH_4) or nitrogen oxide (N_2O). Land utilization activities could lead to such type of greenhouse gases to be released to the atmosphere or removal of greenhouse gases from the atmosphere. United Nations Framework Convention on Climate Change acknowledges that land use could provide significant contributions in mitigating the climate change, including encouragement of other terrestrial, coastal and sea ecosystems in addition to sustainable management of forests and oceans. The Convention also indicates that precautions should be taken to ensure that land use is adapted adequately to climate change and that this is important for not threatening the food production (Dogan, 2011).

10.1. Precautions Against Deforestation and Reduction of Forest Amount (REDD)

Forests and trees store the carbon. When they are burnt or cut off – as a result of this process which is called deforestation – this stored carbon is released back to the atmosphere as carbon dioxide and contributes to climate change. Deforestation contributes to around 12% of the carbon dioxide emissions arising from human activities. This number increases up to 15% when the tropical turfs that could include ten folds more carbon from the forests and have now been exposed to degradation to a high extent, are included (DeFries, 2016). In the last ten years, the biggest deforestation occur in tropical regions. Although it is hard to measure, current global estimations demonstrate that there is a loss of 13 million hectares (an area which is half the size of the UK) annually between 2000 – 2010. It is known that the purpose of the population that destroys the forest is to transform these into monoculture farms that produce high value products such as soya from the agricultural areas to feed their families (Koglo, 2018). Scientists know the value of protecting the forests in struggling against climate change. In response to this, policy makers have developed a policy which is known as Reducing Emissions from Deforestation and Degradation (REDD) in order to provide a financial incentive to the governments, agricultural enterprises and communities so as to protect the forests. This policy is named as REDD. Climate Change Carbon Project and Market Terms Glossary included this climate policy, which is named as REDD, in the glossary of terms as the mitigation of emissions from deforestation and degradation of forest areas. In general, reducing the emissions arising from deforestation and soil degradation, is defined as mitigation action towards protecting the existing carbon stocks in forests (in general tropical rain forests) and turf areas. This approach is towards providing additional contribution to project based works.

These policies not only mitigate the carbon emissions, but also provide benefits from the point of protecting the biodiversity taking into account the fact that tropical forests are the richest terrestrial living areas. In places where the local people are included suitably in the REDD process, assistance could be provided towards alleviating the rural poverty. Recently, REDD was extended to include broader benefits beyond only reducing deforestation and degradation. The expanded scope, which is called REDD+, involves the act of managing the forests in a more sustainable manner and providing bigger protection efforts. REDD policies have been operated through various mechanisms including those managed by the United Nations (UN-REDD) and the World Bank. REDD financing is also taken into account in international climate change negotiations and continue to be a key component of international climate financing discussions. Within the scope of REDD, forest protection payments are made by developed countries to the developing countries and depend on the deforestation mitigation performance. Although experts have shown how REDD could significantly mitigate CO_2 emissions and prevent the loss of biodiversity, it is not devoid of problems. Some developing countries could be attentive against foreign intervention in their land use policies. Researchers also emphasize their operational concerns such as challenges in monitoring and measuring the deforestation rates or associating the changes in deforestation with REDD financing. Many tropical forest countries lack the capabilities to overcome these challenges. As a conclusion, capacity development is an important component of REDD.

10.2. Effects of Land Consolidation Applications

Countries which will be highly affected from climate change and food supply dangers are mainly the developing countries where there are multipiece and small family enterprises.

Since multipiece lands are inefficiency within the context of both infrastructure and natural resource use, they should be handled indirectly in the sense of land use in the climate changes.

Land consolidation provides for very important benefits in terms of consolidating small and amorphous agricultural areas. Since the small parcels will be brought together with consolidation, the distance between the operating center and the parcels is shortened and accordingly emission related to in0field transportation is reduced and fuel is saved. Besides, since the number of parcels is decreased, shapes are adjusted and sizes are increased, the efficiency increases and losses are decreased in agricultural inputs such as seeds, fertilizers and chemicals. Reduction of these losses means the reduction of the emission that occurs during the production of each agricultural input.

As the parcels are enlarged, they will have border with roads and canals, which will increase the waters used as a result of irrigation as well as transportation performance. Synchronous contribution could be provided to rural development and climate change as a result of all services such as environmental protection, erosion prevention, forestation, village renewal, planning of any type of roads, making village zoning plans, preparation of land use plans, being planned and implemented together with consolidation projects.

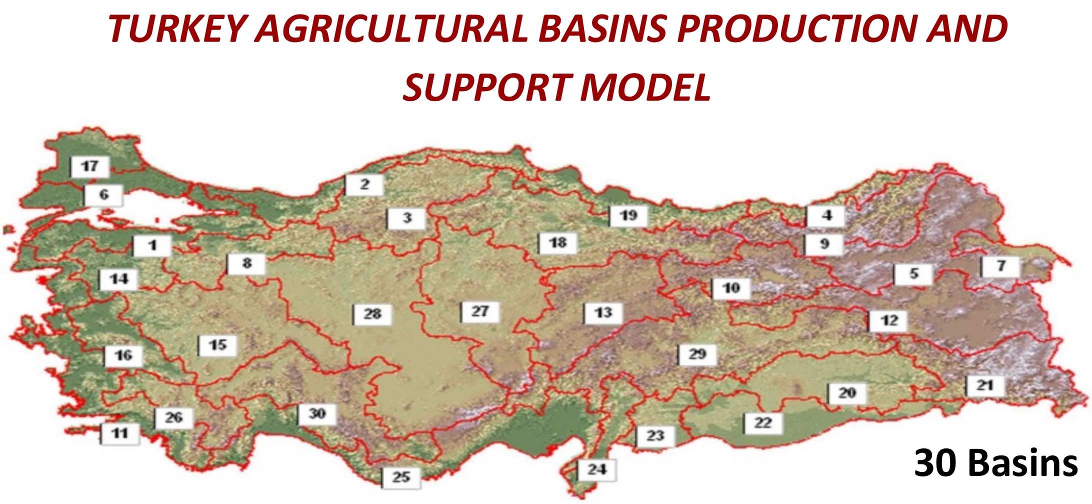
The planning and implementation of canals and roads in irrigation projects without consolidation remain dependent upon the parcel borders and pass from the borders to the extent it is possible. Since parcels are small and their shapes are irregular, canal lengths extent more than necessary, which increases the facility cost. If the irrigation projects are implemented by consolidation, irrigation, water and evacuation planning is made in the most economic manner without being dependent on parcel borders and it is possible to provide a saving in investment costs up to 40%. Water waste is minimized, and irrigation rate and performance are increased (Turker, 2015).

11. EVALUATION OF AGRICULTURAL BASINS IN TURKEY IN TERMS OF EFFECTS CLIMATE CHANGE

Agricultural basins are limited at sizes that could be managed in accordance with the administrative structuring of the country with economic similarities, and express the regions where the agricultural products could be grown most suitable in ecologic and economic terms.

Within the framework of adaptation to climate change, in the 5th Climate Change National Communication, planting of the products at the basin which is most appropriate according to ecologic demands of the products on 30 agricultural basins that were determined according to climate, soil and topography data within the scope of Turkey Agricultural Basins Project that were launched in 2009.

Figure 5: *30 Main Basins Defined in Turkey's Geography (Republic of Turkey Ministry of Agriculture and Village Affairs, 2009).*



The purpose of the project is to develop and implement agricultural projects which do not damage the environment throughout the chain of production with the participation of the local people and ensuring integration of multifaceted agricultural practices with other sectors and thus maximize the wealth of society, ensure sustainability in agriculture, develop the rural trade capacity in order to expand the commercial opportunity areas of producers and increase the efficiency of products against climate change. A database was created in relation to the agricultural basins determined (agricultural inventory) and a total of 527.782.613 data was recorded in the system. For the purposes of determining the product sowing areas, product support amount per basin and the agricultural product important and export amounts, a decision support system that ensures reaching the solution using optimization techniques was established. In this project which has been followed since 2009, both the climatic and economic efficiencies of 30 different agricultural basins are optimized with computer modellings every year and government subsidies are provided to the citizens for specified products (Republic of Turkey, Ministry of Environment and Urbanisation, 2013).

Academic studies that have been carried out within the scope of improving the agricultural basins specified and adaptation to climate change have been increasing day by day. Among the indicators used for the purposes of understanding the effects that could be created by climate change on agriculture, the first and last frost dates of the year and the dates on which the temperature value desired in the soil for triggering the growth in plants, which is 10 C, is reached as well as the last day thereof, are given in Table 12 and 13 respectively.

Table 12: *The current status in the reference period (1971 – 2000) of first and last frost dates of the year seen in spring and autumn months in general according to averages on the basis of basin (of days that have zero-degree air temperature at 2 m), and the trends of change in climate change projections for 2015-39, 2040-69 and 2070-99. In basins signed with " – " , a general trend could not be determined for representing the basin average (Kadıoğlu et al., 2017).*

BASIN NO	BASIN NAME	1971-2000 (REFERENCE PERIOD)	2015-2039 (START - END)	2040-2069 (START - END)	2070-2099 (START -END)
1	SOUTH MARMARA BASIN	-	-	-	-
2	WEST BLACK SEA BASIN	-	-	-	-
3	NORTH WEST ANATOLIAN BASIN	11 MARCH - 30 NOVEMBER	11 MARCH – 13 DECEMBER	3 FEBRUARY - 12 DECEMBER	11 FEBRUARY - …
4	EAST BLACK SEA BASIN	18 FEBRUARY - …	2 MARCH -…	-	-
5	KARASU ARAS BASIN	9 APRIL – 5 NOVEMBER	8 APRIL – 12 NOVEMBER	5 APRIL – 17 NOVEMBER	25 MARCH – 30 NOVEMBER
6	NORTH MARMARA BASIN	-	-	-	-
7	GREAT AGRI BASIN	27 MARCH – 23 NOVEMBER	23 MARCH - 26 NOVEMBER	12 MARCH – 1 DECEMBER	29 FEBRUARY - 10 DECEMBER
8	SÖĞÜT BASIN	3 MARCH – 27 DECEMBER	23 FEBRUARY - …	8 JANUARY-…	-
9	ÇORUH BASIN	5 APRIL – 27 DECEMBER	8 APRIL -…	2 APRIL -…	25 MARCH -…
10	HIGHER FIRAT BASIN	4 APRIL – 14 NOVEMBER	3 APRIL – 19 NOVEMBER	19 MARCH – 21 NOVEMBER	18 MARCH – 4 DECEMBER
11	COASTAL AEGEAN BASIN	-	-	-	-
12	VAN LAKE BASIN	29 MARCH – 19 NOVEMBER	28 MARCH - 24 NOVEMBER	17 MARCH – 23 NOVEMBER	18 MARCH – 9 DECEMBER
13	ERCİYES BASIN	27 MARCH – 24 NOVEMBER	24 MARCH – 5 DECEMBER	4 MARCH – 3 DECEMBER	22 FEBRUARY - 20 DECEMBER
14	KAZ MOUNTAINS BASIN	-	-	-	-
15	CENTRAL AEGEAN BASIN	3 MARCH – 26 DECEMBER	23 FEBRUARY – …	26 JANUARY-…	9 JANUARY-…
16	GEDİZ BASIN	-	-	-	-
17	MERİÇ BASIN	-	-	-	-
18	YEŞİLIRMAK BASIN	10 MARCH – 1 DECEMBER	4 MARCH – 14 DECEMBER	5 FEBRUARY - 23 DECEMBER	19 JANUARY-…
19	CENTRAL BLACK SEA BASIN	-	-	-	-

BASIN NO	BASIN NAME	1971-2000 (REFERENCE PERIOD)	2015-2039 (START - END)	2040-2069 (START - END)	2070-2099 (START -END)
20	KARACADAĞ BASIN	24 JANUARY-…	6 FEBRUARY -…	-	-
21	ZAP BASIN	28 MARCH – 21 NOVEMBER	27 MARCH – 2 NOVEMBER	19 MARCH – 24 NOVEMBER	6 MARCH – 9 DECEMBER
22	GAP BASIN	-	-	-	-
23	WEST GAP BASIN	-	-	-	-
24	EAST MEDITERRANEAN BASIN	-	-	-	-
25	COASTAL MEDITERRANEAN BASIN	-	-	-	-
26	AEGEAN PLATE BASIN	20 FEBRUARY – 27 DECEMBER	19 FEBRUARY - …	-	-
27	CENTRAL KIZILIRMAK BASIN	10 MARCH – 18 DECEMBER	3 MARCH – 14 DECEMBER	2 FEBRUARY - 26 DECEMBER	14 JANUARY-…
28	CENTRAL ANATOLIA BASIN	4 MARCH – 23 DECEMBER	2 MARCH – 16 DECEMBER	1 FEBRUARY -…	11 JANUARY-…
29	FIRAT BASIN	14 MARCH – 27 NOVEMBER	7 MARCH – 6 DECEMBER	2 MARCH – 8 DECEMBER	12 FEBRUARY - 24 DECEMBER
30	LAKES BASIN	10 MARCH – 19 DECEMBER	2 MARCH – 15 DECEMBER	2 FEBRUARY -…	12 JANUARY-…

Table 13: *Current status in reference period (1971 – 2000) of start and end dates of plant growing seasons according to 10 C soil temperature according to averages on the basis of basin (1971 – 2000) and the change trends in 2015 – 39, 2040-69 and 2070-99 climate change projections. In basins signed with " – " , a general trend could not be determined for representing the basin average (Kadıoğlu et al., 2017).*

BASIN NO	BASIN NAME	1971-2000 (REFERENCE PERIOD)	2015-2039 (START - END)	2040-20697 (START - END)	2070-2099 (START - END)
1	SOUTH MARMARA BASIN	22 FEBRUARY - 14 NOVEMBER	19 FEBRUARY - 14 NOVEMBER	17 FEBRUARY – 14 NOVEMBER	17 FEBRUARY - 14 NOVEMBER
2	WEST BLACK SEA BASIN	3 MARCH – 14 NOVEMBER	7 MARCH – 14 NOVEMBER	19 FEBRUARY – 14 NOVEMBER	20 FEBRUARY - 14 NOVEMBER
3	NORTH WEST ANATOLIAN BASIN	4 APRIL – 9 NOVEMBER	2 APRIL – 6 NOVEMBER	19 MARCH – 12 NOVEMBER	17 MARCH – 11 NOVEMBER
4	EAST BLACK SEA BASIN	14 MARCH – 12 NOVEMBER	10 MARCH – 12 NOVEMBER	25 FEBRUARY – 13 NOVEMBER	24 FEBRUARY - 14 NOVEMBER
5	KARASU ARAS BASIN	15 MAY – 11 OCTOBER	4 MAY – 16 OCTOBER	25 APRIL – 23 OCTOBER	7 APRIL – 25 OCTOBER
6	NORTH MARMARA BASIN	17 FEBRUARY – 14 NOVEMBER	16 FEBRUARY - 14 NOVEMBER	16 FEBRUARY -14 NOVEMBER	16 FEBRUARY - 14 NOVEMBER
7	GREAT AGRI BASIN	5 APRIL – 26 OCTOBER	3 APRIL – 30 OCTOBER	25 MARCH – 4 NOVEMBER	13 MARCH – 10 NOVEMBER
8	SÖĞÜT BASIN	27 MARCH – 7 NOVEMBER	27 MARCH – 10 NOVEMBER	28 FEBRUARY – 12 NOVEMBER	1 MARCH – 13 NOVEMBER
9	ÇORUH BASIN	26 APRIL – 11 NOVEMBER	25 APRIL – 1 NOVEMBER	17 MARCH – 28 NOVEMBER	5 MARCH – 1 NOVEMBER
10	HIGHER FIRAT BASIN	12 MAY – 17 OCTOBER	1 MAY – 26 OCTOBER	23 APRIL – 28 OCTOBER	3 APRIL – 29 OCTOBER
11	COASTAL AEGEAN BASIN	16 FEBRUARY – 14 NOVEMBER	16 FEBRUARY - 14 NOVEMBER	16 FEBRUARY – 14 NOVEMBER	16 FEBRUARY - 14 NOVEMBER
12	VAN LAKE BASIN	29 APRIL – 18 OCTOBER	25 APRIL – 25 OCTOBER	13 APRIL – 31 OCTOBER	29 MARCH - 12 OCTOBER
13	ERCİYES BASIN	8 APRIL – 31 OCTOBER	10 APRIL - 4 NOVEMBER	4 APRIL - 10 NOVEMBER	26 MARCH - 12 NOVEMBER
14	KAZ MOUNTAINS BASIN	5 MARCH- 13 NOVEMBER	13 MARCH- 14 NOVEMBER	21 FEBRUARY- 14 NOVEMBER	22 FEBRUARY- 14 NOVEMBER
15	CENTRAL AEGEAN BASIN	30 MARCH- 8 NOVEMBER	28 MARCH- 9 NOVEMBER	9 MARCH- 12 NOVEMBER	1 MARCH- 12 NOVEMBER
16	GEDİZ BASIN	5 MARCH- 12 NOVEMBER	3 MARCH- 14 NOVEMBER	21 FEBRUARY – 14 NOVEMBER	22 FEBRUARY- 14 NOVEMBER
17	MERİÇ BASIN	6 MARCH- 14 NOVEMBER	3 MARCH- 14 NOVEMBER	19 FEBRUARY- 13 NOVEMBER	19 FEBRUARY- 14 NOVEMBER
18	YEŞİLIRMAK BASIN	3 APRIL- 5 NOVEMBER	30 MARCH- 8 NOVEMBER	12 MARCH- 14 NOVEMBER	5 MARCH- 12 NOVEMBER
19	CENTRAL BLACK SEA BASIN	3 MARCH- 13 NOVEMBER	3 MARCH- 13 NOVEMBER	19 FEBRUARY- 14 NOVEMBER	21 FEBRUARY- 14 NOVEMBER
20	KARACADAĞ BASIN	16 MARCH- 11 NOVEMBER	19 MARCH- 14 NOVEMBER	1 MARCH- 14 NOVEMBER	22 FEBRUARY- 14 NOVEMBER

BASIN NO	BASIN NAME	1971-2000 (REFERENCE PERIOD)	2015-2039 (START - END)	2040-20697 (START - END)	2070-2099 (START - END)
21	ZAP BASIN	8 APRIL- 3 NOVEMBER	8 APRIL – 7 NOVEMBER	27 MARCH- 5 NOVEMBER	15 MARCH- 13 NOVEMBER
22	GAP BASIN	3 MARCH- 14 NOVEMBER	1 MARCH- 14 NOVEMBER	19 FEBRUARY- 14 NOVEMBER	17 FEBRUARY- 14 NOVEMBER
23	WEST GAP BASIN	15 MARCH- 12 NOVEMBER	16 MARCH- 14 NOVEMBER	24 FEBRUARY- 14 NOVEMBER	19 FEBRUARY- 14 NOVEMBER
24	EAST MEDITERRANEAN BASIN	19 FEBRUARY- 13 NOVEMBER	19 FEBRUARY- 14 NOVEMBER	18 FEBRUARY- 14 NOVEMBER	17 FEBRUARY- 14 NOVEMBER
25	COASTAL MEDITERRANEAN BASIN	17 FEBRUARY- 14 NOVEMBER	17 FEBRUARY- 14 NOVEMBER	16 FEBRUARY- 14 NOVEMBER	16 FEBRUARY- 14 NOVEMBER
26	AEGEAN PLATE BASIN	23 MARCH- 8 NOVEMBER	22 MARCH- 14 NOVEMBER	28 FEBRUARY- 11 NOVEMBER	26 FEBRUARY- 14 NOVEMBER
27	CENTRAL KIZILIRMAK BASIN	4 APRIL- 5 NOVEMBER	1 APRIL – 10 NOVEMBER	16 MARCH- 11 NOVEMBER	4 MARCH- 12 NOVEMBER
28	CENTRAL ANATOLIA BASIN	30 MARCH- 5 NOVEMBER	28 MARCH- 8 NOVEMBER	8 MARCH- 13 NOVEMBER	1 MARCH- 12 NOVEMBER
29	FIRAT BASIN	6 APRIL- 3 NOVEMBER	3 APRIL- 4 NOVEMBER	22 MARCH- 11 NOVEMBER	5 MARCH- 13 NOVEMBER
30	LAKES BASIN	5 APRIL- 1 NOVEMBER	31 MARCH- 5 NOVEMBER	19 MARCH- 5 NOVEMBER	3 MARCH- 11 NOVEMBER

The objectives, targets and benefits of the project are summarized as follows by the Ministry of Environment and Urbanisation:

Purpose and objectives

- Determining the agricultural basins
- Preparing healthy agricultural inventory
- Providing opportunity for production planning
- Determining which product could be produced where and how much
- Increasing the income of the farmer
- Making demand projections towards the future
- Using supports in a rational, directing and effective manner
- Ensuring production increase in products with supply gap
- Protecting natural resources and ensuring sustainable use
- Meeting sector demand in relation to basin based planning and management
- Planning the production according to various scenarios

Benefits to be provided by the model:

- Withdrawal from traditional production habit
- Basin borders and provincial borders being different
- Applying different supports at basins

What will the implementation of the model grant to the country?

- Efficient production planning will be conducted
- Biodiversity, soil and water resources will be protected
- Efficiency will be increased
- Profit of the producer will increase

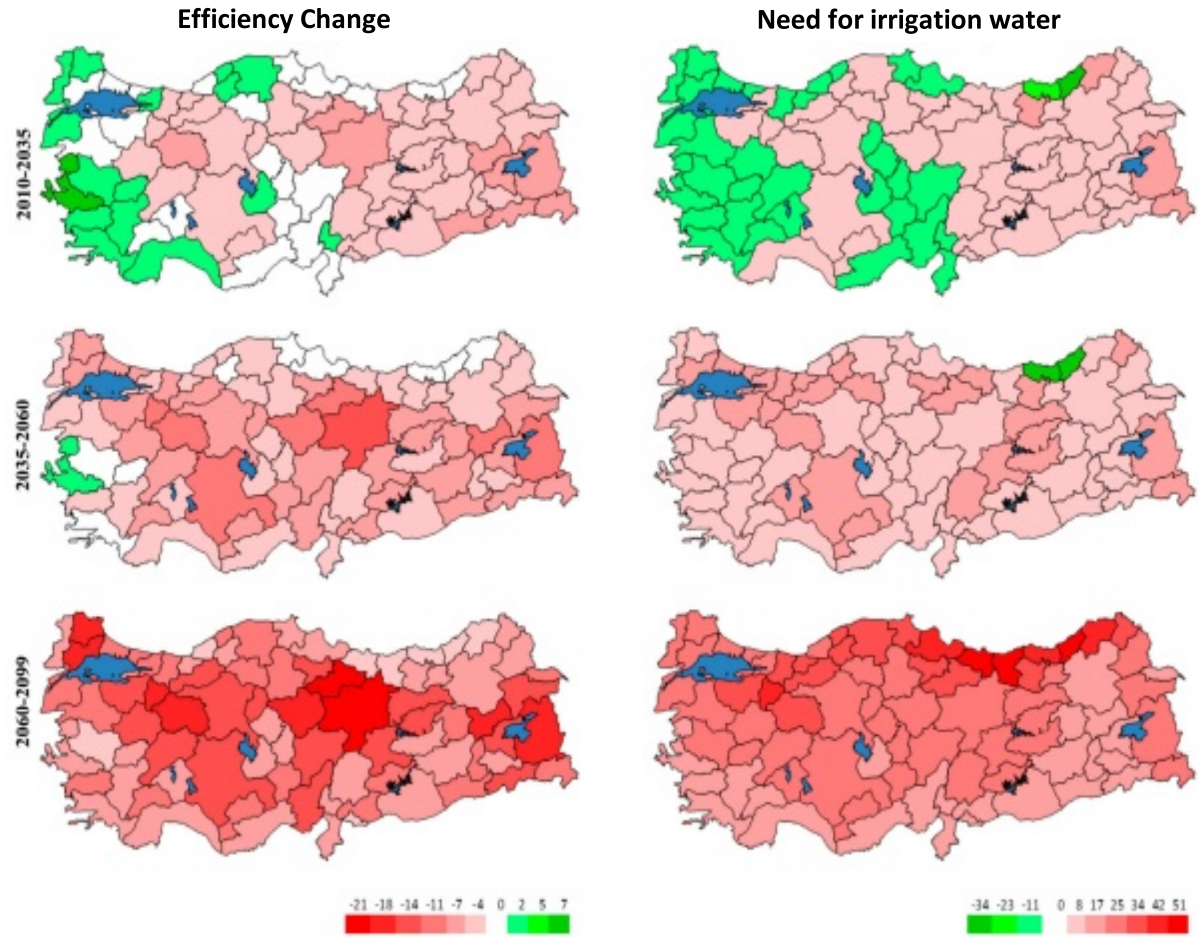
- Supply and demand balance will be ensured
- Public financing burden arising from purchases will decrease
- International competitive power will increase with production planning
- Economic impacts of possible developments in Turkey's EU harmonization process on important agricultural products will be analyzed (Republic of Turkey Ministry of Environment and Urbanisation, 2013).

11.1 Efficiency and Irrigation Water Need in Our Country

When it comes to climate change, the increase or decrease in irrigation water needs shall also be taken into account in addition to efficiency changes. The efficiency of agricultural basin is a sensitive element in terms of both climate change and the economic contribution to be provided to the country. It should not be forgotten that even if a soil is productive, the potential water need is highly important for both factors in question. The sowing of a product which has high irrigation cost could lead to climate change arising from non-efficient use of water resources and also economic losses. In the studies conducted, it is highlighted that our provinces and basins located in Mediterranean climate belt are the regions which will be most affected from the climate change in terms of efficiency and the need for irrigation (Akalin, 2014). The interruption of agricultural works carried out in this region could create problems for our country which could not be remediable both in terms of food accessibility and the economic factors.

In our central regions where the efficiency is relatively lower and need for irrigation is higher, the sustainability of agriculture is under significant threat due to the temperature increases foreseen in the future and the irregularity of precipitation. It should be taken into account that even our North East Anatolian Basins, which do not have any additional irrigation need most of the time, could become dependent on irrigation over time. Percentages of efficiency change and irrigation need change over time are shown in Figure 6. Whereas, in the time intervals that are first observed, a decrease is seen in the irrigation need and efficiency increase in western regions, the efficiency changes and irrigation needs demonstrated minor changes in central sections. Severe efficiency losses and irrigation need increases are seen in the second ant third observation intervals (Dudu and Cakmak, 2018)

***Figure 6:** Efficiency and Irrigation Water Need Changes Projected in Certain Periods (Dudu and Çakmak, 2018)*

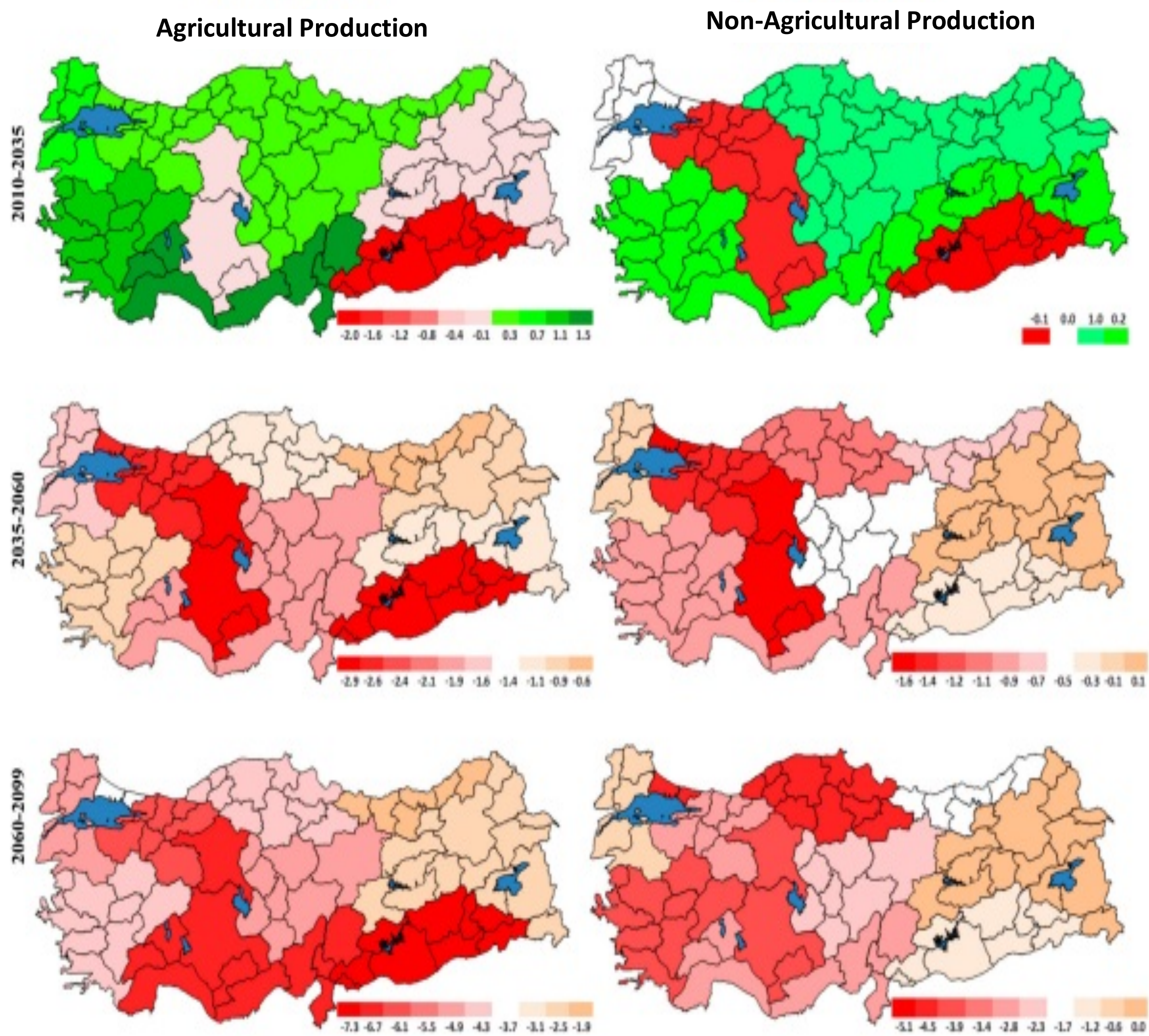


Global agricultural sector has opted the way to adapt the rapidly increasing climate change and to mitigate the greenhouse gas emissions during this adaptation to the extent possible. However, only a part of the greenhouse gas emissions in question arise from agricultural activities. For that reason, no climate scientist will be surprised against the fact the soil efficiency creases and irrigation water need increases will become inevitable over time.

Alternative production means should be researched in the basins in order not to be affected or be affected less from the food supply problems foreseen overall the globe.

At the top of these is the non-agricultural food sector. As it could be seen in Figure 7, the problem of decrease of agricultural production in some of our regions could be relatively changed with non-agricultural food steps (Dudu and Cakmak, 2018).

Figure 7: *Agricultural Production and Non-Agricultural Food Production (Dudu and Çakmak, 2018).*



12. EVALUATION OF CONTRIBUTION OF PROTECTION OF AGRICULTURAL BIODIVERSITY TO TURKEY'S STRUGGLE AGAINST CLIMATE CHANGE AND CLIMATE -SMART AGRICULTURE PRACTICES

12.1. Agriculture and Biodiversity

Living and consumable resources, which are very important in terms of food and agriculture and have been gradually decreasing, are defined as the strategic advantages owned by a country today. Areas and water resources that have the characteristics suitable for agriculture overall the world are rapidly being polluted and destroyed by non-agricultural uses. Scientists share the idea that a significant food and water scarcity will be encountered by human beings in the near future.

Under these circumstances, the biodiversity that the countries have creates a condition of superiority for themselves. Wild living sources are used in order to develop species that are resistant against environmental pressure and have high production – efficiency capacity. Human factor is important either directly or indirectly in almost all of the causes which decrease or negatively affect biodiversity in almost every part of the world. It is the duty of human beings to protect, manage and sustainably use the biologic richness for overcoming the reasons that reduce it.

"Biodiversity Convention" was opened to signature by underlining that it is an international problem to prevent and coordinate the decrease of biodiversity in the "World Sustainable Development Summit" which took place in Rio de Janerio in 1992 as a result of a four-year action that was launched by United Nations Environmental Program (UNEP), and almost all of the countries completed the signature procedure.

On the other hand, United Nations has announced the years 2011 – 2020 as the "Biodiversity Decade". Biodiversity relates to the whole world at the same degree as the climate change and population increase. Biodiversity is handled at three hierarchical categories being the genetic diversity, species diversity and ecosystem diversity and all of the biodiversity should be preserved for adequate and balanced nutrition of all livings things living on the earth.

The roots of living resources, which have an indispensable place in meeting the fundamental needs of human beings including at the top the need for nutrition, rely on biodiversity. According to the data of United Nations Food and Agriculture Organization (FAO), there are around 300.000 edible plant species on the world. Ignoring the plants that are produced at local level, among such rich source of plants on the world, those for agricultural purposes are very limited. According to the data of the American Plant Science Community, around 95% of the global need for food is covered by only 30 different plant species. These plants are the products which have been agriculture for years, for which seeds and cultivation techniques are developed, which have become commercialized, industrialized and adopted as food. These agricultural products, which are commonly accepted among farmers – producers, industrialists-processors and consumers, direct the agriculture.

Wheat, rice and corn types, which cover all calorie and protein need for almost 3.5 billion people, are the main products accepted. Soya and sugar cane, which are produced towards industry, are among the products which are produced the most. On the other hand, vegetables such as potato, tomato and fruit species such as banana and papaya are the important and privileged products overall the world. According to the data of FAO, there has been a decrease of 75% as of the year 2000 in the product diversity produced by the producers since the beginning of 1900s. According to a study carried out in California University, experts have prepared the gene map of 360 different tomatoes and determined that certain genetic specifications disappeared among the tomatoes over time (Morris et al., 2000; Qualset et al., 1995; Rick, 1948)

There are two main reasons for the decrease of biodiversity. These are natural and artificial selections. Struggle against diseases and pests which have arisen during long years and survival of plant species that are more resistant to climate conditions ensured for the natural selection. Artificial selection is provided by applying modern reclamation techniques developed in recent years for obtaining more resistant, more nutrient plants with higher efficiency and less costs, which is defined as selectivity in agriculture.

With these selections in question, “good”s become “better”, and the weak ones are disfavored and the producers are directed towards good ones which bring more income to them, and do not produce the others. This leads to some plant species and types to become lesser over time and even face the threat of extinction, and as the agricultural trade reaches to big dimensions with globalization, local species are disfavored.

Why other species are needed while there are “good” species that meet the needs at global level? Or, in other words, why should the biodiversity be protected? There are several answers to this question: Before all, it is not always possible to project what the climate and market conditions could bring in agriculture. In order to have suitable alternatives for plant species and types that could adapt to every condition, the producers and scientists should have a broad biodiversity range. Biodiversity is an asset against the risks that could be caused by climate change, disease and pests. For example, as a result of leave burnt disease which hit corn production in the USA, a loss of around 1 billion USD was experienced due to the decrease of genetic diversity.

Besides, monocultural production creates a risk for both producers and the regional and country academy. The best measure against this is the existence of alternative products. The QUINOA plant, which has been produced for 5.000 years, is a legume plant which is even not known in many regions. The United Nations has announced 2013 as the Global Kinoa year for its promotion due to its high nutrient values and adaptation skills, and provided recommendations to the producers for the sowing in regions where the climate is suitable. Quinoa has become an alternative plant for wheat in certain parts of the world with its increasing production.

The main elements which threaten biodiversity, namely the gradual decrease of efficiency of soils on which agricultural production is made, opening of agricultural land to non-agricultural use, pollution of the earth and environment, urbanisation and industrialization policies not only lead to the narrowing of the areas where agriculture is made, but also lead to irrevocable loss of plant diversity.

Agricultural biodiversity does not only include the plants. Soil organisms that ensure growing of the products and the organic substances have been gradually decreasing on soils that have been processed for hundreds of years. In addition to the pollution of soil with various wastes, living things and insects which are effective in fertilizing and pest control as animal species that add value to agriculture, are under significant threats. In this scope, the unconscious and excessive use of agricultural pesticides and chemicals constitute a great threat. Considering that around 35% of agricultural products pollenate by means of bees, the actions that have been ongoing particularly in the Europe in relation to increasing the bee population becomes meaningful.

Total use of plant diversity in the agriculture could take place with agricultural researches, agricultural policies, market structure and participation of producers. It is necessary that a huge segment from politicians to scientists, scientists to producers and finally to the consumers have awareness in relation to the importance of biodiversity. Even though the agriculture has an elective and selective role in relation to biodiversity, the protection and development of this diversity and its conversion into value could take place with correct agricultural activities.

12.2. Basic Elements of Climate Friendly Smart Agriculture Approach

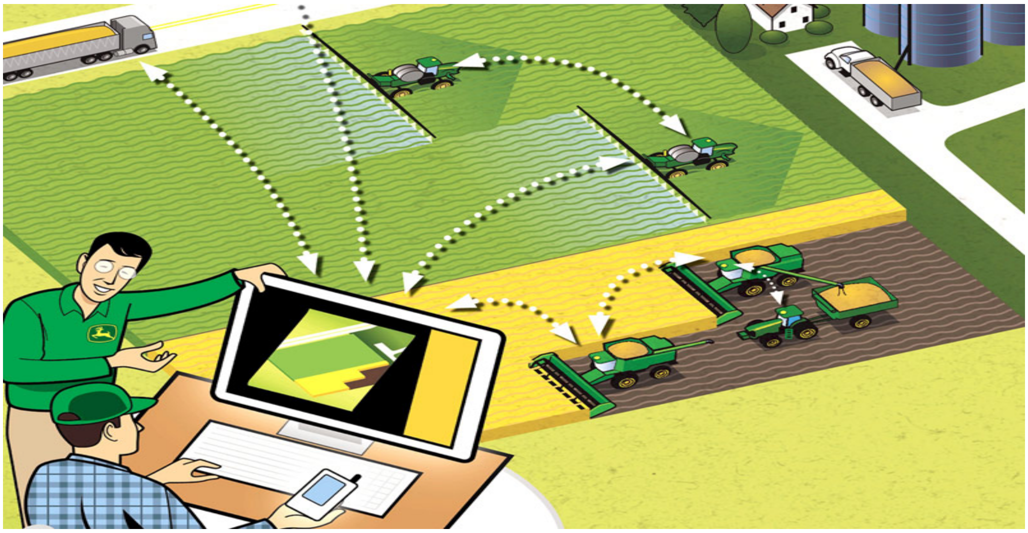
The negative impacts of climate change could be mitigated by increasing the adaptable capacities of farmers in agricultural production systems and increasing flexibility and resource utilization efficiency. CSA (Climate SMART Agriculture) encourages coordinated actions towards ways resistant against climate conditions by the farmers, researchers, private sector, civil society and politicians through four main action areas. These are:

- Producing evidence
- Improving local institutional efficiency
- Encouraging consistence between climate and agricultural policies
- Connecting climate and agricultural financing one another

Climate Smart Agriculture is a method that is different from the "ordinary" approaches by emphasizing the capacity to implement content-specific solutions, supported by innovative policy and financing actions The total carbon dioxide (CO_2) greenhouse (GHG) emissions obtained from agriculture in year 2010 constitute 10-12% of the annual global anthropogenic emissions. It is estimated that this is 5.3 – 5.8 gigatons CO_2 equivalent. The most widely used agricultural activities are enteric fermentation, fertilizer stored in the pastureland, synthetic fertilizer, paddy agriculture and biomass.

Taking into account the need for agricultural growth for food safety, it is foreseen that the agricultural emissions will increase. Many factors such as the main resources of emission increase projected, water quality and soil protection, which traditionally rely on agricultural growth assumptions, could lead to significant consequences for biodiversity and ecosystem services.

Figure 8: *Brief Schematic Indication of Climate SMART Agriculture (Industry 4.0 t.y.).*



Unless the planning and investment approaches change, we face the risk of increasing agricultural systems which contribute to the increase of climate change and do not support food safety. Climate Smart Agriculture (CSA) could prevent this risk by integrating climate change to the planning and implementation of sustainable agriculture strategies. Climate Smart Agriculture uses the synergies between food safety, adaptation and mitigation as a basis for recreating the policies as a reaction to climate change.

In the absence of these efforts, IPCC projections demonstrate that agricultural and food systems would be less flexible and food safety would be under higher risk. Climate Smart Agriculture demands for a series of actions by decision makers from farmers in the villages to the global level in order to increase resilience of agricultural systems and livelihoods and mitigate the food insecurity risk in the future. Climate based transformation ways determined by IPCC are shown (Figure 9).

Agriculture faces with a series of biophysical and socio-economic stresses including the climate change. Measures taken at various decision points determine which ways are followed: Climate Smart Agriculture ways end up with higher resilience and lower risks toward food security.

The general objective of Climate Smart Agriculture is to ensure food and nutrient security of all humanity all the times for a sustainable use of agricultural systems at the local level, integrate required adaptations and catch up the potential mitigation. Three objectives have been defined to reach this objective:

- Increasing sustainable agricultural efficiency in order to support just increases in incomes, food security and development.
- Adaptation to climate change at all stages from farms to global levels.
- Developing opportunities for mitigating the greenhouse gas emissions obtained from agriculture compared to trends (Climate-Smart Agriculture Sourcebook Executive Summary, 2013).

Although Climate Smart Agriculture targets at reaching all three objectives, it does not mean that every application practiced produce "triple wins" Climate Smart Agriculture requires following all three objectives from local to global scales at medium and long terms in order to acquired locally acceptable solutions. The importance of every objective may change depending on the potential synergy and connections, positions and conditions between objectives. In developing countries where the harmony of agricultural growth and food security and the economic growth has priority and the poor farmers are most affected from the climate change – with least contribution in climate change – it is particularly important to identify the emission points. In efficient mitigation, these actions could be beneficial mostly for the improvement of food safety and adaptation, however, additional costs could be necessary for realizing this benefit. Determining the cost of low emission growth strategies compared to traditional high emission growth means could assist in merging the agricultural development efforts that provide benefit for climate financing resources.

Climate Smart Agriculture presents applicable options and required effectiveness activities that emphasize the importance of producing evidence for determination. Under the effects of climate change that are specific to the field, it provides tools for evaluation of different technologies and practices in relation to impacts on national development and food security targets.

***Figure 9:** Diagram of Climate Resistance Transformation Way, Adapted to The Concept of Special Agriculture (Lipper et al, 2014).*

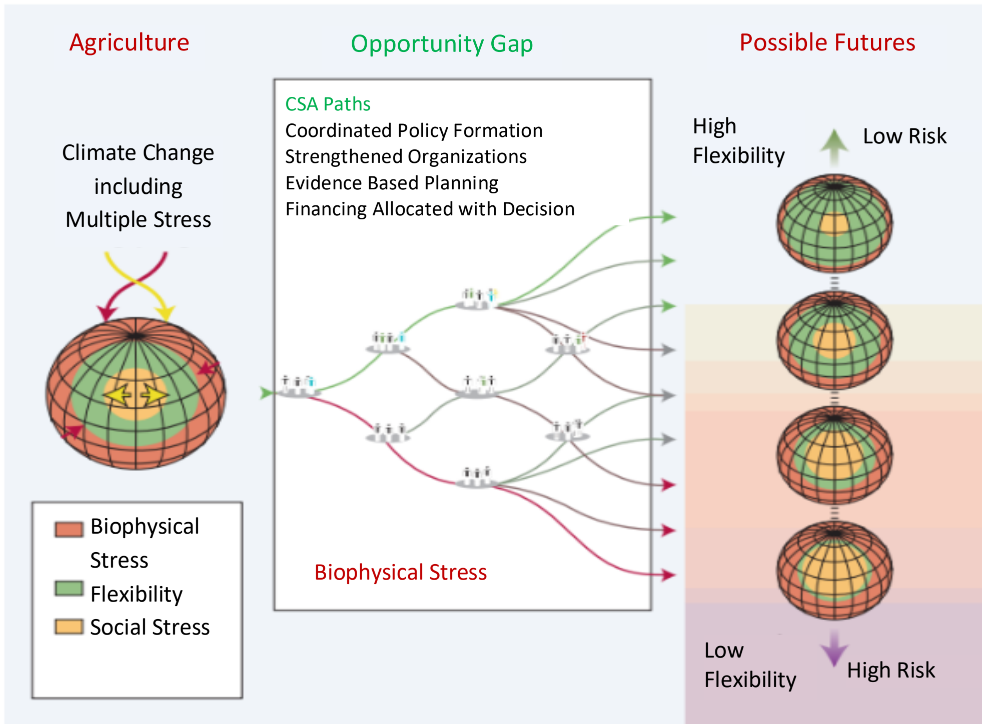
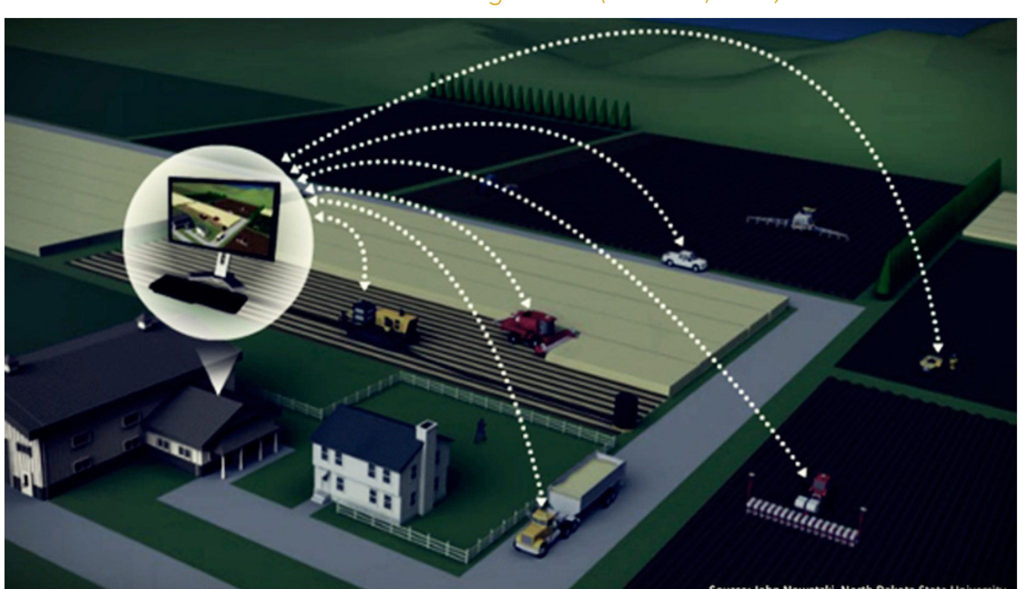


***Figure 10:** Brief Schematic Indication of Climate Smart Agriculture (Nowatzki, 2016)*



What is necessary for effective implementation of climate smart agriculture?

Development and implementation of problem oriented approaches for adaptation planning have a significant role in determining strong actions against uncertainty. As a matter of fact, uncertainty should never be seen as an excuse. Performing global, regional and local actions in a coordinated manner is among the most important factors. In order to determine the potential of different policies and technologies for adaptation and mitigation from local to global scales, it is necessary to evaluate the end effects of the events and also determine together the mitigation options and costs for emission increase with the tools that evaluate the resilience tools that increase in agricultural and food system, which cover the changes that are observed relatively slowly in agriculture and food security.

Climate Smart Agriculture applications may require the farmers to access to certain inputs such as tree seedlings, seeds or fertilizers. The lack of such inputs naturally restrict the common expectations. Timely access to fertilizer is an important determinant of productivity and efficient resource use, however it is missing most of the times.

The priority action area for Climate Smart Agriculture is to create effectiveness policy and produce regulatory contents by increasing the coordination of agriculture – environment – food system policies. An efficient policy environment requires harmonization among policy areas, which ensures a suitable dialogue between trade ministry and relevant ministries in order to handle the gaps and overlaps.

International supports enable various actions such as coordinated approaches towards climate change, agriculture and food security policy areas, capacity development, technology development/ transfer and the financing enabling the national NGO actions in terms of creating resource for the efforts at national level. The fourth action plan which is determined in this scope increases and improves the finance targeting in order to support to transition to Climate Smart Agriculture. Connecting the climate financing with traditional agricultural finance resources is an important part of these efforts. Adaptation of agricultural systems will require making increased investments and is an important tool for determining and crediting the mitigation side-benefits created by the adaptation process, and increasing the financial resources.

Investment financing for agriculture fails to meet the demand (State of Food and Agriculture Investing in Agriculture for a Better Future, 2012). Although climate financing will increase significantly in the coming years, it will cover only a small part of the total need for agricultural investment to satisfy the increasing demand (estimated to be 209 billion USD annually).

12.3. Impact of Climate Friendly Agriculture Applications to Emission Mitigation and Food Security

Agriculture is a disputed issue due to its climate change effects and its importance in terms of food safety. As a matter of fact, it is estimated that agriculture is an important source of emission increase that threatens food safety in the future. For that reason, while climate smart agriculture prioritizes food security, it also takes into account the potential and costs of mitigation benefits. Mitigation is a supportive element for ensuring food security and adaptation, rather then preventing or using them.

For example, more effective resource use in agricultural production system provides for an important potential in increasing the resilience of rural livelihoods together with the reduction of intensity of agricultural emissions.

Options for improvements have the target at increasing efficiency in different production systems and improving the resistance potential of the producers. However, the rates of adopting developed stockbreeding practices could rarely exceed 1% per year. Accelerated harmonization is a system which has the potential of increasing both the efficiency and incomes of stockbreeding at a significant level. This system provides for around 7% of the agricultural mitigation potential in the world by 2030.

12.4. New Technologies Directing the Agriculture

Technology has changed the face of agriculture. The power of irrigation, fertilizer, agricultural tools and technology in production came into effect.

12.4.1. Cloud Solutions in Climate Smart Agriculture Practices

M2M services which are included in the cloud business solutions provided by Turkish telecom companies to the corporate customers also provide for big ease for producers who are dealing with agriculture and stockbreeding. Monitoring and regulating any type of value that could affect the health of cattle and sheep in stockbreeding sector directly increase the product quality. At this point, particularly the "Animal Shelter Control and Monitoring Solutions" which are developed specially for enterprises on the mobile side provide for remote smart management possibilities for the producers on the issues of heat monitoring and control, disease preventing observation and alarm systems, controlled illumination, feeding and entry follow up. Besides, cloud solutions provide great benefits in terms of correct maintenance of agricultural lands and products. With applications such as sowing area management, frost notifier, heat follow up system, irrigation management, drought notifier and unpermitted entry monitoring, which created revolution in agriculture, the farmers obtain more information about the production processes and have the opportunity to receive more yields from their soils by taking measures at a correct time.

12.4.2. Other Smart Agriculture Solutions of Telecommunication Companies

- **Greenhouse Follow Up Solution:** Farmers can remotely follow up the temperature and humidity levels of their agricultural areas, operate their climatization units without going to their greenhouses and ensure protection of the required heat level and thus help increase the efficiency. It is possible with the solutions created by some telecommunication companies and business partners to ensure soil moisture on correct time and at optimum level with solutions that ensure water pumps to be turned on and off without going to the land and all operations to be managed from the center.
- **Coop Monitoring Application:** By the positioning of temperature monitoring products of telecommunication companies and business partners, the existing climatization systems of the coop farms could be controlled by transmitting SMS or alarm over call centers to authorized persons when required. Thus, chick death are prevented and control and efficiency are increased.
- **Cattle Step and Location Monitoring:** Besides, the step number of the cattle is used for determining the anger period.
- **Milk Measurement and Monitoring Solutions:** This enables for close monitoring of vital values related to the amount and quality of milk.
- **Fish Farm Monitoring:** Among the solutions provided by telecommunication companies are the sensors and M2M devices that are located to fish farms, which make it possible to instantaneously monitor parameters such as temperature, amount of oxygen in water, salinity, turbidity of water, pH and ammonium amounts,

12.4.3. Farmer Club

Another telecommunication company contributes in agricultural and rural development with an application that is has presented in 2009 in collaboration with the Ministry of Food, Agriculture and Stock breeding and Agricultural Marketing and which reached to more than 1 million farmers up to date, supporting the farmers to equally participate in social and economic life with the target of ensuring digital transformation in agriculture. With this program which is developed as the first social business model focused on farmers in Turkey, a broad range of solutions and services are provided from privileged tariffs and campaigns to awareness raising on water use in rural area and agricultural efficiency. Members of this application manage the business processes more effectively and have important advantages towards ensuring efficiency and saving. The application provides its members with effective solutions focused on communication, information, marketing and mobile technology. On the other hand, training is provided in villages in line with the needs of the farmers with Training TIR application, and with the Guide application developed for smart phones, it is possible to provide the farmers with information on 5-day district based weather forecast, category based sector news, detailed product price information, giving free and easy ads.

12.4.4. New Generation Mobile Tractors

New generation mobile tractors provide the farmers with smart phones and tablet applications that will facilitate the lives of farmers and change their habits. With this application, it is possible for the farmers to easily reach the information and follow the smart agriculture calendar and weather forecast which provides for important days and activities in the month, as well as up to date agricultural news. With the "news" feature of the application, the farmers will be able to read many up to date news related to themselves and the agricultural sector and with the smart "agriculture calendar" feature, they will be able to inquire agricultural works to be done in relation to months on the issues of Vinery, Stockbreeding, Fruit, Vegetable, Field Agriculture, Poultry and Beekeeping. Using the "Weather Forecast" feature, they can learn the weather forecast for their locations on the basis of hours and 10 days, and they can also access information on sun rise, sun set times and wind speed from the system.

12.4.5. Soilless Agriculture

Soilless agriculture, or as alternatively called the "hydroponic cultivation" is defined as a production wherein materials such as volcanic rocks, water, rock wool, coco pit or perit are used and the minerals needed by plants are produced with the computer system. In soilless agriculture where there is no need for such factors as fertilization, chemical application, excessive irrigation in addition to the opportunity to grow hygienic and more tasty products, sensitive medical plants and greens that do not contain tuber root could be cultivated healthier and it is possible to minimize the disease level. This application has reached to a size of 40 billion USD in the world. In soilless agriculture, the efficiency is five times more than the normal agriculture. 16 thousand tomatoes could be cultivated from 1 seed. Turkey is among the luckier countries in terms of agriculture. However, the divided lands, erosion and drought prevent the efficiency in agriculture. It is determined in the studies conducted that the soil efficiency of Turkey has decreased by 23% in the last 10 years. The soilless agriculture, which has started to newly develop in the field of agriculture, has started to carry its place to top positions as the field of investment for today and for the future. There is a flow of investors to the culture of soilless agriculture. Soilless agriculture applications are intensely carried out in Adana, Mersin, Afyon, Denizli, Urfa, Diyarbakır and Antalya. In Turkey, of 48 thousand hectares of greenhouses, 4 thousand decare have shifted to soilless agriculture. It is said that the greenhouse areas where soilless agriculture is performed in Turkey will increase to 15 thousand decares within two-three years.

Figure 11: *Soilless Agriculture Practice (Cukurova University Farmers' Leaflet, 2013).*

12.4.6. Digital Agricultural Machines

Another trend in agriculture and stockbreeding is the digitalization of machines. Harvesters, tractors, plows and other agricultural tools have now become smart machines. Agricultural machines have now become bigger, heavier and smarter. These machines are characterized as technological innovations that take the burden from the farmers, protect the environment and increase the harvest. With this machines, it is even possible now to perform sowing and harvesting with a millimetric accuracy. Now the plows have satellite antennas. Thus it has become for the end irons to process the field with an accuracy of centimeters. Plowing does not constitute a problem even in the dark. The vehicle is being directed by the computer and the parameters are entered on the touch screen.

The biggest reason for the crisis in agriculture is known to be the negative weather conditions. It is hard to find a solution to drought. On the other hand, hail and frost, which lead to crop losses are no further a problem. Besides, agricultural machines could now be operated with remote control system. With the agricultural machines such as tractors and harvesters and automatically controlled agricultural machines that operate with satellite receiver signals, operators using the tractors and the harvesters could sow any place of the field without even touching the steering wheel. In addition to sowing, the area to be sown and harvested on the field is determined by satellite signals with the computer system on the tractor. Thus all processes could be performed with almost zero error.

12.4.7. Nanotechnology

The emergence of nanotechnology developments and use of nanotools/nanomaterials, has brought together new applications in the agriculture and food sector. Nanotechnology has the potential to create a revolution in the agricultural and food industry with such new approaches as molecular treatment of diseases, rapid diagnosis of diseases, increasing the plants capacity of absorbing the nutrients. Smart biosensors and controlled emission systems will help agricultural industry fight against viruses and other pathogens. In a near future, by means of catalysts that have nano structure, it will be possible to make pesticides and herbicides to be more effective at lower doses. Nanotechnology will also mitigate pollution with the use of alternative (renewable) energy components and filter/ catalyzer and protect the environment indirectly by cleaning the existing pollutant materials (Scott and Chen, 2002).

12.4.7.1. Smart Fertilizer

The fact that the general soil structure of our country is calcareous and has high pH value makes it difficult for the plants to absorb various minerals. Fertilization which is applied for compensating the lack of minerals fails to be sufficiently effective. In particular, in the case of fertilizers applied on the leaves; the fact that the stoma gap on the leave structure is less makes it considerably high for the fertilizer passage from the molecules at macro and micro dimensions. By means of nanotechnological fertilizer use, fertilizer waste will be prevented and maximum efficiency will be acquired from the sowing. Around 2 million tons of fertilizer is used annually in Turkey. With nanotechnological fertilizer, it is possible to both use less fertilizer and receive the highest level of efficiency that could be received from fertilizer used at low amount. As a result of research and development studies that were launched in the Mediterranean University in 2011, smart fertilizer was obtained with nanotechnological methods. By means of this fertilizer which is called Nanoixir, the photosynthesis speed and efficiency of the plant was increased and a higher efficiency in vegetative production, increase in product quality, improvement in flavor and aroma, early harvesting and increase in storage period were ensured. Smart fertilizers have been started to be produced by many fertilizer producers in Turkey.

12.4.7.2. Nanopesticides

In the near future, producers will be able to protect their products with nanopesticides. It is aimed at reducing the use of pesticides with these drops that are even smaller than hair but could disseminate to a wider area. Studies are ongoing on nanopesticides which are believed to be a revolution for agriculture and food production. The effect of nanopesticides, which have advantages such as increasing the resistance of products and reducing the use of pesticides, on the pests is more and longer compared to other chemicals. A nanopesticide particle could cover a greater area.

12.4.8. Robotic Farms

Farms which are defined as enterprises where human beings grow and benefit from plants and animals, have started to change their faces with the advancement of technology. Farms are no more managed by human beings but by robots, and they have become more effective and active compared to past thanks to the robots. Cattle in the farms are being milked by robots, and the monitoring of other animals is carried out by robots which control the feed they eat, the rate of fat and protein in the milk they deliver and their disease possibility. In addition to milking robot, there are feed pushing robot, fertilizer cleaning robot and even feeding robot for the calf in the farms. Robotic farms, examples of which are found overall the world, also exist in Turkey.

12.4.9. Smart Irrigation Systems

Due to being located at arid and semi-arid climate zone, a high portion of the existing water resources are being used in agricultural irrigation. For that reason, irrigation is one of the most important inputs of agricultural production. By means of smart irrigation systems, unnecessary irrigation will be prevented and thus the water resources will be protected and the deformation to occur in plants and soil due to excessive irrigation will be prevented. Smart irrigation systems follow the path of providing water to the product if the percentage rate of soil moisture is lower than the rate of moisture needed by the plant, since the water need of every plant in the field is different. There is the capability to program irrigation with mobile tools, and make seasonal, monthly, weekly, daily and even hourly programs.

13. IMPACT OF CLIMATE CHANGE ON WATER SECURITY IN AGRICULTURE, SOME EXAMPLES ON EFFECTIVE USE OF WATER IN AGRICULTURE IN TURKEY

Agricultural systems that are under the effect of climate change are required to experience transformation in order to mitigate the risks and socio-economic fragilities in global food security. Climate change creates more uncertainty and risk for farmers and politicians. In order to handle the issue of food security at all levels within the scope of climate change, an integrated, evidenced based and transformative approach should be demonstrated. Besides, in order to reach to scale and change rate, coordinated actions are required from research to policies, investments, private, public and civil society sectors, global level to local level. Whereas correct applications, policies and investments will enable the agricultural sector to contribute in food security in the long run, these support overcoming the food insecurity and mitigating the poverty in the short run.

Irrigated agriculture performs irrigation over fresh water resources that are limited in developing countries where water evacuation is not frequently regulated, no pricing is done and even no subvention is provided, creating an ever increasing pressure on these systems. A significant improvement is required in water use efficiency in order to shift to a more sustainable water use in agriculture against climate change without damaging the food security and livelihoods of hundreds of millions of small enterprise owners. Some ways of doing this are shown below.

13.1. Identifying the Effect of Irrigation Systems on Water Security

Drop and rain irrigation systems are at the top of the most efficient irrigation systems. These systems transmit water directly to the roots of the plant, reducing the vaporization that occurs during irrigation. Timers could be used to program irrigation during cool times of the day and this reduces water loss. Drop irrigation systems could provide 80% more water saving compared to traditional irrigation and even could contribute in the increase of product efficiency.

Basin Management Systems

Water security could be effectively handled by means of integrated management in the basin. Basins provide for a natural geologic and hydrologic water budget for planning the water cycle. With integrated basin management, the following effective steps could be planned for the sake of water security:

- Mitigating the negative impacts of drought on plants and stockbreeding;
- Encouraging desertification control and renewal of ecologic balance
- Encouraging the economic development of village dwellers

Irrigation Planning

Modern water management is related not only with how the water is provided but also at what time, in what frequency and in what amount it is provided. In order to prevent crops from remaining under water or being excessively irrigated, the farmers should carefully monitor the moisture of earth and plant and adapt their irrigation programs according to the existing conditions. Some farmers supply water along the night in order to slow down the vaporization and permit the water to leak into the soil and fill the water table.

Plant Pattern Resistant Against Drought

In areas which have tendency towards drought where water scarcity is a permanent problem, perfect returns could be ensured by growing less water intensive plants and with more water requirement. With the advancements in biotechnology, many product species that have less water requirement could be included in the plant pattern.

Dry Agriculture

Use of mulch could help the soil protect its moisture. Farmers who perform dry agriculture practices do not use irrigation and they are dependent on the existing soil moisture in order to produce crops in the arid season. It is important to pay attention to special growing practices and micro climates. However, it should be known that dry agriculture performs production with less efficiency.

Rotational Grazing

Rotational grazing is a method used for protecting the animals and pasture lands. Good grazing management increases water absorption of the field and reduced surface flow, thus making pasture lands resistant against drought. Increasing soil organic material and better feed cover are the benefits of rotational grazing that provide for water saving.

Mulch and Compost

It has been found that compost or dissolved organic substance which are used as fertilizer increase water retention capacity and improve soil structure. Mulch is a material spread over the soil in order to protect the moist of the soil. Mulch could be produced from organic materials such as wood chips or straw that could be turned into compost. It further increases the water retention capacity of the soil. Compost and mulch could assist keeping more water in the soil during the dry season. Farmers could use lack plastic mulch as soil cover in order to suppress the weeds and mitigate the vaporization.

Vegetative Cover

Plants that cover the ground preserve the moisture of the soil. They reduce weeds, and also increase soil efficiency and organic substances. These help prevention of erosion and compaction simultaneously. Cover plants permit the water to permeate further into the soil, which increases water retention capacity. Some researches indicated that areas sown with cover plants are 11% to 14% more efficient compared to traditional areas in drought years.

Soil Processing

In case of soil processing for protection purposes, special plows or other equipment that leaves plant product remnant at a minimum rate of 30% is used. Like the use of cover plants, these types of applications help in increasing the water absorption and mitigating vaporization, erosion and compaction (Tendall, 2015). Mitigated soil processing or soil processing helps the crop not to burn the wastes and enriches the soil efficiency by decomposing it.

Organic Agriculture

The researches conducted (Santoshkumar et al., 2017) have determined that corn which is grown on organic fields has 30% more efficiency compared to traditional fields in the drought years. In addition to keeping many pesticides, which are more toxic, away from the water ways, organic methods help the protection of soil moist. Healthy soil which is rich in terms of organic material and microbial life, functions as a sponge that absorbs and retains the moist for the plants (Zwang, 2016).

13.2. Some Examples of Efficient Use of Water in Agriculture in Turkey

13.2.1. "Project for Efficient and Effective Use of Water" Carried Out By GAP Regional Development Administration Presidency (GAP Administration).

The "Project for Efficient and Effective Use of Water", which has been realized by the GAP Regional Development Administration Presidency (GAP Administration), was launched in 2009 and implemented in Kilis, Gaziantep and Adıyaman, Diyarbakır, Şanlıurfa ve Mardin, Batman, Siirt and Şırnak provinces.

The general purpose of the project is to increase the practices towards efficient and effective use of water in order to ensure sustainable use of water resources in GAP Region, provide capacity development programs and increase the level of awareness of local public on this issue.

In this scope, the utilization of water was handled by the project in question (irrigation types in agricultural irrigation, importance of irrigation, correct and wrong irrigation examples, problems of farmers, advantages and disadvantages of the irrigation methods used by the farmers). With the project, trainings have been organized towards increasing the experiences and knowledge of our farmers.

13.2.2. Project for Ensuring Adaptation to Climate Change in Ankara- Golbasi Region with Effective Water Use and Rain Water Harvesting

Ankara University Water Management Institute has prepared a project in order to ensure effective use of current water resources for irrigation and domestic consumption in Golbasi Region, where the water resources are quite problematic in terms of amount and quality, and to benefit from the roof water harvest and rain water, and this project was accepted and supported by the United Nations, UBPD and EVERY DROP MATTERS program.

Topographic maps were prepared in relation to 6 parcels that were allocated to the project and studies have been completed in relation to soil and water analysis. Demonstrations were established in these areas towards irrigation management (mainly drop irrigation) (drop and raining irrigation for grass, vegetables, fruit, vinery, field plants, underground drip irrigation, lateral and dropper types, low pressure drop irrigation, moist distribution in soil in drop irrigation, effect of slope on moist distribution etc.) In these fields, farmers and technical staff- engineers were trained on irrigation principles, irrigation materials, irrigation projects, operation of irrigation systems, automation use in irrigation, maintenance and repair of irrigation systems. Rain water harvest system was mounted on the roof of Kucuk Bahcivanlar School building and demonstration was constructed in relation to utilization of water collected from the roof and filtered in the water closet flush and irrigation of drop watering system.

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