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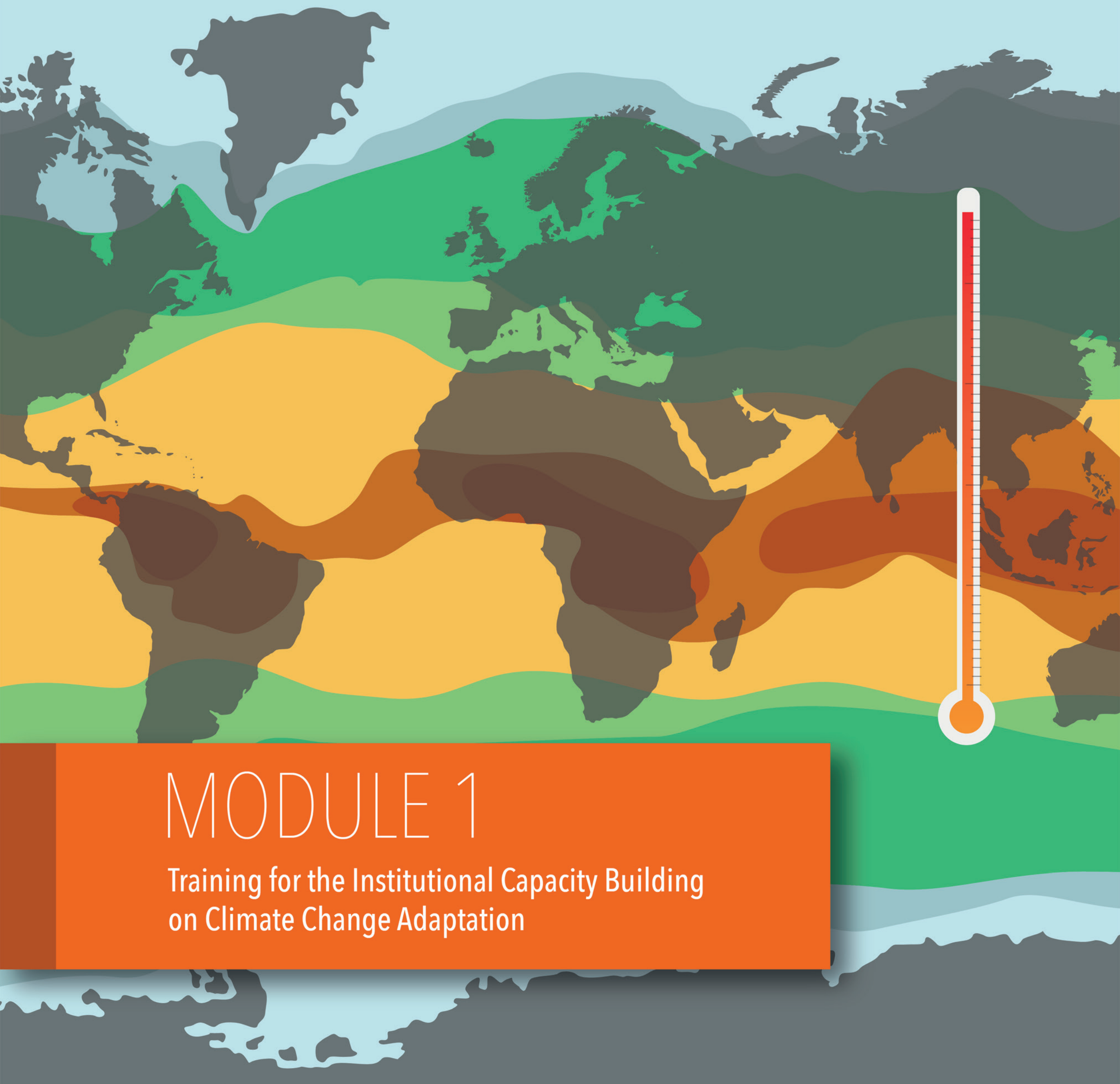

MODULE 1

Training for the Institutional Capacity Building on Climate Change Adaptation

REPUBLIC OF TURKEY
MINISTRY OF ENVIRONMENT
AND URBANISATION

Environment and Climate Action
Sector Operational Programme

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ABBREVIATION

AO	Arctic Oscillation
APSIM	Agricultural Production Systems simulator
Ar	Argon
AR5	IPCC Fifth Assessment Report
C	Carbon
CAT	Climate Action Tracker
CBS	Geographic Information Systems
CERES	Crop Estimation through Resource and Environment Synthesis
CFC	Chlorofluorocarbon
CFC-11	Trichlorofluoromethane
CFC-113	Trichlorotrifluoroethane
CFC-12	Dichlorodifluoromethane
CH_4	Methane
CLC	CORINE Land cover
CLCC	Change in CORINE Land Cover
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
COP21	21st Conference of the Parties
COPD	Chronic obstructive pulmonary disease
CORINE	Coordination of Environmental Information
COVID 19	Corona Virus Disease
CRF	Common Reporting Format
CropSyst	Cropping Systems Simulation Model
CROPWAT/ AquaCrop	Model Determining Water and Irrigation Needs of Crops
CRU	Climate Research Unit
CVA	Change Vector Analysis
DSSAT	Decision Support System for Agritechnology Transfer
EC	Electrical Conductivity
ECHAM5	Global Atmospheric Circulation Model No. 5
EEA	European Environment Agency
EIONET	European Environmental Information and Observation Network
EM-DAT	International Disasters Database
ENIAC	Electronic Digital Combiner and Computer

ENSO	El Nino Southern Oscillation
EPIC	Erosion Efficiency Impact Calculator
ES	Ecosystem Services
ESA	European Space Agency
ESCI	Ecosystem Services of critical importance
EUMETSAT	European Meteorological Satellites Operation Organization
FAO	United Nations Food and Agriculture Organization
FAO	United Nations Food and Agriculture Organization
FAST	Free Air Retention Technologies
G20	Group of 20 Finance Ministers and Central Bank Governors
GAIN	Green Job Evaluation Agencies Network
GCM	Global Climate Model
GDP	Gross domestic product
GDWM	General Directorate of Water Management
GIO	GMES Initial Operations
GMES	Europe World Tracking Program
GNP	Gross national product
GPG	Good Practice Guide
GS	Gramm-Scmidt
GT	Gigaton
GWP	Global Warming Potential
H20	Water / Water vapor
HCFC-22	Chlorodifluoromethane
HFC	Hydrofluorocarbon
HRL	High Resolution Layers
IACB	Internal Audit Coordination Board
IARC	International Agency for Research on Cancer
ICD	International Disease Codes
ICNRP	International Commission on Non-ionizing Radiation Protection
ICTP	International Abdus Salam Center for Theoretical Physics
IEA	International Energy Agency
IEEFA	Institute of Energy Economics and Financial Analysis
ILW	Incoming Long Wavelength
IMF	International Monetary Fund
INSPIRE	Spatial Information Infrastructure in the European Community
IPCC	Intergovernmental Panel on Climate Change
IR	Infrared
IRS LISS	India Remote Sensing Satellite Sensors

ISO	Istanbul Chamber of Industry
ISW	Incoming Short Wavelength
ITCP	International Center for Theoretical Physics
ITU	Istanbul Technical University
KP	Kyoto Protocol
LPIS	Land Parcel Identification System
LPJmL	Lund-Potsdam-Jena managed Terrain model
LUCAS	Land use/cover area framework survey
LULC	Land use-land cover
LULUCF	Land use, land use change and forestry
LULUCF	Land use, land use change and forestry
MECLEP	Migration, Environment and Climate Change: Evidence for Policy
Met Office	British Meteorological Service
MGM	General Directorate of Meteorology
MIKE	Modeling System for Rivers and Channels
M-K	Mann-Kendall
Mt	Billion Tons
MtC	Billion tons of carbon
$MtCO_2e$	Billion Tons of CO2 equivalent
N2O	Dinitrogen monoxide
NAO	North Atlantic Oscillation
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organizations
NIR	National Greenhouse Gas Inventory Report
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen Oxides
O_3	Ozone
OH	Hydroxide
PAGE	Partnership of Action for Green Economy
PCA	Principal Component Analysis
PFC	Perfluorocarbon
Pg	Petagram
PgC	Petagram Carbon
PH	Public Health
PPBV	One Molecule in one Billion Volume
PPMV	One Molecule in one Million Volume
R&D	Research and Development
RCM	Regional Climate Model

RCP	Representative Concentration Routes
RE	Renewable energy
REDD	Reducing Emissions from Deforestation and Forest Degradation
RegCM	Regional Climate Model System
RegCM3	Regional Climate Model System-3
RMSE	Root Mean Square Error
ROYGBIV	Red, Orange, Yellow, Green, Blue, Indigo and Violet
SARS COV-2	Severe Acute Respiratory Syndrome Corona Virus 2
SEP	Special Environmental Protection
SF6	Sulfur Hexafluorite
SG (GHG)	Greenhouse Gas
SGS	Greenhouse Gas Emission
SPI	Standard Precipitation Index
SPOT	French Earth Observation Satellite
SRES	Emissions Reports Special Report
STICS	Multi-disciplinary simulator for Standard Crops
SWAT / SWIM	Soil Water Assessment Tool / Soil and Water Integrated Model
SWR	Short Wavelength Radiation
TM/ETM	Thematic Mapping/Augmented Thematic Mapping
TOBB	Union of Chambers and Commodity Exchanges of Turkey
TPES	Total Primary Energy Source
UDBR	Long Wavelength Radiation
UDELe	University of Delaware
UML	Unified Modeling Language
UNCTAD	United Nations Conference on Trade and Development
UNCTs	United Nations Country Teams
UNDESA	UN Department of Economic and Social Affairs
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UV	Ultraviolet
UVI	Ultraviolet Index
UVR	Ultraviolet Radiation
WCRP	World Climate Research Program
WHO	World Health Organization
WMO	World Meteorological Organization

EXECUTIVE SUMMARY

1. Introduction to Climate Change Science

Prof. Dr. Murat Türkeş

The global climate has shown significant changes and transformations in all scales of space and time since the formation of the Earth, which is about 4,6 billion years old, until today. Very important and major changes have taken place in the physical geography (landforms, air and climate, soil and vegetation, surface and groundwater, rivers and lakes, glaciers, ecosystem, biome, and biological diversity, etc.) of the Earth during these changes, and of Anatolia, since the time it first began to form.

The most important result of the greenhouse effect, which has strengthened as a result of the rapid increase in the accumulation of greenhouse gases in the atmosphere due to various human activities since the industrial revolution, is that it has created an additional positive irradiative force on the energy balance of the Earth, thus making the Earth's climate warmer and more variable. On the other hand, regardless of whether on a global or regional scale, climate change causes significant changes in the frequency, intensity, spatial distribution, length, and timing of extreme weather and climate events. For example, in the period between 1950-2011, significant tendencies of decrease and increase were observed in various regions of the world in precipitation that are characterized by high spatial and temporal variability. Furthermore, increases have been observed in heavy rainfall events in many regions in the world and in Turkey, and significant changes have also occurred in some extreme events.

In addition to the observed changes and tendencies, climate model simulations show, in general relationship with the increased tendencies in the lower troposphere and surface air temperatures, increased thermal energy (positive irradiative forcing), and accelerating and/or intensifying hydrological cycle, that there may be increases in the frequency and/or severity of extreme weather and climate events in many regions of the world in the 21st century.

The primary objective of the Introduction to Climate Change Science module can be summarized as discussing what climate change is conceptually and theoretically, the scope of climate change, its causes and understanding, and ensuring that the climate change issue is based on a scientific framework (the physical science basis of the climate change). The second objective is to make a wide-angle and multi-disciplinary scientific synthesis of the climate change observed in the world and in Turkey with the future climate change and variability according to the climate model predictions that are run based on various greenhouse gas emission scenarios. The third objective of the module is to provide brief information on the United Nations Framework Convention on Climate Change (UNFCCC) and explain its role in preventing human-induced climate change.

2. Greenhouse Gases in the Atmosphere, Strengthened Greenhouse Effect, and Global Warming

Prof. Dr. Murat Türkeş

The increase observed in anthropogenic greenhouse gas accumulations in the atmosphere since the industrial revolution is continuing. In order to understand the causes of natural and human-induced (anthropogenic) climate change in the most general sense, among other factors, it is necessary to know the operation principles and mechanisms of the irradiatively effective concentrations of variable greenhouse gases and greenhouse effect, which is required for the Earth-atmosphere system to warm and to reach a temperature to be experienced. This basic knowledge is also vital in terms of combating and mitigating the human impact, human-induced climate change, and human-induced climate change that have led to the change of the global climate system after the industrial revolution, especially since the last quarter of the 20th century.

Air consists of many gases and particles, in other words, of matters that are suspended in the air (volatile), whose accumulation in the atmosphere varies significantly from time to time and from place to place. Carbon dioxide (CO_2), water vapor (H_2O), dinitrogen monoxide (N_2O), methane (CH_4), various suspended particles, and ozone (O_3) are important examples of variable gases and aerosols. Although the rate of accumulation of these gases in the atmosphere is small, their effects on air and climate are very important. CO_2, CH_4, and N_2O have both natural and anthropogenic sources. Although not given here, for example, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), chlorofluorocarbons (CFCs), and their various derivatives have been produced by industrial processes (human origin) and released into the atmosphere since the 20th century.

The greenhouse gases, whose accumulation in the atmosphere increases as a result of various human activities such as the burning of fossil fuels, deforestation, industrial processes, agricultural activities, etc. and use of fuel-based energy, weaken the cooling efficiency of the Earth through long wavelength radiation and provide a positive irradiative forcing that tends to further warm it. The positive contribution made to the energy balance of the Earth/atmosphere common system is called the strengthening of the greenhouse effect. This means that the natural greenhouse effect, which has been working for hundreds of millions of years, is strengthened with the help of natural greenhouse gases (water vapor, CO_2, CH_4, N_2O, and O_3) in the Earth's atmosphere.

In this context, global warming can be defined as the temperature increase detected in the lower layers of the atmosphere, as a result of the strengthening of the natural greenhouse effect due to the rapid increase in the accumulation of greenhouse gases in the atmosphere as a result of various human activities such as burning fossil fuels, deforestation, agricultural activities and industrial processes with the contribution of urbanization since the industrial revolution.

As can be understood from the definition, greenhouse gases that cause human-induced climate change and global warming are mostly the results of fossil fuel burning (energy and cycle), industry (energy-related; chemical processes and cement production, etc. non-energy), transportation, land-use change, waste management, and agricultural (energy-related; stubble burning, rice production, animal husbandry, and fertilization, etc. non-energy) activities. The magnitude of global warming caused by the strengthened greenhouse effect depends on the magnitude of the increase in the accumulation of each greenhouse gas, the irradiative properties of these gases (global warming potential), atmospheric lifespan, and the accumulation of other greenhouse gases in the atmosphere.

3. Natural and Anthropogenic Greenhouse Effect

Prof. Dr. İhsan Çiçek

The sources of greenhouse gas emissions can be divided into two groups: natural systems and sources related to anthropogenic activities. Greenhouse gases emitted from natural sources are generated by emissions from forest fires, oceans, wetlands, permafrost, volcanoes, and mud volcanoes.

In the absence of sufficient volcanic emission data and without taking into account seismic emissions, natural global greenhouse gas emissions are estimated to be in the range of 181,3 to 393 Mt CO_2-eq per year. Forest fires constitute the largest natural emission source with 37,8% of the total, followed by oceans, permafrost and wetlands with 21,05%, 20,64%, and 17,2%, respectively. Volcano and mud volcano emissions account for only 1% - 3% of total greenhouse gas emissions.

Global anthropogenic greenhouse gas emissions were 36,2 Gt CO_2-eq and global annual greenhouse gas emissions were approximately 54,33-75,5 Gt CO_2-eq in 2016, therefore anthropogenic emissions constituted 47.9% - 66.6% of total global emissions; 55,4% on average. The ratio of natural to anthropogenic greenhouse gas emissions is approximately 0,5-1,09, with the most probable ratio being 0,8. Total greenhouse gas emissions from natural systems are slightly less than anthropogenic activities. If earthquakes and volcanic greenhouse gas emissions are included, the ratio of natural system greenhouse gas emissions will increase.

The total amount of greenhouse gas absorbed by the ocean and terrestrial ecosystems through the sink effect is 14,4-26,5 Gt CO_2-eq per year, which is approximately the same amount as the emissions from natural systems. Therefore, Earth's natural system can be considered to be self-balancing, and greenhouse gas emissions from human activities put extra pressure on the Earth system.

4. Sink Mechanisms and Their Strength

Prof. Dr. İhsan Çiçek

The movement of carbon in the atmosphere towards the ocean and terrestrial sinks, which reduces the negative effects of climate change, is called carbon sequestration. It is necessary to develop certain mechanisms to ensure that greenhouse gas is absorbed more into biological systems in land and oceans. This type of fixation is essentially a temporary solution, because almost all of these carbons eventually return to the atmosphere in the respiration process. However, the carbon retention time (i.e. capture and storage) allows the longest possible retention times to occur with the choice of product and management regimes. For this reason, forests are natural candidates for possible improvements to terrestrial carbon sinks, where most of the fixed carbon has been retained in trees and soil organic matter for centuries.
A carbon sink is a natural or artificial reservoir that absorbs and stores the atmosphere's carbon by physical and biological mechanisms. Coal, oil, natural gases, methane hydrate and limestone, carbon are examples of these sinks. After long processes and under certain conditions, carbon has been stored in these sinks for thousands of years. On the contrary, the use of these resources, which are considered to be fossils, re-injects the carbon they carry into the atmosphere. Today, other carbon sinks become involved, such as humus-storing soils (such as peat), some plant growing environments (such as creating forests) and of course, some biological and physical processes that take place in the marine environment.

Healthy coastal ecosystems play a mitigating role against climate change, especially by sequestering carbon. For example, mangroves, sea grasslands, and salt marshes

are important carbon sinks. These three examples store at least ten times more carbon than forests when they flourish by retaining carbon in their calcium skeleton. Globally, terrestrial systems have been a large carbon sink, absorbing about a quarter of the carbon emitted into the atmosphere as CO_2 from the burning of fossil fuels.
If biological solutions are too risky or short-lived, are there physical ways to move carbon into long-term reserves? What are the techniques used to eliminate CO_2 at source? This section covers the answers to these problems.

5. Possible Effects and Risks of Climate Change on Natural Resources in the World and Turkey

Prof. Dr. Ayşe Gül Tanık

Surface and underground water resources, soil resources, especially the marine system, ecosystem, biodiversity and forestry are the natural resources of the world. The possible impacts of climate change on these natural resources in the world and in Turkey are discussed in this section. The observed and expected impacts on water resources are the occurrences of less snowfall, less glacier, more varied rainfall patterns and more intense downpours. According to various climate model results, some regions will receive less rainfall than today, while some regions will receive more. As extreme weather events will increase the recurrence rate of flood and drought, water storage will become more important. Determining the effects of climate change on water quality is of great importance in terms of determining the policy on issues such as ecology, species diversity, human health, agriculture, industry, drinking water, recreation and insurance sectors. Decrease in river flows and decrease in water levels in lakes cause deterioration of water quality due to the presence of nutrients and pollutants in less volume of water. The impact of climate change on flow and groundwater varies regionally, and this change is mostly affected by predicted changes in precipitation, depending on climate scenarios. Sea level rise can cause saltwater intrusion into islands and coastal aquifers.

It is stated that as of 2080, 20% of the world population will live in basins where flood damages will have increased due to the effect of climate change and that floods with 100-year frequency will be experienced more frequently. One of the most important effects of climate change is drought and water scarcity events. The short-term effect of drought is reduction in the amount of available water. In the long term, groundwater resources and reservoirs will become unable to meet excessive consumption; the situation will worsen with the effect of new drought periods and the emergence of water scarcity. Decrease in the amount of water and drought due to climate change can have serious consequences in many sectors, especially in drinking water, agriculture, energy and forestry. Activities that require large amounts of water withdrawal such as drinking water demand, irrigation, hydroelectric power generation, industry, use of cooling water, etc. will be affected by changing flow regimes and decreasing annual water volumes. There may be an increase in the amount of irrigated land and water withdrawal for irrigation in many regions. Soil is an important and often neglected element in the climate system. It is the second largest carbon store or "sink" after the oceans. The rehabilitation of key ecosystems on the land and the sustainable use of land in urban and rural areas can help mitigate and adapt to climate change.

6. Scenarios and Positions of the Countries

Prof. Dr. İhsan Çiçek

The performances of the countries were evaluated according to the Climate Change Performance Index 2020. Sweden has led the group of high performing countries, as in the past two years. Denmark went up ten positions to become the second-best performing country in this year's Climate Change Performance Index. Morocco maintains its overall performance despite dropping one place in the overall ranking. Three countries with the worst Climate Change Performance are Taiwan, Saudi Arabia and the USA. This year, Taiwan dropped three places to the rank of 59. Saudi Arabia still ranks very low, and for the first time has not been placed in the lower ranks of the index. The United States continued its downward trend, dropping to the bottom of the rankings after dropping three places in last year's rankings. No country has performed well enough to achieve an overall very high rating in the index in all index categories. Therefore, the top three rankings of the overall ranking remained empty, once again.

While only two G20 countries were placed among the high performers (UK and India), eight G20 countries were ranked below the very low performers. Poland ranked as the worst performing EU country in this year's index. While eight EU countries had high performances, the EU as a whole fell down six places and was placed under the middle performer group in this year's index.

Sweden has the lowest total per capita emissions based solely on consumption-based emissions, which is rated very high for their compliance below 2 °C. Egypt has scored high for its performance in the category, with its current greenhouse gas emissions per capita at relatively low levels, further emission reductions in recent years and an environmental target of 2030. The UK is still rated medium for the current level of emissions per capita, but achieves high ratings for the remaining indicators in the greenhouse gas emissions category. This includes good compliance below the relatively high-rated 2 °C of the 2030 greenhouse gas emission target.

The Republic of Korea is not making progress in the category of greenhouse gas emissions, which is very low both due to the current level of per capita emissions and its compliance with the country's greenhouse gas target of below 2 °C. Taiwan has a very low rating for all indicators in the greenhouse gas emissions category. Saudi Arabia ranks low for the past trend of greenhouse gas emissions per capita in this year's index, whereas the relatively high level of per capita emissions is still rated too low for 2 °C compliance.

The countries with high and low performance are listed by examining the per capita greenhouse gas emissions of some selected countries. Evaluations of the countries were also made according to their renewable energy performances. Ten of the G20 countries are rated low or very low due to their performance in the Renewable Energy category. The current shares of renewable energy are rated relatively low for these countries due to their unpretentious 2030 renewable energy targets and below

2 °C compliance.

Brazil and the UK are the only two G20 countries to achieve high scores for their performance in the Renewable Energy category. While Brazil's performance is based on the high share of renewable energy sources in the energy mix, the UK scored very high for the positive trend in renewable development between 2012 and 2017. Countries are grouped by making evaluation in terms of Climate Policies Implemented by Countries.

7. IPCC Climate Change Scenarios

Prof. Dr. İhsan Çiçek

The most important study in predicting the climate likely to be encountered in the future is climate modeling. In this way, the current conditions are taking into consideration and it is tried to calculate the change of these conditions with certain physical equations and to draw the general framework of the weather or climatic conditions after a certain time. The biggest challenge in modeling the climate is the need to simulate changes in climate conditions much faster than the real time process.

Global climate models (GCMs, also known as General Circulation Models) play a very important function in defining global climate statistics such as the global average surface temperature. GCMs represent the physical processes in the atmosphere, oceans, cryosphere, and land surface. These models are the most advanced tools for demonstrating the climate system's response to rising greenhouse gas emissions.

These changes, which are expected to occur in the atmosphere, constitute inputs for adaptation and effect studies, and decision-making processes are completed with the production of policies based on these. This approach has been used in the IPCC 3rd and 4th Assessment Reports while writing the Emission Reports Special Report (SRES) scenarios and climate change scenarios. SRES scenarios were produced with four main scenario families (A1, A2, B1 and B2) and by separating them into different scenarios.

Due to computational difficulties, Global Climate Models (GCMs) generally have a horizontal resolution of 100-300 km. It is not possible to reflect the regional climatic changes, topography, coastal areas and details of the land surface with this resolution appropriately. Therefore, small-scale weather events and atmospheric processes such as front systems or precipitation systems cannot be displayed in GCMs or they are included in a very crude manner. For the purpose of using the calculation capacity in limited areas in the most appropriate way and eliminating the deficiencies mentioned above, Regional Climate Models (RCMs) are used. In this section, general information about global and regional climate models is provided, and SRES scenarios are introduced.

8. Common Response and Compliance with Scenario Goals

Prof. Dr. İhsan Çiçek

Ranking results in the Climate Change Performance Index are defined by the aggregate performance of a country in a globally unique policy section for 14 indicators in the "Greenhouse Gas Emissions", "Renewable Energy" and "Energy Use" categories.

The results of the Climate Change Performance Index 2019 show the main regional differences in climate protection and performance within the 56 countries assessed and within the EU. No country has performed well enough to rank in the index in 2019, meaning no country was ranked in the top three in the ranking (Burck et al., 2019).

In the 2019 index, Sweden ranked first in the rankings of Morocco and Lithuania. The group of countries with medium performance includes countries such as France, Mexico, Germany and the Czech Republic. Generally, underperformers include Indonesia, Austria and New Zealand. The bottom five countries on this year's Climate Change Performance Index Are Saudi Arabia, the USA, the Islamic Republic of Iran, the Republic of Korea, and Taiwan, and they scored low or very low in almost all categories.

9. Possible Effects and Risks of Climate Change on Sectors in the World and in Turkey

Prof. Dr. Mehmet Somuncu

Climate change is no longer just a future scenario, but it is an ongoing phenomenon, whose the effects are already being felt in many parts of the world. Examples of more frequently occurring heat waves and droughts, melting glaciers and permafrost, increases in heavy rainfall and early start of the growing season are evidences of this. All these are indicators of our changing climate. Therefore, adaptation to climate change has a vital importance for the future of both the humans and of the ecosystem. Recent studies have shown that even a complete cessation of greenhouse gas emissions will not prevent the rise in global temperatures. In the coming decades, despite all efforts and gains in climate change mitigation, the challenges to climate change adaptation are expected to increase.

Climate change will increase existing risks and create new risks for natural systems as well as for human systems. Risks are unevenly distributed and are generally higher for the disadvantaged people and communities in countries of all development levels. Increased warming will increase the likelihood of severe, widespread and irreversible impacts for humans, species and ecosystems. Continuous high emissions will often have negative impacts on freshwater resources, ecosystems and biodiversity, food security and food production systems, coastal systems and lowlands, urban areas, rural areas, extreme weather events and human health.

A large part of Turkey is located in the dry subtropical Mediterranean climate zone. Therefore, Turkey is situated among medium-high risk countries in terms of the current climate, climate change, and variability in future climate. The effects of climate change are already being felt in Turkey. The most obvious consequences are warmer winters, drier and hotter summers, changes in biodiversity, and retreat of mountain glaciers. Climate change has an impact on terrestrial, marine, and freshwater ecosystems and it increases the overall pressure on the environment. Weather and climate-induced extreme events and social and economic losses from disasters is a significant area in Turkey, which is increasing with variability between years. It is expected that the climate in Turkey will be subject to significant changes over the next decade.

10. Possible Effects of Climate Change on Health and Risks in the World and Turkey

Prof. Dr. Didem Evci Kiraz

Climate change can have a direct or indirect impact on health by affecting social and environmental determinants of health such as clean air, clean drinking water, adequate food and safe shelter. Its direct effects are health problems caused by heat and cold weather waves and extreme weather events.

Extreme weather events can cause injuries, post-disaster epidemics, problems such as malnutrition and adverse effects on mental health. Especially in the elderly, the risk of death due to cardiovascular diseases, stroke, hypertension, renal and respiratory system disorders and metabolic disorders increases with the increase in temperature.

The indirect health effects of climate change are much more complex. Diseases associated with drought due to climate change, changing infectious disease factors, vector-related diseases, mental illnesses, recurring and new diseases are expected results of climate change. The Covid-19 (SARS CoV-2) pandemic, which started in December 2019 and made the World another World in 2020, has caused humanity, scientists, and decision-makers to look back on these issues. As yet, there is no "data and evidence collection system to link the climate" with food, water, and vector-related diseases, changing infectious disease factors, and re-emerging or new diseases. It is necessary to initiate scientific studies on the events observed from the neighborhood, city, region, up to the international level in order to reach the manpower, time, budget and start with the sustainable political determination to address the health effects of climate change as a whole. For this purpose, it is beneficial to establish "Regional Climate and Health Research Centers".

11. Climate Change and Model Use in Agricultural Production

Prof. Dr. Zeynep Zaimoğlu

The impact of climate change is a growing concern for decision-makers. In agriculture, crop production will be affected by a combination of factors (climatic, physiological, technological, hydrological, economic) with complex interactions between them. In this regard, combining different models in one modeling system offers several advantages:

The Modeling System for the Agricultural Impacts of Climate Change is the first stage of planning for the future, including the impact of climate change on agriculture, the differences in crop yield, and their effects on national economies. However, it should be decided, in the use of models, whether it is more appropriate to use the short-term models with local outputs or long-term national and later international models.

A: Short Term, Incremental, Autonomous, Reactive and Localized:

Changes in planting dates, in the field or crop selection may include the adaptation of water, nutrient, residue, and canopy management. By changing the planting date, farmers can take advantage of the extended growing season associated with climate warming. In addition, planting date shifts provide the possibility of avoiding exposure to certain climatic stresses such as heat or drought during sensitive phenological stages. If the growing season is prolonged, double cropping or even triple cropping may be viable options to increase land fertility under climate change.

Switching to varieties or crops with greater tolerance to the most dominant stressors can help reduce climate risks.

B: Long Term, Transformative, Strategic, Prospective, and Large Scale (Regional, National, or International):

It may include spatial changes in production areas, structural changes in production systems that indicate significant changes in farming activities, or the cultivation of new crops and varieties. For farmers, this could mean investing in infrastructure for new production systems. For this reason, it is of great importance that farmers have the necessary educational infrastructure and that the possible works are carried out by the relevant institutions and organizations urgently.

12. Effects on Climate Change: Land Use/Cover

Prof. Dr. Süha Berberoğlu

With the recognition of the role of terrestrial ecosystems in climate change, the concept of "Land use, land-use change and forestry (LULUCF)" has emerged. Terrestrial ecological systems in which living biomass, decaying organic matter, and soil are held play an important role in the global carbon cycle. Carbon naturally moves between these systems and the atmosphere through photosynthesis, respiration, decomposition, and combustion. Changes in land use cause the change of this cycle (IPCC, 2000).

It is currently estimated that approximately 30% of the 2,3 Gt of carbon or human-induced emissions per year are removed by terrestrial ecosystems. On the other hand, emissions from the carbon pools of terrestrial ecosystems due to the change in land use constitute more than 20% of 1,6 Gt of carbon or human-induced emissions per year. However, when 4,6 Gt of the total 7,9 Gt carbon released into the atmosphere each year is retained by terrestrial ecosystems and oceans, the remaining 3,3 Gt remains in the atmosphere.

13. Possible Effects and Risks of Climate Change on Industrial Production Sector in the World and in Turkey

Prof. Dr. Mehmet Somuncu

The direct impact of climate on the industry is not as strong and pronounced as in the sectors that are based on nature or dependent on nature such as agriculture or tourism. However, industry is indirectly affected by the climate, especially the components of the industry such as raw materials, water, transportation, and energy and site selection for some industries. According to the figures provided by Intergovernmental Panel on Climate Change (IPCC), 25% of total global emissions are caused by electricity and heat generation, 21% by industry, 14% by transportation, and 10% by other energy-related activities (IPCC, 2014). In this regard, it can be said that the interaction between the industrial sector and the phenomenon of climate change is reciprocal.

Industrial sector is affected by the climate change in many different ways in the world and in Turkey. Even though these effects may be negative, they may also create new opportunities. Climate change can affect the manner businesses operate, affect the profitability of their operations, or create opportunities. For this reason, businesses may be exposed to different risks as a result of climate change, which can be both direct and indirect. The said risks may be physical risks, supply chain and raw material risks, reputation risks, financial risks, product demand risks, and regulatory risks. Exposure of companies to these risks varies depending on their business activities and the industry in which they operate.

In general, when industrial production is considered in a holistic manner, it is seen that it is performed within a concept framework, which is defined as a value chain, composed of interconnected factors starting from the supply of raw materials and including production and marketing. In this context, the industrial sector will be affected by climate change in terms of variability and difficulties in sourcing raw materials or commodities; possible restrictions and difficulties in production due to changes in water quality and water availability; problems to be experienced in the transportation sector and their possible reflections to the industry; infrastructure damage and operational disruption due to extreme weather events and flooding, and potential impacts of climate change on the workforce.

14. Possible Social Effects of Climate Change and the Risks in the World and in Turkey

Prof. Dr. İhsan Çiçek

Since the last quarter of the twentieth century, one of the most fundamental problems in the field of environment is the negative effects of climate change. In this respect, the concept of climate security can be considered as a subtitle of the concept of environmental security. The pressure put on the main elements of sustainable development such as water, agriculture, health, energy, and the environment by the physical effects of global climate change give rise to the reassessment of the concept of security. In this context, the concept of climate security includes the effects of climate change, which manifests itself with droughts, heat waves, floods, and fires, having influence on the security perception, assessments, and applications.

15. Possible Effects of Climate Change on Urban Ecosystems and the Risks in the World and in Turkey

Prof. Dr. İhsan Çiçek

On the one hand, while there is a global phenomenon of climate change in the world, on the other hand, a rapid urbanization process is being experienced. Half of the world's population lived in urban areas in 2007, and it is estimated that 66% of the world's population will live in urban areas by 2050. Urban climate differs from rural areas in that it is generally more polluted, warmer, more rainy and less windy. This shows that, with the expected increase in temperature and more extreme weather events, the impact of climate change will be more experienced in urban areas than in rural areas. Events such as changing climate, rising urban temperatures and floods can also increase the negative effects of urbanization already being experienced.

Nature-based solutions play an important role in achieving a future compact city that is livable and sustainable. Vegetation in different forms can contribute to climate adaptation to varying degrees, depending on the type and quality of nature-based solutions, climatic and socio-ecological contexts. By integrating modeling techniques with collaborative processes, we can provide a climate-efficient strategic planning of green space interventions that ensure environmental justice.

Most of the arising global climate risks are concentrated in urban areas. Rapid urbanization and the rapid growth of large cities in low- and middle-income countries have been accompanied by the rapid growth of highly vulnerable urban communities living in slums, many of which are at high risk due to extreme weather conditions.

Urban climate adaptation provides opportunities for both incremental and transformative development. Urban adaptation provides opportunities for incremental and transformative adjustments in development trajectories towards resilience and sustainable development through effective multi-level urban risk governance, harmonization of policies and incentives, strengthened local government and community adaptation capacity, synergy with the private sector and appropriate financing and institutional development.

Ecosystem-based adaptation makes an important contribution to urban resilience. Adaptation measures related with effective urban food security (including especially social safety nets, as well as urban and urban agriculture, local markets and green roofs) can reduce climate vulnerability, particularly for low-income urban residents. Reducing key service gaps and building resilient infrastructure systems can significantly reduce especially exposure to the hazard and vulnerability to climate change. For most of the main hazards associated with climate change in urban areas, risk levels are increasing from now (with current adaptation) to near term, but high adaptation can significantly reduce these risk levels. It is less possible to do this in the long run, especially under the global average temperature rise of 4 °C

Leadership within local governments, as well as at all scales, is important to ensure successful adaptation and to build and maintain wide support base for the urban adaptation agenda.

International financial institutions provide limited financial support for adaptation in urban areas. There is limited existing commitment from different levels of government and international organizations to finance urban adaptation.

Information and data are needed to take into account local risk and vulnerability assessments and current and future risk and adaptation and development options for an effective adaptation action. Dealing with the uncertainty associated with climate change forecasts and balancing them with actions to address current vulnerabilities and adaptation costs helps to assist implementation in urban regions.

16. Climate Change and Urban Floods

Prof. Dr. İhsan Çiçek

The measures to be taken to combat floods in cities in outlines are as follows; Each risk scenario is different: There is no flood management plan. Designs for flood management must be able to cope with a changing and uncertain future. Rapid urbanization requires that existing risk management be integrated into regular urban planning and governance. An integrated strategy requires the use of both structural and non-structural measures and good measurements to “get the balance right”. Heavy engineering structures can transfer risks up and down. It is impossible to eliminate the flooding risk completely. Many field management measures have multiple benefits. It is important to consider the wider social and ecological consequences of business management expenditure. Clarity of responsibility is important in setting up and running flood risk programs. Implementing flood risk management measures requires multi-stakeholder collaboration. Continuous communication is required to increase awareness and strengthen preparedness. Planning must be made for rapid recovery after flood and recovery capacity must be increased.

It is important to plan a rapid recovery, as flood events will continue to devastate communities despite best practices of flood risk management. This includes planning for the right human and financial resources to be available. The best rescue plans use the opportunity for restructuring to build safer and stronger communities that have the capacity to withstand the future floods better.

17. Possible Effects of Climate Change on Increasing of the Disasters and the Risks in the World and in Turkey

Prof. Dr. İhsan Çiçek

According to the World Bank and many other data, the economic damages of disasters are increasing rapidly. The reason for this cannot be attributed to the increase in disasters. Although there are periodic increases, the information that disasters are increasing gradually is not very reliable. The problem is not that disasters increase but that disasters become more damaging. Regional income distribution increases vulnerability in disasters.

The global climate is already changing and will continue to change over the next decades and centuries. In many places, local trends in mean temperature and precipitation due to climate change have become significant today. These significant trends allow very reliable projections to be made for the future. However, climate change is not just about gradual or linear changes. The main impacts of climate change will result from changes in climate variability and extreme weather conditions.

18. Disasters of Meteorological Character and Insurance Sector

Prof. Dr. İhsan Çiçek

The effect of natural hazards caused by weather variability, extreme climatic conditions and geophysical events on economic welfare and human losses has increased alarmingly. More than three-quarters of recent casualties can be attributed to other hazards related to climatological and meteorological events such as windstorms, floods, and drought. Low-income and middle-income countries, and particularly vulnerable communities in these countries, are the most affected by the losses associated with loss of life and property. In the last quarter century (1980-2004), more than 95% of deaths from natural disasters occurred in developing countries and direct economic losses have become 54 billion US dollars on the average annually. This loss is increasing constantly and reached 175 billion US dollars in 2016.

Developed and developing countries differ not only in the human and economic burden of natural disasters, but also in insurance coverage. In rich countries, around 30% of losses (about 3.7% of GNP) were insured during this period. In contrast, only 1% of losses (12.9% of GNP) were insured in low-income countries.

Insurance products are one of the many approaches that offer innovative methods to manage and reduce the economic development risks of climate change, especially in emerging markets. Insurance can also help businesses and consumers withstand financial shocks caused by climate-related events, and they can be an important component for managing the impact of climate change on growth. Nevertheless, challenges remain in establishing insurance markets in these economies and developing products that manage climate change risks.

19. Climate Migration

Prof. Dr. İhsan Çiçek

Anthropogenic climate change increases existing environmental, economic and social vulnerabilities even further. Consequently, adaptation to climate change should be broader than tackling the marginally increasing impact of anthropogenic climate change. Focusing on the ineffective effects of climate change in the local context leads to some strange policy distortions. For example, in the Philippines, policy makers have begun to acknowledge the projected flood threats of annual sea level from 1 to 3 millimeters per year due to climate change. However, they are also unaware of or ignorant of the excessive groundwater withdrawal that lowers the land surface by a few centimeters every year, which is one of the main reasons for increasing flood risk.

In the current climate change scenarios, migration due to enhanced climate change is a key point. However, the amount of this depends on how well international societies adhere to the mitigation and adaptation plans. It is unavoidable to confront the international community with the prospect of massive displacement because of climate change. There is a need for international recognition of the problem, a better understanding of its dimensions, and a willingness to deal with it. This can happen in several ways

1. The international community must formally acknowledge the impasse of forced climate migrants. While it is not clear that an expanded definition of refugee that includes environmental degradation as a “valid” driver of displacement will provide clear benefits for all (traditional and environmental) refugees, the position needs to be kept on the international agenda for some form of international awareness.

2. Development and adaptation policies in the potential source countries of forced climate migrants must focus on reducing people's vulnerability to climate change, moving people out of marginal areas and supporting livelihoods that are more

resilient. Especially, more efficient use of existing resources will balance some of the predicted effects of climate change. For example, irrigated agriculture in Pakistan uses 85 percent of the country's fresh water supply, but because of leakage and evaporation, only 50 to 65 percent of it is efficient.

3. More research is needed to understand the causes and consequences of climate migration and to monitor the numbers. In the meantime, implementers should develop better communication and working relationships between different human rights, population, environment, and migration organizations that share authority to respond to displacement of the population.

4. Finally, the international community needs to help developing countries generate incentives to retain skilled labor, and also allow the developing countries enjoy the benefits that streamlined labor markets can bring. International regulation of labor migration is inherently intertwined with climate change adaptation and capacity building in vulnerable countries. Migration will be used by some households in vulnerable countries as a means of adapting to climate change. Obviously, there must be a policy balance that supports incentives for workers to stay in their home country while not closing the door to international labor mobility.

INTRODUCTION TO CLIMATE CHANGE SCIENCE

Prof. Dr. Murat Türkeş

The global climate has shown significant changes and transformations in all areas and time scales since the formation of the Earth, which is about 4.6 billion years old. During these changes, very important and big changes took place during the formation of the World and in Ana-tolia's physical geography (landforms, air and climate, soil and vegetation, surface and ground-water, rivers and lakes, glaciers, ecosystem, biome and biological diversity, etc.).

The most important result of the greenhouse effect, which has been strengthened as a result of the rapid increase in the accumulation of greenhouse gases in the atmosphere since the industrial revolution due to various human activities, is that the Earth's climate is warmer and more variable by creating an additional positive radiative force on the energy balance of the Earth. On the other hand, whether on a global or regional scale, climate change causes significant changes in the frequency, intensity, spatial distribution, length, and timing of extreme weather and climate events. For example, in the period of 1950-2011, significant decreases and increases tendencies were observed in various regions of the world in precipitation, characterized by high spatial and temporal variability. In addition, the world observed the increase in heavy rainfall events in many regions, and Turkey and significant changes have also occurred in some extremes.

In addition to the observed changes and trends, climate model simulations show that there may be increases in the frequency and/or severity of extreme weather and climate events in many regions generally including the predicted increase trend in the lower troposphere and surface air temperatures, increased thermal energy (positive radiative forcing) and accelerating and/or intensifying hydrological cycle.

1. INTRODUCTION

Climate change can be defined as "statistically significant changes in the average condition of the climate or its variability over tens or more years " (Türkeş, 2008a and 2008b). Climatic variability can be defined as " changes in the average condition of the climate at all time and area scales and in other statistics such as standard deviations and the frequency and probability of occurrence of extreme events" (Türkeş, 2008a and 2008b). Climate change and variability may occur due to natural internal processes within the climate system or changes in humans (anthropogenic) and naturally sourced external forces.

Global climate is a very complex system with five main components named the atmosphere (atmosphere), hydrosphere (water), ice sphere, lithosphere (stone sphere), and biosphere (life sphere) and includes the interactions between these components, and it is also called climate system for short. (Türkeş, 2010). External forces and factors include changes that interact with and are affected by the subsystems of the climate system, such as volcanic eruptions, changes in solar activity, and anthropogenic changes in the composition of the atmosphere, such as natural events such as changes in the astronomical relationships between the Earth and the Sun (Türkeş, 2012a, and 2013a). Greenhouse gases and aerosols released into the atmosphere as a result of human activities are the main external forces and factors that can cause climate changes, although their duration of action varies.

Potential 'external' causes of climate change mainly include plate motions in the Earth's solid crust, changes in solar activity, and astronomical relationships between the Earth and the Sun. In other words, changes caused by external forces and factors develop under the control and influence of natural events outside the climate system and anthropogenic forcing and factors. Astronomical relationships include a series of periodic changes, also called Milankovitch cycles, and can provide important evidence to explain long-term climate changes (Erlat, 2010; Türkeş, 2013a).

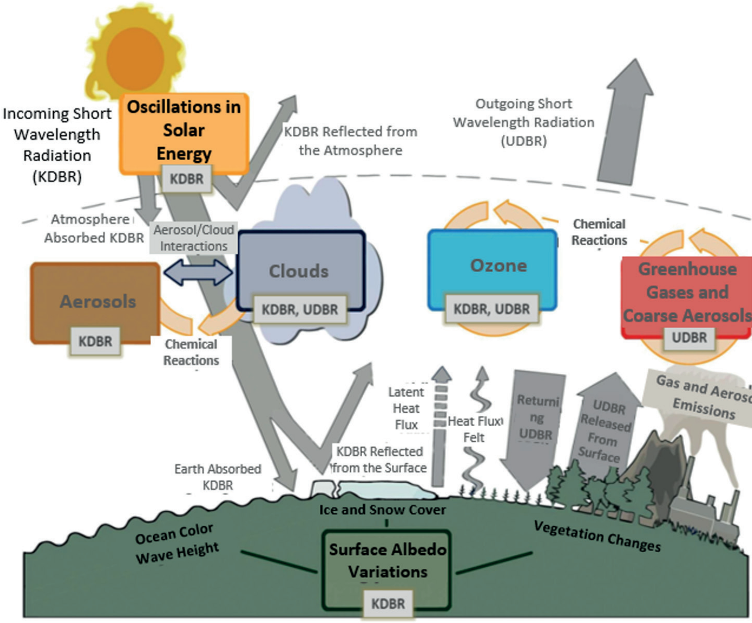
2. GLOBAL CLIMATE CHANGES AND ITS CAUSES

2.1. Main Drivers of Climate Change

The main natural greenhouse gases, which have variable concentrations in the atmosphere and are affected by many human activities and are responsible for the operation of the natural greenhouse effect mechanism, are carbon dioxide (CO_2), water vapor (H_2O), diazotmonoxide (N_2O), methane (CH_4) and ozone (O_3) and human-made (artificial) chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and a wide variety of derivatives thereof.

Figure 1 shows the diagrammatic synthesis of the main drivers and causes of climate change in a very broad perspective from the short wavelength radiation (KDBR) that reaches the upper limit of the atmosphere from the sun (incoming, G) and the long-wavelength radiation (UDBR) emit-ted from the earth (outgoing, G), to interactions and radiative forcing of aerosols, clouds, ozone layer, greenhouse gases and coarse aerosols with the climate system, from energy flows in the earth and atmosphere to albedo and vegetation changes in the earth.

Figure 1: Graphical representation of the main drivers of climate change (Redrawn and arranged according to Cubasch et al., 2013).



The radiative balance between GKDB solar radiation (radiation) and GUDB ground radiation is affected by many climate directors ('drivers') on a global scale. Natural oscillations in the solar flux output (solar cycles) can cause changes in the Earth's energy balance through oscillations in the value or intensity of the DDB solar radiation. Human activities such as burning fossil fuels, industrial processes, land-use changes and deforestation etc. alter the gas and aerosol emissions associated with chemical reactions in the atmosphere that result in changes in O_3 and aerosol amounts in the air. O_3 and aerosol particles in the atmosphere change the energy balance by ab-sorbing, scattering and reflecting the GKDB Sun radiation. Some types of aerosols may affect precipitation formation and characteristics, possibly by acting as cloud condensation nuclei, changing or distorting the properties of cloud droplets (Figure 1). Since the interaction of clouds with KDBR and UDBR is strong, even small changes in cloud properties can have important consequences in terms of the radiation or energy budget of the climate system.

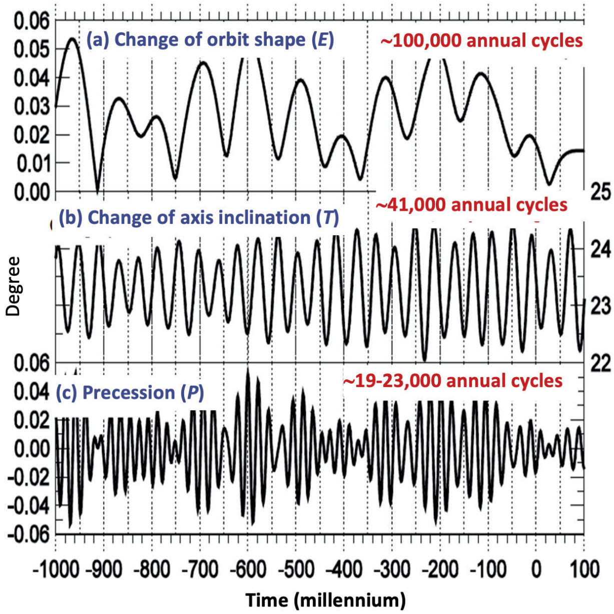
Greenhouse gases in the atmosphere (eg. CO_2, CH_4, N_2O, O_3, CFCs) anthropogenic changes, and coarse aerosols (> 2,5 µm) change the amount or intensity of GUDB radiation by absorbing the GUDB ground radiation and releasing less energy at lower air temperature. The albedo of the earth's surface may change due to land (land) cover and vegetation, snow or ice cover, and changes and distortions in ocean color. All these changes are driven and/or controlled by natural seasonal and daily changes (eg snow cover) and human influence and activities (eg land-use changes, changing vegetation formations or types, etc.).

2.2. Natural Causes of Climate Change

According to our current knowledge, the climate has shown an oscillation over millions of years between very hot conditions characterized by air temperatures above 10 °C in the polar regions of the average annual surface temperatures over millions of years, during glacial periods when inlandsis (glacial shields or continental glaciers) occupy the majority of mid-latitude land-scapes (Türkeş, 2013a). It could be seen that lower amplitude fluctuations were observed in the near-present part of the time sequence spectrum, which is approximately 545 million years long from the Paleozoic (First Time) to the present day, and in the Holocene period of the last 10,000 years, in which we currently are, there has been np year in which almost one year is exactly the same as the previous year, developing over scales of years, ten years or longer time scales (Er-lat, 2010; IPCC, 2013; Türkeş, 2010, 2012a ve 2013b). The total radiant energy (total Sun irradiance, or Sun constant, W/m2), emitted by the Sun in all wavelengths from the photosphere layer at the average Sun-Earth distance in relation to its evolution and reaching a unit area per unit time perpendicular to the sun's rays at the upper limit of the atmosphere has increased by about 30% over its 4.6 billion-year history. Changes in total Sun irradiance over shorter time scales generally have a similar amplitude. Low-frequency changes in Earth's orbital characteristics change the amount of solar energy received in a given season on each point on the Earth's surface. The most important fluctuations occurring in this context are observed between 10,000 - 100,000 years. Single volcano eruptions cause a general cooling in the first years following the eruption (Erlat & Türkeş, 2019). In addition, volcanic activities may be responsible for a low frequency forcing if they are concentrated over a certain decade or centennial period. On longer time scales, for example, large-scale mountain formation areas (e.g. Andes in South America) and island collisions formed as a result of convergence and collision of an oceanic plate with a continental plate and/or two oceanic plates, mainly due to plate tectonics, increasing volcanic activities associated with its arcs (e.g. those in the Pacific Ocean) may cause a strong cooling trend that can last for long periods from thousands to mil-lions of years (Türkeş, 2010).

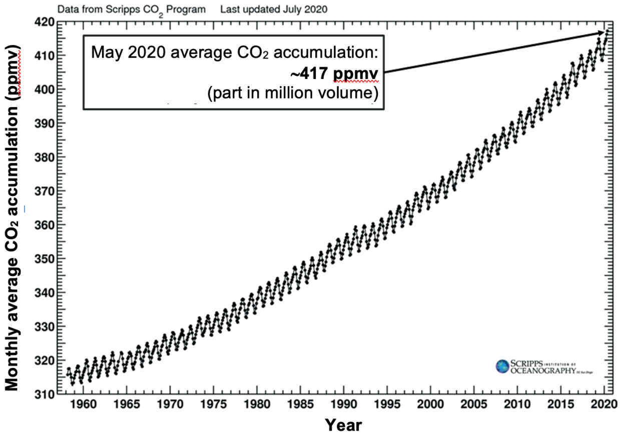
In this context, atmospheric oscillations such as El Niño - Southern Oscillation (ENSO), North Atlantic Oscillation (NAO) or Arctic Oscillation (AO), or distant link patterns are important examples that can be given to the atmospheric internal forces of the global climate system (Şahin et al., 2015 Türkeş, 1998, 2000; Türkeş and Erlat, 2003, 2006, 2008 and 2009). Secondly, due to the great inertia of the oceans and inlandsis, the dominant effect of any perturbation (shaking) may be linked to the convergence or integration of the strain on long time scales, while high-frequency changes are suppressed.

Figure 2: Changes in the Earth's motion to eccentrite (E), axial inclination (T, in degrees), and climatic precession (P), possibly in the last million years and the next 100,000 years (Year 0 corresponds to 1950 AD). The lowest value of the climatic precession corresponds to the boreal (KYK polar) winter (December) solstice at perihelion time.



Insolation defined as " instantaneous solar energy (W/m^2) received per unit time (s) on a horizontal plane of 1 m^2 width at the top of the atmosphere (or on earth when we ignore the effect of the atmosphere)" is a function of the distance between the Sun and the Earth and the cosine of the Sun's zenith distance. In climatology, the astronomical relationships between the Earth and the Sun are called Milankovitch Cycles. Astronomical relationships are determined specifically by the three orbital parameters known as the tilt of the Earth's axis (tilt, T), the shape of the Earth's orbit around the Sun, or the eccentrite (E) and precession (P). In short, the inclination (T) is "a measure of the inclination of the ecliptic plane with respect to the equatorial plane" (more oblique or steeper), and the eccentricity is defined as (E), " a measure of the orbit of the Earth around the Sun "[e.g. more elliptical (less rounded) or less elliptical (more round-ed)]. The climatic precession (P), on the other hand, is associated with changes in the 'perihelion time', with a more explicit saying in the Sun-Earth distance at the summer solstice (solstice). Therefore, the major astronomical relationships that may cause changes in the global climate include changes in the shape of the Earth's orbit around the Sun (orbital forcing), axial inclination, and precession (at perihelion time) (Türkeş, 2013a) (Figure 2).

Figure 3: Monthly changes and long-term trend of CO_2 accumulation in the atmosphere between 1958-2020 (1).

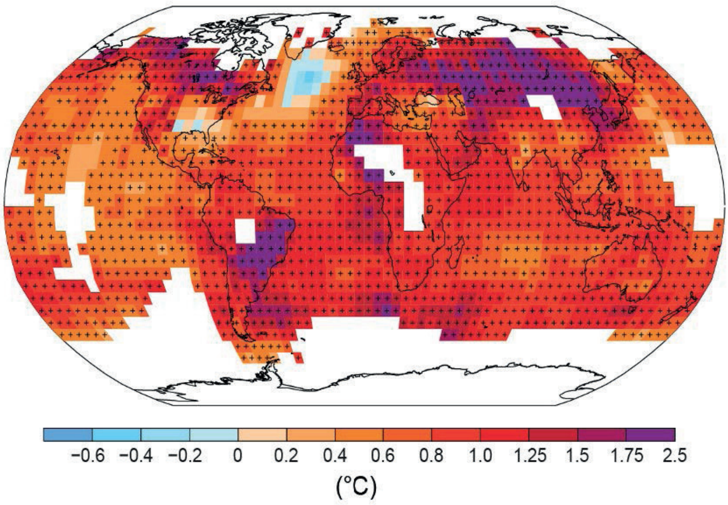


2.3. Human-induced Climate Change and Global Warming

The increase in anthropogenic greenhouse gas accumulations in the atmosphere has been continuing since the industrial revolution. The importance of CO_2 is better understood, especially when considering the size of its accumulation in the atmosphere, its rate of increase, its life span ranging from 50-200 years, and its ability to absorb most of the (GUDB) infrared ground radiation. CO_2 accumulation in the earth's atmosphere is increasing very rapidly. When the monthly average CO_2 time series measured were examined, the annual average CO_2 accumulation in the atmosphere, which was approximately 280 ppmv (one molecule in a million volume or parts per million) before the industry and about 315 ppmv in 1958, reached 414 ppmv in 2020 (Türkeş, 2013b and 2020) (Figure 3). The current level of CO_2 accumulation in the atmosphere is well above the natural CO_2 accumulation changes (varying between about 180-300 ppmv) in the past 700,000 years. These increases in greenhouse gas accumulations weaken the Earth's cooling efficiency by GUDB infrared radiation, resulting in a positive radiative forcing that tends to further heat it. Therefore, the positive contribution made to the energy balance of the Earth/atmosphere common system is called the strengthening greenhouse effect (Türkeş, 2008a and 2008b). This means that the natural greenhouse effect, which has been operating for hundreds of millions of years, is strengthened by the natural greenhouse gases (water vapor, CO_2, CH_4, N_2O, and O_3) in the Earth's atmosphere.

In this context, global warming can be defined as the temperature increase detected in the lower layers since the industrial revolution, especially due to the rapid increase in the accumulation of greenhouse gases in the atmosphere as a result of various human activities such as burn-ing fossil fuels, deforestation, agricultural activities, and industrial processes, as a result of the strengthening of the natural greenhouse effect with the contribution of urbanization (Türkeş, 2012a). As can be understood from the definition, greenhouse gases that cause human-induced climate change and global warming are caused mostly by fossil fuel burning (energy and cycle), industry (energy-related; chemical processes and cement production, etc. non-energy), transportation, land-use change, waste management, and agricultural (energy-related; stubble burning, rice production, livestock, and fertilization, etc. non-energy) activities.

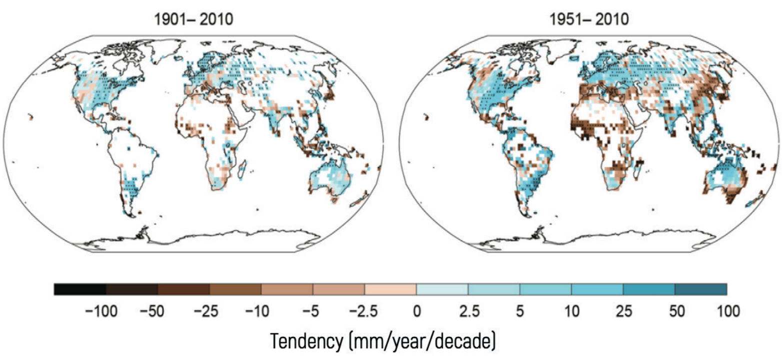
Figure 4: The spatial distribution of the observed changes in the annual average surface temperatures ac-cording to the linear trend ratios calculated for the period 1901-2012 (IPCC, 2013).



3. CLIMATE CHANGE OBSERVED IN THE WORLD AND IN TURKEY

The most important result of the greenhouse effect, which has been strengthened as a result of the rapid increase in the accumulation of greenhouse gases in the atmosphere since the industrial revolution due to various human activities, is that the Earth's climate is warmer and more variable by creating an additional positive radiative force on the energy balance of the Earth. (Figure 4 and Figure 5) Whether on a global or regional scale, climate change causes significant changes in the frequency, intensity, spatial distribution, length, and timing of extreme weather and climate events. For example, precipitation showed a high spatial and temporal variation globally in the period 1900–2012, and drought and increasing trends were observed in the amount of precipitation on a regional scale (Figure 5). North and South America in the eastern parts of Northern Europe and observed significant upward trend in Asia in the north recorded rainfall amounts with the central region, while significant drought or downward trend in the Sahel, the Mediterranean basin, including Turkey, and at South Asia (IPCC, 2013; Türkeş, 2012a, and 2012b, 2013b). Moreover, there have been significant increases in the heavy rainfall cases (extreme high and extremely low rainfall, etc.) and average air temperatures in many parts of the world and in Turkey (IPCC, 2013; Turkes, 2013c and 2014).

Figure 5: According to linear trend calculations, areal distribution patterns of rainfall changes were observed in (a) 1901 - 2010 and (b) 1951 - 2010 periods (IPCC, 2013).



3.1. Changes in the Global Climate

According to the Intergovernmental Panel on Climate Change (IPCC, 2013), global climate warming is decisive, and most of the changes observed in the climate since the 1950s were never before seen until the last millennium. Each decade of the past 30 years has been warmer than any decade of global surface temperatures recorded on Earth since 1850. According to calculations including updated surface temperature observations up to 2020, the human-induced global warming value reached approximately 1.15 °C (2). During this period, almost the entire surface of the Earth and the lowest layer of the atmosphere, the troposphere, and oceans, have warmed globally since the mid-20th century, the amount of snow and ice has decreased, the average sea level has increased, and the accumulation of greenhouse gases in the atmosphere has increased.

As expected, the warming in the global oceans controls the increase in energy accumulated in the climate system. In this context, more than 90% of the energy accumulated in the oceans during 1971-2010 is related to the warming in the oceans. In addition, regions of high salinity where evaporation occurs more than precipitation are saltier, while regions of low salinity where precipitation is greater than evaporation have been less salty since the 1950s. These regional trends in ocean salinity provide indirect evidence that evaporation and precipitation over the oceans are changing.

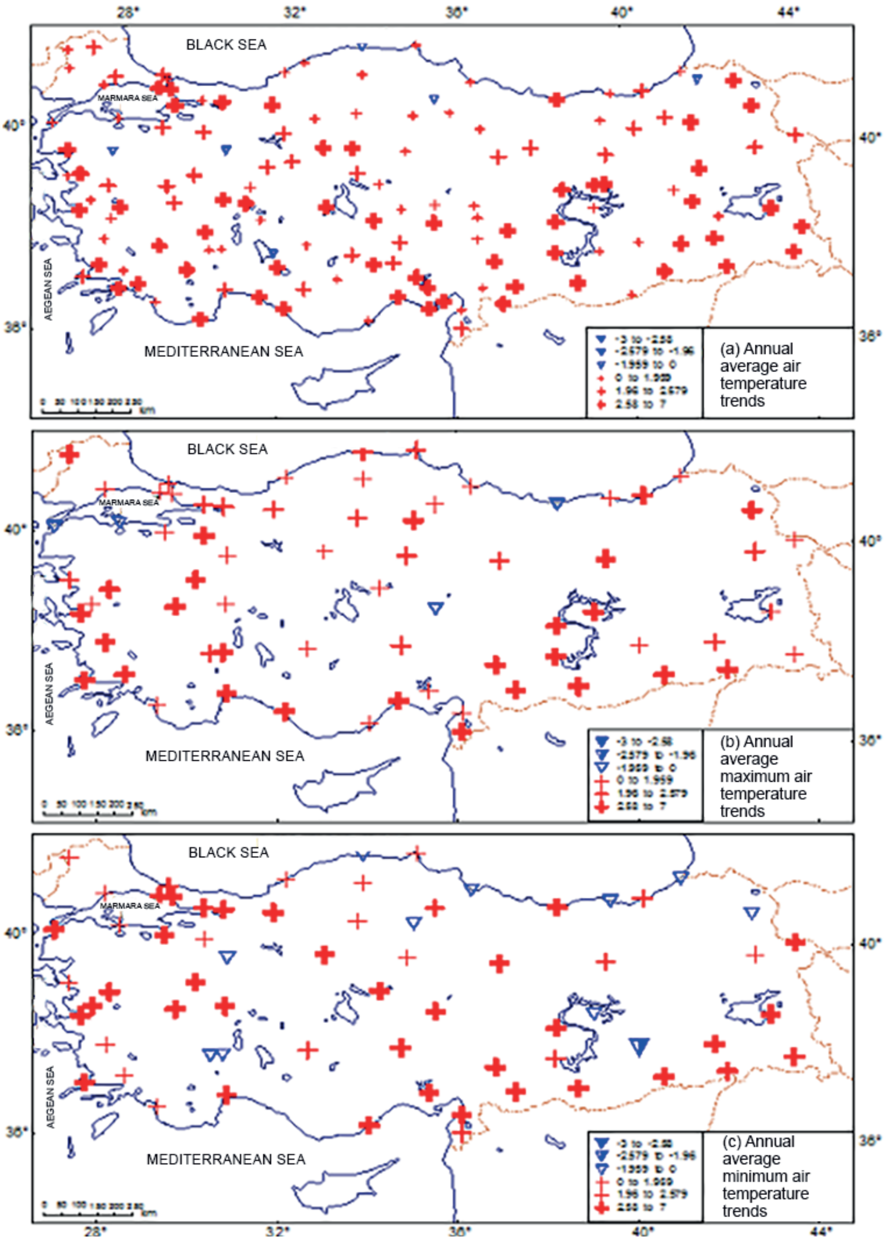
Greenland and Antarctic ice shields have lost mass in the past 20 years, mountain valleys and skullcap glaciers are shrinking almost globally, Arctic sea ice and Northern Hemisphere spring snow cover continue to decrease areally. The rate of sea-level rise observed since the mid-19th century is greater than the average rate of rising over the previous two thousand years. The global mean sea level increased 19 cm (0.19 [0.17- 0.21] m) in the period 1901 to 2010 (IPCC, 2013).

In the Northern Hemisphere lands, precipitation has increased since 1901. In the subtropical and some tropical regions covering the Mediterranean Basin and the western and southern regions of Turkey where the Mediterranean climate is prevailing, the significant decrease in the amount of precipitation was observed in the same period (Figure 5). Changes have been observed in much extreme weather and climate events since 1950. With high probability, the number of cold days and nights has decreased and the number of hot days and nights has increased on a global scale. The frequency of heatwaves likely increased in large areas of Europe, Asia, and Australia. The land regions, where the number of heavy rainfall events increases, are likely more than the land where the heavy rainfall decreases. The frequency or severity of heavy rainfall events likely increased in North America and Europe.

3.2. Changes in Turkey's Climate

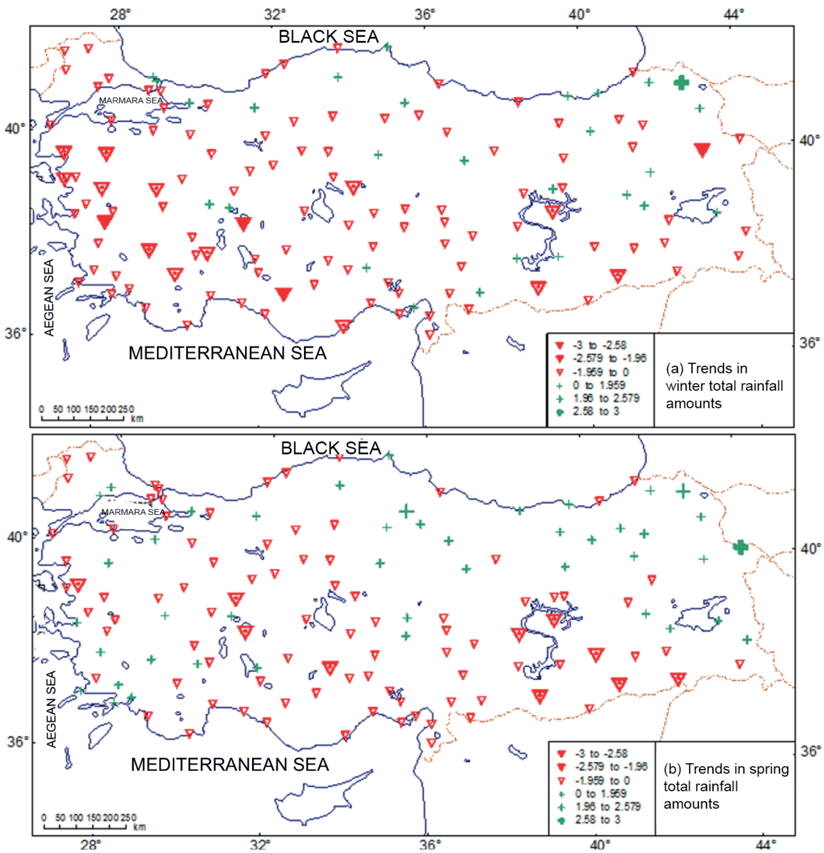
In this section, long-term trends and changes in rainfall and temperature series in Turkey were examined using the data of monthly average, monthly average maximum (highest), and monthly average minimum (lowest) air temperature data (°C) recorded in the climatology and meteorology stations of General Directorate of Meteorology (MGM) in the period 1950-2010 as stated by Turkes (2013b) and the results of statistical and climatological time series analysis of monthly total precipitation (mm). In order to determine trends in station data, the Mann-Kendall (M-K) order correlation coefficient method was applied to long time series (Sneyers, 1990; Turkes et al., 2002). Considering the conditions and rules such as the homogeneity and continuity of the data, the monthly missing data not exceeding 5% of the total data at that station, etc. (Turkes, 1996, 1998, 1999), the data of 138 stations were used for statistical analysis and significance testing of monthly average air temperature and total precipitation trends.

Figure 6: According to the MK rank correlation coefficient significance test, average annual Turkey (a) the average annual maximum (b) and average annual minimum (c) The spatial distribution pattern of long-term trends in air temperature (Turkes, 2016). Inverted triangle icons indicate downward trends in air temperature strings, while crosshairs indicate upward trends in strings. The larger triangular symbols with dotted and filled (relatively thick and thicker crosshairs) show the 5% and 1% significance level decreases (increase) trends in the sequences, respectively, compared to the legend containing the map symbols corresponding to the M-K u(t) test sample values.



To determine the trends in the average maximum and average minimum air temperature series, the longest time series of temperature observations with 70 stations heterogeneity and randomness detailed analysis in Turkey, determined by Türkeş et al., (2002) was used. Although all data were analyzed for seasonal and annual series, annual and seasonal M-K results were given for rainfall totals, and only annual MK results were given for average, average maximum, and average minimum air temperatures.

Figure 7: According to the M-K sequence correlation coefficient significance test, Turkey's winter (a) and spring seasons spatial distribution pattern of long-term trends in total precipitation amount (Tur-kes, 2016). Inverted triangular symbols indicate decreases or drier streams in total rainfall strings, while plus symbols show trends in total rainfall strings to increase or to become wetter (humid). The larger triangular symbols with dotted and filled (relatively thick and thicker crosshairs) show the 5% and 1% significance level decreases (increase) trends in the sequences, respectively, compared to the legend containing the map symbols corresponding to the MK u(t) test sample values.



3.2.1. Changes and Trends in Air Temperature

As determined at annual average, annual average maximum, and annual average minimum air temperatures and seasonal air temperatures (not all seasonal analysis results are provided here) and according to the results of temperature trend studies conducted for Turkey the warming has become stronger (Figure 6a, 6b, and 6c). Except for a few stations characterized by a randomly distributed decline in annual average, annual average maximum, and annual average minimum air temperatures, most stations show a distinct warming trend. The observed warming trend is statistically significant at most stations. Weak warming and cooling tendencies are generally distributed in the Black Sea Region and the northern parts of Central and Eastern Anatolia regions. Statistically, significant warming signals show a very distinct spatial consistency pattern. All these results, as well as others, suggest that global warming, which is one of the most obvious and relatively easy to determine the result of human-induced global climate change, is effective in Turkey.

3.2.2. Changes and Trends in Precipitations

Seasonal and annual rainfall trends observed in Turkey (Figure 7), are not as strong as trends observed in air temperature. As in many regions of the world, changes in precipitation are in the form of significant changes determined in the frequency and magnitude of dry and humid (precipitation) periods, together with various changes and fluctuations, rather than long-term trends (Tatlı and Türkeş, 2008 and 2011; Trenberth et al., 2007; Trigo et al., 2006; Türkeş, 1996, 1998, 2011, 2013b; Türkeş and Erlat, 2003, 2005; Türkeş and Tatlı, 2009; Türkeş et al., 2009a and 2009b, etc.). The spatial variability of precipitation changes is also strong. Aegean, Marmara, Interior, and Southeast Anatolia regions are affected by these desertification trends mentioned.

Taking into account the annual changes in precipitation especially during winter into account, the most severe and widespread drought events in Turkey occurred in 1971-1974, 1983-1984, 1989-1990 and 2007-2008, with the 2013-2014 and 2019-2020 periods and 996 and 2001 peri-ods (Tatlı and Türkeş, 2008; Türkeş, 1996, 1998, 1999, 2008b, 2014ab, 2020, 2021; Türkeş and Erlat, 2003 and 2005; Türkeş and Tatlı, 2009; Türkeş et al., 2009a and 2009b, etc.). Following the 2007-2008 drought which caused effective and severe water gap and deficiency in most parts of Turkey, in the 2009-2011 period, more rainy conditions than the long term aver-age or normal rains were effective (rainy or wet circuit). Later, in the 2013-2014 and 2019-2020 periods, conditions with less precipitation than normal precipitation (drought or dry period) dominated (Türkeş, 2014a, 2014b, 2021). For example, 2013-2014 and 2019-2020 droughts have transformed from a meteorological drought into agricultural and hydrological droughts in many regions and regions considering the standardized precipitation index (SPI) distribution patterns calculated for 6 months and longer time scales (Türkeş and Yıldız, 2014; Türkeş, 2014a, 2014b, 2021).

When the long-term trends and changes in Turkey's precipitation are examined, generally in the winter and spring precipitation totals, a significant decrease trend (desertification) occurred in the Marmara, Aegean, Mediterranean, and South East Anatolia Regions, where the Mediterranean precipitation regime is dominant and in the inner and southern parts of Central and Eastern Anatolia (Figures 7a and 7b). Some of the drier trends observed in the Aegean, Mediterranean, and Southeastern Anatolia regions during the winter season are statistically significant (Figure 7a). These results are generally consistent with studies on rainfall trends and changes previously made on Turkey (Turkes 2014b).

In the literature, similar to the results of previous studies, both upward and downward trends prevail, few of which are statistically significant. In autumn, apart from previous studies, it is seen that the previous upward trends are getting stronger and the number of stations showing an upward trend has increased. In the fall, an increase in precipitation is dominant, covering an area outside the southeast corner of Turkey. In consideration of the total annual rainfall in Turkey, mainly as a reflection of trends and anticipated changes in winter and autumn rainfall, a decreasing trend is seen in the western and southern regions of Turkey where Mediterranean precipita-tion prevails.

In addition, new findings from long-term climatological and meteorological observations have shown that since the 1950s, significant changes occurred in the frequency and length of some extremes particularly prone to extreme daily temperatures (e.g. highest and lowest temperatures, tropical and summer days, etc.), frost days, and heatwaves. Such changes generally have been in the form of the significant decrease in the frost and snowy days in the Eastern Mediterrane-an and Turkey with the 1990s; increase in the number of hot days and nights and the lowest and highest daytime air temperatures, a significant part of which is statistically significant; and a de-crease in the difference between the highest daytime and the lowest temperature difference at night (Erlat and Türkeş, 2008, 2012 and 2013; Türkeş et al., 2002; Türkeş and Sümer, 2004; Kartum et al., 2011; etc.). In other words, in about the last 30 years, both the temperature regime changed significantly towards warmer (tropical) conditions in Turkey, and also significant changes occurred in the strength and the frequency of heat waves (Turkes, 2008b, 2012A, 2013b).

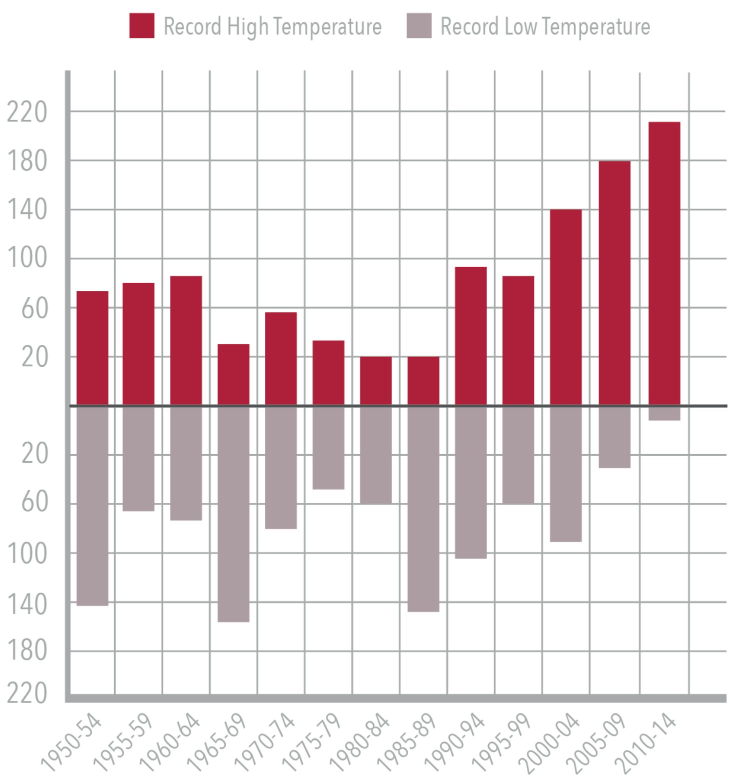
3.3. Changes and Trends Observed in Extreme Weather and Climate Events

Although extreme weather and climate events do not occur frequently, they have great effects on economic conditions and human health, especially in sectors such as agriculture and food security. The increasing population, which is predominantly concentrated in cities and coasts, and infrastructure facilities that have become more complex, increase the potential of societies to be adversely affected by extreme weather/climate events compared to the past (Türkeş & Erlat, 2018).

When the changes in the number of summers (≥ 25 °C) days and tropical days (≥ 30 °C) are examined in Turkey in the 1950- 2010 period, it is observed that there are spatial and temporal differences. The number of summer and tropical days showed a slight decrease in the 1950-1975 period, and there is a significant increase in the values after 1975. The most remarkable year in terms of the number of summer and tropical days in Turkey is 2010. This year, in almost half of the stations examined in Turkey, including the North East Anatolian region, the number of summer and tropical days increased above 3 standards deviations over 1961 - 1990 average.

Another climate change indicator on the subject is a climate index called 'tropical night'. The tropical night is defined as the night when the lowest (minimum) air temperatures (Tmin) at night observed at 2 meters are greater than 20 °C and examined through a simple index which is defined as the number of days with daily Tmin higher than 20 °C. According to a new study examining, the changes and trends observed in the annual number of tropical nights in 1950- 2016 period in 92 climatological and meteorological stations in Turkey (Erlat and Turkes, 2017), tropical nights show a statistically significant increasing trend in the majority of stations (in the 92's, 87).

Figure 8: Change of the annual number of record maximum and record minimum air temperature events observed in 81 stations in Turkey by pendants in 1950 - 2014 period (Turkes and Erlat, 2018).



When the temporal changes in the annual number of record maximum and minimum air temperatures recorded in the 1950 - 2014 period in Turkey are examined, it could be seen that record mini-mum air temperature frequency decreased from the 1950s up to date (Turkes and Erlat, 2018). On the other hand, there is an increasing trend in the record maximum air temperature frequency, especially in the 2000s, and half of the record maximum temperature events since 1950 were recorded in the 2000-2014 period (Figure 8). In the 81 stations used in the study, the highest temperature values were recorded in 2000 and the lowest temperatures in 1950.

4. GLOBAL AND REGIONAL CLIMATE CHANGE FORECASTS

According to IPCC (2013), ongoing emissions of greenhouse gases will cause further warming and changes in all components of the climate system, particularly evaporation and precipitation. Limiting climate change will require significant and sustained reductions in greenhouse gas emissions. Projected climate change based on the new scenarios in IPCC 2013 (Representative Concentration Pathway - RCP) is similar to the previous IPCC Report (2007) in both patterns and size, after taking into account scenario differences.

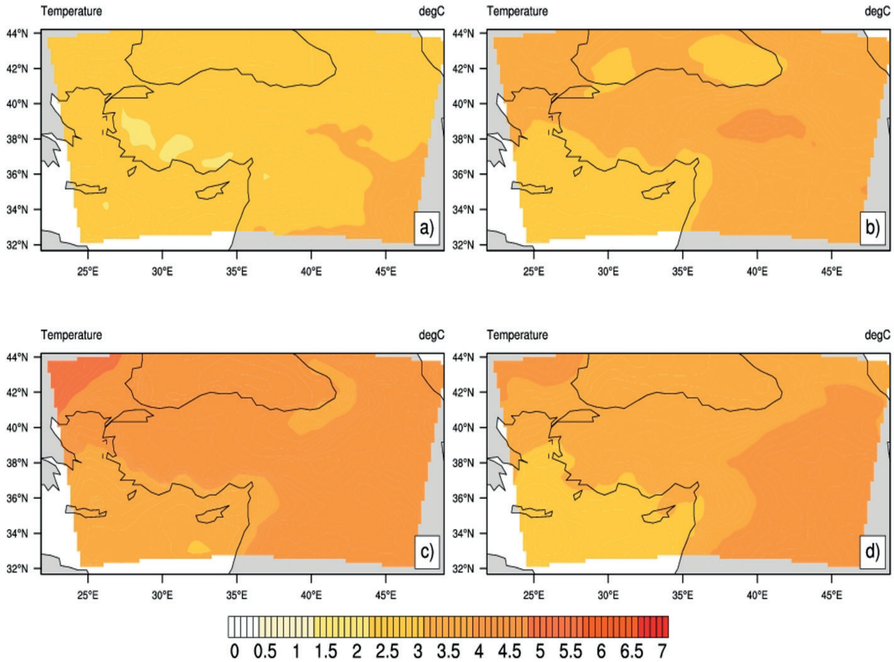
The global surface temperature change will likely rise by the end of the 21st century, based on all-new IPCC scenarios (RCPs) except one (RCP2.6), by 1,5 °C relatives to the period 1850-1900 and according to two new scenarios (RCP6.0 and RCP8). 5), it will likely exceed 2 °C. Global warming will continue after 2100. Warming and precipitation variations will continue to exhibit variations ranging from inter-year variability to ten-year variability and will not be regionally homogeneous. The oceans will continue to warm throughout the 21st century. The heat energy accumulated at the surface will pass into the deep ocean and affect ocean circulation. Arctic sea ice cover is likely to continue to decline and become thinner, and Northern Hemisphere spring snow cover will decrease over the course of the 21st century as the global mean surface temperature rises. The global average sea level will continue to rise throughout the 21st century. All IPCC scenarios show that the rate of sea-level rise will most likely exceed the rise observed during 1971-2010 due to increased ocean warming and increased mass loss from glaciers/ice shields.

Studies regarding the climate change and variability observed in Turkey and the area sur-rounding it (the Eastern Mediterranean Basin generally comprising the Balkans and Middle East Region) and estimates and projections of global and regional climate models demonstrate that there are important climatic changes in Turkey and

Turkey will be negatively affected from cli-mate changes along with many countries in the Mediterranean basin(IPCC, 2007, 2013; Trigo et al., 2006; Turkes, 1996, 1998, 1999, 2008b, 2012 and 2012b, 2013b and 2014; Turkes and Sumer, 2004; Turkes and Tatlı, 2009; Türkeş et al., ., 2002; Türkeş et al., ., 2009a and 2009b; Türkeş et al., 2011; Turp et al., ., 2014; Öztürk et al., ., 2015, etc.). For all these reasons, to reduce or at least prevent the effects of climate change is vitally important for projecting the future climate of Turkey in terms of adaptation. Tatlı and Türkeş (2008, 2011), Önol and Semazzi (2009), Altınsoy et al., (2012), Önol and Unal (2014); Öztürk et al., (2012, 2013, 2015), Turp et al., (2014), Turkes et al., (2011, 2020) and Sen et al., (2012) could be given as examples of regional climate model studies towards demonstrating Turkey's future climate and climate variability.

According to hadgem2 RCP4.5 climate models and emission scenarios, the air temperatures in summer seasons are expected to increase between 4-6.5 °C in Turkey between the years 2070-2100 compared to the climatology of 1970-2000. While the increases in average air temperatures are around 3.5 °C for the winter season, these increases go up to 4-4.5 °C in the spring and autumn seasons. According to the HadGEM2 climate model and RCP8.5 emission scenario (not shaped), the estimated air temperatures between 2070-2100 in the summer season are expected to increase between 5.5-7 °C compared to the 1970-2000 climatology. It is seen that the increase in average air temperatures for the winter season is around 4.5 °C, and for the spring and autumn seasons, it is between 5-7 °C, increasing towards the east.

Figure 9: The patterns of geographical distribution over Turkey and its close vicinity of the changes in average air temperatures estimated for (a) winter, (b) spring, (c) summer and (d) autumn sea-sons in 2070 - 2100 period using the outputs of the global climate model HadGEM2 RCP4.5 emission scenario, according to the 1970- 2000 reference period climatology of RegCM, (Ozturk et al., 2014).



When the total rainfall estimates are examined, in the simulation using the HadGEM2 climate model and RCP4.5 emission scenario, it is expected that for Turkey and for years 2070-2100, it is expected that there will be a decrease (negative deviation) in the precipitation in the winter season by 2 mm/day on the south of the country, and an increase by 1.6 mm/day on the north east (positive deviation) compared to 1970-2000 period. On the other hand, it is seen that precipitation will change a little negatively in the summer season, and the trend in winter will be weaker in spring and autumn (not shaped).

5. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Today, it is widely accepted that climate change is one of the most important, real, oppressive, progressive global problems that create significant negative effects on all socioeconomic and ecological systems and living life. On the other hand, there are still important discussions on such issues as how much the climate will change, the spatial and temporal dimensions of change, which effects will occur, how and to what extent it will affect which sectors, how best to adapt to climate change, or more importantly, what is the best way to combat the anthropogenic causes of deforestation and land-use changes, including rising greenhouse gas emissions caused by the burning of fossil fuels primarily. Nonetheless, a large number of politicians and decision-makers are increasingly aware that the impacts of climate change are enormous and the cost of delaying, doing nothing, or ignoring climate change is much higher than the cost of doing something serious.

The United Nations Framework Convention on Climate Change (UNFCCC) is the most important intergovernmental effort that can reduce human-induced greenhouse gas emissions (SGS) at the global level (Turkes, 1995). UNFCCC regulates general principles, action strategies, and obligations to protect the global climate and reduce greenhouse gas emissions. The main obligation of developed countries under the UNFCCC was to keep human-induced greenhouse gas emissions at 1990 levels until 2000. The ultimate goal of the UNFCCC is to achieve a level that prevents the accumulation of greenhouse gases in the atmosphere at a level that prevents the dangerous effects of humans on the climate system " (Turkes, 2001).

Greenhouse gases in the atmosphere and their emissions to the atmosphere are both natural and human-originated and are radiative-active gas formations that absorb and re-emit infrared radiation (Turkes, 2010). According to the UNFCCC, each Party will adopt national policies and take appropriate measures to reduce climate change by limiting human-induced greenhouse gas emissions and protecting greenhouse gas sinks and reservoirs. In line with the purpose of the convention, it will show that developed countries will play a leading role in changing the long-term trends of anthropogenic emissions, and the reduction of anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol will contribute to this change (Turkes, 2001).

6. SHORT DISCUSSION

Climate Change is one of the most discussed global change issues, on which many scientific researches are conducted and discussions at intergovernmental levels are held today. Human activities such as burning fossil fuels, deforestation, and land-use changes, urbanization, industrial processes have caused the accumulation of greenhouse gases such as CO_2, CH_4, N_2O, CFCs, HFCs, PFCs in the atmosphere to increase rapidly since the industrial revolution. This changes the energy balance of the Earth-Atmosphere system (global climate change) and causes the earth and the layer of the atmosphere close to the earth to become more warmed (global warming).

Projected climate changes have both positive and negative impacts on water resources, agri-culture, natural ecosystems, and human health. As the changes in climate grow, so do the negative effects. Socioeconomic sectors (e.g. agriculture, forestry, fisheries, water resources, and human settlements, etc.), land and water ecosystems, human health which is very vital for the development and wealth of mankind, are highly sensitive against the size and rates of climate change as well as weather and climate extremities and disasters and climate variability.

Many features and effects of global climate change can last for centuries even if CO_2 and other greenhouse gas emissions are stopped. In addition, this phenomenon indicates that an important climate change obligation (e.g. UNFCCC, Kyoto Protocol, and Paris Agreement) will continue to exist for centuries caused by past, present, and future emissions of anthropogenic greenhouse gases.

Findings obtained from new climate model simulation studies (e.g. Ozturk et al.,, 2015; Rad-ish et al., 2014; Turkes et al., 2020) demonstrate that Turkey will be more affected from climate change due to generally increasing air temperatures and decreasing precipitation amounts. Except the Mediterranean coastal zone and Taurus mountains, the south and central-south regions of Turkey, which already have less precipitation and are hotter and drier under current climate conditions (with summer drought that is effective from the end of spring to the mid of autumn), will have a climate that will have high precipitation variability on seasonal and over-year basis and therefore with a high possibility of drought. All these results also show that Turkey will have high exposure to human-oriented climate change in the future as well as its possible consequences.

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GREENHOUSE GASES IN THE ATMOSPHERE, STRENGTHENED GREENHOUSE EFFECT AND GLOBAL WARMING

Prof. Dr. Murat Türkeş

The increase in anthropogenic greenhouse gas accumulations in the atmosphere has been continuing since the industrial revolution. In order to understand the causes of natural and human-induced (anthropogenic) climate change in the most general sense, it is necessary among other factors to know the working principles and mechanisms of the radiation-efficient and atmospheric accumulations (concentration) of the variable greenhouse gases and the greenhouse effect, which are necessary for the warming of the Earth-atmosphere system and reaching a living temperature. This basic knowledge is also vital in terms of combating and mitigating the human impact, human-induced climate change, and human-induced climate change that have led to the change of the global climate system after the industrial revolution, especially since the last quarter of the 20th century.

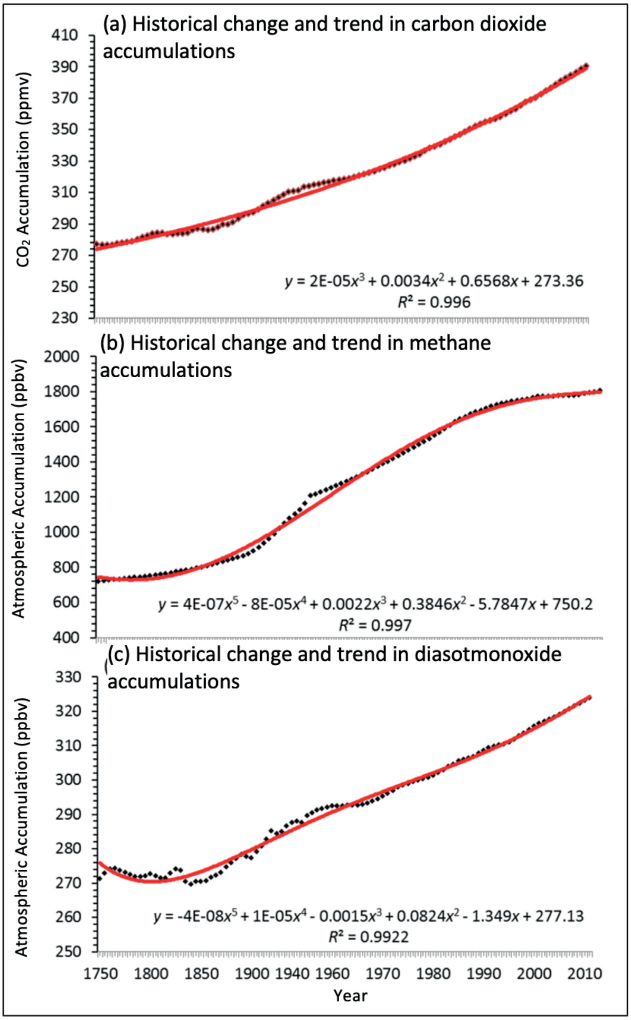
This booklet has been prepared by directly using the relevant chapters of two textbooks (Türkeş, 2010, 2017) in which climatology and meteorology are comprehensively discussed.

1. VARIABLE GASES AND AEROSOLS IN THE ATMOSPHERE

Air consists of many gases and particles whose accumulation in the atmosphere varies significantly from time to time and from place to place, more clearly speaking, particles that can hang in the air (volatile). Carbon dioxide (CO_2), water vapor (H_2O), diazotmonoxide (N_2O), methane (CH_4), various suspended particles and ozone (O_3) are important examples of variable gases and aerosols. Although the rate of accumulation of these gases in the atmosphere is small, their effects on air and climate are very important.

In order to make a comparison between the amounts in the atmosphere of important greenhouse gases such as CO_2, N_2O, and CH_4, whose accumulation in the atmosphere is variable and affected by human activities, the changes of these greenhouse gases from pre-industrial times to the present are given in Figure 1. CO_2, CH_4 and N_2O have both natural and anthropogenic resources. Although not provided here, for example, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), chlorofluorocarbons (CFCs) and their various derivatives have been produced by industrial processes (human origin) and released into the atmosphere since the 20th century.

Figure 1: Long-term changes observed in the annual average accumulations of (a) CO_2, (b) CH4 and (c) N_2O gases in the atmosphere from pre-industrial until today and long-term trends according to 3rd and 5th order polynomial regression curves (Türkeş, 2010, 2017).



The biggest greenhouse effect is water vapor together with CO_2. However, the accumulation of water vapor in the troposphere, which is evaluated on a global scale and by the internal processes of the climate system, is not affected by anthropogenic sources and sinks. Today, it is believed that global warming will increase the accumulation of water vapor in the atmosphere, and the increased accumulation of water vapor will strengthen the natural greenhouse effect and increase global warming for a relatively long time. Therefore, water vapor and its changes are included in climate models as important atmospheric inputs. Ozone accumulation changes both in the stratosphere and in the troposphere as a result of various human activities. A thousand years before the industrial revolution, the amounts of greenhouse gases in the atmosphere remained relatively stable. However, in parallel with the rapid increase in the world population, rapid industrialization, increases in energy production based on fossil fuels and agricultural developments, greenhouse gas accumulations in the atmosphere increased significantly (Figure 1). As a result, it is well known that the concentrations of greenhouse gases in the atmosphere have changed naturally during the ice ages and have increased since the industrial revolution as a result of human activities (see Figure 6).

Table 1: Chemical composition and gas accumulations of air (dry air) without water vapor (updated according to Türkeş 2017).

Gas (atoms and molecules)	Accumulation	Hacim (%)
Dry air	1,000,000.0	100.0
Nitrogen (N_2)	780,790.0	78,079
Oxygen (O_2)	209,450.0	20,945
Argon (Ar)	9,339.0	0,934
Carbon dioxide (CO_2) (in 2019)	413.0	0.0413
Neon (Ne)	18.2	0.001818
Helium (He)	5.2	0.000524
Methane (CH_4)	1.8	0.000179
Krypton (Kr)	1.1	0.000114
Hydrogen (H_2)	0.55	0.000055
Diazotmonoxide (N_2O)	0.33	0.000033

(*) Taken together, the accumulation of gases in the atmosphere is shown as parts per million (ppmv) volume, in other words, units per million. Here, the quantitative value of the gas is explained based on a dry air sample of 1 million members. For example, the accumulation of CO_2 at 413 ppmv (ppm for short) indicates that this greenhouse gas has an accumulation of 413 molecules in a volume of dry air containing one million gas molecules. 413 ppm can be represented as 0.0413% in percent.

1.1. Water vapor

The amount of water vapor (H_2O) in the air varies considerably. However, its accumulation does not exceed about 4% by volume. So why is such a small ratio of gas so important? The absolute truth is that water vapor is the source of all condensation products (fog, clouds, rainfall, etc.). Water vapor also has other functions. Water vapor has the ability to absorb some of the solar energy such as CO_2 and the long wavelength radiation (heat energy) emitted by the Earth. Therefore, water vapor is a radially efficient greenhouse gas like CO_2 and its role in understanding the warming process of the atmosphere is very important. When water moves from one state or phase (phase) to the other (for example, liquid water to water vapor or ice), it absorbs or releases heat. This energy is called latent heat. Depending on the type of phase (state) change, for example, the heat received during evaporation is called the vaporization latent heat, and the released during condensation is called the latent heat of condensation.

As we will see later in the book, the water vapor in the atmosphere carries latent heat from one area to another. Transport of latent heat is thunderstorms, super cell storms or tornadoes, and tropical cyclones, etc. It is the main source of energy that helps in severe weather events and storms.

Table 2: Sources and sinks of major greenhouse gases and volatile particles in the atmosphere (Türkeş, 2017)

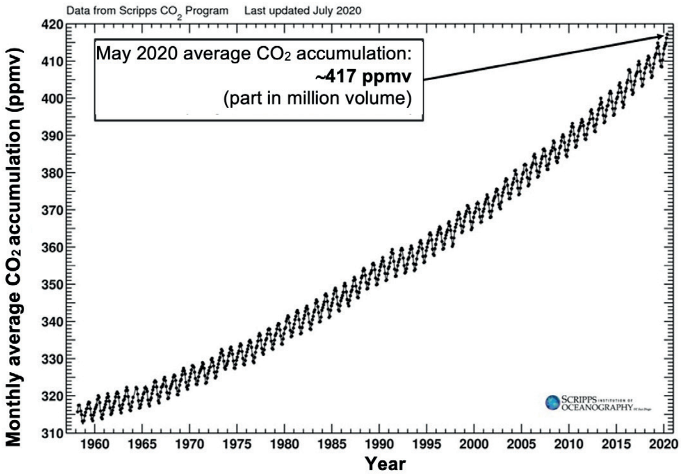
Substance	Resource	Sink
H_2O	Evaporation from large water surfaces (ocean, sea, lakes and swamps, dams, etc.) airplane traces (air traffic, combustion, cooling towers, etc.	Cloud droplets, precipitation, snow-ice cover and glaciers
CO_2	Burning of fossil fuels (oil, coal, natural gas, etc.), deforestation, biomass burning, cement production, plant respiration, organic matter decomposition, biological and physiochemical processes in oceans etc.	Resention at the ocean and land biosphere basically through photosynthesis

Substance	Resource	Sink
CH_4	Paddy fields, natural wetlands, ruminant livestock, biomass burning, fossil fuel production (mining, gas well drilling, mine-gallery ventilation, conveying, transportation, etc.), termites, animal and household waste, etc.	Reaction with hydroxyl radicals in the atmosphere
N_2O	Biological resources in water and soil, using fertilizers biomass burning, industrial sources, etc.	Photochemical degradation in the atmosphere
CFCs and halons	Industrial resources: sprayers, coolants, foaming tools, solvents, fire extinguishers and extinguishers, etc.	Photochemical deterioration in the stratosphere
Aerosols	Fossil fuel combustion, soot, biomass combustion, volcano activity, powder, sea salt, herbs, etc.	Washing with rain

1.2. Carbon dioxide

The most important greenhouse gas that is directly affected by human activities is carbon dioxide. Another feature of CO_2 is that it is present everywhere in the Earth system. On the other hand, carbon dioxide should not be regarded as a passive element of the Earth's system, but as an integral part of the evolution of the carbon cycle, which includes the oceans and atmosphere as well as the reverse biosphere. Carbon dioxide is mainly produced by fossil fuel combustion, industrial processes, plant respiration and organic matter decomposition in the biosphere, and physicochemical processes in the oceans (sources), and is consumed by photosynthesis in the biosphere and physicochemical processes in the oceans (sinks) (Table 2; Figure 3).

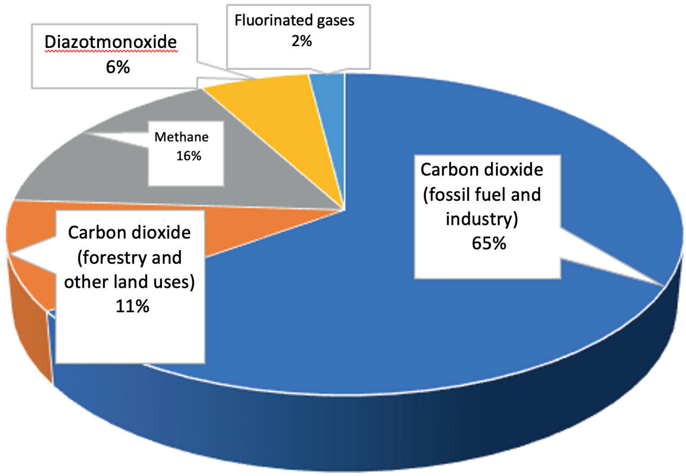
Figure 2: Atmosferdeki CO_2 birikiminin 1958-2020 yılları arasındaki aylık değişimleri ve uzun süreli eğilimi [1].



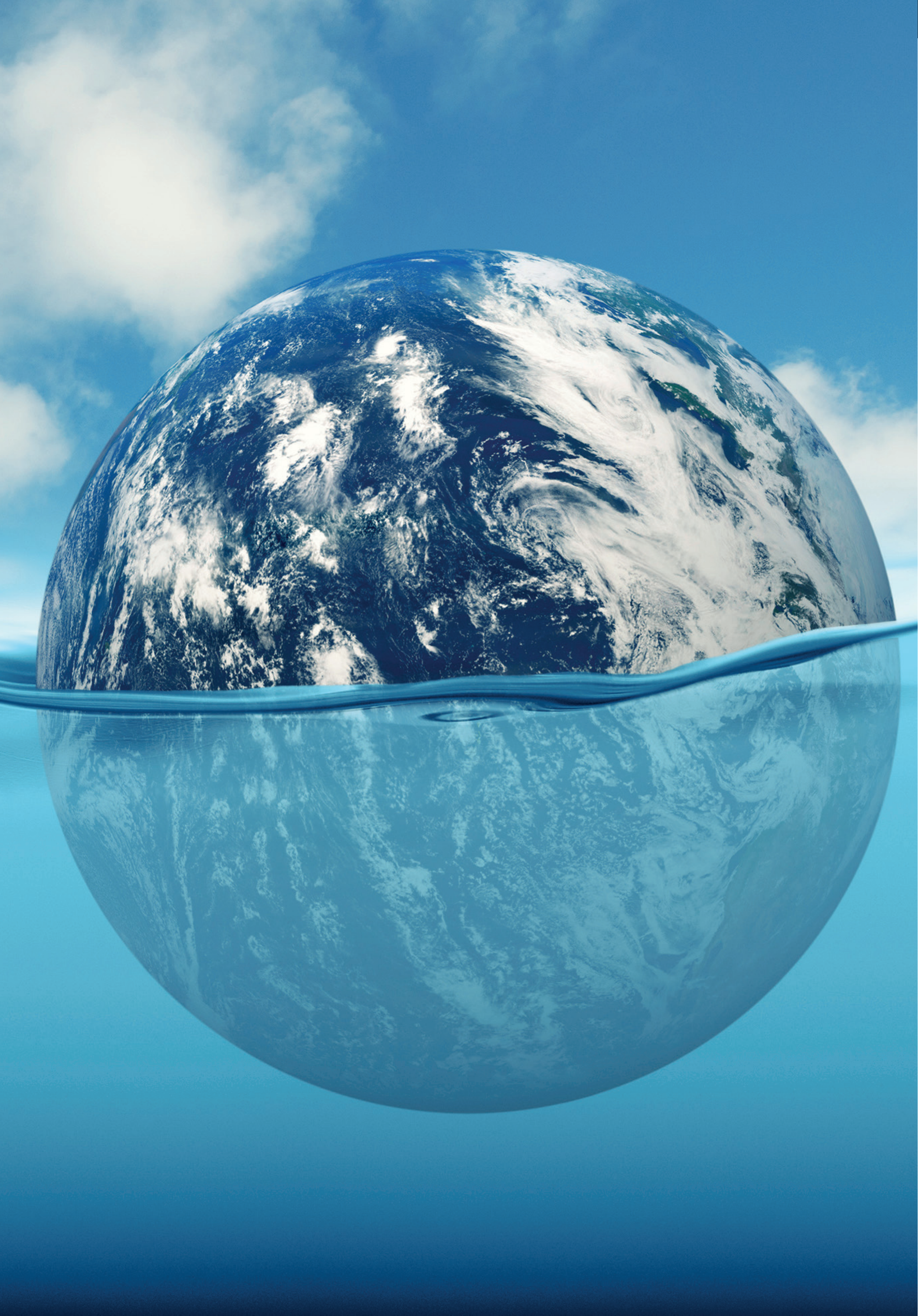
Although its accumulation in the atmosphere is very small, CO_2 (Table 1) is a very important and remarkable gas for climate and atmospheric scientists as it effectively absorbs (absorbs) the long-wavelength energy emitted by the Earth and therefore warms the atmosphere. The importance of CO_2 is better understood, especially when considering the size of its accumulation in the atmosphere, its rate of increase, its life span ranging from 50-200 years, and its ability to absorb most of the outgoing long-wavelength (GUDB) infrared ground radiation. In reality, although the proportion of CO_2 in the atmosphere is not very variable (its distribution is quite homogeneous), it has been steadily increasing for about 250 years since the industrial revolution (generally accepted starting the year 1760, period 1760-1840) (Figure 1a).

Current instrument CO_2 measurements, which have been carried out since 1958 at the Mauna Loa Observatory on the Mauna Loa volcano on the great island of Hawaii, show that the accumulation of CO_2 in the Earth's atmosphere is rapidly increasing. When the monthly average CO_2 time series measured at Mauna Loa were examined, the annual average CO_2 accumulation in the atmosphere, which was approximately 280 ppmv (one molecule in a million volume or parts per million) before the industry and about 315 ppmv in 1958, reached 414 ppmv in 2020 (Figure 2). The current level of CO_2 accumulation in the atmosphere is well above the natural CO_2 accumulation changes (varying between about 180-300 ppmv) in the past 700,000 years. This increase in CO_2 is mainly explained by the ever-increasing burning of fossil fuels (oil, coal, natural gas, etc.) and industrial processes, as well as large-scale land-use changes and deforestation (Figure 2). Carbon dioxide alone is responsible for 76% of global human-induced greenhouse gas emissions.

Figure 3: Share of 2018 greenhouse gas emissions by gas (%) (IPCC, 2014).



Much of this additional CO_2 is absorbed in ocean waters or used by plants during photosynthesis. Still, about half of human-induced CO_2 emissions remain in the atmosphere. These increases in greenhouse gas accumulations weaken the Earth's cooling efficiency by GUDB infrared radiation, resulting in a positive radiative forcing that tends to further heat it. Therefore, the positive contribution made to the energy balance of the Earth/atmosphere common system is called the strengthening greenhouse effect (Türkeş, 2010, 2017). This means that the natural greenhouse effect, which has been operating for hundreds of millions of years, is strengthened by the natural greenhouse gases (water vapor, CO_2, CH_4, N_2O and O_3) in the Earth's atmosphere.



According to global calculations, the global carbon balance is no longer off equally due to the anthropogenic greenhouse gases released into the atmosphere (Figure 4). In addition to the normal fluxes of the global carbon cycle, a total of about 7,5 Mt of carbon (C) is released into the atmosphere each year, with about 1,5 Mt of net vegetation degradation and about 6,0 Mt from fossil fuel combustion, mostly through land-use changes and deforestation. Terrestrial ecosystems (all land plants and soils, including forests) and oceans, which make up the two major components of the global carbon cycle, account for about 4.5 MtC of the total amount (Figure 4). When the amount of carbon removed by terrestrial ecosystems (biotopes or biomes) from the atmosphere by photosynthesis and oceans by phytoplankton is subtracted from the total amount of 7,5 MtC of anthropogenic origin released into the atmosphere, it is found that anthropogenic net 3,0 MtC each year remains in the atmosphere. Therefore, the focus of preventing human-induced climate change is the efforts to limit and/or reduce greenhouse gas emissions into the atmosphere, as well as removing approximately 3,0 MtC of excess carbon that remains in the atmosphere each year from the atmosphere through various sinks and accumulating in reservoirs.

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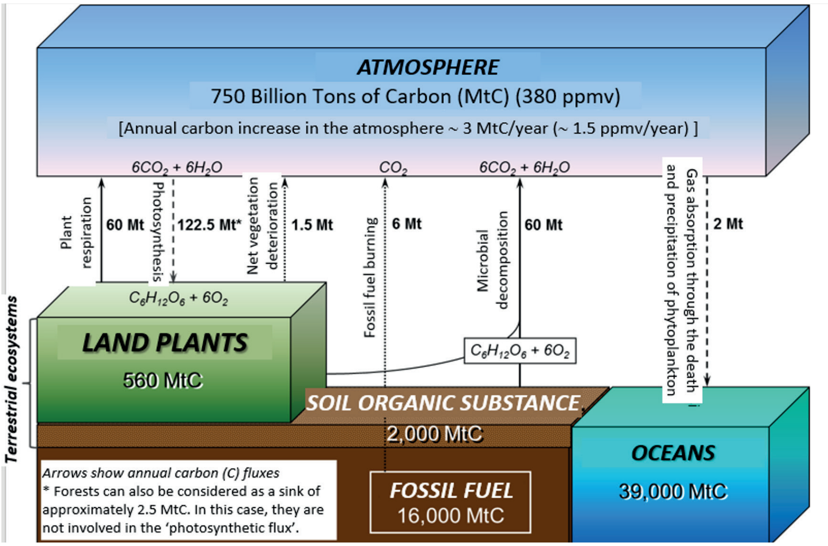
Figure 4: Annual global carbon cycle and human-induced greenhouse gas emissions changes in the global carbon balance in the 1990s (rearranged and drawn according to Ochsner 1998 and Türkeş 2010). Units are given in billion tons of carbon (MtC). Since 1 unit of C is equal to 3.7 units of CO_2, using this coefficient, C units can be converted into CO_2.



In this context, it is known that various sedimentary rocks of chemical and biochemical origins such as dolostone (dolomite) and limestone (limestone) and the carbonate cycle in waters play a regulatory role in the carbon cycle. Indeed, the oceans and rock cycle have served as an important sink for CO_2 throughout Earth's geological history. The uncertainties about the effects of carbon dioxide on biological resources and climate change in the form of deforestation and conversion of forest land to agricultural land are valid for industrial CO_2 sinks.

CO_2 projections (estimates) based on various greenhouse gas emission scenarios show that CO_2 levels from the early 20th century will nearly double in the second half of the 21st century. Most of the atmospheric and climate scientists are in agreement that the increasing CO_2 accumulation in the atmosphere, together with the increasing trends in other greenhouse gases, will trigger and accelerate global climate change by causing warming in the lower atmosphere (troposphere). This phenomenon is called the strengthening of the natural greenhouse effect and human-induced climate change.

Table 3: Stabilization of significant greenhouse gas accumulations in the atmosphere (IPCC, 1990)

Greenhouse gases	Required reduction (%)
CO_2	60<
CH_4	15 - 20
N_2O	70 - 80
CFC-11	70 - 75
CFC-12	75 - 85

Therefore, the number of anthropogenic greenhouse gases (GHG) in the atmosphere should be reduced in order to keep these gases at present levels of accumulation (stabilization) (Table 3). The term atmospheric stabilization is often used to mean stopping or limiting greenhouse gas accumulations to a certain level. Stopping each of these gases will have different effects on the climate system, and this is likely to happen in the future. As can be seen from Table 3, for example, in order to stop CO_2 accumulations at the 1990 level, either CO_2 emissions had to be reduced by more than 60% in the 1990s, or a 2% reduction had to be made every year after 1990.

In fact, none of these predictions and expectations have so far been realized under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, nor has it been reported in the Intergovernmental Panel on Climate Change (IPCC) Global Warming Special Report (IPCC ÖR1,5). °C, 2018) according to the Paris Agreement. IPCC ÖR1,5 °C emphasizes that it is still possible to limit the global warming level to 1,5 °C or to keep it below 2 °C, which is one of the goals of the Paris Agreement. However, in order to limit global warming to 1,5 °C, for example, human-induced CO_2 emissions must be reduced by 45% by 2030 compared to 2010, and net-zero emission by 2050. This means that CO_2 emissions from energy, industry, agriculture, housing and transportation will be reduced by 75-90% by 2050 compared to 2010.

When we look at the current global GHG emissions and the Nationally Determined Contributions (NDCs) or 'Declarations of Intent' submitted by the countries to the

UN under the Paris Agreement, it is clear that this level of global warming will not be achieved. In order to follow the 1,5 °C global warming path (or a 1,5 °C temperature increase), global GHG emissions, estimated to be around 52 Billion-Ton CO_2 equivalent/year ($MtCO_2e$/year) in 2016, should be limited to 25-30 $GtCO_2e$ in 2030. The unconditional 52-58 (or conditional 50-54) $GtCO_2e$ targets estimated according to NDCs are much higher than the '25 -30 $GtCO_2e$ limitation. In other words, it is possible to limit global warming to 1,5 °C neither until 2030 nor until the end of the century, with the current NDCs offered by countries under the Paris Agreement.

1.3. Methane

There are many natural and anthropogenic sources of methane (CH_4). Methane is released by degradation or decomposition under anaerobic conditions. Major sources of CH_4 are paddy cultivation, wetlands, wild and domestic animals (especially the stomach fermentation of antelope, buffalo and cattle), white ants, natural gas and coal mining, biomass combustion and landfills where urban garbage is collected.

Today (2011), the accumulation of methane in the atmosphere has reached 1803 ± 4 ppbv, exceeding 2,5 times its pre-industrial value (Figure 1b) and is increasing by approximately 1% each year. Part of this increase is attributed to the widespread use of livestock breeding, especially cattle breeding, and increases in paddy agriculture, as well as increases in anthropogenic resources such as natural gas leaks and landfills. Methane is removed from the atmosphere through chemical processes. The main sink is the reaction with the hydroxyl radical (OH). OH accumulation in the atmosphere is controlled by a complex series of photochemical reactions involving CH_4, carbon monoxide (CO), other non-methane hydrocarbons, nitrogen oxides (NOx) and tropospheric ozone (O_3). Therefore, in some studies, it has been stated that the sink effect in question may have decreased during the 20th century, due to the expected decrease in OH accumulation due to the increase of greenhouse gases in the atmosphere in general. The life span of methane in the atmosphere is predicted to be 11 years. This period is relatively short compared to the lifetime of other greenhouse gases. For example, it has been suggested that a 15-20% reduction in anthropogenic global emissions is urgently necessary to keep or stop methane emissions at 1990 levels.

Changes in methane emissions from natural sources can also be effective in changing climate. CH_4 production in tropical wetlands and paddy fields depends on soil moisture and therefore changes in evaporation and precipitation. However, the size and symptoms of these changes are not yet well known. Apart from this, the thawing of permafrost and semi-frozen soils in high northern latitudes can lead to the release of methane gas trapped in these lands. Should global warming occur, significant additional methane emissions can also be produced in this way? It is also difficult to estimate the size of this resource.

1.4. Diazotmonoxide

Diazotmonoxide (N_2O) is produced by various biological sources. Earth is the main resource; another important resource is the oceans. Making a quantitative assessment of emissions, particularly soil-borne emissions, is difficult due to the complexity of the process (e.g. N_2O can be both produced and degraded in soil) and the scarcity of observational data. However, about 90% of global N_2O emissions are predicted to come from the soil.

Today (2011), the accumulation of diazotmonoxide (N_2O) in the atmosphere is approximately 17% higher than in the pre-industrial period, with a global average value of 324 ± 1 ppbv (Figure 1c). The main processes thought to be responsible for the increase of N_2O in the atmosphere are the production of N_2O in the soil as a result of the application of nitrogen and ammonium fertilizers and, to a lesser extent, fossil fuel consumption and biomass burning.

The main atmospheric sink for diazotmonoxide is photochemical degradation in the atmosphere. The life span of this gas in the atmosphere is predicted to be 150 years. Since long-wavelength ground radiation is an effective absorber for some wavelength ranges and can stay in the atmosphere for a very long time, the potential contribution of N_2O to global warming is large. In order to keep the N_2O accumulation in the atmosphere at the level of 1990, it has been determined that a 70-80% reduction in N_2O emissions after 1990 is necessary.

1.5. Chlorofluorocarbons

Chlorofluorocarbons (CFCs), which reduce the ozone layer by causing ozone deterioration in the stratosphere, are also among the important greenhouse gases. The most important CFCs, all of which are of human origin, are CFC-11, CFC-12, CFC-113 and HCFC-22. Its main areas of use are tools and materials such as aerosol sprayers, foam extractors, coolants and solvents. CFCs have been widely used by mankind, as they are chemically inactive and stable, among other reasons. These properties of chlorofluorocarbons make them resistant to degradation once they are released into the atmosphere. The only major process that will drive CFCs out of the atmosphere is photochemical degradation in the stratosphere; however, this process is slow. CFC-11 and CFC-12 have a lifespan of 65 and 130 years, respectively. Other CFCs have similar or longer lifetimes as well.

The accumulation of CFCs and hydro-chlorofluorocarbons in the atmosphere increased rapidly in the 1960s when the use of these substances began to increase. Although the annual increase rate in CFCs was higher than the increase rates of other greenhouse gases until the 1990s, their accumulation in the atmosphere started to decrease after 1995 as a result of the global limitations of their use. The accumulation of these gases in the atmosphere continues their existence mostly with no significant change or a slight decrease in the 2000s.

As a result of the widespread acceptance of the harmful or destructive effect of chlorofluorocarbons on the ozone layer, the Vienna Convention on the Protection of the Ozone

Layer in 1985 and the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987 were signed by many governments and became a party. The Montreal Protocol agreed on measures and obligations to reduce and freeze the production of many CFCs. Ongoing negotiations by countries that are party to the Montreal Protocol have focused on more effective measures to significantly reduce or stop CFCs and halons emissions in the future; they have also started to be successful in this. In addition, new items are added to the initial list. However, even if all the obligations agreed in the Montreal Protocol are fulfilled, the accumulation of CFCs in the atmosphere could be high, at least in the 21st century, as the lifetime of these substances in the atmosphere is quite long.

1.6. Aerosols

Atmospheric movements are sufficient to keep large amounts of solid and liquid particles suspended in the air. Although visible dust in the air (e.g. dust clouds, especially from hot deserts) sometimes obscures or clouds the sky, these particles are very heavy in terms of their long stay in the air. Yet most of these particles are microscopic in nature and can remain suspended in the air for an important weather event period. Small particles (aerosols) suspended in the air come from many sources of natural and human origin. These include soot and fumes (carbon) from forest fires and burning of fossil fuels, particles released from the chimneys of thermal power plants and cement factories, salts from wave breaking, fine soil flying into the air, pollen and micro-organisms raised by the wind, volcanic ash and dust from volcanic eruptions.

Aerosols are more often found in the lower atmosphere near their primary source. However, aerosols are also found in the high atmosphere. This is because some dust is transported up to the upper atmosphere as a result of rising air currents. Other particles formed by the breakdown of meteorites (meteorites) entering the atmosphere contribute to the amount of aerosol in the atmosphere. These fine and mostly invisible particles are of climatological and meteorological importance. First of all, most of these particles, which can be suspended in the air and can be transported by atmospheric movements, serve as condensation nuclei, the surfaces on which water vapor can condense. This feature is an important function for the formation of clouds and fog. This property of dust and similar particles is called condensation nucleus. Second, aerosols can absorb or reflect incoming solar radiation. For this reason, sunlight reaching the earth may be significantly reduced during periods of air pollution or when ashes cover the sky after volcanic eruptions. Finally, it also contributes to the formation of an optical phenomenon observed at sunrise and sunset, with various shades of red and orange.

2. GLOBAL WARMING POTENTIAL OF GREENHOUSE GAS

Another important concept that should be known within the context of human-induced climate change and global warming is global warming potential (GWP). The global warming potential of greenhouse gas is its ability to absorb relatively more (extra) heat energy in the atmosphere over a given period of time compared to, or ın proportion to carbon dioxide. The GWP is mostly calculated for a 100-year period and is therefore referred to as the 100-year GWP (Table 4).

Table 4: 100-year global warming potential values of some greenhouse gases according to IPCC 4th Assessment Report (IPCC, 2007)

Greenhouse gases	Chemical formula	Global warming potential
Carbon dioxide	CO_2	1
Methane	CH_4	25
Diazotmonoxide	N_2O	298
Sulfur Hexafluoride	SF_6	22.800

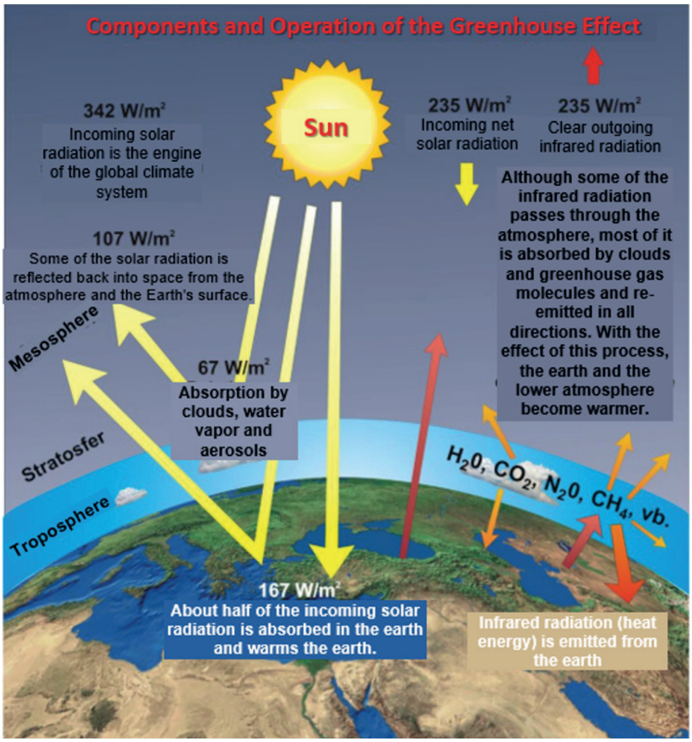
GWP is closely linked to two factors. First, how effective is the greenhouse gas at absorbing heat while in the atmosphere? The other is, how long does a greenhouse gas molecule remain in the atmosphere until it degrades and/or is removed by various devices and is held in the sinks or accumulated? For example, the methane molecule decays and disappears in the atmosphere quite rapidly in an average of about 12 years. On the other hand, methane absorbs heat energy more effectively than CO_2, and methane has a longer lifespan in average conditions.

GWP also facilitates and/or enables us to answer the following question. If a greenhouse gas (eg CO_2, CH_4, N_2O, etc.) absorbs a certain amount of heat, how much CO_2 will it absorb the same amount of energy? For example, the 100-year

GWP of the methane molecule is 25 (Table 4). Therefore, if 1 tonne of methane gas is released into the atmosphere, this amount of methane will cause the same level of warming as 25 tonnes of CO_2. This is explained, for example, in terms of methane, as 25 tonnes of CO_2 eq. (CO_2e).

A common scale developed for all greenhouse gases such as GWP allows an objective comparison between greenhouse gas emissions from different human activities and sectors. This capability also makes it easy to decide as objectively as possible how much effort should be made to reduce the emission levels of the various greenhouse gases. It also enables the setting of targets for different greenhouse gases while minimizing economic impacts for emission reduction strategies.

Figure 5: Schematic representation of the greenhouse effect (Turkes, 2010). The natural greenhouse effect, which is the most important process in the establishment of the Earth's temperature balance, basically occurs because the atmosphere tends to pass high-energy short-wavelength solar radiation, as opposed to retaining low-energy long-wavelength ground radiation




CO_2

3. NATURAL GREENHOUSE EFFECT

The greenhouse effect is one of the most important natural factors for the climate system (Figure 5). Plant greenhouses GKDB pass the solar radiation, whereas GUDB released prevents the escape of most of the ground radiation. The infrared radiation kept in the greenhouse warms the greenhouse, creating a suitable growing environment for sensitive or commercially valuable plants. The atmosphere behaves similarly. The greenhouse effect can be explained in simplified terms: In clear and cloudless weather, a significant portion of the short-wave solar radiation passes through the atmosphere to the earth and is absorbed there. However, some of the infrared radiation emitted from the earth is absorbed and then released again by the many radiative active equilibria (greenhouse gases), mostly in the troposphere, before escaping into space. The most important natural greenhouse gases are CO_2, CH_4, N_2O and O_3, especially H_2O, which provides the biggest contribution.

The formation of the natural greenhouse effect, which is the most important process in the establishment of the Earth's temperature balance, depends on the tendency of the atmosphere to pass the GKDB solar radiation, whereas the GUDB tends to hold the ground radiation (Figure 5). Considering the quantities of energy fluxes, it is seen that approximately 31% of the incident solar radiation (342 W m-2) (107 W m-2) is reflected back into space by reflecting from the surface, atmospheric aerosols and cloud tops (Figure 5). Thus, the average albedo of the Earth is about 31% and the solar radiation entering the system is net 69% (235 W m-2). About two-thirds (168 W m-2) of incoming net solar radiation is absorbed by the surface and one-third (67 W m-2) by the atmosphere. This 69% of solar energy, which is kept in the combined Earth-atmosphere system, is absorbed by the main components (atmosphere, hydrosphere, lithosphere and biosphere) that make up the global climate system and provide their heating.

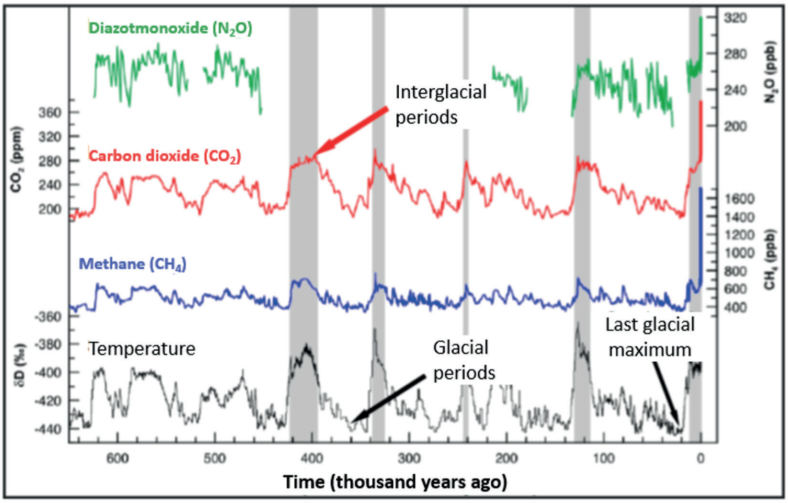
The energy held in the earth and in the atmosphere is distributed to the earth by the circulation of the atmosphere and the ocean and is released back into the atmosphere as UDB ground radiation. A significant portion of GUDB infrared radiation is absorbed and re-released by greenhouse gases and clouds. As a result, the net input of solar radiation (235 W/m2) is offset by the net output of infrared ground radiation (235 W/m2) (Figure 5). Thanks to the greenhouse effect, the earth is approximately 33 °C warmer than the ambient conditions where this process does not exist. At this point, we can ask the following questions. Is this phenomenon important and what does it mean? According to the laws of physics, the Earth's emission temperature would have been –18 °C had it not been for the greenhouse effect. In reality, the average temperature of the earth is about 15 °C. In other words, thanks to the greenhouse effect, the Earth's average surface air temperature is approximately 33 °C is higher than the conditions without the greenhouse effect. Within the framework of these explanations, since the gases in the atmosphere are permeable to incoming solar radiation but much less permeable to the long-wave ground radiation emitted back, this natural process that warms the Earth more than expected and regulates the heat balance is called the greenhouse effect.

There is a lot of evidence on the functioning of the natural greenhouse effect in the light of scientific principles on the Earth:

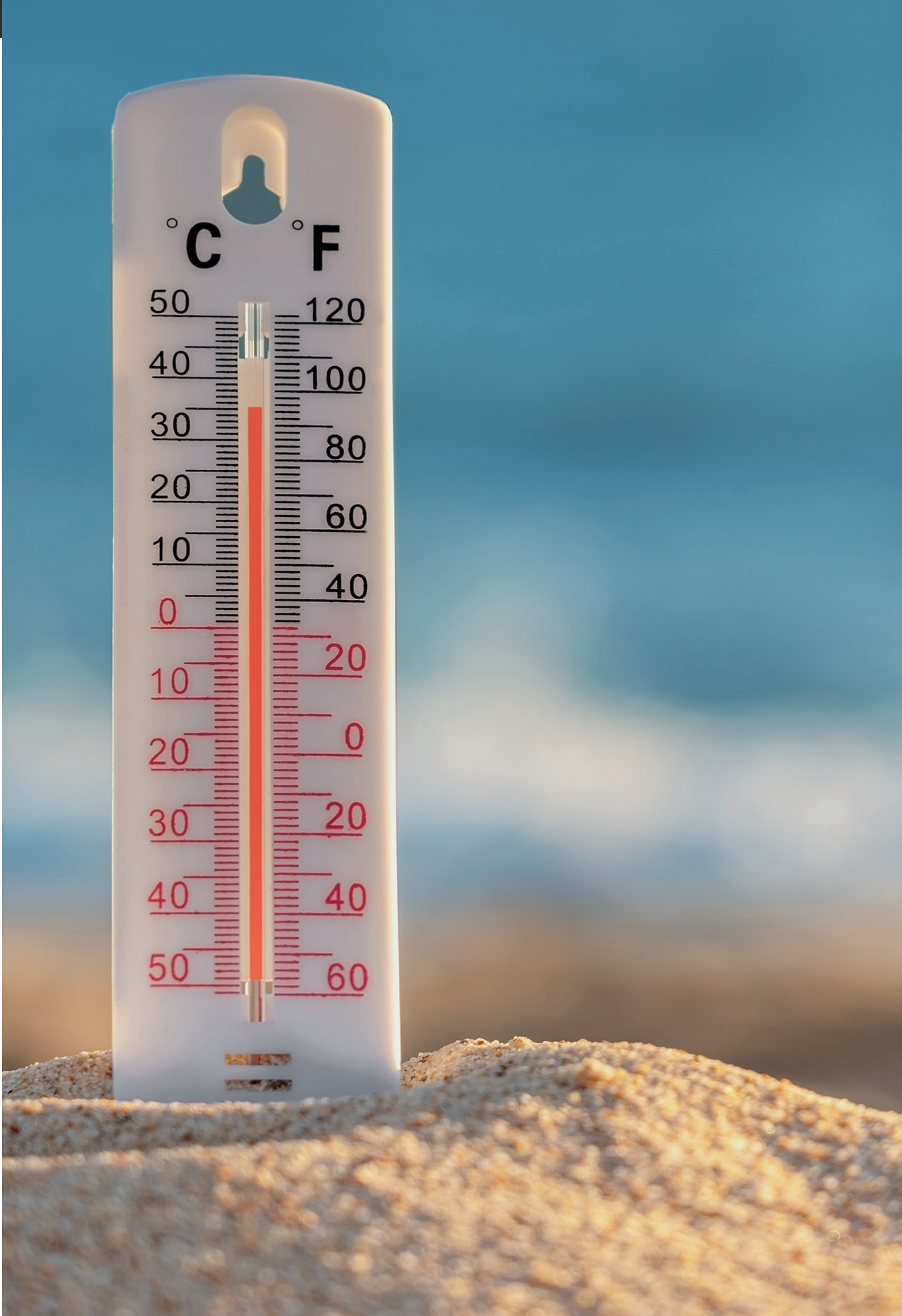
The first of these; if there were no natural greenhouse gases in the atmosphere, the Earth's temperature (emission temperature) would be approximately 33 °C colder than today, i.e. -18 °C, assuming that the Earth's ability to reflect solar radiation in DDHB does not change. This effect of greenhouse gases has also been proven by satellite observations made in recent years regarding the GUDB infrared radiation emitted from the earth and the atmosphere.

Latter; the atmospheric compositions of Earth, Venus and Mars are known to be very different, and the surface temperatures of these planets are generally explained by the greenhouse effect theory.

Figure 6: According to 650 thousand years of consecutive ice carotid data from Antarctica, long-term changes in past air temperatures indirectly represented by deuterium (δD) changes are closely related to changes in the accumulations of methane, carbon dioxide and diazotmonoxide in the atmosphere (Türkeş 2010; rearranged according to Jansen et al., 2007).



Thirdly; according to indirect climate records obtained from ice samples dating back 650 thousand years from today, the temperature of the Earth has changed and is changing in close relation with the accumulations of diazotmonoxide, methane, and carbon dioxide in the atmosphere (Figure 6). For example, analyzes of air trapped in ice samples taken from the Antarctic glacier have shown that CH_4, CO_2, and N_2O accumulations in the atmosphere demonstrated the possible harmony with the deuterium changes, which is a good indirect record and indicator for local temperature conditions during the last 650 thousand years of Quaternary, and consequently glacial and interglacial ages. (Figure 6). The gray-shaded belts in the figure show the previous and last (Holocene) interglacial warm periods that occurred during the 650-thousand-year period. Among these warmer periods, which correspond to more positive deuterium values, are the long and distinct ice ages dominated by more negative deuterium values. Although details on causes and effects are unknown, calculations show that changes in greenhouse gases are cyclical, possibly controlling significant temperature swings between the glacial and interglacial ages.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4. STRENGTHENED GREENHOUSE EFFECT AND GLOBAL WARMING

The increase in anthropogenic greenhouse gas accumulations in the atmosphere has been continuing since the industrial revolution. The importance of CO_2 compared to other greenhouse gases can be understood better, especially when the size of its accumulation in the atmosphere, itsrate of increase and life span and its strong absorption of long-wavelength ground radiation is taken into account. According to Mauna Loa measurements that have been carried out since 1958, the accumulation of CO_2 in the Earth's atmosphere is increasing very rapidly (see Figure 1 and 2) Global measurements show that atmospheric accumulations of other important greenhouse gases are also increasing. In 'normal conditions', GKDB solar energy entering the Earth/atmosphere system and GUDB ground radiation released back are in equilibrium under average conditions. Any factor that changes this balance between solar radiation and ground radiation, or the distribution of energy in the atmosphere and between the atmosphere and the land and ocean, can also affect the climate. Any change in the energy balance of the earth/atmosphere system is called radiative forcing.

The greenhouse gases(CO_2, CH_4, N_2O, hydrofluorocarbons(HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6)] controlled by the UNFCCC Kyoto Protocol (KP) are the most important radiative forcing factors. Apart from these greenhouse gases (affected by human activities and anthropogenic) included in the UNFCCC and the Kyoto Protocol, there are other radiative forcing factors such as CFCs, aerosols, solar radiation, and albedo changes controlled by the Montreal Protocol, as they cause depletion of the ozone layer in the stratosphere.

On the other hand, the slow changes in Earth's orbit around the Sun and its axis tilt affect the seasonal and latitudinal distribution of solar radiation. Therefore, some climatologists have long blamed the occurrence of climate changes (e.g. glacial and interglacial ages), as well as changes or deviations in the Earth's axis tilt and shape of its orbit, among other factors. In addition to all these, it should be kept in mind that the climate has a unique natural variability that is valid for many different areas and time scales. Earth's geological history is full of rich examples of this.

These increases in greenhouse gas accumulations weaken the Earth's cooling efficiency by long-wavelength infrared radiation, resulting in a positive radiative forcing that tends to further heat it. The positive contribution made to the energy balance of the Earth/atmosphere common system is called the strengthening greenhouse effect (Türkeş, 2010). This means that the natural greenhouse effect, which has been operating for hundreds of millions of years, is strengthened by the natural greenhouse gases (water vapor, CO_2, CH_4, N_2O and O_3) in the Earth's atmosphere.

In this context, global warming can be defined as the temperature increase detected in the lower layers since the industrial revolution, especially due to the rapid increase in the accumulation of greenhouse gases in the atmosphere as a result of various human activities such as burning fossil fuels, deforestation, agricultural activities and industrial processes, as a result of the strengthening of the natural greenhouse effect with the contribution of urbanization (Türkeş, 2017).

As can be understood from the definition, greenhouse gases that cause human-induced climate change and global warming are caused mostly by fossil fuel burning (energy and cycle), industry (energy-related; chemical processes and cement production, etc. non-energy), transportation, land-use change, waste management, and agricultural (energy-related; stubble burning, rice production, livestock, and fertilization, etc. non-energy) activities. The magnitude of global warming caused by the intensified greenhouse effect depends on the size of the increase in the accumulation of each greenhouse gas, the radiative properties of these gases (global warming potential), atmospheric lifespan, and the accumulation of other greenhouse gases that continue to exist in the atmosphere.

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NATURAL AND ANTHROPOGENIC GREENHOUSE EFFECT

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

1.1. Natural Greenhouse Effect

Greenhouse effect is the process in which some of the infrared radiation emitted by the Earth's surface is "captured" by greenhouse gases. This helps to moderate temperatures on the Earth's surface. By "trapped" it is mean that the greenhouse gas molecules absorb some infrared radiation. These gases then send some of the infrared radiation back to Earth. This makes the temperatures at the surface warmer than others. The greenhouse effect has occurred naturally on Earth for millions of years, as the atmosphere contains greenhouse gases since the first formation. Therefore, this process, now known as the natural greenhouse effect, enabled life to flourish on this planet. Without it, the temperatures experienced on Earth would be similar to those on the Moon at the same distance as the Sun. This means it will be too hot during the day and too cold during the night to survive. The Moon has no atmosphere and therefore no greenhouse gases to help moderate temperatures on its surface. The average surface temperature on the Moon is -18 °C. Earth, which has an atmosphere containing greenhouse gases, has an average temperature of 15 °C, 33 °C higher than the Moon.

Table 1: The greenhouse effect on the planets of the inner solar system

Planet	The average distance from the sun (10 6 km)	The proportion of essential greenhouse gases in the atmosphere	Average albedo value	Surface temperature without greenhouse effect	Average surface temperature observed	Greenhouse effect
Mercury	58	Has no atmosphere	0,06	167 °C	167 °C	0 °C
Venus	108	More than 90% CO_2 (Very dense as the surface pressure is 100 times higher than the Earth)	0,78	-48 °C	464 °C	510 °C
Earth	150	About 0.003% CO_2 , about 1% H_2O	0,30	-18 °C	15 °C	33 °C

Planet	The average distance from the sun (10 6 km)	The proportion of essential greenhouse gases in the atmosphere	Average albedo value	Surface temperature without greenhouse effect	Average surface temperature observed	Greenhouse effect
Mars	228	More than 90% CO_2 (Very thin as the surface pressure is 0.01 times lower than the Earth)	0.17	-57 °C	Around -53 °C	4 °C

Resource: URL1

1.2. Increased Greenhouse Effect

Increased greenhouse effect is the term used to describe the extra warming of the Earth's atmosphere, soil and oceans caused by the increase in the amount of greenhouse gases in the Earth's atmosphere. The increase in greenhouse gases in our atmosphere is mainly due to human activities burning fossil fuels (coal, oil and natural gas), agriculture and land opening. Scientific modeling, using data collected from ice core studies by atmospheric scientists and meteorologists, and measurements of atmospheric temperatures and gas concentrations in the atmosphere, suggests that the increase in concentration of greenhouse gases in the atmosphere above natural levels is the primary cause of global warming.

2. GREENHOUSE GASES

Greenhouse gases include carbon dioxide and water vapor. Some other gases in the atmosphere also act as greenhouse gases, but their percentage in the lower atmosphere is much less than carbon dioxide and water. These gases include methane and nitrous oxide. Greenhouse gases have one thing in common: their molecules contain 3 or more atoms (Table 2).

Table 2: Basic gases and atomic numbers that make up the atmosphere

Gas	Approximate ratio in air (in dry air)	Chemical formula	Total number of atoms in each molecule	Whether it is greenhouse gas
Oxygen	20.9	O_2	2	Not
Nitrogen	78.1	N_2	2	Not
Argon	0.9	Ar	1	Not
Carbon dioxide	0.03	CO_2	3	Yes
Methane	0.0002	CH_4	5	Yes
Nitrous oxide	0.00004	N_2O	3	Yes

Not: Argon is classified as an inert gas. Inert gases exist as separate atoms in nature, so they are not called molecules.

Resource: URL2

The more atoms in the greenhouse gas molecules allow them to absorb the infrared radiation emitted from the Earth's surface and then emit some back to the surface. This warms the Earth even more.

Table 3: Greenhouse gas lifetimes, radiation efficiency, and direct (excluding CH_4) global warming potentials relative to CO_2

Industrial Description and Common Description	Chemistry Formulas	Life Time (year)	Radiative Efficiency (W m-2 ppb-1)	SAR‡ (100-yıl)	Given Time Horizon 20-yr	100-yıl	500-Years
Carbon dioxide	CO_2	Değşken	1.4x10–5	1	1	1	1
Methane	CH_4	12	3.7x10–4	21	72	25	7.6
Nitrous oxide	N_2O	114	3.03x10–3	310	289	298	153
Substances controled by Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	CClF2CClF2	300	0.31		8,040	10,000	8,730
CFC-115	CClF2CF3	1,700	0.18		5,310	7,370	9,990
Halon-1301	CBrF3	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435
Methyl bromide	CH_3Br	0.7	0.01		17	5	1
Methyl chloroform	CH_3CCl_3	5	0.06		506	146	45
HCFC-22	$CHClF_2$	12	0.2	1,500	5,160	1,810	549
HCFC-123	$CHCl_2CF_3$	1.3	0.14	90	273	77	24
HCFC-124	$CHClFCF_3$	5.8	0.22	470	2,070	609	185
HCFC-141b	CH_3CCl_2F	9.3	0.14		2,250	725	220
HCFC-142b	CH_3CClF_2	17.9	0.2	1,800	5,490	2,310	705
HCFC-225ca	$CHCl_2CF_2CF_3$	1.9	0.2		429	122	37
HCFC-225cb	$CHClFCF_2CClF_2$	5.8	0.32		2,030	595	181
Hydrofluorocarbons							
HFC-23	CHF_3	270	0.19	11,700	12,000	14,800	12,200
HFC-32	CH_2F_2	4.9	0.11	650	2,330	675	205
HFC-125	CHF_2CF_3	29	0.23	2,800	6,350	3,500	1,100
HFC-134a	CH_2FCF_3	14	0.16	1,300	3,830	1,430	435
HFC-143a	CH_3CF_3	52	0.13	3,800	5,890	4,470	1,590

Industrial Description and Common Description	Chemistry Formulas	Life Time (year)	Radiative Efficiency (W m-2 ppb-1)	SAR‡ (100-yıl)	Given Time Horizon 20-yr	100-yıl	500-Years
HFC-152a	CH_3CHF_2	1.4	0.09	140	437	124	38
HFC-227ea	CF_3CHFCF_3	34.2	0.26	2,900	5,310	3,220	1,040
HFC-236fa	$CF_3CH_2CF_3$	240	0.28	6,300	8,100	9,810	7,660
HFC-245fa	$CHF_2CH_2CF_3$	7.6	0.28		3,380	1030	314
HFC-365mfc	$CH_3CF_2CH_2CF_3$	8.6	0.21		2,520	794	241
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$	15.9	0.4	1,300	4,140	1,640	500
Perfluorinated Component							
Sulphur hexafluoride	SF_6	3,200	0.52	23,900	16,300	22,800	32,600
Nitrogen trifluoride	NF_3	740	0.21		12,300	17,200	20,700
PFC-14	CF_4	50,000	0.10	6,500	5,210	7,390	11,200
PFC-116	C_2F_6	10,000	0.26	9,200	8,630	12,200	18,200
PFC-218	C_3F_8	2,600	0.26	7,000	6,310	8,830	12,500
PFC-318	$c\text{-}C_4F_8$	3,200	0.32	8,700	7,310	10,300	14,700
PFC-3-1-10	C_4F_{10}	2,600	0.33	7,000	6,330	8,860	12,500
PFC-4-1-12	C_5F_{12}	4,100	0.41		6,510	9,160	13,300
PFC-5-1-14	C_6F_{14}	3,200	0.49	7,400	6,600	9,300	13,300
PFC-9-1-18	$C_{10}F_{18}$	>1,000[d]	0.56		>5,500	>7,500	>9,500
trifluoromethyl	SF_5CF_3	800	0.57		13,200	17,700	21,200
sulphur pentafluoride							
Fluorinated ethers							
HFE-125	CHF_2OCF_3	136	0.44		13,800	14,900	8,490
HFE-134	CHF_2OCHF_2	26	0.45		12,200	6,320	1,960
HFE-143a	CH_3OCF_3	4.3	0.27		2,630	756	230
HCFE-235da2	$CHF_2OCHClCF_3$	2.6	0.38		1,230	350	106
HFE-245cb2	$CH_3OCF_2CHF_2$	5.1	0.32		2,440	708	215
HFE-245fa2	$CHF_2OCH_2CF_3$	4.9	0.31		2,280	659	200
HFE-254cb2	$CH_3OCF_2CHF_2$	2.6	0.28		1,260	359	109
HFE-347mcc3	$CH_3OCF_2CF_2CF_3$	5.2	0.34		1,980	575	175
HFE-347pcf2	$CHF_2CF_2OCH_2CF_3$	7.1	0.25		1,900	580	175
HFE-356pcc3	$CH_3OCF_2CF_2CHF_2$	0.33	0.93		386	110	33

Industrial Description and Common Description	Chemistry Formulas	Life Time (year)	Radiative Efficiency (W m-2 ppb-1)	SAR‡ (100-yıl)	Given Time Horizon 20-yr 100-yıl		500-Years
HFE-449sl (HFE-7100)	$C_4F_9OCH_3$	3.8	0.31		1,040	297	90
HFE-569sf2 (HFE-7200)	$C_4F_9OC_2H_5$	0.77	0.3		207	59	18
HFE-43-10pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$	6.3	1.37		6,320	1,870	569
HFE-236ca12 (HG-10)	$CHF_2OCF_2OCHF_2$	12.1	0.66		8,000	2,800	860
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$	6.2	0.87		5,100	1,500	460
Perfluoropoly ethers							
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$	800	0.65		7,620	10,300	12,400
Hydrocarbons and other components – Direct Effects							
Dimethylether	CH_3OCH_3	0.015	0.02		1	1	<<1
Methylene chloride	CH_2Cl_2	0.38	0.03		31	8.7	2.7
Methyl chloride	CH_3Cl	1.0	0.01		45	13	4

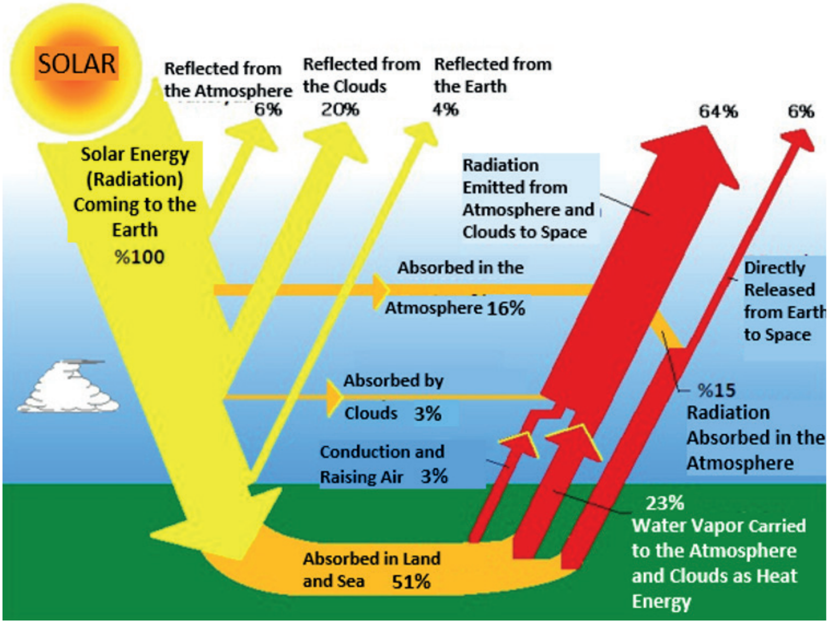
Resource: Climate Change 2007 - The Physical Science Basis

Carbon dioxide equivalents (CO_2 -eq) are units that represent the relative effect of a given gas on atmospheric warming, depending on the gas's global warming potential. For example, a ton of methane can be expressed as 21 tonnes of CO_2 -eq tonnes of nitrogen oxides and CO_2 can be expressed as 310 -eq tonnes. Using a common unit is helpful when preparing greenhouse gas inventories or comparing greenhouse gas emission reduction strategies.

3. SOLAR CONSTANT

Figure 1 shows what happens when solar radiation reaches the earth.

Figure 1: The distribution of solar radiation



Resource: URL2

When the system is in equilibrium, the total energy emitted from Earth into space is equal to the total incoming energy. When the radiation from the Sun reaches the Earth, about 30% of the solar radiation is reflected back to Space by atmospheric particles, clouds and the Earth's surface. Some of them are absorbed by water vapor and clouds in the atmosphere. Some (about 3%) are absorbed by the ozone layer. Absorption by the atmosphere reaches 19%. The remaining 51% of solar energy is absorbed by the Earth's surface (soil and oceans). If the incoming solar radiation continued to be absorbed by the atmosphere and the earth, and if there was no energy escape into space, the Earth would get much warmer and all of the oceans would evaporate.

Fortunately for us, this does not happen because the Earth radiates its heat energy back into the atmosphere in the form of infrared radiation and as a result the atmosphere radiates heat energy back into space.

3.1. What is infrared radiation and why is it important?

The solar radiation emitted into space by the sun is not just the light you can see. Besides visible light, the Sun also emits ultraviolet waves (UV) and infrared waves (IR). These cannot be seen with the naked human eye. The entire range of radiation is known as the electromagnetic spectrum.

Figure 2: Schematic diagram of the electromagnetic spectrum

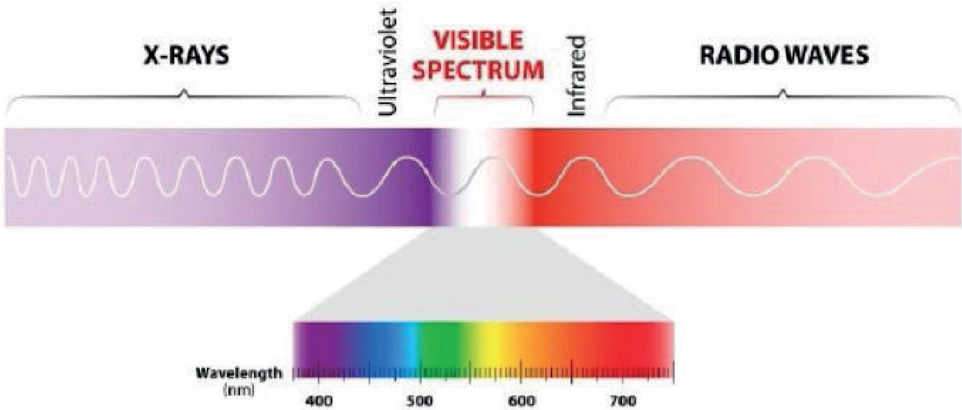


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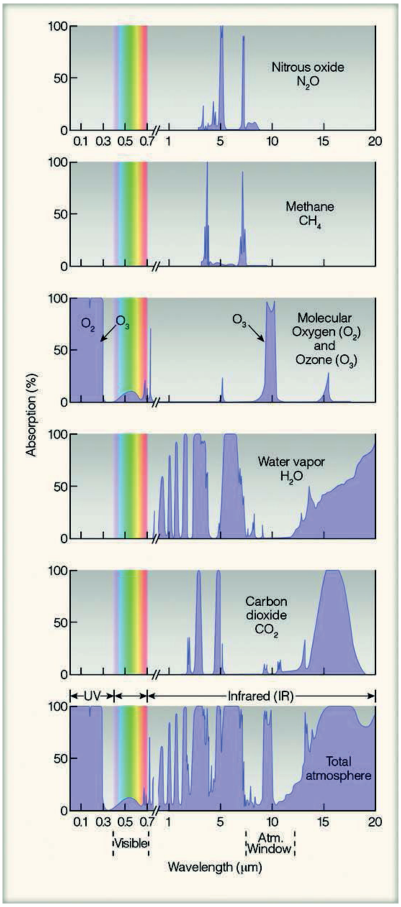
Figure 2 shows the electromagnetic spectrum. The Sun's radiation spreads in space in waves. This is why different parts of the spectrum are distinguished by the frequency or wavelength of the waves. The highest-energy radiation is to the left of the diagram -ie x-rays (and gamma rays). UV radiation has more energy than visible light, so too much radiation exposure can cause damage. IR radiation has less energy than visible light but is responsible for the warmth we feel. Radio waves have very low energy.

In Figure 2, the wavelength band matching the visible light expands to show the colors that together make up the visible light. In fact, there is a continuous range of colors, not the seven individual colors listed in the well-known "ROYGBIV" (Red, Orange, Yellow, Green, Blue, Indigo and Violet).

FIGURE 3 Absorption of radiation by atmospheric gases. The dark purple shaded area represents the percentage of radiation absorbed by each gas. The strongest absorbers of infrared radiation are water vapor and carbon dioxide. The figure below represents the percentage of radiation absorbed by all atmospheric gases.

Figure 3: Absorption of radiation by gases in the atmosphere



Resource: Ahrens, C., D., Henson, R., (2014)

Figure 3 shows some of the most important selectively absorbing gases in our atmosphere. The shaded area represents the absorption properties of each gas at various wavelengths. They are powerful infrared radiation absorbers of both water vapor (H_2O) and carbon dioxide (CO_2) and weak absorbers of visible solar radiation. Other, less important selective absorbers include nitrous oxide (N_2O), methane (CH_4) and ozone (O_3), which are most abundant in the stratosphere. As these gases absorb infrared radiation emitted from the Earth's surface, they gain kinetic energy (motion energy). Gas molecules share this energy by colliding with neighboring air molecules such as oxygen and nitrogen (both are weak absorbers of infrared energy). These collisions increase the average kinetic energy of the air, which causes the air temperature to increase. Thus, most of the infrared energy emitted from the Earth's surface keeps the lower atmosphere warm. In addition to being selective absorbers, water vapor and CO_2 selectively emit radiation at infrared wavelengths. This radiation diffusesfrom these gases in all directions. Some of this energy radiates towards the Earth's surface and is absorbed, thus heating the ground. Earth, in turn, constantly emits infrared energy upward, where it is absorbed and warms the lower atmosphere. In this way, water vapor and CO_2 absorb and emit infrared energy and prevent some of the Earth's infrared radiation from quickly escaping into space. As a result, Earth's surface and lower atmosphere are warmer than they are due to selectively absorbing gases. In fact, as we've seen before, without the Earth's CO_2 and water vapor, the average radiation equilibrium temperature would be about -18 °C or about 33 °C lower than it is now. The absorption properties of water vapor, CO_2, and other gases such as methane and nitrous oxide (as shown in Figure 3) were once thought to be similar to the glass of a florist's greenhouse. In a greenhouse, glass allows visible radiation to enter, but to some extent prevents the passage of outgoing infrared radiation. Therefore, the absorption of infrared radiation from Earth by water vapor and CO_2 is popularly called the greenhouse effect. However, studies have shown that warm air inside a greenhouse is likely due to the inability of the air to circulate and mix with the outside air, rather than because more air is trapped by infrared energy. Because of these findings, some scientists suggest that the greenhouse effect should be called the atmospheric effect. To accommodate everyone, the term atmospheric greenhouse effect continues to generally be used to describe the role water vapor, CO_2 and other greenhouse gases play in keeping the Earth's average surface temperature higher than normal. As seen in Figure 3, in the bottom diagram there is a region of about 8 to 11 μm where neither water vapor nor CO_2 readily absorbs infrared radiation. The void in the specific wavelength range (between 8 and 11 μm) towards the atmosphere and space is known as the atmospheric window. Clouds can increase the atmospheric greenhouse effect. Small liquid cloud droplets are selective absorbers as they are good absorbers of infrared radiation but weak absorbers of visible solar radiation. Clouds even absorb wavelengths in the range of 8 to 11 um which would otherwise be "passed" by water vapor and CO_2. Thus, they have the effect of increasing the atmospheric greenhouse effect by closing the atmospheric window. Clouds - especially low, thick ones - are excellent emitters of infrared radiation. The bottoms radiate back to the Earth's surface, while their tops radiate infrared energy upward. This process keeps calm, cloudy nights warmer than calm open ones. Because the ground does not get as warm as in full sunlight, it is normally cooler on cloudy and calm days than on clear, calm days. Therefore, the presence of clouds tends to keep nighttime temperatures higher and daytime temperatures lower. In summary, the atmospheric greenhouse effect occurs because water vapor, CO_2 and other greenhouse gases are selective absorbers. They allow most of the Sun's visible radiation to reach the surface, but absorb most of the Earth's outgoing infrared radiation, preventing it from escaping into space. So it is the atmospheric greenhouse effect that keeps the temperature of our planet at a level where life can survive. The greenhouse effect is not just a "good thing"; it is very important for life on Earth because without it, the air at the surface would be very cold (Ahrens, C., D., Henson, R., 2014).

4. GREENHOUSE GAS EMISSIONS

4.1. Natural System Greenhouse Gas Emissions

Greenhouse gas emission studies from natural systems include global and regional total emission estimates and field flow observations from specific sources. (Yue X., L., Gao, Q., X., 2018).

4.1.1. Forest fires

Forest fires are an important source of greenhouse gas emissions and natural causes include drought, heat and lightning. Approximately 90% of the gases emitted from forest fires are CO_2. Globally experts have conducted extensive research to estimate this source of greenhouse gas emissions using a variety of techniques and tools. At the regional scale, boreal forest fires have received widespread attention and many quantitative greenhouse gas results have been published. Scholars also analyzed forest fire fluxes. Using the modal results of mod emissions as a result of forest fires, annual global greenhouse gas emissions from forest fires range between 7-16 Gt CO_2 -eq. Greenhouse gas emission as a result of forest fires is most likely 11 Gt CO_2 -eq.

4.1.2. Oceans

Oceans create a large carbon reserve. The carbon content of the oceans is 50 times that of the atmosphere and 20 times that of the biosphere. As the global oceans simultaneously serve as a source of carbon and a carbon reserve, they play an extremely important role in regulating greenhouse gas concentrations in the atmosphere. North Atlantic and coastal Norway Greenland to the north of 40 °N are powerful CO_2 sinks of the oceans . However, the North Pacific CO_2 exchange, shows a significant change seasonally, so in winter it is a powerful source of CO_2 and in summer it has CO_2 absorbent role. Elliott and Angell (1987) found that equatorial waters are the largest source of global CO_2. In the Equatorial Pacific alone, 1.0 Pg C is emitted into the atmosphere each year (Yue X., L., Gao, Q., X., 2018), which accounts for 60% of the total CO_2 released by the oceans. The global ocean emits about 6.12 Gt of CO_2 equivalent per year, and the amount of CO_2 absorbed by the ocean is about 9.3-12.6 Gt per year. Therefore, the ocean acts as a large carbon sink.

4.1.3. Wetlands

Wetlands are vital ecosystems that include swamps, peat fields, and lakes. At the same time, it is one of the most important carbon reserves on land, with carbon stocks that make up about 15% of the total land surface carbon. Wetlands are the main source of natural CH_4 emissions. Since changing temperatures can affect the concentration of CH_4 emissions and hydrological conditions, global annual CH_4 emissions from natural fresh water wetlands is greatly changing. Annual emissions can reach 110 Tg or more, accounting for about 15% to 30% of total global CH_4 emissions. On a global scale, CH_4 emissions from wetland systems have been studied extensively. Kirschke et al., (2013), the total global CH_4 emitted from wetlands in 2000-2009 was about 177-284 Tg per year, which is equivalent to 4.4-7.1 Pg of CO_2 per year (Yue X., L., Gao, Q., X., 2018). Current studies show that, using mode values, global annual greenhouse gas emissions from wetlands are about 2.4-7.5 Gt CO_2 -equivalent and the most likely value is about 5 Gt CO_2 equivalent.

4.1.4. Permafrost

Permafrost areas are especially common in Siberia, Canada and Alaska. The global permafrost area is approximately 18,782,106 km^2. Research on greenhouse gas emissions from permafrost has focused on C, CO_2, CH4 and N_2O, most of which are flux observations. For example, Koven et al., (2011) simulated CH_4 emissions under different scenarios for the period 1860-2100 at high latitudes for three large frozen regions. The author found that from the end of the 19th century to the beginning of the 21st century, annual CH_4 emissions at high latitudes remained at 30-40 Tg

(0.75-1 Pg CO_2-eq), but will reach 71-74 Tg by 2080. A quantitative flux study in Western Canada shows that the flows of CO_2 and CH_4 range from 0.2 to 14.6 mmol CO_2 m-1d-1 and -24 to 344 mmol CH_4, respectively. Meanwhile, Marushchak et al., (2011) show that the highest daily N_2O release is 2.6-31.4 mg m-2 in non-vegetation areas and -0.6 to 0.4 mg m-2 in areas with sparse vegetation (Yue X., L., Gao, Q., X., 2018). The mode values for annual greenhouse gas emissions from permafrost range from 2.3 to 7.8 Gt CO_2 -eq, with the most likely value being around 6 Gt CO_2 eq per year.

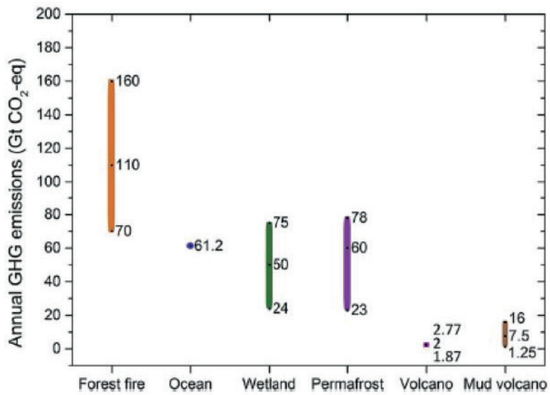
4.1.5. Volcanoes

Volcanic eruptions can release a large number of volcanic gases, including CH_4 and CO_2, into the atmosphere. Volcanic eruptions can be rapid and have high fluxes. Volcanoes with intermittent activity release gas much more slowly, but for longer periods, so the total amount of greenhouse gases released by intermittent volcanoes may be higher than eruptive volcanoes. Simkin (1993) reported the spatial distribution of 1300 volcanoes on the earth, some of which are scattered in spot-like patterns and most concentrated in the area of about 20 bands. Little research has been done on volcanic greenhouse gas emissions. There are various studies on volcanic flux and predictions of volcanic events. The level of greenhouse gas emissions from large volcanic eruptions is very high. For example, the eruption of Pinatubo volcano in the Philippines in June 1991 released more than 20 Mt SO_2 and 200 Mt CO_2 into the atmosphere, creating the largest volcanic cloud event of the 20th century. McCartney et al., (1990) estimated that CO_2 emissions from Tegan basalt at the peak of the explosion (1.36 Ma) were 13,000 Gt. The total amount of C emitted by Siberian volcanoes is estimated to be 20,000 Gt. However, satellite observations show that volcanic activity contributes, on average, about 0.1 Gt of CO_2 per year to the atmosphere. By choosing the mode values, it is estimated that the greenhouse gas emissions from global volcanic eruptions are between approximately 20 and 110 Mt CO_2 -eq per year and interfaced with approximately 167 Mt CO_2 eq. Therefore, total annual greenhouse gas emissions from volcanoes range from about 187 to 277 Mt CO_2 -eq, with the most likely value being 200 Mt CO_2 -eq per year.

4.1.6. Mud volcanoes

Mud volcanoes are "volcanoes" characterized by mud explosions. During their formation and subsequent activity, they can also generate large amounts of hydrocarbon gas. The main greenhouse gas emitted by mud volcanoes is CH_4, which together with a small amount of CO_2 makes up 95% of the total hydrocarbon gas. It is estimated that the greenhouse gases released during the mud volcano eruption are approximately 60-80% of the total gas content. Large amounts of gas may be released during periods of calm. Milkov (2000) predicted that the number of mud volcanoes around the world will range from 103 to 105 depending on the observed volcanic densities. Given this number, scientists used CH_4 emission flux observations to estimate global CH_4 emissions from intermittent and explosive activities of continental and marine mud volcanoes. Based on the mod values, global annual CH_4 emissions from mud volcanoes are estimated to range from about 0.5 to 6.15 Mt, which is equivalent to 0.125-1.6 Mt CO_2 -eq. Total greenhouse gas emission from mud volcanoes is approximately 750 Mt CO_2 -equivalent per year.

Figure 4: Global naturally sourced greenhouse gas emissions; maximum, minimum and recommended (point) values.



Resource: Yue X.,L., Gao, Q.,X., (2018)

Figure 4 shows the most likely greenhouse gas emissions from natural systems and their amplitude. Global greenhouse gas emissions from natural systems are estimated to be in the range of about 18.13 to 39.30 Gt CO_2 -eq per year, with the most likely value being 29.07 Gt CO_2 equivalents. Emissions from forest fires constitute the major component of total emissions with 37.8%, followed by oceans, permafrost and wetlands with 21.05%, 20.64% and 17.20% respectively. Volcanoes and mud volcanoes contribute to relatively low amounts of greenhouse gas emissions, about 1% - 3% of the total.

4.2. Greenhouse gas emissions from human activities

According to greenhouse gas inventory data for global human activity (GCP, 2017) compiled by UN, CO_2 emissions resulting from global fossil fuel and cement production, rose from 22,3 Gt in 1990 to 36,2 Gt in 2016 with an increase of 70%. Fossil fuel energy consumption continues to be the primary source of greenhouse gas emissions. Emissions from coal, petroleum, natural gas and cement production in 2016 accounted for 40.3%, 34.7%, 19.4% and 5.6% of the total, breing respectively 14.5, 12,5, 7,0 and 2,0 Gt (GCP, 2017). In 2018, the growth in total global greenhouse gas emissions (excluding those from land-use change) resumed at a rate of 2,0%, reaching 51,8 $GtCO_2$ eq after six years, with a somewhat lower annual growth of around 1,3%. The 2018 global greenhouse gas emissions amounted to 55.6 $GtCO_2$ eq when also including those from land-use change. This increase occurred while global economic growth in 2018 continued at about the average annual rate of 3.4% since 2012. Present greenhouse gas emissions that exclude those from land-use change are about 57% higher than in 1990 and 43% higher than in 2000 (Olivier, Peters 2020).

Since the 1960s, the greenhouse from coal, oil and gas combustion, respectively, increased from 5 Gt to 14,5 Gt, from 3 Gt to 12,5 Gt and from 0,8 Gt to 7,0 Gt. There has been a significant increase in gas emissions (GCP, 2017). Meanwhile, greenhouse gas emissions from oil increased significantly during the 1960-1980 period, and greenhouse gas emissions from coal combustion grew considerably at the beginning of the 21st century, but have declined slightly since 2014. Greenhouse gas emissions from gas have shown a steady and continuous growth trend. Coal and oil are the two main sources of anthropogenic greenhouse gas emissions and contribute to the highest CO_2 emission rate. Greenhouse gas emissions in cement remained 1-2 Gt of CO_2 -eq per year representing a relatively small contribution. In addition, global greenhouse gas emissions due to land use change are about 4-5 Gt per year from 1850 to 2016.

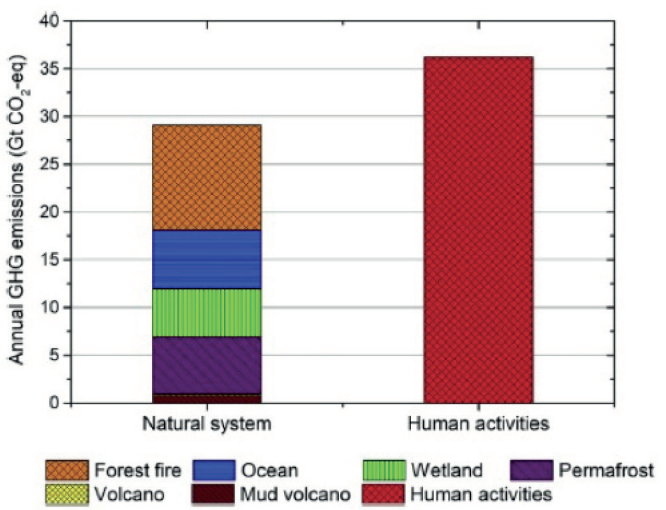
According to GCP (2017), in 2016, China's total annual greenhouse gas emission amounted to 10,5 Gt, the largest worldwide, followed by US, EU. and India with a total of 5,3, 3,5 and 2,5 Gt, respectively. However, in terms of emissions per capita, the USA ranks first in the world with 16,5 tons of CO_2 -eq, the EU is third with 6,7 tons of CO_2 eq, and China is second with 7,2 tonnes of CO_2 -eq. All of these countries have exceeded global per capita emissions of 4,2 tonnes of CO_2 -eq (GCP, 2017).

In terms of cumulative emissions from fossil fuels and cement production in 1870-2016, North America and the EU accounted for more than 70% of the total. Before 1960, cumulative emissions were highest in North America and the EU, while other countries accounted for only a small percentage of emissions. Since the 1960s, the share of greenhouse gas emissions from fossil fuels and cement production in the EU has shown a marked downward trend in terms of total global anthropogenic emissions. In contrast, there was no significant proportional trend for the US and developing countries such as China, Russia, India and others showed a marked upward trend. However, in terms of the total quantity, North America and the EU continue to be responsible for the majority of emissions.

4.3. Contribution of natural systems and human activities to global greenhouse gas emissions

Based on the above analysis, total global anthropogenic greenhouse gas emissions are currently estimated at around 36.2 Gt. Natural system emissions are estimated to be around 18.13-39.30 Gt CO_2 -eq per year and most likely 29.07 Gt CO_2 -eq per year. Thus, the total annual global greenhouse gas emissions are approximately 54.26 to 75.43 Gt CO_2 -eq. The ratio of natural to anthropogenic releases ranges from 0.5 to 1.09 and is most likely 0.8. This shows that anthropogenic and natural greenhouse gas emissions are of the same magnitude. Anthropogenic greenhouse gas emissions account for approximately 47.9-66.6% of total global greenhouse gas emissions, with the most likely value being 55.4% (Figure 5). However, if greenhouse gas emissions from volcanic eruptions are included, natural greenhouse gas emissions are likely to exceed anthropogenic greenhouse gas emissions (Yue X., L., Gao, Q., X., 2018).

Figure 5: Global greenhouse gas emissions from natural systems and human activities



Resource: Yue X.,L., Gao, Q.,X., (2018) The atmosphere, oceans, and terrestrial ecosystems are three possible sinks for greenhouse gases. Half of the globally available CO_2 budget resides in the atmosphere, and the rest is stored in the surface system, namely ocean and terrestrial ecosystems. The ocean carbon sink is about 9.13-12.6 Gt per year. Simulation results for terrestrial ecosystem carbon sinks show that global carbon sinks were 5.1-13.9 Gt of CO_2 -eq per year in the 1990s. Therefore, the total amount of greenhouse gas that is absorbed by ocean and terrestrial ecosystems (14.4-26.5 Gt CO_2 -eq.) is slightly less than the natural emissions (18.13-39.3 Gt CO_2 -eq.), but is roughly the same size. While the Earth's natural systems can be considered as self-balancing, greenhouse gas emissions from fossil fuel combustion, that is, human activities have reached 36.2 Gt CO_2 eq and exert additional pressure on the Earth system (Yue X., L., Gao, Q., X., 2018).

5. CONCLUSIONS

Sources of greenhouse gas emissions can be divided into two groups: natural systems and sources linked to anthropogenic activities. Greenhouse gases emitted from natural sources are generated by forest fires, oceans, wetlands, permafrost, volcanoes and mud volcanoes.

In the absence of sufficient volcanic emission data and without considering seismic emissions, natural global greenhouse gas emissions are estimated to range from 181.3 to 393 Mt CO_2 -eq per year. Whereas forest fires constitute the major emission of the total with 37.8% of the natural resources, it is followed by oceans, permafrost and wetlands with 21.05%, 20.64% and 17.20% respectively. Volcano and mud volcano emissions account for only 1% - 3% of total greenhouse gas emissions.

Since global anthropogenic greenhouse gas emissions were 362 Gt CO_2 -eq in 2016 and global annual greenhouse gas emissions were about 54.33-75.5 Gt CO_2 -eq, anthropogenic emissions accounted for 47.9% -66.6% of total global emissions, on average 55.4%. The ratio of natural to anthropogenic greenhouse gas emissions is about 0.5-1.09, the most likely ratio being 0.8. Total greenhouse gas emissions from natural systems are slightly less than anthropogenic activities. If earthquakes and volcanic greenhouse gas emissions are included, the rate of natural system greenhouse gas emissions will increase.

The total amount of greenhouse gases absorbed by oceanic and terrestrial ecosystems is 14.4-26.5 Gt CO_2 -eq per year, approximately the same as emissions from natural systems. Therefore, Earth's natural system can be considered self-balancing, and greenhouse gas emissions related to human activity put extra pressure on the Earth system (Yue X., L., Gao, Q., X., 2018).

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SINK MECHANISMS AND THEIR STRENGTH

Prof. Dr. İhsan Çiçek

1.INTRODUCTION

The carbon cycle has two components. These are the fast carbon cycle and slow carbon cycle. While the fast carbon cycle includes biological processes such as photosynthesis and decomposition, the slow carbon cycle includes inorganic carbon transitions such as the weathering of rocks and soils. The slow carbon cycle manages climate change throughout millions of years, while the fast carbon cycle is associated with climate change from a decade to a thousand years.

The main natural source of CO_2 in the atmosphere comes from the release of volcanic gases from mid-ocean ridges and volcanoes. When carbonate rocks are subjected to intense pressure and temperature, CO_2 is released from the mixing zones at the edges of the tectonic plates. CO_2 released into the atmosphere dissolves in the oceans and is taken up by living organisms. Some of the large global reserves of carbon are therefore atmospheric CO_2, dissolved CO_2 and its ions in the oceans, and carbon in living matter.

2. SINKS

2.2. Terrestrial Sinks

As evidence of the link between atmospheric greenhouse gases (GHGs) and climate change grows, international efforts have focused on ways in which emissions of greenhouse gases can be reduced. 1997 Kyoto Protocol decided to reduce total greenhouse gas emissions by 5.2% of their emissions in 1990 between the years 1990-2012 in developed countries. (Read et al., 2001). As the Kyoto Protocol will expire in 2020, the Paris Agreement, which will be valid after 2020, was adopted at the 21st Conference of the Parties (COP21) held in Paris, France in 2015. The agreement entered into force on 4 November 2016, with the condition that at least 55 parties ratified the agreement as of October 5, 2016, which accounts for 55% of global greenhouse gas emissions. The Agreement aims to improve the implementation of the United Nations Framework Convention on Climate Change in the context of sustainable development and elaminate poverty. The long-term goal of the agreement is to keep the global average temperature increase 2 °C below the pre-industrial period; in addition, it refers to the continuation of global efforts to keep this increase below 1,5 °C. Increasing adaptability and climate resilience to the adverse effects of climate change; providing development with low greenhouse gas emissions and not damaging food production while realizing these are stated as another main target. Finally, stabilizing the flow of finance is among the targets on the path to low emission and climate-resilient development. The principle of "common but differentiated responsibilities and relative capabilities" has been adopted as a principle both in achieving the stated goals and in the implementation of other articles. Accordingly, it is envisaged that countries contribute to global climate actions as much as possible in line with their means. It is envisaged that countries will submit "National Contribution Declarations" every 5 years, which includes activities to fulfill the main objective of the Agreement on mitigation, adaptation, finance, technology transfer and capacity building, in accordance with the principle of common but differentiated responsibilities and relative capabilities. Since 1800, CO_2 concentrations in the Earth's atmosphere have increased from 280 ppm to over 418 ppm. Analyzes of CO_2 concentrations within the Antarctic and Arctic ice sheets since 1957 have shown that the accumulation of this greenhouse gas has recently become increasingly rapid, with direct measurements of CO_2 concentrations in the atmosphere. The increase coincides with the industrialization of human society and has evidence to show that it is due to CO_2 emissions from human activities. The most important contribution to the recent increase in the global atmospheric CO_2 stock is the burning of fossil fuels (eg in power plants) and intense deforestation, especially in the tropics. Carbon dioxide, along with a number of other gases in lower concentrations (called 'trace gases' such as methane (CH_4) and nitrous oxide (N_2O) traps the thermal radiation emitted from the Earth's surface, thus causing the Earth's atmosphere to warmt up. This warming (known as the "greenhouse effect"), increased by the accumulation of these gases especially in the 19th and 20th centuries, led to a global average increase in surface temperature of about 0.6 °C. Projections based on the ongoing trajectory of CO_2 emissions have shown that the global average surface temperature could increase between 1.4 and 5.8 °C over the next 100 years. Paleoclimatic data show that temperature changes of this magnitude occurred before, but the rate at which the change took place persisted for at least the last 10,000 years. In addition, large changes in precipitation, cloudiness and moisture distribution and density are expected to occur. While such changes cause direct and indirect problems for human societies, their emergence rates pose a threat to the balance of natural ecosystems (Read et al., 2001).

The increasing recognition of the scale of the problems posed by global climate change has prompted scientists and policymakers to consider approaches to reduce the warming trend. Given that the increased atmospheric CO_2 concentration will be the main driver of climate change, emphasis has been placed on the possibility of reducing CO_2 and other greenhouse gas emissions on the one hand, or removing greenhouse gas emissions on the other. Obviously, care should be taken to restrict both activities, as the use of fossil fuels and various land use and land cover change, particularly deforestation, have been identified as major anthropogenic sources of

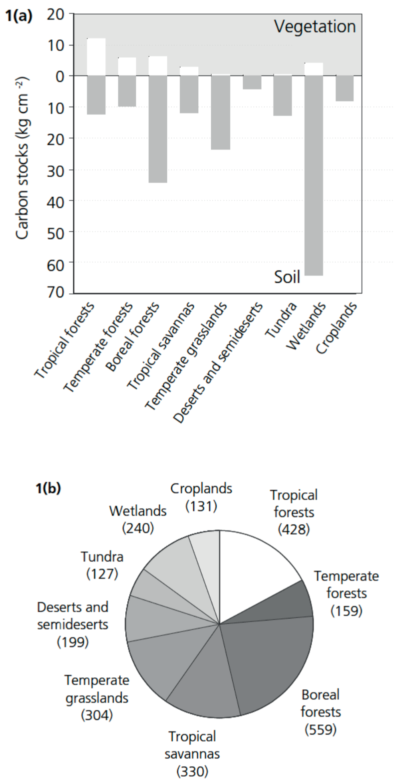
CO_2. Today, energy production and use, which contributes about 75% of global anthropogenic CO_2 emissions, is at the center of economic development, and policies designed to achieve reduction in this area are met with great resistance. The most affordable and the least costly of carbon sinks is the development of natural "carbon sinks" for CO_2 on land and oceans. It is necessary to develop a number of mechanisms to ensure that greenhouse gas is absorbed more into biological systems in land and oceans. The most important mechanism for this uptake in both terrestrial and aquatic environments is the photosynthesis process in which CO_2 is first converted into sugars and then into structural plant polymers such as cellulose and lignin. This type of fixation is essentially a temporary solution, as almost all these carbons eventually return to the atmosphere during the respiration process. However, the period of carbon sequestration (i.e. uptake and storage) allows the longest possible retention times to be achieved with the choice of product and management regimes. Therefore, forests, where most of the fixed carbon is held in wood and soil organic matter for centuries, are natural candidates for possible improvements to black carbon sinks (Read et al., 2001).

The requirement to regulate forests and agricultural lands to reduce CO_2 emissions was stated in the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The Kyoto Protocol in 1997 did not endorse the idea that governments should use policies to improve the sink capacity of terrestrial areas, and develop ways of using soils to reduce their natural carbon sink capacities as well as emissions from fossil fuel consumption. While acknowledging that the oceans are a potential sink for CO_2, the Kyoto Protocol focused on terrestrial sinks rather than the ocean basin. Because the fact that the ownership and sovereignty issues are very difficult to solve in the first case and terrestrial carbon sinks can be developed more easily will also encourage clean development in less developed countries. Suggestions to increase the CO_2 uptake of the ocean through fertilization with nutrients, including iron, to increase the density of photosynthesizing phytoplankton in the seas are highly speculative, and recent modeling and observations show that carbon fixed in this way is rapidly recycled (Read D. et al., 2001).

2.2.1. Global carbon stocks

Globally, vegetation contains 550 + 100 petagrams of carbon (PgC), soils contain much more 1,750 + 250 PgC. Soils and vegetation together contain about three times more carbon than the atmosphere (760 PgC). While most of the plant carbon is found in forests, especially in the tropics, most of the soil carbon occurs in both forests and grasslands in northern high and temperate latitudes. The ratio of soil carbon to vegetation carbon is about 5 in boreal forests, but less than 1 in most tropical forests (Figure 1).

Figure 1: Carbon stocks in soil and vegetation: a) Carbon mass stored in soil and vegetation per square meter (kgC m^{-2}) for different terrestrial systems; b) Relative percentage of carbon calculated by multiplying the carbon stock by the total area of the terrestrial system in different terrestrial systems (Numbers in parentheses are an estimate of the total global carbon stock in PgC).



Resource: Read D. et al., 2001

2.2.2. Annual carbon change with atmosphere

All atmospheric CO_2 is actively converted between soil and atmosphere to be replaced with a time scale of about 10 years. Carbon is removed from the atmosphere by plants during photosynthesis (about 120 $PgCy^{-1}$). Plant respiration (about 60 $PgCy^{-1}$) is returned to the atmosphere by decomposition of organic matter by decomposers in the soil (about 55 $PgCy\text{-}^{1}$) and natural and man-made fires (about 4 $PgCy^{-1}$). Similar fluxes occur between the oceans and the atmosphere (Read et al., 2001).

2.2.3. Current changes in the carbon cycle

Small imbalances between these fluxes can result in net absorption or carbon emissions by soil of comparable size to existing fossil fuel emissions (estimated at 6,4 + 0,4 $PgCy^{-1}$). Carbon budget constraints (i.e. considering various carbon sources and sinks) indicate that the average net carbon sequestration by vegetation and soil was 1,5 + 0,7 $PgCy^{-1}$ by the 1990s. Although vegetation and soil are absorbing 3,2 PgCy-1, about 1,7 $PgCy^{-1}$ is released back due to deforestation, hence net uptake of around 1,5 $PgCy^{-1}$). This net carbon sequestration represents about 23% of emissions from fossil fuels. Therefore, the global terrestrial carbon sink is an important component of the current carbon budget. Unfortunately, it is difficult to partially measure the size and location of the terrestrial carbon reserve. Because it differs significantly from year to year. These annual changes are primarily due to climate anomalies such as El Niño events or large volcanic eruptions (Read et al., 2001).

3. SINK MECHANISM IN THE OCEANS

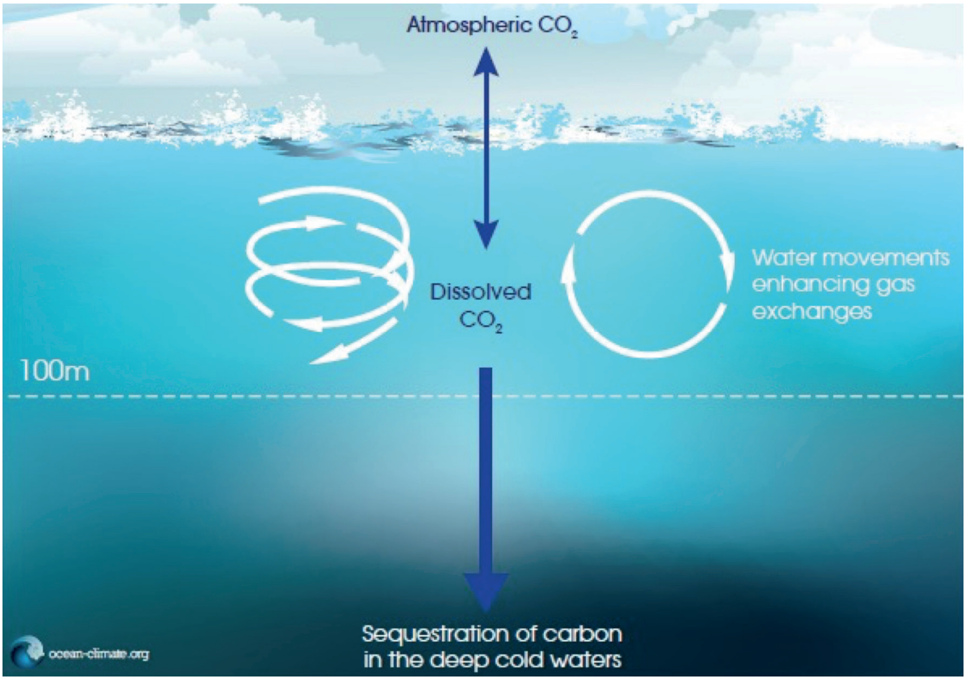
A carbon sink is a natural or artificial reservoir that absorbs and stores atmospheric carbon by physical and biological mechanisms. Coal, oil, natural gases, methane hydrate and limestone, carbon are examples of these sinks. After long processes and under certain conditions, carbon has been stored in these sinks for thousands of years. On the contrary, the use of these fossil resources re-injects the carbon they carry into the atmosphere. Today, other carbon sinks come into play, such as humus-storing soils (such as peat), some plant growing environments (such as creating forests), and of course some biological and physical processes in the marine environment (Bussi-Copin et al., 2016).

These processes make up the well-known "ocean carbon pump". This pump consists of two parts. The first is a biological pump that transfers surface carbon through the food web to the seabed (where it is stored over the long term), the other is a physical pump originating from the ocean circulation (Figures 2 and 3). In the Arctic Regions, denser water moves towards the deep sea carrying dissolved carbon. In fact, at high latitudes, water stores CO_2 more readily because lower temperatures facilitate atmospheric CO_2 dissolution (hence the importance of the Polar Regions in the carbon cycle). It is difficult to determine the amount of carbon stored by these mechanisms, but it is estimated that 50 times more carbon is concentrated in the atmosphere than in the atmosphere (Figure 2). For some scientists, the deep seas and water column may be the largest carbon sink on Earth, but its large-scale structure is still unknown. Also, with ocean acidification, this process can become less efficient due to the lack of available carbonates (Bussi-Copin et al., 2016).

The concept of time is very important in carbon storage. The biological pump is sensitive to parasites. As a result, it can be destabilized and re-emit carbon into the atmosphere. The physical pump acts at another time scale and is less susceptible to disturbances in the atmospheric and oceanic cycle, but is affected in the long run. Once the machine is activated, it is difficult to stop. Carbon transferred to the deep sea due to ocean circulation is temporarily removed from the surface loop, but this process is measured rather poorly.

The biological pump is actually easier to evaluate. Biological pump is associated with the health of ecosystems. For example, plankton play an important role in open seas. All organic materials that reach the bottom are added to the biological pump and also participate in oil formation when conditions permit. Calcium-containing materials such as cocolytichosphorus, such as a microscopic unicellular alga, are involved in removing carbon from the natural cycle. When they die, they produce a vertical net stream of carbon. This carbon is then stored in the deep sea for geological periods (Figure 3). These processes leave residual in the sediments they create. For example, chalk cliffs are the accumulation of cocolithores (micro algae with a crust made of limestone) on the ocean floor, which later reached the sea surface due to geological movement (Bussi-Copin et al., 2016).

Figure 2: Physical carbon pump

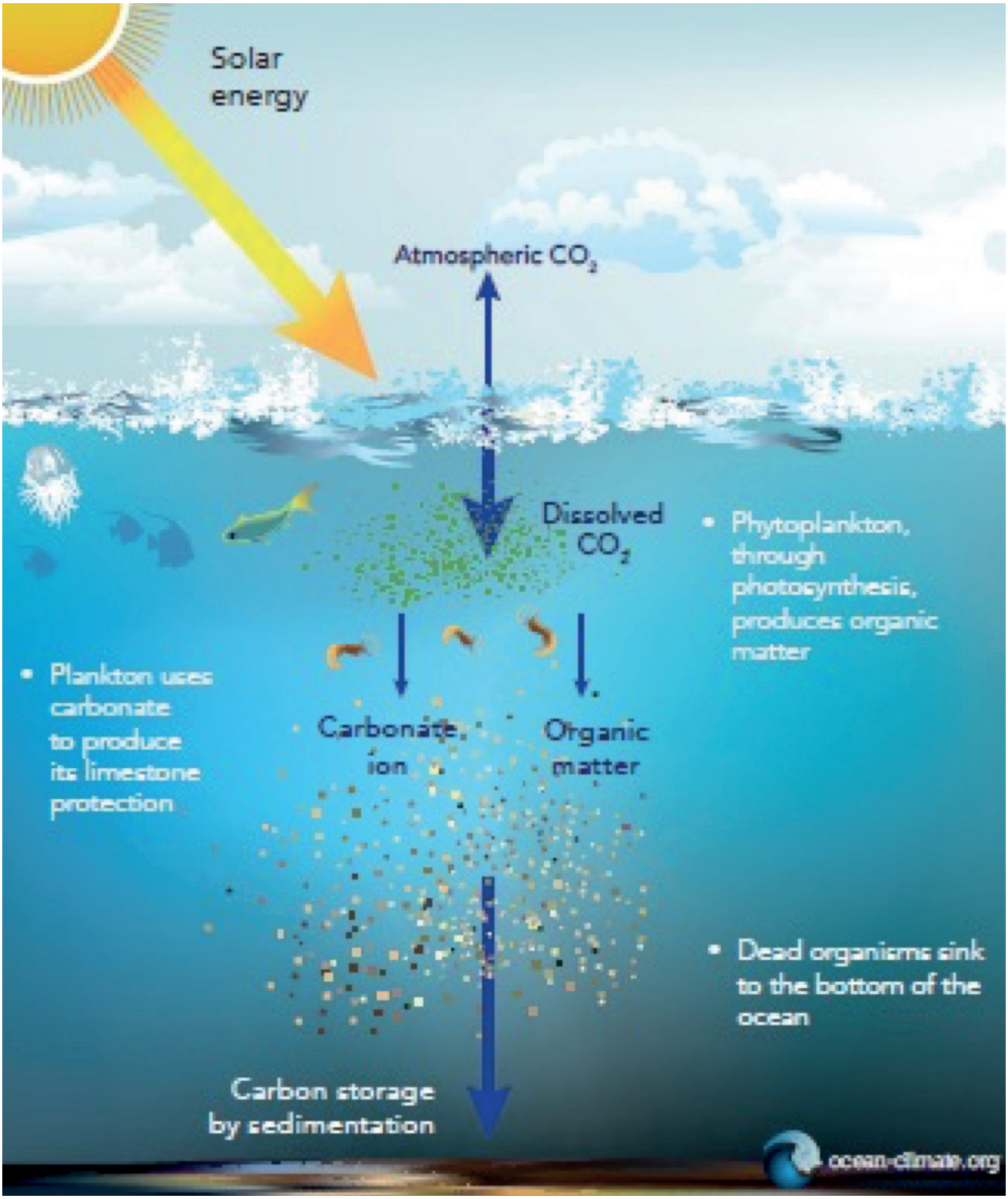


Kaynak: Bussi-Copin vd 2016.

Healthy coastal ecosystems play a mitigating role against climate change, especially by sequestering carbon. For example, mangroves, sea grasslands, and salt marshes are important carbon sinks. These three samples store at least ten times more carbon than forests when they thrive by retaining carbon in their calcium skeleton. However, these coastal ecosystems cover very little surface on a global scale. In addition, these ecosystems are weakened by coastal urbanization and economic activities. Ecosystem restoration requires continued priority and ambitious policies to improve the storage of excess carbon released into the atmosphere (Bussi-Copin et al., 2016).

To combat climate change, geoengineering techniques are being developed to artificially store CO_2 in ocean carbon sinks. Scientists are concerned about these techniques as the negative consequences of potential imbalance have not yet been investigated. However, the concept of carbon sink is very controversial. The carbon cycle is highly complex as it relates to other cycles that support global warming. As a result, storing CO_2 also releases water vapor, which plays an important role in the greenhouse effect. In addition, due to the increase in greenhouse gas concentration, the water temperature and acidity are also changing. This alters the physical, chemical and biological balances and can affect the ocean pump. All these data make people think about the future of marine ecosystems. This uncertainty should encourage us to be more careful and protect marine ecosystems (Bussi-Copin et al., 2016).

Figure 3: Biological carbon pump



Resource: Bussi-Copin et al., 2016.

4. HUMAN IMPACT ON THE CARBON CYCLE

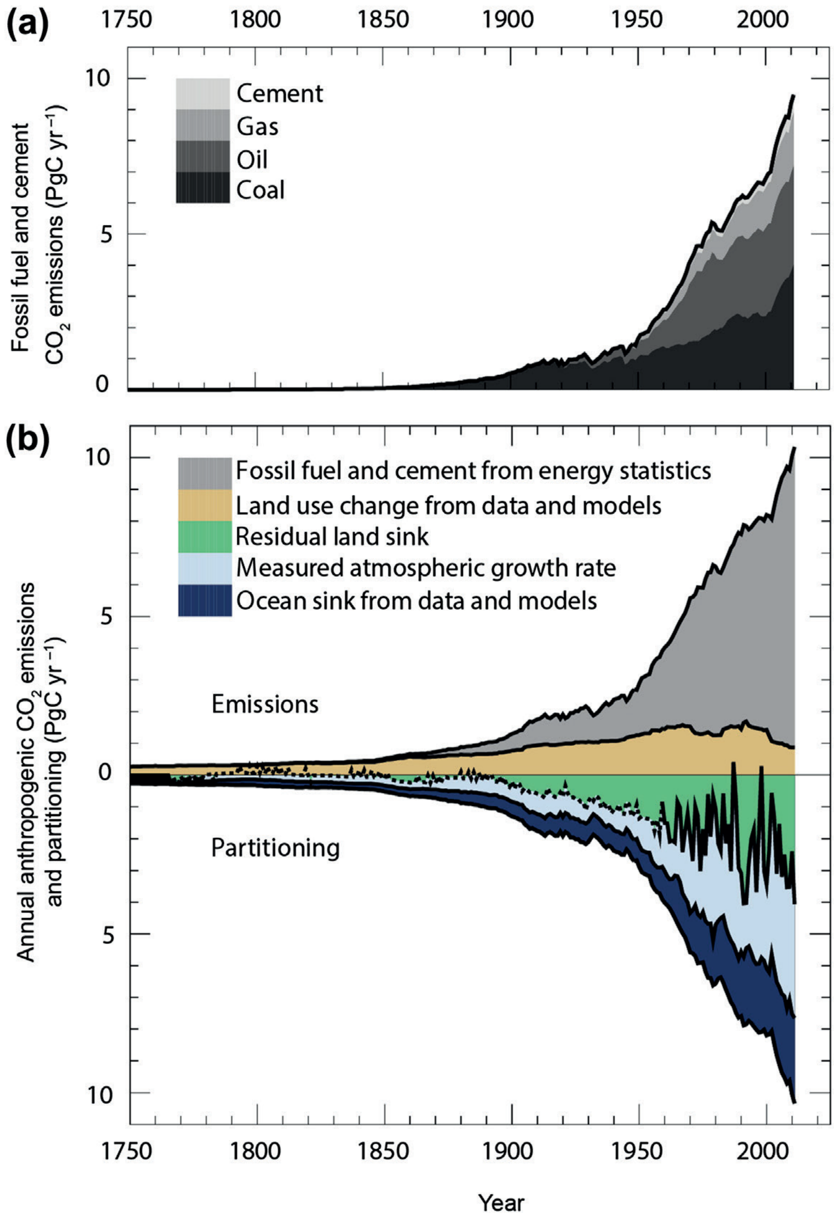
Humans have released large amounts of CO_2 into the atmospheric carbon reserve by burning fossil fuels from previously stored carbon. Since CO_2 contains carbon, its release into the atmosphere also has implications for the global carbon cycle (Hannah L., 2015).

Since the Industrial Revolution, burning fossil fuels has added about 330 billion metric tons (330 Pg) of carbon to the Earth's atmosphere. Land use changes, mostly deforestation and burning, added about 158 million metric tons (158 Pg) over the same period. CO_2 from land use change outside the tropics was significant until about 2000, but since then almost all land-use change emissions have come from the tropics (Hannah L., 2015).

The current fossil fuel emissions are 8.4 billion metric tons (8.4 Pg) of carbon added to the atmosphere each year. Land use add 1,5 billion metric tons (1,5 Pg) more, ensuring that the annual CO_2 emissions reach to about 10 billion metric tons of annually (9,9 Pg) Total emissions are increasing by about half a billion metric tons per year and have increased by 35% since 1990 (Hannah L., 2015).

Where does all this CO_2 go? The atmosphere contains about 45% of the emissions released by human (Figure 4). Ocean and terrestrial carbon reserves each hold about a quarter of carbon (30% in land sinks and 24% in ocean sinks).

Figure 4: Annual CO_2 emissions partitioned in the carbon cycle Annual CO_2 emissions from fossil fuel use and land use change (upper half of panel b) are balanced by partitioning into atmosphere, ocean and land reserves (lower half of panel b). Panel a shows the distribution of fossil fuel emissions by source type.



Resource: Hannah L., 2015

While these carbon additions have huge implications for climate change, their quantities are not large in terms of natural carbon reserves and fluxes. Annual human emissions of about 10 Pg of carbon are 10% less than the annual terrestrial or ocean carbon exchange with the atmosphere and 5% less than the composition of terrestrial and ocean fluxes. The total cumulative human emission of 330 Pg total since the Industrial Revolution is small compared to Earth's large carbon reserves, especially that of the deep ocean containing 3700 Pg of carbon alone. The soils contain 2300 Pg of carbon. Cumulative human emissions amount to 1% of the total global combined atmospheric, oceanic and terrestrial carbon reserves (Hannah L., 2015).

However, human emissions are large in relation to atmospheric reserves and the carbon released affects the climate. The total cumulative human emission of 330 Pg is almost half of the total atmospheric carbon pool (over 800 Pg of carbon). Since approximately 45% of human emissions remain in the atmosphere, the total amount of carbon remaining in the atmosphere is approximately 150 Pg of carbon. This value is about 20% of the atmospheric carbon pool (Hannah L., 2015).

When human-made CO_2 is added to the atmosphere, the flows, reserves and pumps of the carbon cycle are activated. The increased CO_2 in the atmosphere dissolves in ocean waters, where it is removed from the surface by surface mixing and transported to depths by thermohaline circulation created by the difference in dissolved salt concentration between deep water and surface waters (Hannah L., 2015).

The solubility pump transports CO_2 dissolved in surface water to the deep parts of the oceans. As the levels of CO_2 in the atmosphere rise under human influence, more CO_2 dissolves in seawater and more dissolved CO_2 is transported deeper by the solubility pump. The solubility pump is an important short-term sink mechanism for human-induced CO_2 emission, although this unit, which lasts for hundreds or thousands of years in deep seas in the tropics, will eventually release CO_2 back to the surface (Hannah L., 2015).

On the other hand, the biological pump does not play a strong role in modulating the CO_2 released from human sources into the atmosphere. This is because CO_2 is not a limiting factor for photosynthesis in the oceans. As a result, higher CO_2 from man does not alter ocean photosynthesis rates and does not affect the speed of the biological pump (Hannah L., 2015).

CO_2 remaining in the atmosphere, stimulates photosynthesis in plants and increases the terrestrial carbon sequestration. Since CO_2 is an essential input for photosynthesis, increasing CO_2 concentrations in the atmosphere accelerates photosynthetic reactions. As cool, high latitude regions warm-up, photosynthesis increases due to the accelerating effect of temperature on chemical reactions. The growth of trees and other vegetation is stimulated by higher CO_2 and temperature, resulting in more carbon storage in the plants. Globally, terrestrial systems have been a large carbon sink, absorbing about a quarter of the carbon released into the atmosphere as CO_2 from burning fossil fuels.

5. RECENT TRENDS IN TERRESTRIAL SOURCES AND SINKS

Some new trends in carbon sources and sinks have important implications for how the carbon cycle responds to CO_2 input from human sources. While some regions that have been sources of carbon for the last two centuries have switched to carbon sinks, other areas have recently passed from sink to source (Hannah L., 2015).

Net primary productivity is the amount of carbon deposited in plant biomass through photosynthesis. Increasing net primary productivity areas are carbon storage and carbon sinks. Areas where net primary productivity has decreased are emitting carbon and are the sources of carbon (Hannah L., 2015).

The drought experienced in large areas causes areas that were previously sinks to turn into resource areas. As the drought continues, the plants' utility water decreases in photosynthesis and the net primary productivity decreases. This is happening in large areas in South America, Australia, South Africa and Southeast Asia. Amazon in particular is transforming from a carbon reserve into a carbon source. Overall, net primary productivity declined over 70% of the land area between 2000 and 2009 in the entire Southern Hemisphere (Hannah L., 2015).

However, in the Northern Hemisphere, forests are growing again in areas previously cleared for agriculture, resulting in increased net primary productivity. Net primary productivity increased at 65% of vegetation cover in the Northern Hemisphere. In high-latitude forests whose growth was formerly restricted by cold, net primary productivity increases as the climates are warm. These northern carbon sinks become ineffective by Southern Hemisphere systems such as Amazon, where terrestrial systems are a net source of CO_2, which turns into a source of emissions from the sink (Hannah L., 2015).

6. CARBON CYCLE AND CARBON SEQUESTRATION

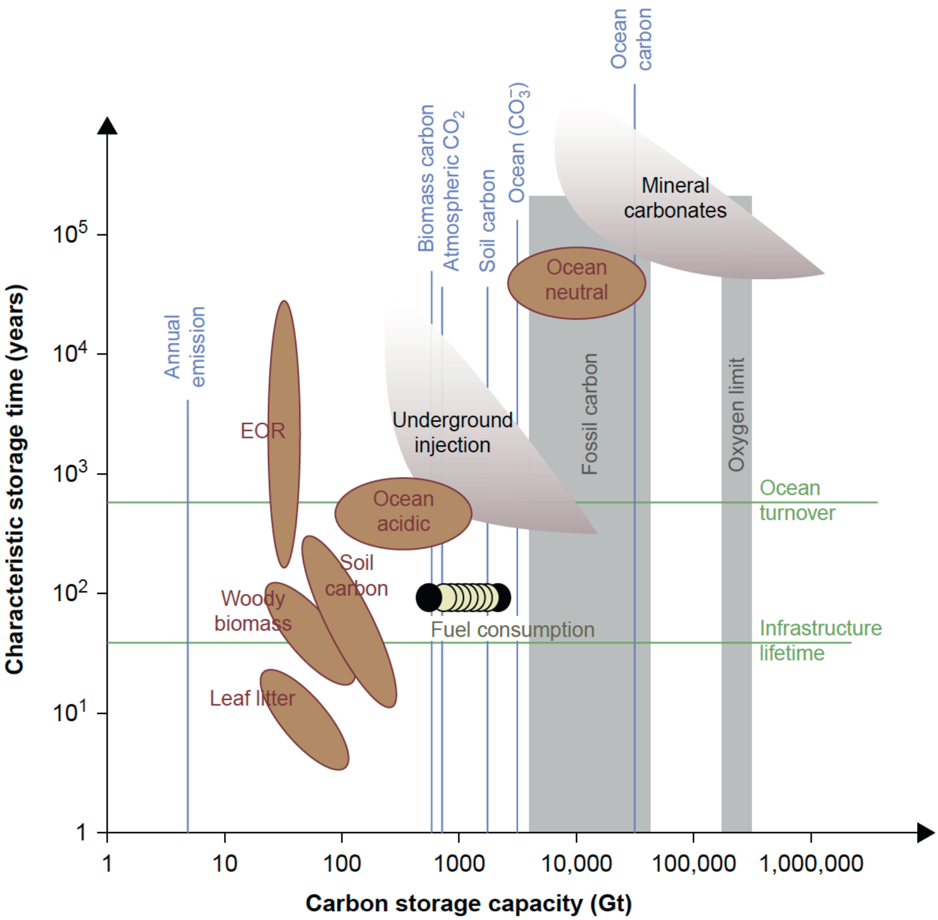
Transporting CO_2 from the atmosphere to terrestrial or ocean carbon reserves will reduce the impact of global climate change. Ocean and terrestrial systems currently capture more than half of human-induced CO_2 emissions. Because ocean and terrestrial carbon reserves are larger structures than annual human emissions, these sinks still continue to function as carbon sequestration. The movement of atmospheric carbon towards ocean and terrestrial sinks, which reduces the negative effects of climate change, is called carbon sequestration (Hannah L., 2015).

To put an upper limit on the problem, we can first ask if people can continue to burn fossil fuels without consuming all the oxygen in the atmosphere. For millions of years, organic matter produced by photosynthesis has not been fully combined with oxygen in decomposition, but instead remains in the rocks as hydrocarbons (trees are the lungs of the planet only at geological time intervals). If all these hydrocarbons could be burned, the oxygen we trust would be consumed to breathe. Only a small percentage of geological hydrocarbons are in forms such as coal, oil or tar sands that can be used as fuel. Thus, even using optimistic estimates of global fossil-fuel reserves, it is clear that burning fossil fuels will not make the planet uninhabitable for breathing with O_2 (Hannah L., 2015).

Burning fossil fuels will not consume all the oxygen necessary for human survival. The main problem of fossil fuel use is the impact of CO_2 emissions on the global climate. One way to reduce this concern is to capture the carbon released by fossil fuel use in carbon sinks. A great indicator for carbon retention is the length of time the carbon remains in different reserves. A sink that has released carbon to the atmosphere over years or decades has little effect on mitigating the effects of climate change. But a sink that absorbs carbon for centuries plays an important role in mitigating climate change over multiple generations. Carbon returning from sinks to the atmosphere in the future may further increase the effects of climate change. However, more sophisticated involvement methods can be developed during this time. A centuries-long sinkhole is worth considering, but it should be borne in mind that it has consequences for future generations. A sink that holds carbon for thousands or tens of thousands of years is roughly equivalent to a permanent sink on human time scales (Hannah L., 2015).

Unfortunately, most carbon pools that can be readily manipulated are small or have short residence times (Figure 5). Forest carbon reserves can be increased by restoring forests. However, global carbon in forests is only about 300 Pg, or 30 years of CO_2 emissions. Once around 30% of global forest cover is removed, even the most ambitious forest sink program will only store global CO_2 emissions for a few years. The potential for sequestration of grasslands transformed from forest is even smaller, and while the restoration potential of soils is much greater, it will take decades to accumulate. While solutions that include these terrestrial reserves can provide short-term sequestration, longer-term options are needed to mitigate climate change (Hannah L., 2015).

Figure 5: Carbon sequestration storage options–capacity and longevity. (On log scales, capacity and storage time are plotted for each option. For example, CO_2 injections into used oil wells have low capacity but moderate and variable storage time. Biomass and soil carbon has low capacity and short residence times (fast carbon cycle), so they are part of short-term solutions, but must be combined with long-term solutions with residence times specific to the geological carbon cycle. Ocean acidic liquid is the deep injection of CO_2 into ocean bottom waters. Changing fossil fuel consumption, total fossil fuel reservoirs (including oil sands and shales) and total oxygen content of the atmosphere (oxygen limit for fossil fuel burning) are shown for comparison.)



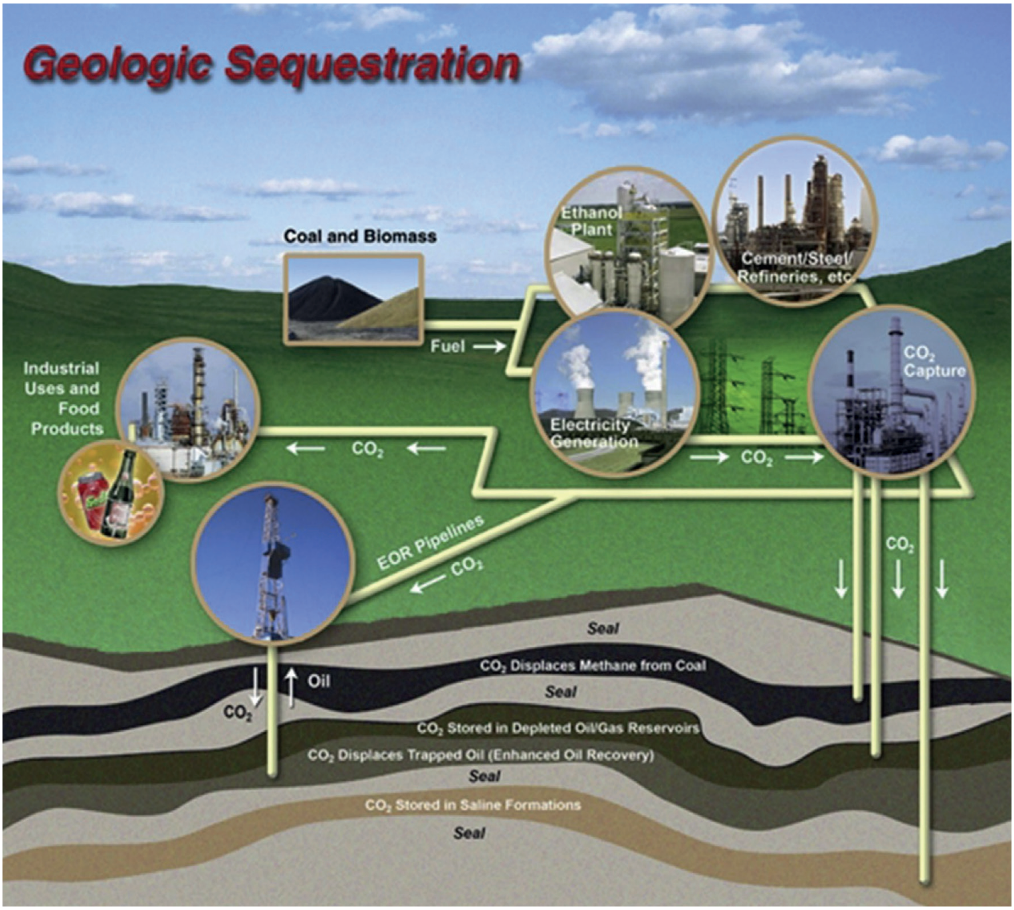
Kaynak: Hannah L., (2015)

One option for longer storage is to get the biological pump ready in the oceans. Photosynthesis is limited in the southern oceans by iron. Therefore, the fertilization of surface waters with iron causes algae to bloom. As the algae die, their bodies will join the rain of debris from the biological pump, transporting CO_2 from surface seawater to the deep ocean slow carbon cycle, where it will be captured for hundreds or thousands of years. However, experiments with iron fertilization have shown it to have lower yields than the theory predicts. Other environmental problems are likely to occur as thousands of square kilometers of natural marine networks are intervened (Hannah L., 2015).

If biological solutions are too risky or short-lived, are there physical ways to move carbon into long-term reserves? CO_2 becomes liquid at the high pressures prevailing in the deep oceans, so one proposal has been to capture CO_2 emissions by different mechanisms and inject it into deep oceans at high pressure. Again, the impacts on ocean ecology are alarming. CO_2 from deep ocean fluid reservoirs will enter the thermohaline circulation and eventually be transported back to the surface. But more importantly, it will change ocean pH and chemistry in an unknown way for organisms living in deep oceans (Hannah L., 2015).

Geological capture in the field can be more promising (Figure 6). By injecting CO_2 into underground formations in advanced oil recovery operations, underground injection and containment is proving possible. There are large underground geological formations capable of retaining CO_2 (such as salt domes) or neutralizing CO_2 (such as carbonates or bicarbonates). However, the capacity of salt domes and saline aquifers is limited and neutralization requires additional costs (Hannah L., 2015).

Şekil 6: Geological sequestration (CO_2 capturedat the source can be injected into an abandoned oil well or geological formations. A small amount can be used in industrial production, eliminating CO_2 production for these purposes.)



Resource: Hannah L., (2015)

One problem faced by all geological retention options is the recapturing of CO_2 released into the atmosphere. CO_2 can be captured at the point of emission for large facilities and sources at specific points, which is the first step in capturing and storage initiatives. However, it is not possible to capture CO_2 from small or mobile sources such as automobiles or from land use change. This leaves large amounts of emissions into the atmosphere that must be recaptured (Hannah L., 2015).

7. CO_2 RECOVERY

Once CO_2 is released into the atmosphere, it is much more difficult to capture and contain. However, it is possible by developing absorption techniques similar to those used to remove CO_2 at its source. Technologies that recover CO_2 in the atmosphere are called free air sequestration technologies FAST (Figure 7).

The biggest technical obstacle in FAST systems is carrying large amounts of air over the absorption surface. Since CO_2 concentrations are below 400 ppm, more than 2500 liters of air must be transported to decompose one liter of CO_2. Removing one ton of CO_2 from the atmosphere would require more than one million liters of air to be passed through an absorbing device. The biggest obstacle to the low cost of the process is that it is very expensive to mechanically move the volume of this air (Hannah L., 2015).

Figure 7: The designer understanding of the FAST sequence. (FAST removes CO_2 from the atmosphere. This allows past or widespread emissions to be kept. Technologies for removing and separating free atmospheric CO_2 are still under development.)

Resource: Hannah L., (2015)

FAST is under development. Some prototypes will produce a mineral product that can be stored anywhere and is relatively ineffective. Other processes recycle the adsorbent to create pure CO_2, which is then trapped in geological formations. No technology has gone beyond the prototype stage. The commercial viability of the devices is controversial and their applicability is highly dependent on the carbon price in world markets (Hannah L., 2015).

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POSSIBLE EFFECTS AND RISKS OF CLIMATE CHANGE ON NATURAL RESOURCES IN THE WORLD AND TURKEY

Prof. Dr. Ayşe Gül Tanık

1. INTRODUCTION

Water, soil, air and natural vegetation are the world's natural resources. Natural structure and resources are affected by climate change (weather events). The main natural resources are listed below.

- Water resources
- Surface water resources non-flowing waters – (lake, pond and wetlands), streams – (creeks, rivers, streams) groundwater resources, marine system)
- Soil resources
- Ecosystem services, biodiversity and forestry
- Natural disasters (landslides, floods, drought, sea level rise, etc.)

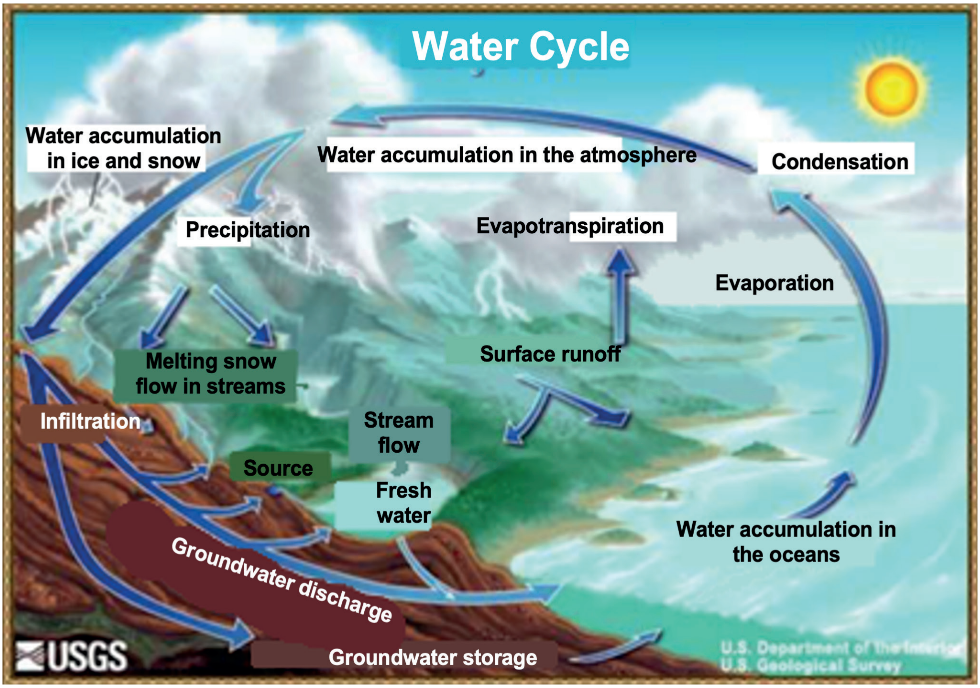
This section will be dealing with the possible effects of climate change on natural resources in the world and in Turkey.

2. POSSIBLE EFFECTS OF CLIMATE CHANGE ON NATURAL SOURCES

2.1. Important changes caused by climate change in the hydrological cycle

Figure 1 shows the natural hydrological cycle (water cycle).

Figure 1: Natural hydrological cycle (Url-1).



The changes that may occur as a result of climate change in this cycle are;

- Changes in seasonal distribution and amount of precipitation,
- Changes in average annual surface flow,
- Hydrological effects in coastal areas,

- Changes in water quality,
- Changes in groundwater,
- Effects on floods and drought,
- Effects on water temperatures,
- Changes in water demand.

The seen and expected impacts on water resources are primarily less snowfall, less glaciers, more varied precipitation patterns and more intense downpours (Karabay, 2015; Eleventh Development Plan, 2018; Climate Change and Adaptation, 2020). These changes will be briefly mentioned in the subsections.

2.1.1. Changes in Precipitation Pattern

The effects of climate change on precipitation are more complex and uncertain than expected effects in temperature. Possible changes in the amount and pattern of rainfall show regional differences all over the world. The frequency or intensity of heavy rainfall events has increased in many countries of the world. Increases in average precipitation and evaporation are expected with increases in temperature. With warming, evaporation will increase and the warmer atmosphere will hold more moisture because the temperature increase increases the evaporation rate. According to various climate model results, some regions will receive less rainfall than today, while some regions will receive more. Storage of water will become more important as extreme weather events will increase the recurrence rate of flood and drought.

2.1.2. Changes in Surface Flow

Surface flow is the water and rainwater that flows through the earth or seeps from the soil surface and is reunited with water formations on the surface. Changes in surface flow are mainly due to changes in temperature and precipitation, among other variables. According to the report of the European Environment Agency (EEA) published in 2017; significant seasonal changes in river flows in Europe are expected as a result of climate change (EEA, 2017). It is expected that in many regions of Europe, including the regions where annual flows are expected to increase, summer flows will decrease, snowfalls will be replaced by rain, and the dates of peak flows in spring and summer flows will shift further.

2.1.3. Hydrological Effects in Coastal Areas

One of the main effects of climate change observed is the increase in global sea level. In the 3rd Assessment Report of the IPCC, significant impacts of sea level rise on water users in coastal areas were identified (IPCC, 2001). These are:

- Flooding of the lowland and the displacement of wetlands,
- Changing tidal distances in rivers and gulfs,
- Changes in sedimentation pattern,
- More intense storms causing floods,
- Increase in seawater inflow to estuaries and freshwater aquifers,
- An increase in wind and rain damage in areas prone to tropical cyclones.

2.1.4. Changes in Water Quality

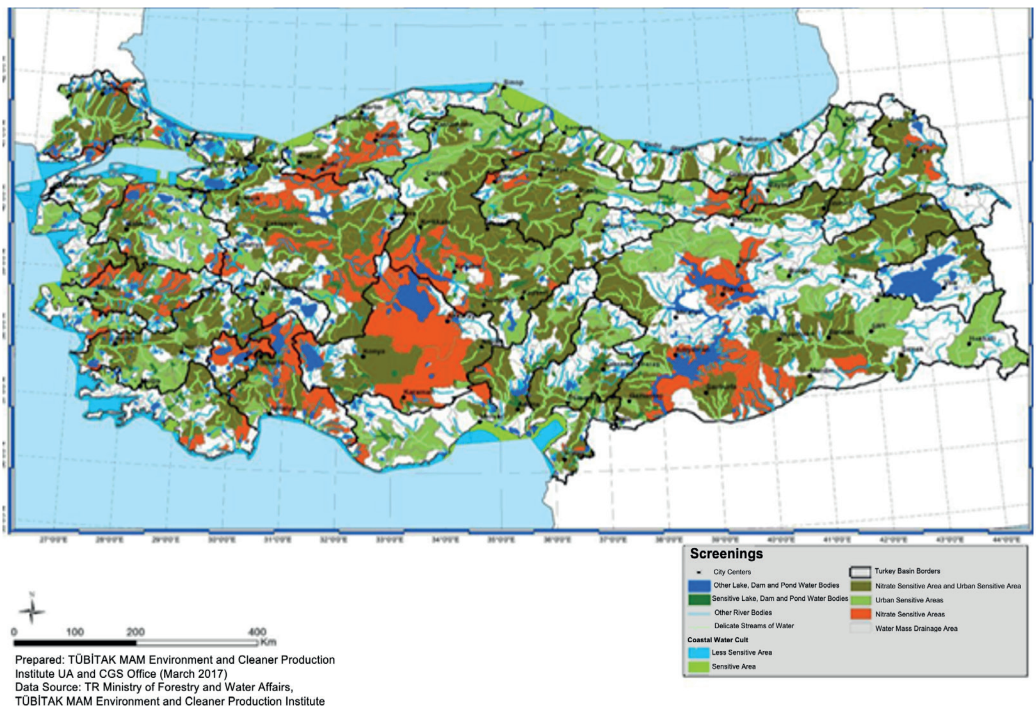
Water quality is directly dependent on many factors such as changes in the amount of water, changes in water temperatures, and the increase in pollution load due to migration. Water quality is expected to be adversely affected in many areas as a result of climate change.

Determining the effects of climate change on water quality is very important in terms of determining policies on ecology, species diversity, human health, agriculture, industry, drinking water, recreation and insurance sector. Decrease in stream flows and decrease in water levels in lakes cause degradation of water quality due to the presence of nutrients and pollutants in less volumes of water. Increase in water temperatures directly affects water quality by reducing the amount of dissolved oxygen.

A long-lasting drought causes pollutants to accumulate on the soil surface, causing a risk to the quality of water resources when rainfall begins. Another extreme event is that rainfall intensely transports sediments and dispersed pollutant sources to streambeds. Floods, in particular sewage floods, increase the risk of degradation of agricultural areas, urban surface flows and quality of water resources.

Figure 2 gives the Map of Turkey's Sensitive Water Bodies, Urban Sensitive Areas and Nitrate Sensitive Areas. As can be seen from this map, many areas in our country have urban characteristics. As it is still an agricultural country, it is also rich in nitrate sensitive areas. Therefore, domestic and agricultural pollutants cause possible changes in water quality. With the effect of climate change, this possibility and the risk of pollution will increase even more.

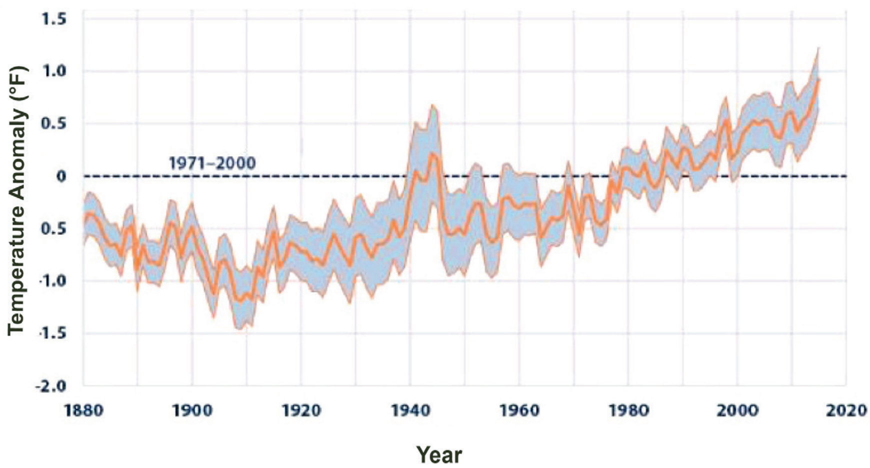
Figure 2: Map of Turkey's sensitive water bodies, sensitive urban areas and nitrate sensitive areas (TUBITAK-MAM, 2017).



2.1.5. The Effect of Climate Change on Water Temperature

Climate change affects water temperatures like other water quality parameters. The sea surface temperature has increased in the 20th century and continues to rise. From 1901 to 2015, the temperature rose at an average rate of 0.07°C over ten years.

Figure 3: Sea surface temperature (Climate Change and Adaptation, 2020).

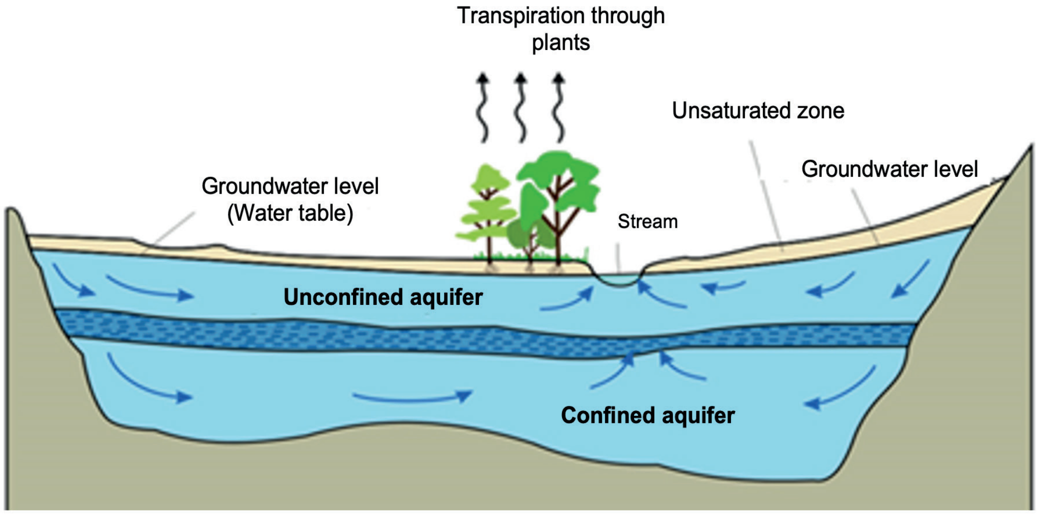


The water temperature in Europe's major rivers increased 1-3°C compared to the last century. It shows that lake and river temperatures have increased across Europe since the early 1900s. Lake and river surface temperatures will increase with projected increases in air temperature. Increasing water temperature may cause significant changes in the diversity of species and the function of aquatic ecosystems (Gönençgil, 2017).

2.1.6. Changes in Groundwater

Groundwater is the main water resource for irrigation, potable and industrial water supply in most regions of the world. "Groundwater level" or "groundwater table" is called the surface between two zones where atmospheric pressure and water pressure are equal. The geological formations whose pores are filled with groundwater and that allow the movement of this water are called aquifers. Figure 4 shows the surrounded and unconfined aquifer view over the soil section.

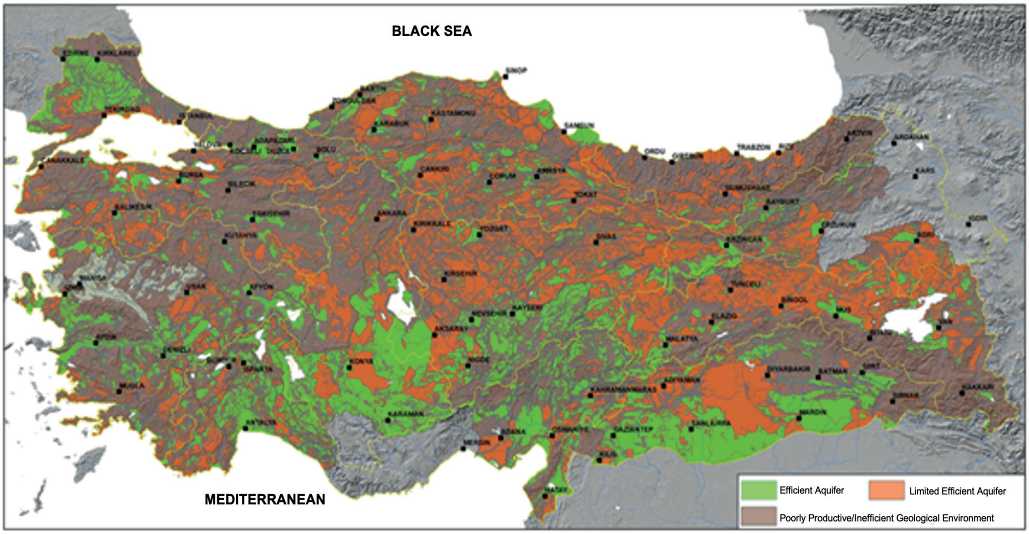
Figure 4: Cross section of aquifer (Url-2)



The flow and groundwater impact of climate change changes regionally, and this change is mostly affected by predicted changes in precipitation, depending on climate scenarios. Groundwater is an important source of freshwater, especially for arid and semi-arid regions. However, there are few studies on the effects of climate change on these resources. Rising sea level can cause seawater intrusion into islands and coastal aquifers. The change in precipitation causes change in CO_2 concentration with dilution in rocks. Therefore, the formation and development of karstic groundwater aquifers are affected.

Figure 5 gives the 1/500 000 scale hydrogeological map of Turkey. This map shows the yield conditions in our country's aquifers.

Figure 5: Turkey 1/500 000 scale hydrogeological map (Karşılı, 2011)



2.2. The Impact of Climate Change on Floods

In the 4thAssessment Report of the IPCC, it is stated that excessive rainfall will increase the frequency and severity of flood events in the coming years, as well as the deterioration in water quality, pollution of water resources, and loss of life and property with impacts such as water scarcity (IPCC, 2007). It is also stated that by 2080, 20% of the world's population will live in basins where flood damage has increased due to the effect of climate change, and floods with 100-year frequency will be experienced much more frequently. Although there is no consistency in the numbers determined in studies on the amount of this frequency, it is stated in all studies that an increase will occur. From records collected since 1950 in many parts of the world, concrete evidence is provided that extreme weather events have increased significantly in statistical terms. Insurance payments caused by severe weather events have increased 20 times in the last 30 years (Kadıoğlu, 2012). Figure 6 shows the images of flood disasters that took place in the Black Sea Region in 2005 and 2016 in our country.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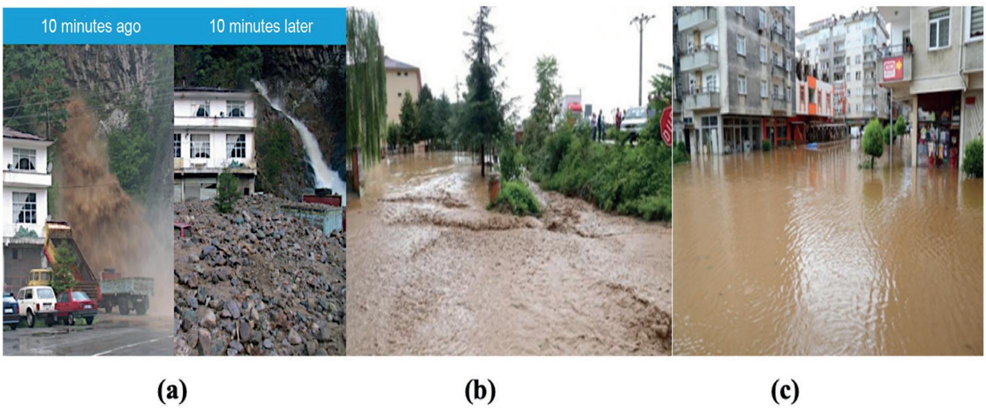
NAVAL

2.3. The Impact of Climate Change on Drought

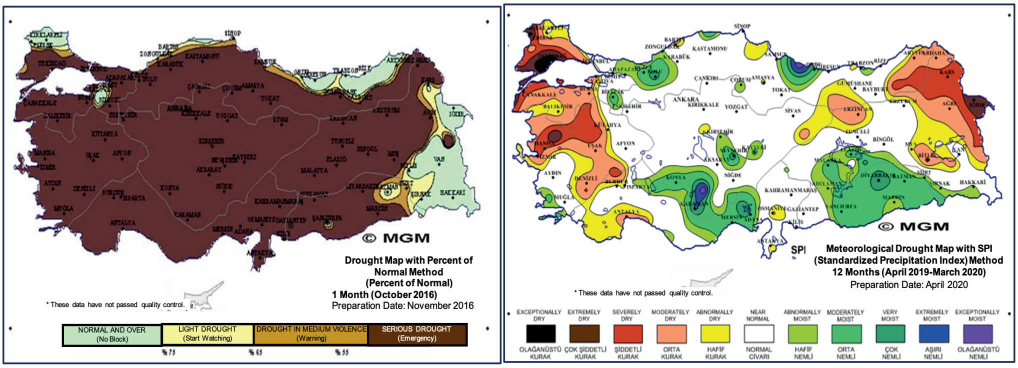
One of the most important effects of climate change is drought and water scarcity events. The short-term effect of drought is a reduction in the amount of available water. As the demand for water increases as a result of human needs, the decrease in the amount of water causes shortage pressure for people and ecological systems. In the long-term, excessive consumption of groundwater resources and reservoirs will cause the situation to be unable to meet the consumption, the situation will worsen with the effect of the new drought periods and the emergence of water shortage.

Figure 6: (a) August 2005 Rize-Çamlıhemşin, (b) and (c) 01 September 2016 Arhavi flood, overflow, mass movement disaster



Hydro-meteorological disasters, including drought, have been occurring with increasing intensity, frequency and time, especially in recent years. Since 1980, there has been a continuous and significant increase in the number of large-scale natural disasters with hydro-meteorological character, which are called "catastrophic", due to global climate change in the world. In Figure 7, drought maps of our country prepared by (a) percentage of normal method and (b) SPI method are shown.

Figure 7: (a) Percentage of normal method, (b) meteorological drought map with SPI method (MGM, 2020)



(a) (b)

In our country, it is expected that the effects of drought will increase with the effects of climate change. The IPCC report, as well as a number of national and international scientific model studies conducted indicate that Turkey will have more heat, more drought and a more uncertain climate structure in terms of precipitation in the near future. According to the initial estimates made with global climate models, in 2030, a big part of Turkey will become quite dry and be under the effects of a warmer climate. Whereas rainfall shows a slight increase in winter, it is estimated that it will decrease by 5-15% in summer; and that the soil moisture will decrease by 15-25% during the summer months. Drought is a recurring feature of the European climate. In the period 2006-2010, an average of 15% of the European region and an average of 17% of its population were affected by meteorological drought each year.

2.4. Changes in Water Demand

The decrease in the amount of water and drought due to climate change can have serious consequences in many sectors including drinking water, agriculture, energy and forestry. Activities such as drinking water demand, irrigation, hydroelectric power generation, industry, cooling water use etc. that require large amounts of water withdrawal, will be affected by changing flow regimes and decreasing annual water volumes. In many regions, there may be an increase in the irrigated area and water withdrawal for irrigation. Wetlands and aquatic ecosystems will also be damaged depending on the goods and services they provide. The water resources map of our country is given in Figure 8.

Since the decrease in snowfall during the winter months will cause less water storage, the hydroelectrical potential may also be affected. Dam safety may also be affected by changing climatic conditions and more frequent over currents. The reduced raw water quality will also affect sectors that need high water quality, such as water-related recreational activities. In the worst case, public health may be adversely affected.

Figure 8: Our Water Resources (Url-3)

2.5. Hydro-meteorological disasters and risks

There has been a significant increase in the occurrence numbers of meteorological, climatic and hydrological disasters associated with global climate change. Atmospheric conditions caused 91% of major natural disasters. In Europe, severe weather and climatic conditions such as floods, storms, drought and heatwaves are directly responsible for 64% of disasters since 1980. The average annual number of disaster-related events caused by weather and climatic conditions in Europe doubled in the 1990s compared to the previous decade, whereas the number of non-climatic disasters such as earthquakes remained the same. In Figure 9, the types and percent distribution of natural disasters seen in the world between 1980-2010 are shown, and Figure 10 shows some images of natural disasters from our country.

Figure 9: Types and percent distribution of natural disasters in the world between 1980 and 2010 (Climate Change and Adaptation, 2020)

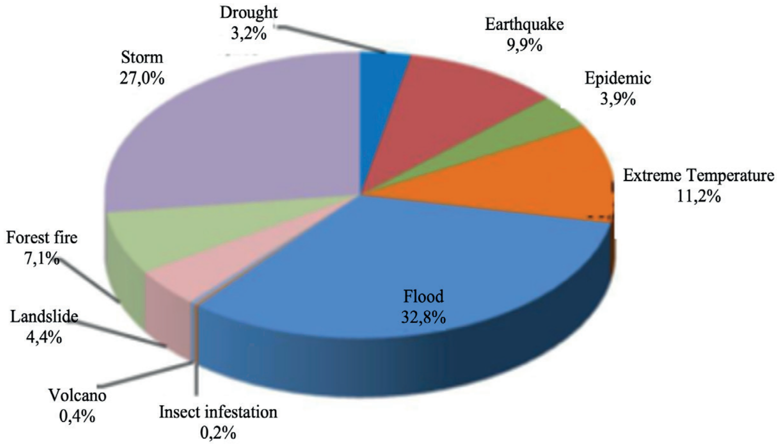


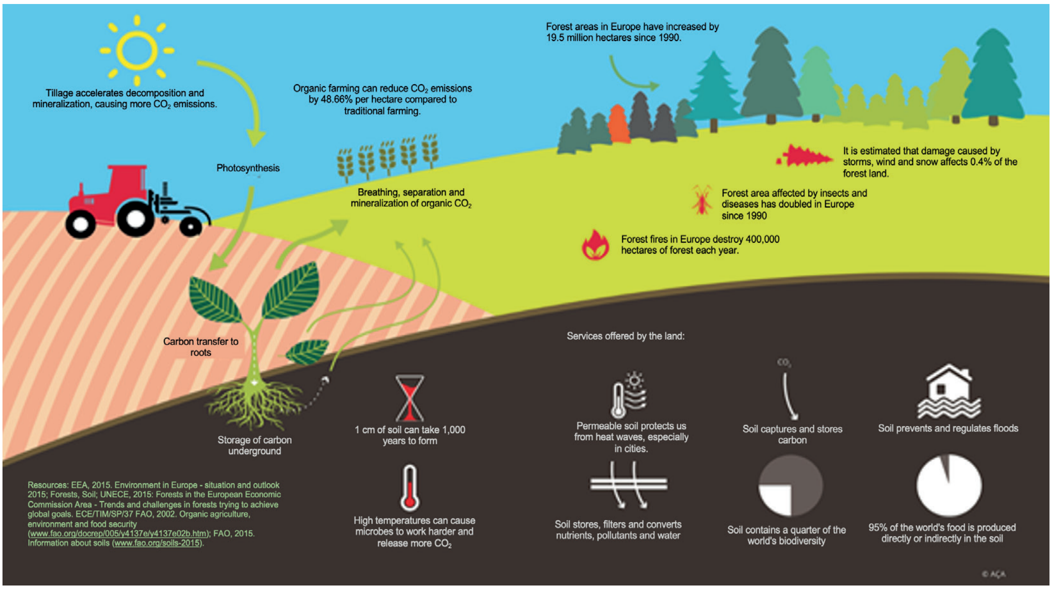
Figure 10: Some images of natural disasters in Turkey

2.6. Climate change impacts on soil

Soil is an important and often neglected element in the climate system. It is the second largest carbon store or "sink" after the oceans. Re-rehabilitating key ecosystems on the soil and sustainable use of land in urban and rural areas can help mitigate and adapt to climate change.

The carbon reserve of European forests is increasing with changes in forest management and environmental changes. About half of the carbon reserve is stored in forest soils. When forests are reduced and destroyed, the stored carbon is released back into the atmosphere. Therefore, forests can contribute net carbon to the atmosphere. Figure 11 presents general information about soils.

Figure 11: Information about soils (EEA, 2015)



2.7. Effects of climate change on the ecosystem

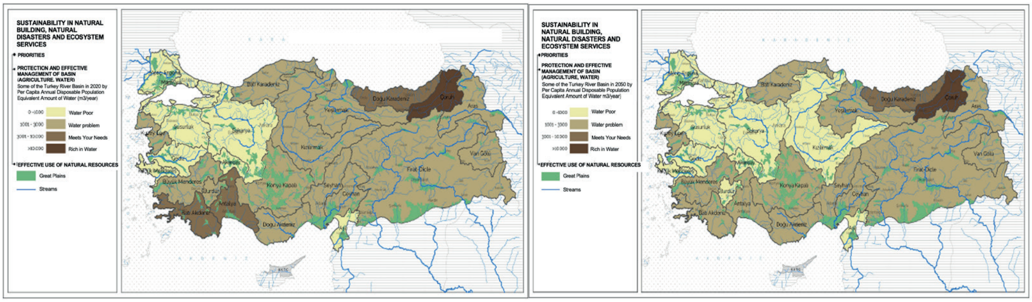
Climate change is among the top five direct factors that cause deterioration in ecosystems on a global scale. It is known that climate change directly causes the effects of other factors (land use-land cover change (LULCC), pollution, excessive use of resources and invasive species) to become stronger. Climate change increases the severity and frequency of climate-related risks (floods, forest fires and droughts), thereby degrading ecosystem services (ES) and in this case, the resistance of ecosystem systems is negatively affected, ending in failure to support climate change adaptation of the communities by becoming fragile in socio-economic terms. All ecosystem services contribute in various dimensions in terms of adaptation to climate change.

Global climate regulation and local climate regulation services are important on a global and local scale in climate change mitigation and adaptation in relation to the capture and storage of atmospheric carbon. Water flow regulation and water cycle ecosystem services are important for climate change adaptation by providing services related to the hydrological functions of basins in relation to stormwater flow regulation, evapotranspiration, water filtration and groundwater storage.

Since ecosystems offer different ecosystem services such as cleaning the air, regulating water, balancing temperature or providing food and energy, they have been identified as areas that offer Critically Important Ecosystem Services (I-CIES) in terms of adaptation to climate change (MSP, 2019).

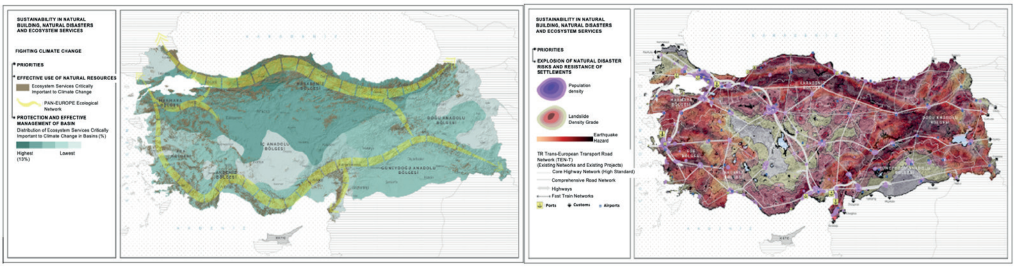
Figure 12 and Figure 13 provide examples from the synthesis maps made in 2019 in line with the spatial planning of our country. Figure 12 shows the situation in river basins based on the amount of available water per capita prepared in the light of present and 2050 projections. In Figure 13, the map showing the distribution of ecosystem services in basins and natural disaster risks is shown.

Figure 12: Impact of Climate Change on per capita water use (a) 2020, (b) 2050



(a) (b)

Figure 13: (a) Protection and Effective Management of Basins, (b) Exposing Natural Disaster Risks and Resilience of Settlements



(a) (b)

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SCENARIOS AND POSITIONS OF COUNTRIES

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

Under the Paris Agreement, governments have pledged to strive to limit global temperature rise to no more than 2 °C above pre-industrial levels and to keep it below 1,5 °C. Current efforts to this end fall short: According to the estimates of Climate Action Tracker (CAT), the total reduction targets set for 2030 will lead to a global warming of approximately 3 °C by 2100. There are deficiencies in the implementation of these goals; it is estimated that greenhouse gas emissions will cause a global warming of approximately 3.3 °C within the scope of the policies currently implemented.

According to the findings of the Intergovernmental Panel on Climate Change (IPCC) Special Report published on the 1,5 °C target, global greenhouse gas emissions are expected to peak as soon as possible in order to stay below the globally accepted limit. It is necessary to reduce these emissions by 45% by 2030 compared to the 2010 level and to increase efforts to reduce CO_2 emissions to net zero by 2050 and total greenhouse gas emissions by around 2070.

We now live in a world where combating climate change is no longer a burden on its own, and is increasingly becoming the most viable option when considered with all socioeconomic aspects. For a low-cost global struggle, it is essential to ensure that these struggle actions are accessible to all countries and that the obstacles remaining in these countries are overcome. In recent years, measures to reduce greenhouse gas emissions have become more attractive to policymakers and private investors around the world in many cases. Reduced technology costs, as well as the negative impacts to be avoided, and the increased awareness of the benefits of reduction measures such as zero-carbon technology and infrastructure development, such as improving air quality and creating new jobs are the main reasons for this (CAT 2019).

2. CLIMATE PROJECTIONS

2.1. Global Model Simulations

Climate change projections require running models on a global scale. Greenhouse gas emissions depend on factors such as population growth, economic growth, increased demand for energy and food (agriculture), and technological change. Future release scenarios are created with different stories based on these factors. These scenarios include information on how much emission will be released into the atmosphere in the coming years and how the amount of greenhouse gases in the atmosphere will change as a result of these emissions.

The level of greenhouse gases that will accumulate in the atmosphere and how this will change the climate can only be revealed by integrating the scenario information into a "Global Climate Model" and running the model for the future. Before the evaluation studies of the IPCC, model running experiments for different scenarios are organized and projection data that will form a basis for these reports are prepared. The experiment carried out in this way for the 4th Assessment Report announced in 2007 was named CMIP3 (Third Coupled Model Intercomparison Project). The experiment carried out in this way for the 5th Assessment Report announced in 2013 was named CMIP5 (Fifth Coupled Model Intercomparison Project). Around 40 different Global Climate Models are used in these experiments.

Although these models are largely similar, they contain differences in terms of resolution, physics parameterization, grid structure, etc. Due to these differences, there are also differences in model projections. Table 1 provides general information on global and regional data sets that can be used in the climate change study.

Table 1: Global and regional projection data sets that can be used in climate change study

Resource:	Reference Period	Future Period	Scenarios	GCMs	Spatial Resolution	Address (URL)
CMIP	1986-2005	2006-2100	RCP2.6 RCP4.5 RCP6.0 RCP8.5	More than 40 models	˜100 km	KNMI climatechange atlas https://climexp.knmi.nl/
CORDEX	1989 -2008	2006-2100	RCP2.6, RCP4.5, RCP8.5	19-26 different RCM-GCM combination simulation	~ 12,5 m ve ~50km	http://esgfdata.dkrz.de http://esgfindex1.ceda.ac.uk http://cordexesg.dmi.dk http://esgfnode.ipsl.fr http://esg-dn1.nsc.liu.se
MGM	1971 -2000	2016-2100	RCP4.5, RCP8.5	HadGEM2-ES MPI-ESM-MR GFDL-ESM2M	20 km	http://mgm.gov.tr
SYGM	1971 -2000	2015-2100	RCP4.5, RCP8.5	HadGEM2-ES NewCBS MPI-ESM-MR CNRM-CM5	10km	http://iklim.ormansu.gov.tr/NewCBS
ITU Eurasia Institute of Earth Sciences	1986 -2005	2046-2065 2081-2100	RCP4.5, RCP8.5	EC-EARTH	12km atmosphere, 3km surface	
World Clim		2041-2060 2061-2080 (Climatology)	RCP2.6 RCP4.5 RCP6.0 RCP8.5	18 models selected from CMIP5 Models	~1km	http://worldclim.org/cmip5_30s

Source: (IBB., 2018).

2.2. Regional Model Simulations

Global climate models are often run at low resolution due to the high computational need. However, low-resolution model printouts do not provide the desired detail, especially in regions where spatial change may be high. One of the most preferred methods to overcome this situation is the use of regional climate model. Regional climate models are regionalized versions of global climate models. However, since it will be operated on a defined region, it needs boundary conditions and these conditions are provided from the global model outputs. Therefore, the purpose of regional modeling is to increase the resolution of global model simulation and to elaborate the information locally. In this case, regional model outputs are not expected to be very different from global model outputs. Particularly in regions where spatial change is not much, change patterns obtained from the global model and regional model that takes boundary conditions from the same global model will be very similar. However, even if the big picture coincides in the regions with complex topography, there will inevitably be positive differences in the local scale.

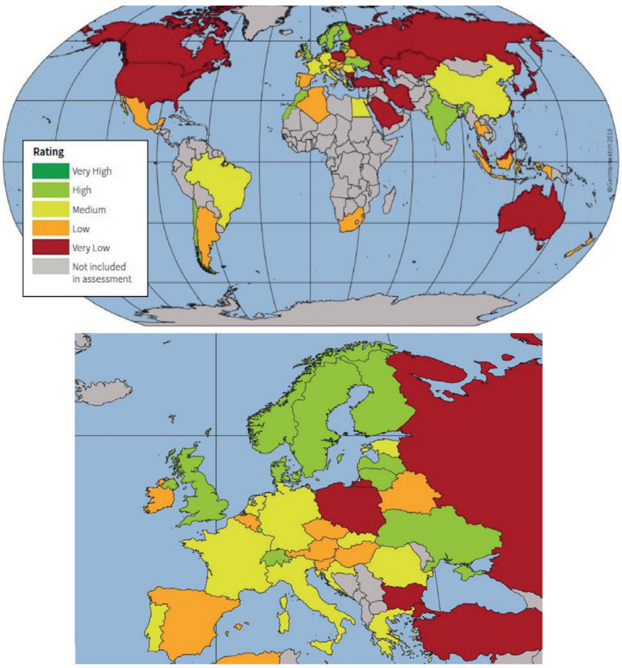
The regional model provides added value at local scale compared to global models by revealing smaller scale local climatic features such as precipitation shadow and microclimate, as it can better resolve the morphological features of the surface such as topography (mountains, valleys, etc.) and vegetation.

3. LOCATIONS OF COUNTRIES

According to the Climate Change Performance Index 2020, Sweden has led the group of high-performance countries, as in the last two years. Denmark moves up ten ranks to become the second best performing country in this year's CCPI. Although Morocco falls one place in the overall ranking, it maintains its overall performance (Figure 1, Table 2).

Climate Change Performance three countries with the worst are Taiwan, Saudi Arabia and the USA. This year Taiwan falls three places to rank 59. Saudi Arabia still ranks very low, but for the first time is not in the lower ranks of the index. The United States continues its downward trend, dropping to the bottom of the ranking after dropping three places in last year's rankings.

Figure 1: Countries' performances against climate change



Source: Burck et al., 2020

As seen in Table 2, none of the countries performed well enough to achieve a very high rating in the index in all index categories. Therefore, once again the top three rankings of the overall ranking remained empty.

Only two G20 countries were among the high performers (UK and India), while eight G20 countries were ranked below the very low performers.

Poland ranked as the worst performing EU country in this year's index. Eight EU countries had high performance, while the EU as a whole dropped to six places and was placed under the middle performer group in this year's index.

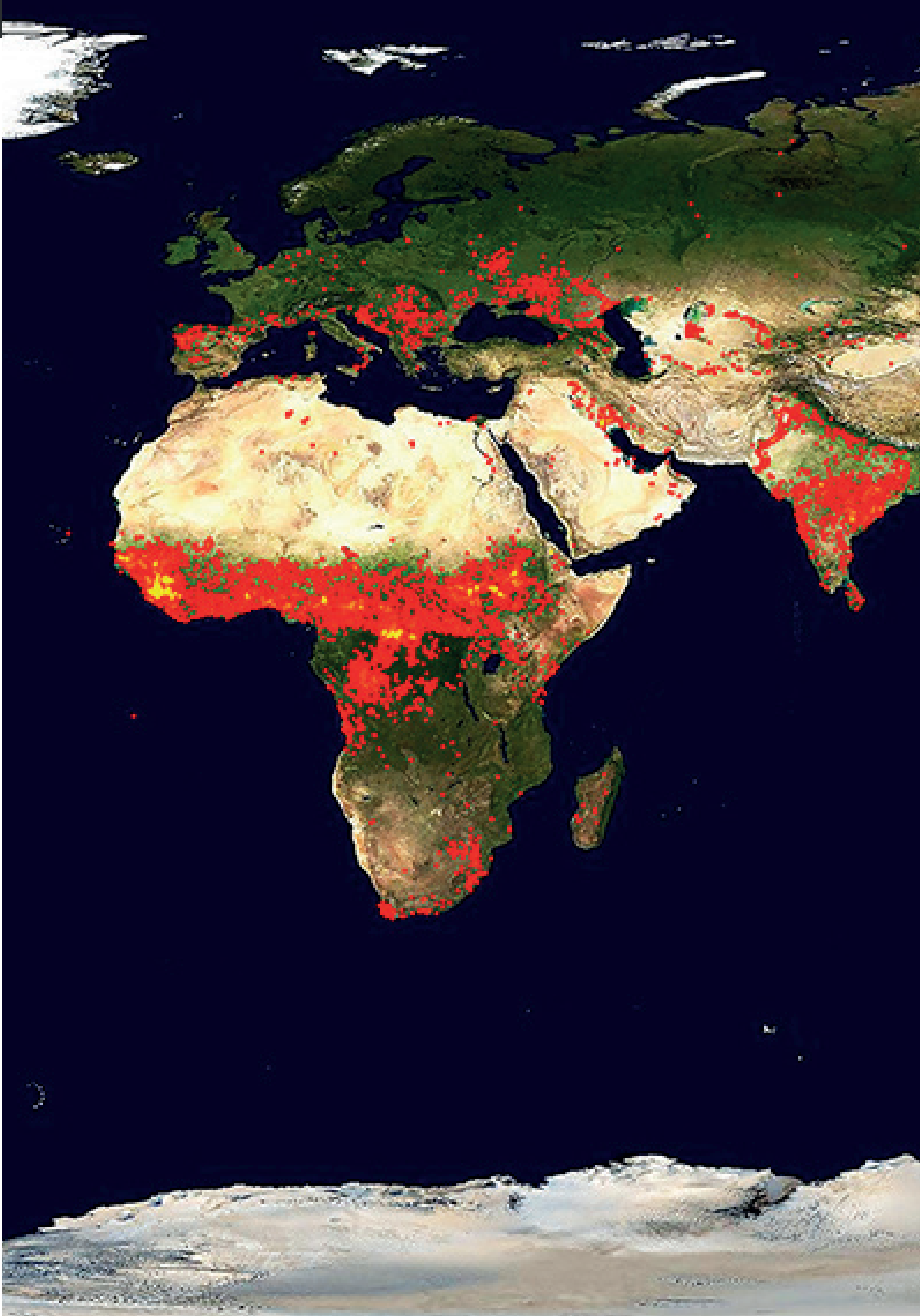


Table 2: Climate Change Performance Index Values of Countries

Rank		Country	Score***	Categories
1.*		–	–	
2.		–	–	
3.		–	–	
4.	–	Sweden	75.77	
5.	▲	Denmark	71.14	
6.	▼	Morocco	70.63	
7.	▲	United Kingdom	69.80	
8.	▼	Lithuania	66.22	
9.	▲	India	66.02	
10.	▲	Finland	63.25	
11.		Chile	62.88	
12.	–	Norway	61.14	
13.	▲	Luxembourg	60.91	
14.	▼	Malta	60.76	
15.	▼	Latvia	60.75	
16.	▼	Switzerland	60.61	
17.**	▲	Ukraine	60.60	
18.	▲	France	57.90	
19.	▲	Egypt	57.53	
20.	▼	Croatia	56.97	
21.	▲	Brazil	55.82	
22.	▼	European Union (28)	55.82	
23.	▲	Germany	55.78	
24.	▼	Romania	54.85	
25.	▼	Portugal	54.10	
26.	▼	Italy	53.92	
27.	▼	Slovak Republic	52.69	
28.	▲	Greece	52.59	
29.	▼	Netherlands	50.89	
30.	▲	China	48.16	
31.	▲	Estonia	48.05	
32.	▼	Mexico	47.01	
33.	▲	Thailand	46.76	
34.	▲	Spain	46.03	
35.	▼	Belgium	45.73	
36.	▲	South Africa	45.67	
37.	▲	New Zealand	45.67	
38.	▼	Austria	44.74	
39.	▼	Indonesia	44.65	
40.	▼	Belarus	44.18	
41.	▲	Ireland	44.04	
42.	▼	Argentina	43.77	
43.	▼	Czech Republic	42.93	
44.	▼	Slovenia	41.91	
45.	▲	Cyprus	41.66	
46.	▲	Algeria	41.45	
47.	▼	Hungary	41.17	
48.	▲	Turkey	40.76	
49.	▼	Bulgaria	40.12	
50.	▼	Poland	39.98	
51.	▼	Japan	39.03	
52.	–	Russian Federation	37.85	
53.	▼	Malaysia	34.21	
54.	▼	Kazakhstan	33.39	
55.	▼	Canada	31.01	
56.	▼	Australia	30.75	
57.	▲	Islamic Republic of Iran	28.41	
58.	▼	Korea	26.75	
59.	▼	Chinese Taipei	23.33	
60.	–	Saudi Arabia	22.03	
61.	▼	United States	18.60	

Index Categories
- GHG Emissions (40% weighting)
- Renewable Energy (20% weighting)
- Energy Use (20% weighting)
- Climate Policy (20% weighting)

* None of the countries achieved positions one to three. No country is doing enough to prevent dangerous climate change.
** The position of Ukraine in the overall ranking is highly influenced by the effects of the ongoing conflict in the Donbas region on key CCPI indicators.

©Germanwatch 2019

Source: Burck et al., (2020)

Greenhouse gas emissions of countries continue to grow despite decreasing emissions in some countries globally. Between 2009-2018, emissions increased by 1,5% per year, with only a slight slowdown in 2014-2016. Preliminary data for 2018 show that global greenhouse gas emissions increased by 1.9%.

Based solely on consumption-based emissions, Sweden has the lowest total per capita emissions, rated very high for their compliance below 2 °C. Egypt has scored high for its performance in the category, with its current GHG of relatively low levels of per capita emissions, further emission reductions in recent years and an environmental target of 2030. The UK is still rated medium for the current emission level per capita, but achieves high ratings for the remaining indicators in the Greenhouse Gas Emissions category. This includes good compliance below the relatively high grade 2 °C of the 2030 GHG emission target.

The Republic of Korea is not making progress in the category of GHG Emissions, which is very low due to both the current level of per capita emissions and compliance with the country's 2030 GHG target below 2 °C. Taiwan has a very low rating for all indicators in the Greenhouse Gas Emissions category. Saudi Arabia is rated low for the historical trend of greenhouse gas emissions per capita in this year's index, whereas the relatively high level of per capita emissions is still rated too low for 2 °C compliance (Figure 2, Table 3).

Figure 2: Greenhouse Gas Emissions of Countries

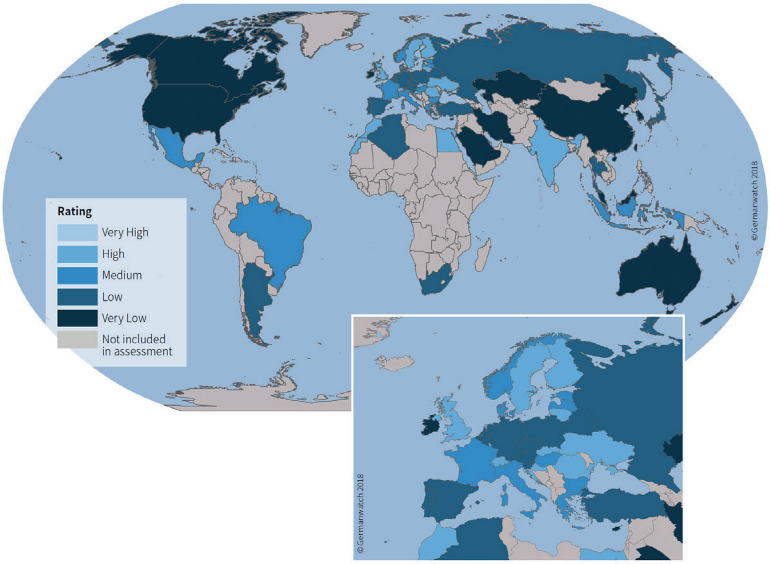


Table 3 provides detailed information on the performance of the G20 countries in the four indicators that define the category of greenhouse gas emissions.

No country's performance is too high for all indicators in the GHG Emissions category, and only two G20 countries fall under the top performers. Although India has one of the biggest growth trends, emissions per capita remain at a relatively low level and are considered too high for their compatibility below 2 °C.

Thirteen of the G20 countries are listed as very low or underperforming countries. Although China is still very low in the Greenhouse Gas Emissions category, it is not in the top ten in the Greenhouse Gas Emissions category for the first time.

The EU is rated medium due to its performance in the Greenhouse Gas Emissions category, as it was last year. Six EU countries are performing well in this year's greenhouse gas. At the degree of emission, Cyprus and Portugal performed the worst. Both are the EU countries with an overall very low rating in this category.

Tablo 3: Greenhouse Gas Emission Values of Countries

Greenhouse Gas Emissions – Rating Table for G20 countries*

Rank	Country	Score	Overall Rating	GHG per Capita - current level (excl. LULUCF)	GHG per Capita - current trend (excl. LULUCF)	GHG per Capita - compared to a well-below-2°C pathway	GHG 2030 target - compared to a well-below-2°C pathway
7.	United Kingdom	75.9	High	Medium	High	Medium	High
12.	India	71.8	High	Very High	Very Low	Very High	High
18.	Italy	67.0	Medium	Medium	High	Medium	Medium
22.	France	62.1	Medium	Medium	Medium	Medium	Medium
23.	European Union (28)	61.6	Medium	Low	Medium	Medium	Medium
25.	Brazil	60.6	Medium	Medium	Low	Medium	Medium
28.	Indonesia	58.8	Medium	Low	High	Very Low	Low
29.	Mexico	58.7	Medium	Medium	Low	Low	Medium
34.	Germany	55.5	Low	Low	Low	Low	Medium
37.	Turkey	54.1	Low	Medium	Very Low	Medium	Low
39.	South Africa	52.7	Low	Low	High	Low	Low
44.	Russian Federation	49.1	Low	Very Low	Low	High	Low
46.	Argentina	46.4	Low	Low	Low	Very Low	Low
47.	Japan	46.1	Low	Low	Low	Very Low	Very Low
49.	Australia	44.2	Very Low	Very Low	Medium	Low	Medium
51.	China	43.6	Very Low	Low	Low	Low	Very Low
54.	Canada	32.5	Very Low	Very Low	Medium	Very Low	Low
57.	United States	21.4	Very Low	Very Low	Medium	Very Low	Very Low
59.	Republic of Korea	13.5	Very Low	Very Low	Low	Very Low	Very Low
60.	Saudi Arabia	2.3	Very Low	Very Low	Very Low	Very Low	Very Low

* The ratings for all 56 countries and the EU can be found here: www.climate-change-performance-index.org

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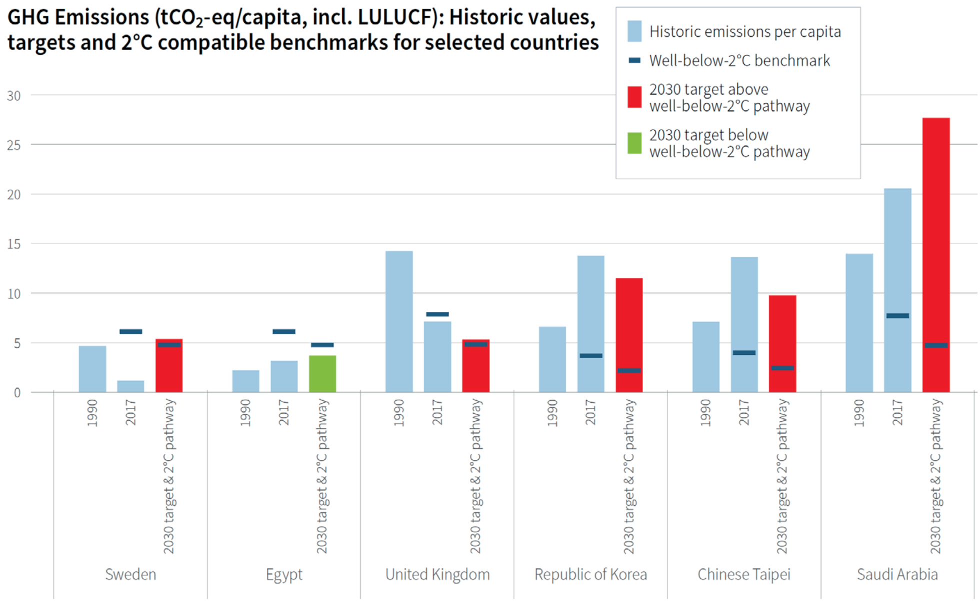
When examining the per capita greenhouse gas emissions of some selected countries, it is seen that the 2030 targets of Sweden, Egypt and the United Kingdom are slightly above or below the targets of keeping the global temperature increase below 2 °C. This country is therefore the country with the highest per capita greenhouse gas performance. In addition to these high performance countries, Saudi Arabia, Taiwan and the Republic of Korea have per capita greenhouse gas emissions far above the targeted per capita emissions in 2030. These emissions will be more than 4 times the threshold in Saudi Arabia in 2030. Therefore, Saudi Arabia is the country with the worst greenhouse gas emissions performance (Figure 3).

Figure 3: Greenhouse Gas Emissions (including tCO_2-eq / capita, Land Use, Land Use Change and Forestry): Historical values, targets and 2 °C compatible criteria for selected countries



In 2018, the addition of renewable energy generation capacity outstripped net fossil fuel and nuclear power installations for the fourth year in a row. Significant growth potential is seen in the offshore wind sector, which is only a small part of renewable energy distribution to date. As two-thirds of global greenhouse gas emissions are related to sectors such as electricity and heat, buildings, transport and industry, the need to accelerate the global energy transition is clear.

When the renewable energy performances of the countries are examined, Latvia is the country rated highly due to its relatively high share of renewable energy, compatibility below 2 °C. Sweden relies on the vast majority of renewable energy and is also among the countries with high scores for adaptation below 2 °C. Denmark was rated highly as it has an adaptation below 2 °C of its current renewable energy share and received a high score for the 2030 target.

Malaysia cannot make any improvements to the Renewable Energy category required to put the country on a compatible path below 2 °C. The Islamic Republic of Iran is rated very low on all indicators in the category. The Russian Federation is the worst performing country in this category. Data for the period 2012-2017 show not only a declining improvement in the share of renewable energy, but also that the country's lack of ambition in the 2030 target is very low (Figure 4, Table 4).

Figure 4: Renewable Energy Performance of Countries

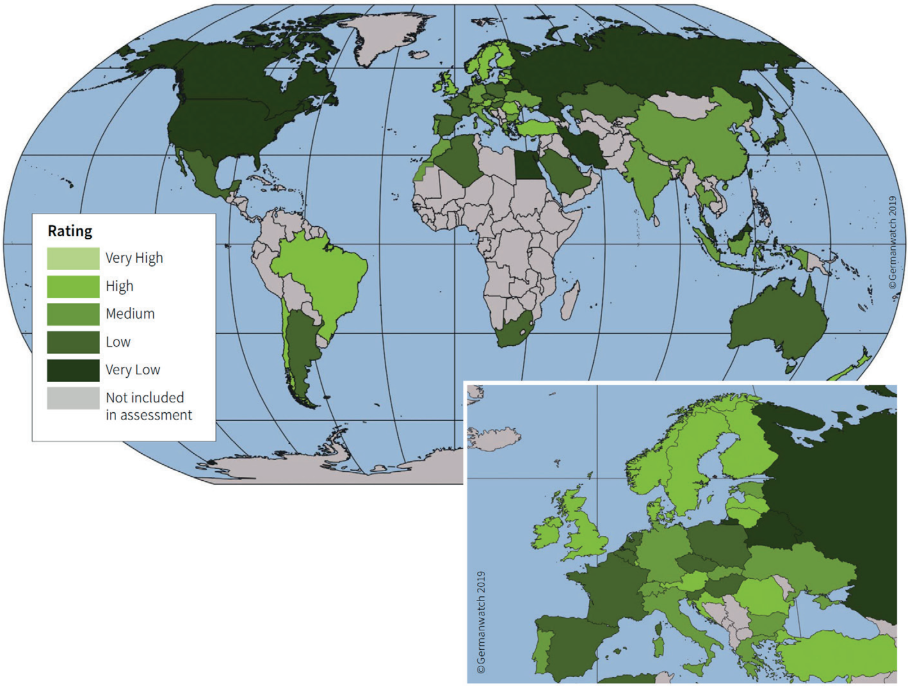


Table 4 provides detailed information on the performance of the G20 countries in the four indicators that define the category of renewable energy. No country is rated too high for all indicators defining the Renewable Energy category. As the energy sector contributes greatly to a country's CO_2 emissions, the results of the Renewable Energy rating show that there is much to improve in reducing emissions with the accelerated distribution of renewable energy.

Ten of the G20 countries are rated low or very low for their performance in the Renewable Energy category. For these countries, the current share of renewable energy is rated relatively low due to their unpretentious 2030 renewable energy targets and below 2 °C compatibility.

Brazil and the UK are the only two G20 countries to score highly for their performance in the Renewable Energy category. While Brazil's performance is based on the high share of renewable energy sources in the energy mix, the UK scored very high for the positive trend in renewable development between 2012 and 2017.

As last year, the EU is among the medium performers. In this year's index, 12 of the 17 countries that received high scores in the Renewable Energy category are EU countries. The Netherlands and Poland are the worst-performing EU countries, rated low or very low for all indicators defining the category.

Table 4: Renewable Energy Performance of G20 Countries

Renewable Energy (RE) – Rating table for G20 countries*							
Rank	**Country**	**Score****	**Overall Ranking**	**Share of RE in Energy Use (TPES)*** - current level (incl. hydro)**	**Share of RE in Energy Use (TPES) - current trend (excl. hydro)**	**Share of RE in Energy Use (TPES) (excl. hydro) - compared to a well-below-2°C pathway**	**RE 2030 Target (incl. hydro) - compared to a well-below-2°C pathway**
12.	Brazil	54.8	High	Very high	Low	High	Medium
13.	Turkey	47.5	High	Medium	Very high	Medium	Low
16.	United Kingdom	45.3	High	Low	Very high	High	Very Low
22.	Germany	40.4	Medium	Medium	High	High	Low
25.	China	38.7	Medium	Low	Very high	Low	Very Low
26.	India	37.3	Medium	Medium	Medium	Low	High
27.	European Union (28)	37.2	Medium	Medium	Medium	Medium	Medium
29.	Italy	36.0	Medium	Medium	Low	High	Medium
32.	Korea	33.0	Medium	Very Low	Very high	Very Low	Very Low
34.	Indonesia	31.8	Medium	Medium	Medium	Low	Low
41.	France	28.5	Low	Low	High	Low	Low
44.	Saudi Arabia	27.0	Low	Very Low	Very high	Very Low	Very Low
45.	Japan	25.7	Low	Low	High	Low	Low
50.	Australia	23.0	Low	Low	High	Low	Very Low
51.	Mexico	21.8	Low	Low	Medium	Very Low	Low
52.	Argentina	19.2	Low	Medium	Low	Low	Very Low
53.	South Africa	19.1	Low	Very Low	Medium	Very Low	Low
54.	Canada	17.8	Very Low	High	Low	Very Low	Very Low
55.	United States	16.6	Very Low	Low	Medium	Low	Very Low
61.	Russian Federation	3.9	Very Low	Very Low	Very Low	Very Low	Very Low

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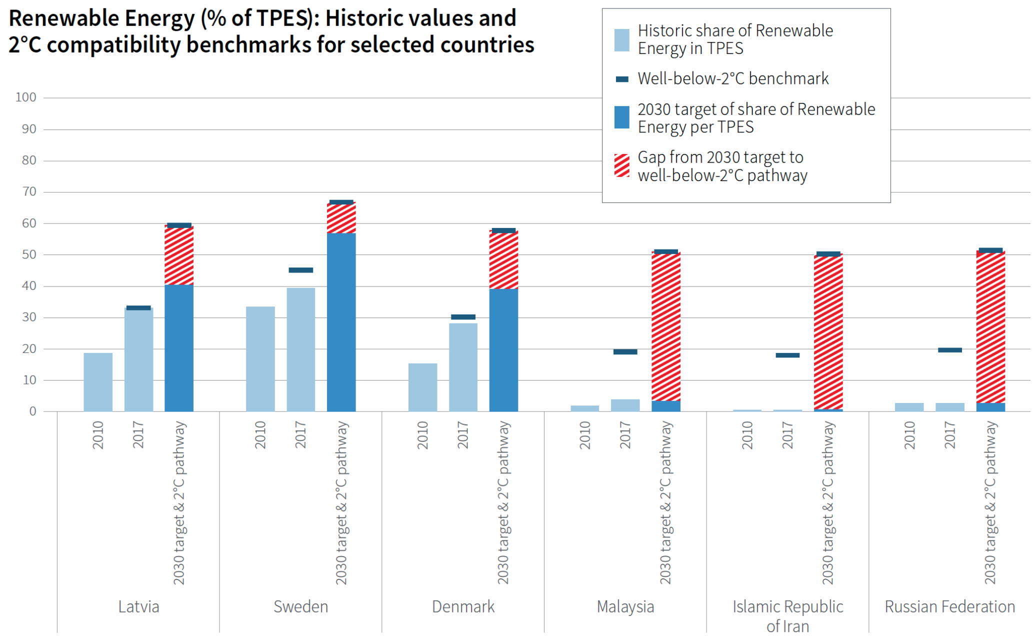
It is seen that countries do not approach the threshold for their 2030 renewable energy targets and the target of keeping the global temperature below 2 °C. Even the countries with the best renewable energy performance have targets below the threshold (Figure 5). To reach this threshold, Malaysia, Iran and the Russian Federation must increase their 2030 targets by about 10 times.

Figure 5: Renewable energy: Historical values and 2 °C adaptation criteria for selected countries



According to the latest IAE Energy Efficiency Report, 2018 marked a historic slowdown in energy efficiency improvements. Deceleration factors are a combination of social and economic trends as well as certain factors such as extreme weather. Although cost-effective technologies are already available, current policy measures and investments cannot keep up with rising energy demands.

Between 2012 and 2017, Malta experienced the largest reduction in per capita energy use for countries considered in this year's Climate Change Performance Index. The country's current per capita energy use and 2030 energy use target scored high due to their compatibility below 2 °C. While rated low for the recent trend in per capita energy use, Morocco's relatively low per capita energy use level is very high due to adaptation below 2 °C. Mexico still has a relatively low level of energy use per capita, which is rated highly for its adaptation below 2 °C.

Saudi Arabia has a very low rating for its performance in the Energy Use category, despite small improvements in the historical trend of per capita energy use. Canada is among the countries with the highest per capita energy use and cannot make any improvement in the Energy Use category. The current per capita energy use of the Republic of Korea and the country's 2030 target are rated very low due to their compliance below 2 °C, making it the worst performing country in this year's Energy Use rating (Figure 6, Table 5)

Figure 6: Energy Usage Performance of G20 Countries

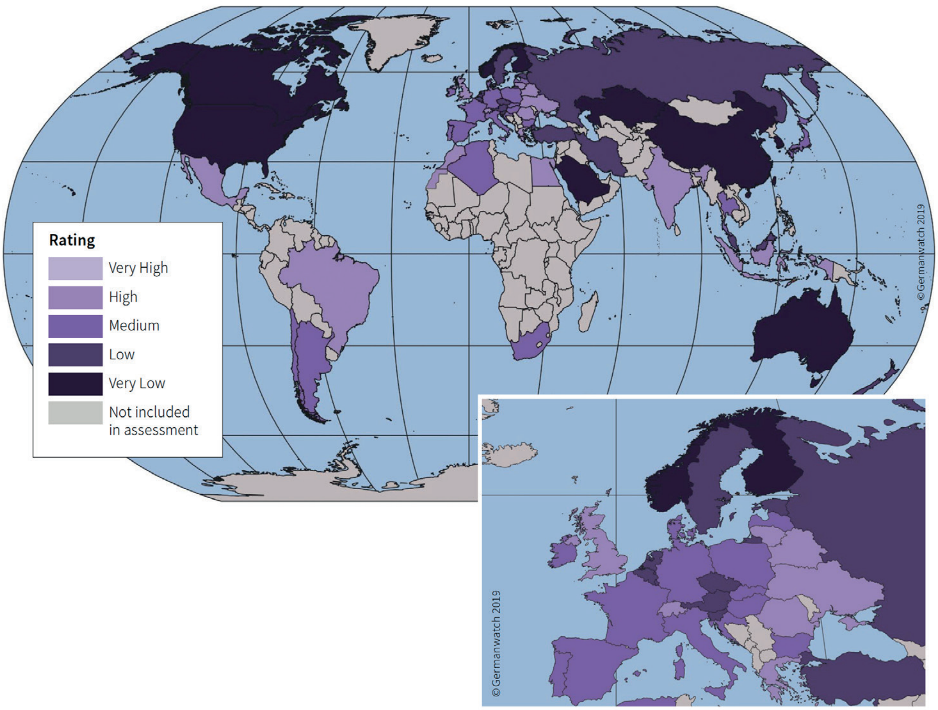


Table 5 provides detailed information on the performance of the G20 countries in the four indicators that define the category of energy use. No country is rated too high for all indicators defining the Energy Use category. Therefore, the first three rows of the Energy Use ranking remain empty.

Except for the G20, five countries scored highly for their performance in the Energy Use category. Mexico and India are among the few countries that score very high for 2 °C adaptatıon of the 2030 energy use targets in this year's Climate Change Performance Index. Six of the ten low performers in the Energy Use rating are G20 countries. The EU is rated medium due to its performance in the Energy Use category, as it was last year. Five EU countries rank high in Energy Use.

Table 5: Energy Usage Performances of G20 Countries

Energy Use – Rating table for G20 countries*							
Rank	Country	Score**	Overall Rating	Energy Use (TPES)*** per Capita - current level	Energy Use (TPES) per Capita - current trend	Energy Use (TPES) per Capita - compared to a well-below-2°C pathway	Energy Use 2030 Target - compared to a well-below-2°C pathway
7.	Mexico	79.3	High	High	High	High	Very high
9.	India	75.5	High	Very high	Very Low	Very high	Very high
13.	Brazil	69.6	High	High	Medium	High	High
15.	United Kingdom	68.1	High	Medium	High	High	Low
17.	Indonesia	65.4	High	Very high	Very Low	High	High
18.	South Africa	63.3	Medium	Medium	High	Medium	Medium
21.	Argentina	60.3	Medium	High	Low	Low	Medium
24.	European Union (28)	58.0	Medium	Low	Medium	Low	Medium
25.	Italy	57.8	Medium	Medium	Medium	Low	Low
29.	Germany	55.5	Medium	Low	Medium	Low	Low
31.	Japan	55.3	Medium	Low	High	Low	Low
32.	France	54.8	Medium	Low	High	Low	Low
44.	Russian Federation	49.9	Low	Very Low	Medium	Low	Medium
47.	Turkey	48.0	Low	High	Very Low	Low	Low
52.	Australia	39.8	Very Low	Very Low	High	Very Low	Very Low
53.	China	38.6	Very Low	Medium	Low	Very Low	Very Low
58.	United States	25.1	Very Low	Very Low	Medium	Low	Very Low
59.	Saudi Arabia	17.9	Very Low	Very Low	Medium	Very Low	Very Low
60.	Canada	16.3	Very Low	Very Low	Low	Very Low	Very Low
61.	Korea	14.4	Very Low	Very Low	Low	Very Low	Very Low

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Increasing public awareness, taking advantage of the growing global climate movement, is putting pressure on governments to make climate policy a priority. It is emphasized that the elections held in many countries this year and their results demonstrate that climate is an increasingly important issue for voters. However, the ambition of the countries at the international level and the implementation of their policies at the national level are not enough. The year 2020 is the first opportunity for Nationally Determined Contribution development and an opportunity to capture the increasing political momentum to achieve a net zero emission future and develop cross-sectoral strategies for national implementation.

When evaluated in terms of Climate Policies Implemented by Countries, Portugal, Finland and Morocco showed the best three performances (Figure 7, Table 6). Portugal is among the few countries to score very high for international climate policy performance as experts observe the country taking an ambitious position in the negotiations. At the EU level, Portugal calls for a net zero emissions target by 2050 and a 55% emission reduction by 2030. Finland moved up 12 places in 2020 Climate Policy rating. Experts praised the newly elected government for setting its goal of making Finnish carbon neutral by 2035. In addition, Parliament passed a coal burning ban by 2029 earlier this year. Morocco continues to rank high for its Climate Policy performance, based largely on the ambitious 2030 goals that put the country in the forefront. However, experts note that implementation requires constant coordinated effort.

Turkey does not yet have 2050 low emission strategy and has not yet approved Paris Agreement, and thus continues to take a very low degree category in general. Under the Trump Administration, the United States fails climate action with a massive return of national policies and becomes a destructive force at all levels of international climate policy. Despite very few positive signals, the US falls short of the very low performers.

Australia scored the lowest in this year's Climate Policy rating as experts observe that the newly elected government continues to worsen performance at both national and international levels.

Şekil 7: Climate Policy Performances of Countries (2020)

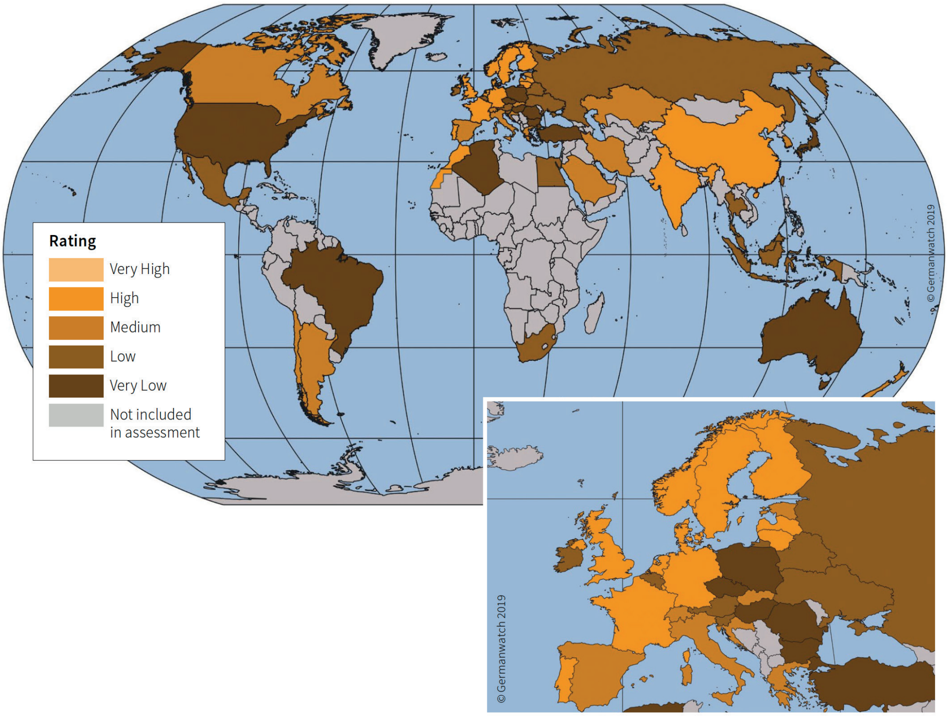

Table 6 provides detailed information on the performance of 57 countries and the EU in two indicators defining the Climate Policy category.

While a few countries rank very high for their international climate policy performance, no country achieves an overall very high rating for the Climate Policy category.

Nine G20 countries are rated low or very low for their performance in the Climate Policy category. South Africa and Mexico are returning to underperformers.

Six G20 countries were placed in the high performance group in this year's Climate Policy ranking, with India and Germany rising from the middle performance indicators.

Despite a ten-place decline in the Climate Policy rating, the EU is still among the top performers in this year's index. 11 EU countries are in high performance in this year's Climate Policy ranking. Poland and Bulgaria are the worst performing EU countries, both with a very low overall rating.

Table 6: Climate Policy Ratings of Countries

Climate Policy – Rating table for all countries					
Rank	**Country**	**Score***	**Overall Rating**	**National Climate Policy Performance**	**International Climate Policy Performance**
4.	Portugal	98.7	High	High	Very high
5.	Finland	93.0	High	High	Very high
6.	Morocco	88.0	High	High	High
7.	Sweden	87.2	High	High	Very high
8.	Lithuania	86.8	High	High	High
9.	Denmark	83.3	High	High	High
10.	China	81.0	High	High	Medium
11.	France	80.4	High	High	High
12.	United Kingdom	79.9	High	High	High
13.	Latvia	79.7	High	High	High
14.	Norway	79.7	High	Medium	Very high
15.	India	73.6	High	High	Medium
16.	Netherlands	73.6	High	High	High
17.	Germany	67.5	High	Medium	High
18.	Luxembourg	66.6	High	Low	High
19.	European Union (28)	65.2	High	Medium	High
20.	Croatia	62.1	Medium	Medium	Medium
21.	Canada	58.6	Medium	Low	High
22.	Italy	57.7	Medium	Medium	Medium
23.	Switzerland	57.5	Medium	Medium	Medium
24.	Argentina	56.4	Medium	Low	Medium
25.	Islamic Republic of Iran	55.3	Medium	Medium	Low
26.	Greece	55.3	Medium	Medium	Low
27.	Chile	55.3	Medium	Low	Medium
28.	Slovak Republic	54.3	Medium	Low	Medium
29.	Korea	54.0	Medium	Medium	Low
30.	New Zealand	53.3	Medium	Medium	Low
31.	Spain	52.9	Medium	Low	High
32.	Cyprus	50.2	Medium	Low	Medium
32.	Kazakhstan	50.2	Medium	Low	Medium
34.	Saudi Arabia	46.9	Medium	Medium	Low
35.	Estonia	46.1	Medium	Medium	Low
36.	Belarus	45.5	Low	Medium	Low
37.	Egypt	42.8	Low	Low	Low
38.	South Africa	42.7	Low	Very Low	Medium
39.	Belgium	41.6	Low	Low	Low
40.	Chinese Taipei	41.1	Low	Low	Medium
41.	Indonesia	38.8	Low	Very Low	Medium
42.	Thailand	38.2	Low	Low	Low
43.	Malaysia	37.6	Low	Low	Very Low
44.	Mexico	37.4	Low	Low	Low
45.	Slovenia	36.6	Low	Low	Low
46.	Austria	35.8	Low	Very Low	Low
47.	Ireland	35.1	Low	Very Low	Low
48.	Russian Federation	34.0	Low	Very Low	Low
49.	Ukraine	30.6	Low	Very Low	Low
50.	Brazil	29.3	Very Low	Low	Very Low
51.	Malta	26.9	Very Low	Very Low	Low
52.	Czech Republic	26.6	Very Low	Low	Very Low
53.	Hungary	25.8	Very Low	Very Low	Low
54.	Romania	25.4	Very Low	Very Low	Very Low
55.	Poland	25.2	Very Low	Very Low	Very Low
56.	Japan	21.2	Very Low	Very Low	Very Low
57.	Algeria	11.9	Very Low	Very Low	Very Low
57.	Bulgaria	11.9	Very Low	Very Low	Very Low
59.	Turkey	4.8	Very Low	Very Low	Very Low
60.	United States	2.8	Very Low	Very Low	Very Low
61.	Australia	0.0	Very Low	Very Low	Very Low

* unweighted and rounded

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IPCC CLIMATE CHANGE SCENARIOS

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

1.1. Climate Model Concept

The most important study in predicting the likely future climate is climate modeling (Akçakaya, A., et al., 2013; Demir, Ö., et al., 2013; Demircan, M., et al., 2014; Demircan, M., et al., 2014). In this way, taking into account the current conditions, it is tried to calculate the change of these conditions with certain physical equations and to draw the general framework of the weather or climatic conditions after a certain period. The biggest challenge in modeling climate is the need to simulate changes in climate conditions much faster than the real time course. This situation brings along the use of many simplified assumptions in modeling and the need for a high computational capacity. Therefore, the setting of the climate model can be in a complex structure in one, two or three dimensions, showing the simple physical properties or all interactions of the components of the climate system (Akçakaya, et al., 2015).

1.2. Historical Development of Global Climate (General Circulation) Models

Climate is one of the most difficult geophysical systems to simulate, due to the large number of components that compose and are related to each other, and to large spatial and temporal physics processes. Climate is in direct interaction with systems such as the atmosphere (clouds, aerosols, atmospheric gases etc.), hydrosphere (oceans, lakes and wetlands), lithosphere (soil moisture and different phases) and biosphere (vegetation, carbon cycle, etc.). This enormous interaction includes physical processes of different dimensions, from the formation of raindrops at the micro level to the macro level ocean currents. This situation causes the climate to have a non-linear feature, which is very complex (Akçakaya, et al., 2015).

Global climate models (GCMs, also known as General Circulation Models) play a very important function in defining global climate statistics such as the global average surface temperature. GCMs represent physical processes in the atmosphere, oceans, cryosphere, and land surface. These models are the most advanced tools for demonstrating the climate system's response to rising greenhouse gas emissions. Increases in carbon dioxide concentration (or concentration of other greenhouse gases with carbon equivalent) are included in the GCM within the framework of certain criteria (Akçakaya, et al., 2015).

GCMs describe climate with the help of 3-dimensional (3D) grids with a resolution of 10 to 80 levels in the atmosphere (sometimes 30 levels in oceans) and 200 to 600 km horizontally. While this representation ability helps us to see the global picture, it is quite insufficient for impact analysis. Many micro-level physical processes such as cloud formation cannot be properly modeled in these models. This deficiency is tried to be overcome by averaging the known properties of the model, which is called the testing of the model (parameterization) in large areas. This method constitutes one of the main sources of uncertainties regarding model findings. Other uncertainties are related to the simulation of feedback mechanisms within the model, such as water vapor, warming, clouds and radiation, ocean cycles, ice and snow albedo. Therefore, GCMs can react quite differently to the same stress factors due to parameterization differences and different feedback modeling, and the findings may differ. In other words, two different global models operated with the same emission scenario for the same time interval, under the same initial conditions, may produce different results due to reasons such as parameterization differences (IPCC, 2013).

Despite all its complexity and practical difficulties, the most important tool in predicting future climate is climate modeling. In this way, taking into account the current conditions, it is tried to calculate the change of these conditions with certain physical equations and to draw the general framework of the weather or climatic conditions after a certain period. Although the first studies on this subject started in the 19th century, the efforts of the scientists at that time were not enough to explain how the gases in the atmosphere move around the planet with the laws of physics, and they could not provide a real mathematical solution. At the beginning of the 20th century, Norwegian scientist Vilhelm Bjerknes defined 7 basic equations to explain the behavior of heat, air mass and humidity, and they were used to predict large areas. Bjerknes's method was aimed at "graphical calculation" and was based on aerial maps. This method was developed until the 1950s. But the lack of observations to validate the method limited its development. After that, the most serious work is Lewis Fry Richardson's work. Richardson divided the area to be predicted into boxes and solved Bjerknes's equations in these boxes, and he was able to calculate the wind speed and direction using the pressure difference. However, even for a small area, his work could not go beyond a certain limit because of very complicated calculations and taking so long to make them. Despite this, this method forms the basis of today's computer-based modeling (Akçakaya, et al., 2015).

Modeling studies, which continued with mathematical and statistical methods until the end of World War II, gained a new dimension with the use of computers after this date. In 1950, the first large digital computer called the Electronic Numerical Integratorand Computer (ENIAC) made a real-time weather forecast. With the increase in computer capacities, climate models have also developed and become more complex. In the early 1970s, the first mathematical model combining ocean and atmosphere processes was developed. In 1975, with the highest capacity computer of its time, a new generation of models with 500 km resolution, 3 vertical levels and 10 minutes time step were developed (Akçakaya, et al., 2015).

As the models evolved, the size of the tiles became smaller, the time steps shortened, the number of tiles in horizontal and vertical direction, and the number of model components increased. In short, the development of climate or weather forecast models occurred directly with the development of computer capacities (Figure 1).

Figure 1: Development of Global Climate Models (GCMs) (IPCC, 2001).

Source: IPCC Synthesis Report, 2007, p.26 (Climate Change 2007: The Synthesis Report

As it could be understood from the brief history, the biggest challenge in modeling climate is the need to simulate changes in climate conditions much faster than the real time course. This situation brings along the use of many simplified assumptions in modeling and the need for a high computational capacity. Therefore, the model construction can be in one, two or three dimensions, changing from simple to complex, showing some or all of the components of the climate system, simple physical properties (for example conservation laws) or all interactions (Akçakaya, et al., 2015).

1.3. Coupled Model Project Phase: 5 (CMIP5)

In September 2008, 20 climate modeling groups members of the World Climate Research Program (WCRP) came together to create a new harmonized set of climate model studies. It is aimed to create a multi-model resource where these studies are together. Within the scope of the studies, the following gains were desired:

- Evaluating the feedback about the carbon cycle and clouds that are not well understood, causing the outputs of different models to differ,
- Investigating the climate prediction capacities of models for ten-year or longer time periods and questioning the predictability of climate,
- Determining the reasons why similarly designed models give different results.
- The results of the model studies conducted within the scope of the "Coupled Model Project Phase: 5" (Coupled Model Intercomparison Project Phase 5 - CMIP5) project were edited by IPCC WG1 and published in September 2013.

CMIP5 adopts the creation of a standard set of model simulations to achieve the following products. These can be listed as follows:

- Evaluating how the models display recent climate (control trials)
- Producing climate projections for the short term (2035) and long term (2100 and beyond)
- Determining the numerical values of the factors that cause differences between model projections, including basic feedback such as carbon cycle and cloudiness (Akçakaya, et al., 2015).

1.4. History of Scenarios Used in Climate Model Studies

Anthropogenic climate change scenarios, in which radiative forcing and options for the climate system's response to these constraints are fundamental, are one of the most important components of the work of the Intergovernmental Panel on Climate Change (IPCC). The IPCC coordinated the scenario development processes until its 25th plenary session. However, at its 25th session (26-28 April 2006), it was decided that the IPCC should undertake the mission of facilitating rather than coordinating the scenario development efforts, and it has been decided that the development of new emission scenarios for the IPCC 5th Assessment Report will be carried out by the research community (Akçakaya, et al., 2015).

In the past, the climate change assessment process called the sequential approach has been used in climate modeling studies. This process is in the form of successive phases. In this approach, firstly, socio-economic scenarios are created and then scenarios are created according to the emissions to be caused by socio-economic developments. Then, according to the emission levels, the radiative forces caused by the emissions are calculated and used as input in climate models (Akçakaya et al., 2015).

In this way, possible changes in climate parameters are tried to be determined. Finally, these changes, which are expected to occur in the atmosphere, constitute inputs for adaptation and impact studies, and decision-making processes are completed with policy-making based on these. Since this approach consists of sequential phases, the time between creating emission scenarios and obtaining the results of impact assessment models is very long. This approach was used in creating, Special Report for Emission Reports (SRES) scenarios and climate change scenarios in IPCC 3rd and 4th Assessment Reports. SRES scenarios are produced by four main scenario families (A1, A2, B1 and B2) and by separating them into different scenarios. These scenarios began to be created in 1997 and took about 3 years to complete. Although the first model results were used in the IPCC 3rd Assessment Report in 2001, detailed assessments could be seen in the IPCC 4th Assessment Report in 2007 (Akçakaya et al., 2015).

2. NEW SCENARIOS

2.1. Next Generation Concentration Scenarios

Following the publication of the IPCC 4th Evaluation Report, a series of decisions were taken regarding the scenarios included in the IPCC 5th Evaluation Report at the IPCC Experts Meeting held in the Netherlands in 2007 and the scenarios were outlined again (Akçakaya, et al., 2015).

In the creation of new climate change scenarios, it has been adopted to use the parallel evaluation method instead of the sequential evaluation method in the SRES scenarios. Since the study of SRES scenarios created by sequential approach in the past took a long time, a new evaluation approach was considered to shorten the time between the development of emission scenarios and the use of climate model results in impact assessment studies. For this purpose, integrated model and climate research environments have collaborated with impact research environments. In the parallel phase of this new approach, climate models, socio-economic and emission models work simultaneously, not sequentially, and thus, unlike the sequential approach, a serious gain is achieved in terms of time. (Akçakaya, et al., 2015)

The new concentration scenarios developed with this new approach are named as Representative Concentration Pathways. In the same meeting, the literature was reviewed in terms of the characteristics determined and 4 RCP types were defined for radiant stress levels and routes. These radiant stress values are RCP3-PD (RCP2.6), RCP4.5, RCP6.0 and RCP8.5' from the smallest to the largest.(Akçakaya, et al., 2015).

Comparing SRES scenarios and RCPs in terms of concentration values (Table 1): It is seen that the RCP8.5 scenario has values with A1F1 and A2, and the RCP6.0 scenario with A1B. B2 and A1T scenarios are located between RCP4.5 and RCP6.0.

RCP4.5 is in parallel with the B1 scenario. RCP3-PD (RCP2.6), on the other hand, is not compatible with any of the SRES scenarios. (Akçakaya, et al., 2015)

Table 1: Approximate Equivalent CO_2 Concentrations (ppm) in 2100 for SRES and RCP scenarios. Equivalent Concentrations of Carbon Dioxide Contain Other Greenhouse Gases and Aerosols

SRES	RCP	2100 yılında yaklaşık eşdeğer CO_2 konsantrasyonları (ppm)
A1FI		1550
	8.5	>1370
A1B		850
	6	850
B2		800
	4.5	650
B1		600
	2.6	490

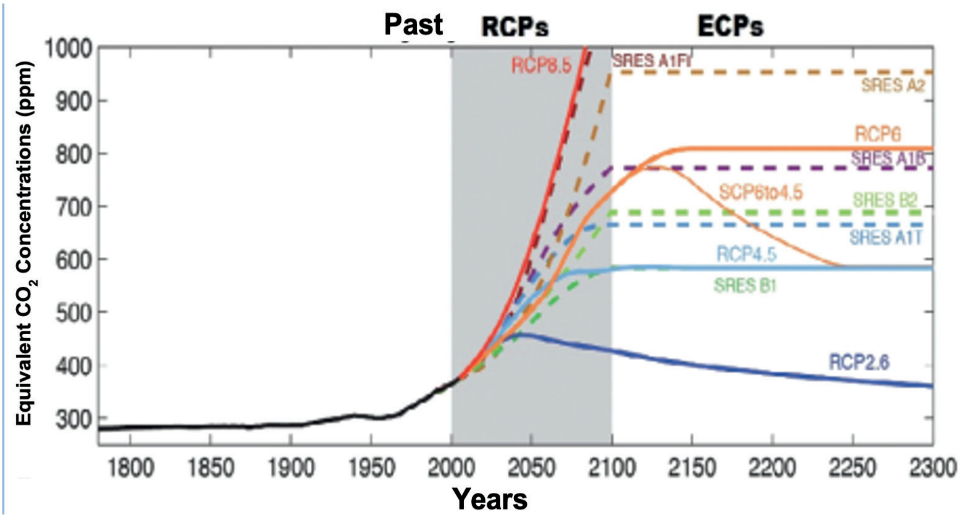
Source: IPCC Synthesis Report, 2007, p.26 (Climate Change 2007: The Synthesis Report

In order to understand climate change over a longer period, the RCP scenarios have been extended until the end of 2300, simply and without much adherence to mandatory criteria in terms of emission and concentration levels. In this context, while predicting constant CO_2 emission and concentration levels after 2100 for RCP 2.6 and RCP8.5, RCP4.5 and RCP6.0 predict that CO_2 emissions and concentrations will gradually stabilize until 2150. RCP8.5 predicts that the CO_2 concentration will only stabilize at 2250 at around 2000 ppm, almost 7 times the pre-industrial level. RCP3-PD (RCP2.6), on the other hand, predicts that the emissions will begin to decrease after 2070 and accordingly, their concentrations will decrease over time until 2300 and reach the level of 360 ppm (Akçakaya et al., 2015).

Comparing RCP scenarios and SRES scenarios in the context of CO_2 concentrations, it is seen that RCP4.5 is close to SRES B1 scenario, RCP6 converges to SRES A1B especially after 2100, and RCP8.5 is slightly less than A2 in 2100 and close to SRES A1F1. It is seen that RCP3-PD (RCP2.6) contains lower values than all SRES scenarios (Akçakaya et al., 2015).

RCP8.5 is the high radiative forcing and concentration route (Table 2, Figures 2, 3, 4). In SRES scenarios, it is similar to A2 and A1F1 scenarios. The difference with the low course (RCP3-PD / RCP2.6) plays an important role in the evaluation of the response of the climate to this scenario, displayed with the help of Atmosphere-Ocean Global Circulation Models (AOGCM) (Akçakaya, et al., 2015).

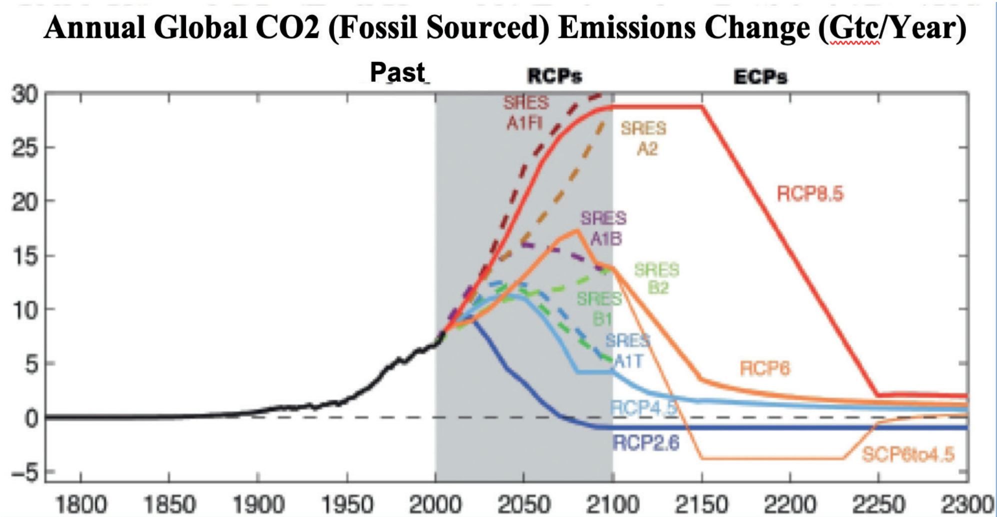
Figure 2: Coupled CO_2 (ppm) Concentrations of SRES and RCPs for the Future Period



Source: IPCC Synthesis Report, 2007, p.26 (Climate Change 2007: The Synthesis Report

RCP3-PD / RCP2.6 is the low radiative forcing and concentration route. The basis of the scenario is the assumption that emissions or radiative forcing will peak and decline before the end of the century. The assumption of peaking first and then falling is a new approach for the climate community. Therefore, the scenario is expected to produce new scientific findings on the "reversibility" of climate change and its effects (Akçakaya, et al., 2015).

Figure 3: Annual Global CO_2 (Fossil Sourced) Emissions Change (GtC/Year) Revealed by SRES and RCPs for the Next Period



Resource: IPCC Synthesis Report, 2007, p.26 (Climate Change 2007: The Synthesis Report

RCP4.5 is a medium equilibrium holding route and it is assumed that the radiative forcing will be fixed at 4.5W/m^2 between the years 2100-2150. This scenario has two advantages over other scenarios. The first is that a very good signal can be obtained due to the difference with the high route, and the second is that there are many published studies on this route in the literature (Akçakaya et al., 2015).

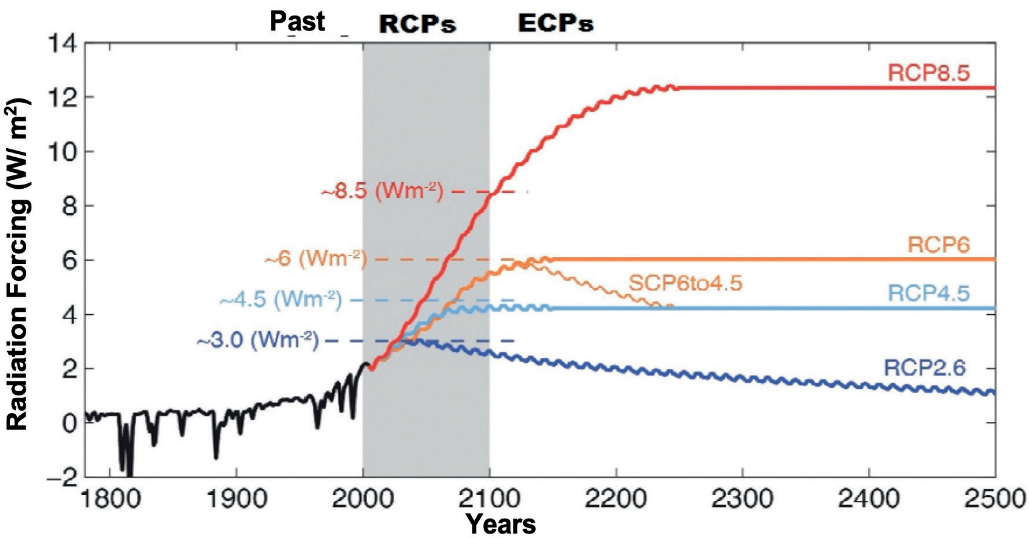
Table 2: RCP Types and features

RCP's	Radiation Forcing	Time	Radiation Forcing Change	Total Concentrations (CO_2 equivalent)	Emissions (KYOTO Protocol Greenhouse Gases)
RCP 8.5	> 8.5 W/m^2	In 2100	Increase	> ~1370 (In 2100)	The increase continues until 2100
RCP 6.0	~6.0 W/m^2	After 2100	Stabilization without passing the target	~ 850 ppm (In 2100)	Decline in the last quarter of the century
RCP 4.5	~4.5 W/m^2	Before 2100	Stabilization without passing the target	~ 650 ppm (In 2100)	Decline since mid-century
RCPE-PD/ RCP2.6	~3.0 W/m^2	Before 2100	Peak and decline without reaching 3.0 W / m2	Peak ~ 490 ppm and decline (In 2100)	Decline in the last quarter of the century

Source: (Moss et al., 2008).

RCP6 is the second middle route and after 2100 it is assumed that the radiative forcing will be fixed around 6W/m^2. In terms of climate model groups, having two different medium concentration routes can provide great convenience in terms of running all RCPs (Akçakaya et al., 2015).

Şekil 4: Global Total Radiation Forcing



Kaynak: IPCC Sentez Raporu, 2007, s.26 (Climate Change 2007: The Synthesis Report.

2.2. Selected Global Models for Turkey

The General Directorate of Meteorology (MGM) launched regional climate projections produced by downscaling methods for Turkey and these rely on global models under the scope of CMIP5 project and RCP scenarios created by the IPCC. Among the scenarios, RCP4.5, which we can describe as medium, and RCP8.5, which can be described as pessimistic, were selected (Akçakaya et al., 2015).

A series of preparatory studies were carried out before starting the studies to produce regional climate projections. Among these, a high-capacity computer was purchased in 2011, and cooperation was made with the faculty members of Istanbul Technical University (ITU) Meteorology Engineering Department for the capacity building training of the personnel who will carry out the studies and the consultancy services in the studies (Akçakaya, et al., 2015).

As a result of interviews with ITU Meteorology Engineering Department members for regional climate projections studies, it has been decided to use the data of 3 commonly used global model data sets (HadGEM2-ES, GFDL-ESM2M, MPI-ESM-MR) from the global model data sets produced within the scope of CMIP5. (Akçakaya, et al., 2015).

In this context, deficiencies in the selection of the regional model and global models as well as the field of study were eliminated. Three global model data sets (3 global models and their 6 RCP scenarios) were downloaded from the International Center for Theoretical Physics (ICTP) headquartered in Italy, from the projection outputs of the Global Climate Model, which constitute input to the regional climate model. Due to the large size of these data sets (24 TB), the download took approximately 3 months. It was checked whether the downloaded data works with the regional model. Along with these procedures, the period intervals, reference period and field of study were determined for the study. After these processes, before the regional climate model is run for the future, the parameterization studies of the model were conducted to find the best model configuration (Akçakaya, et al., 2015).

2.2.1. Hadley Global Environment Model (HadGEM2-ES)

HadGEM2-ES is a 2nd Generation global model developed by the Hadley Center, a research organization affiliated with the UK Meteorological Service (Met Office). There are many versions of this model with similar physical properties but with different builds. The HadGEM2 series includes a combined atmosphere-ocean configuration and a earth-system configuration that includes dynamic vegetation, ocean biology, and atmospheric chemistry (Table 3). HadGEM2 series IPCC 5. it is one of the models used in the preparation of the report. The standard atmosphere composition consists of 38 levels that rise up to 40 km. The horizontal resolution of the model is represented by 192x145 grid cells with latitude 1.25 degrees and longitude 1.875 degrees. These resolution values are approximately 208x139 km at the Equator and 120x139 km at the 55th latitude. The extended vertical height can reach up to 60th km vertically with 60 levels in order to examine the characteristics of the stratosphere and its effect on global climate. The ocean component consists of a total of 360x216 grid cells between the poles and 30 latitudes, with a longitude resolution of 1 degree and a latitude resolution of 1 degree. It consists of 40 unequal levels in the vertical (resolution can reach up to 10 m on the surface). HadGEM2 series includes HadGEM2-A, HadGEM2-O, HadGEM2-AO, HadGEM2-CC, HadGEM2-CCS, HadGEM2-ES versions. The products of HadGEM2-ES, the most comprehensive version of HadGEM2 series, are used in the study (Akçakaya, et al., 2015).

Table 3: Current HadGEM2 versions

HadGEM2-A	Troposphere, Land Surface , Hydrology and Aerosols
HadGEM2-O	Ocean and sea–ice
HadGEM2-AO	Ocean & Sea-ice, Troposphere, Land Surface, Hydrology and Aerosols
HadGEM2-CC	Troposphere, Land Surface & Hydrology, Aerosols, Ocean & Sea-ice, Terrestrial Carbon Cycle, Ocean Biochemistry
HadGEM2-CCS	Troposphere, Land Surface & Hydrology, Aerosols, Ocean & Sea-ice, Terrestrial Carbon Cycle, Ocean Biochemistry, Stratosphere
HadGEM2-ES	Troposphere, Land Surface & Hydrology, Aerosols, Ocean & Sea-ice, Terrestrial Carbon Cycle, Ocean Biochemistry, Chemistry

Kaynak: The HadGEM2 Development Group Team, 2011

2.2.2. MaxPlank Meteorological Institute

Global Model (MPI-ESM-MR) MPI-ESM-MR is a new generation Ground System developed using the European Center Hamburg Model, Model (ECHAM5) atmosphere model and MPIOM ocean general circulation models, as a result of five years of studies carried out by the Institute, headquartered in Hamburg, Germany (ESMEarth System Model). The major differences of MPI-ESM according to ECHAM5 and MaxPlank Meteorology Institute Ocean Model (MPIOM) are the new radiative transfer scheme in the atmosphere, the use of a new aerosol climatology, the incorporation of the carbon cycle (including ocean biogeochemistry) and the interactive and dynamic vegetation scheme on the surface. MPI-ESM evaluates the exchange between important trace gases such as energy, momentum, water and carbon dioxide; and uses the atmosphere, ocean and land surface in the model. This model is one of the General Circulation Models preferred in global-based comparative model calculations within CMIP5. Thanks to the OASIS3 integration program, the atmosphere and land, and the ocean and biogeochemistry are combined separately. Energy, momentum, water and CO_2 exchange within the model was provided by this combination (Akçakaya, et al., 2015).

MPI-ESM is an integrated global climate model in which both the land model and the ocean model are operated simultaneously. While the standard atmosphere component is represented by 192x96 grid cells in MPI-ESM, the number of different levels investigating the atmosphere in the vertical varies according to the versions of the model. 3 different versions of the model have been developed (Akçakaya, et al., 2015).

MPI-ESM-LR: It is a low resolution version of MPI-ESM. This version has a resolution of approximately 1.9° (~210 km) on land, 63 levels on the horizontal and 47 levels on the vertical. Ocean model, on the other hand, consists of 40 levels at 1,5° resolution horizontally in order to create more detailed information for initial conditions.

MPI-ESM-MR: This version, called medium-mixed scale, has higher resolution than low resolution. This version also includes a resolution of 1.9° (~210 km) on land and 63 levels on the horizontal, as in the MPI-ESMLR, and 95 levels on the vertical.

The difference between the MPI-ESM-LR and the MPI-ESM-MR versions is that both versions can analyze the troposphere and stratosphere down to 0.01 hPa (~80 km), while in the low resolution version this analysis contains 47 levels, and the higher resolution version, MPI-ESM-MR, contains 95 different levels. In this way, the atmosphere can be analyzed in more detail and the changes occurring in different levels of the atmosphere can be revealed in more detail (Akçakaya, et al., 2015).

MPI-ESM-P as LR: This version is the version that is the historical (paleo) selection of the low resolution version, that is, it is the version prepared in the form of projections by taking into account the historical data. Historical data are formed by obtaining information about the periods when meteorological measurements were not performed instrumentally, in various ways (tree rings, glacial masses, cave sediments, etc.).

Within the scope of CMIP5 studies, MPI-ESM-LR and MPI-ESM-MR versions among MPI-ESMs were preferred more than the other version. In our study, the MPI-ESM-MR version, which deals with the layers of the atmosphere in more detail, was preferred (Akçakaya, et al., 2015).

2.2.3. Geophysical Fluid Dynamics Laboratory

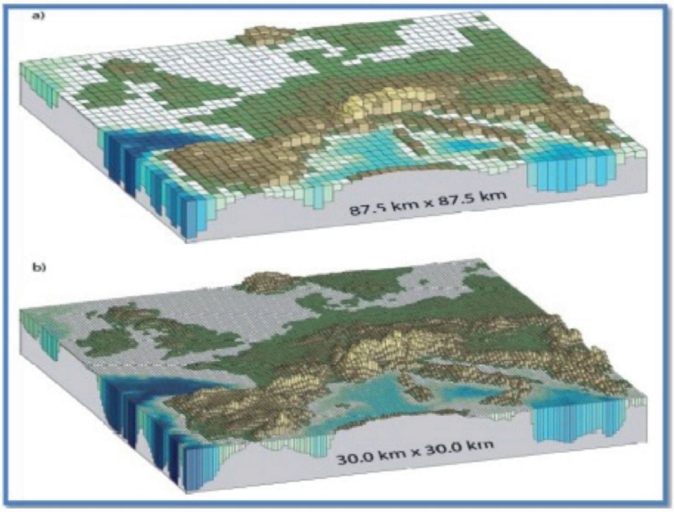
Global Model (GFDL-ESM2M) GFDL-ESM2M is a global Earth System Model developed by the Geophysical Fluid Dynamics Laboratory (GFDL-Geophysical Fluid Dynamics Laboratory) of the National Oceanic and Atmospheric Administration (NOAA). GFDL is a unified global climate model that examines together the interactions of matter cycles (carbon, water, etc.) and human activities on climate systems in the world. During the development of the model, studies were carried out to reveal the interactions of the climate and ecosystem with each other and the changes that may occur due to both natural and human-induced reasons. The model includes atmospheric chemistry (CO_2, NOx, SO4, aerosol, etc.) as well as combined atmosphere and ocean circulation. In addition, model vegetative biology and vegetative surface use, earth physics and hydrology, ocean ecology and biogeochemistry, ocean circulation and sea glacier components have been developed with configurations (Akçakaya, et al., 2015).

The terrain component of the model includes the terrestrial ecology component to simulate accumulations of dynamic carbon and other elements, as well as precipitation and evaporation, streams, lakes, rivers, and runoff. The standard atmosphere component of the GFDL model is represented by a 144x90 grid cell with a resolution of 2 °C latitude and 2,5 °C longitude and contains 40 different levels on the vertical. There are two versions, GFDLESM2M and GFDL-ESM2G. The common feature of these two versions is the development of the climate model named CM2,1, the new land model called LM3, the sea ice model called SIS, and the addition of ocean physics and alternative digital frameworks (Akçakaya et al., 2015). These two models differ only in terms of the physical ocean component. When using the Modular Ocean Model (MOM) version 4,1 with vertical pressure layers in ESM2M; ESM2G is an isopycnic model that uses the independently developed Generalized Ocean Layer Dynamics (GOLD) code base. Both ESMs on land include a modified land model to simulate complex vegetation distribution and functions, including the carbon cycle between vegetation, soil and atmosphere. In the ocean, both models are of 1 °C resolution and feature new biogeochemical algorithms including flexible stoichiometry and phytoplankton function group dynamics. GFDL-ESM2M model was preferred in our projection study (Akçakaya et al., 2015).

2.3. Regional Climate Models and Downsizing

As the data obtained from global climate models represent very large areas, they are not detailed and do not allow for regional analysis. Models that provide more detailed and high resolution information for smaller areas by using this very low resolution gridded information as re-input are described as regional climate models (RCMs) (Figure 5).

Resource 5: Difference Between Low Resolution (a) and High Resolution (b)



Resource: IPCC Synthesis Report, 2007, p.26 (Climate Change 2007: The Synthesis Report

Due to computational difficulties, Global Climate Models (GCMs) usually have a horizontal resolution of 100-300 km. With this resolution, regional climatic changes, topography, coastal areas and details of the land surface cannot be properly reflected. Therefore, small-scale weather events and atmospheric processes such as facade systems or precipitation systems cannot either be displayed in GCMs or are very simply included. Regional climate models (RCMs) are used in order to use the calculation capacity in limited areas in the most appropriate way and to eliminate the deficiencies mentioned above (Akçakaya et al., 2015).

2.3.1. Dynamic Downscaling

Atmospheric dynamic downscaling technique is a common approach used to achieve regional conditions that are not well reflected in low-resolution global models. This approach can be applied in several methods. In this method, a certain area is defined in RCM and certain dynamic climate factors obtained from GCM are applied to the specified area.

Basically, the RCM also exhibits a dynamic structure like the GCM, but consists of 3 main processes. These are:

- Taking limit values from GCM,
- Obtaining own local data for the defined area,
- Solving of RCM's own dynamic equations with the help of these two data and generating values for the redefined area.

In a sense, the results can be described as local estimates determined by GCM and local characteristics. The biggest challenge here is that although the area shrinks, the resolution increases and local conditions are included in the calculations, so a significant computing capacity is needed (Akçakaya et al., 2015).

2.3.2. RegCM-4.3.4

Defined as the Regional Climate Model System (RegCM), it is actually based on a model developed by the American National Center for Atmospheric Research (NCAR). It has been adapted as a regional climate model by the Earth System Physics Department (ESP) of the International Abdusselam Center for Theoretical Physics (ICTP) and is still being developed. The first version, RegCM1, was presented to the scientific community in 1989 and later versions were developed (RegCM2-1993, RegCM2.5-1999, RegCM3-2006, RegCM4 2010). The RegCM4 model, which is the most up-to-date version, is used today and is fully supported by ESP. This version can be used for future climate simulations and historical (paleo) climatological studies for any desired region of the world. With the RegCM4 model, outputs with a resolution of up to 10 km, which is the hydrostatic limit, can be produced. (http://www.ictp.it/, 2012).

2.3.3. Coordinated Regional Climate Downscaling Experiment (CORDEX)

The Coordinate Regional Climate Downscaling Experiment (CORDEX) is a structure created to produce high resolution climate projections to be used in regional climate change adaptation and impact assessment studies. CORDEX is supported by World Climate Research Program (WCRP). Within the scope of CORDEX, the world is divided into 13 different domains (Table 3). For each region, new high-resolution projections are produced by downscaling the outputs of previously run global models with regional climate models. There are different research groups and institutes within the scope of this project. ICTP, which is the developer of the RegCM regional model that we use in our studies, is one of the member institutes of CORDEX (Akçakaya, et al., 2015).

Tablo 4: CORDEX bölgeleri

CORDEX Regions	Whether Includes Our Country Partially or Totally
European Region	✓
Mediterranean Region	✓
Africa Region	✓
South Asia Region	✓
Central Asia Region	✓
Middle East North Africa Region (MENA)	✓
North America Region	x
Central America Region	x
Australia Region	x
Arctic Region	x
South America Region	x
Antarctic Region	x
East Asia Region	x

✓= Includes our country partially or totally. X= Our country is not located within the borders of the region.

Resource: http://wcrp-cordex.ipsl.jussieu.fr/

Our country is partially located within the borders of Europe, Africa, South Asia, Central Asia, Mediterranean and MENA regions. However, no region fully covers our field of study. These six regions either do not contain a part of our country or our country is located at the border points of the region.

2.4. Reference Period and Region Selection

Computer capacity and working time were taken into consideration while choosing the workspace; on the other hand, efforts have been made to choose the most suitable region to reflect the effects of nautical and air systems affecting our region. The selected study area is located between 27.00 °C-51.00 °C north latitudes and 5.00 °C-55.00 °C east longitudes (Akçakaya et al., 2015).

2.5. Testing the Model (Parametrization)

The testing (parameterization) of the model is of great importance in terms of reflecting the climatic values in each grid in the most realistic way. For example; humidity and temperature values in each grid affect cloud formation and the amount of aerosol affects the amount of precipitation. A well-parameterized model result will help decision-makers to make decisions about climate change adaptation activities (Akçakaya et al., 2015).

There are some difficulties in parameterization. Since the testing of the model cannot be done on a grid-based basis, when we make parameterization to correct the values in a region where we get bad results, it affects other regions where we get good results. For this reason, a 100% accurate parameterization does not seem possible in today's possibilities. In our testing of the model, the gridded climate data of the CRU (Climate Research Unit) and UDEL (University of Delaware) were compared with the model results, the threshold values of the grids were re-determined and the model was run in the test scheme of the model that we obtained good results (Akçakaya et al., 2015).

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COMMON RESPONSE AND COMPLIANCE WITH SCENARIO GOALS

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

Climate change is one of the most important threats to nature and will increasingly challenge the way we manage habitats. Some changes already underway due to rapidly changing climate include rising global temperatures, large-scale melting of snow and ice, longer and more frequent drought, changes in the intensity and timing of storms, changes in the timing of seasons, rising sea levels and associated impacts along the coastline, and increased acidification of marine environments. In response to these changes, some plant and animal species are changing and the timing of seasonal events is distorted. In some cases, all ecological zones are changing rapidly, especially in polar, alpine, coral and forest ecosystems. Climate-based changes interact with many other environmental stresses, such as habitat fragmentation and loss, pollution, invasive species spreading and overharvest. The effects of most of these stresses are cumulative (Gross et al., 2016).

The climate change response can be divided into "mitigation" (actions that reduce the amount of carbon dioxide and other heat-trapping gases in the atmosphere) and "adaptation" (adjusting human or natural systems to changing climate). Managers must do everything in their power to improve the carbon capture and storage ability of natural systems and reduce emissions. Key steps for climate change responses are given in Figure 1.

Adaptation Cycle steps for adaptation planning and implementation are as follows:

Step 1: Share knowledge and approaches on adaptation and review existing measures

- Share information and approaches about the necessity and importance of adaptation and concepts.
- Compile information on the adaptation aspects of existing policies and measures and identify areas of gaps.

Step 2: Evaluate the risks associated with the impacts of climate change

- Current, easily available monitoring results information, etc.
- Assess climate change impact risks using available information (identify high risk events and areas).

Step 3: Encourage communication and decide on compliance plans, programs and measures

- Sharing the risk assessment results with the public and stakeholders.
- To determine the necessity of adaptation measures, to consider their significance and to prioritize compliance planning and implementation in policies.

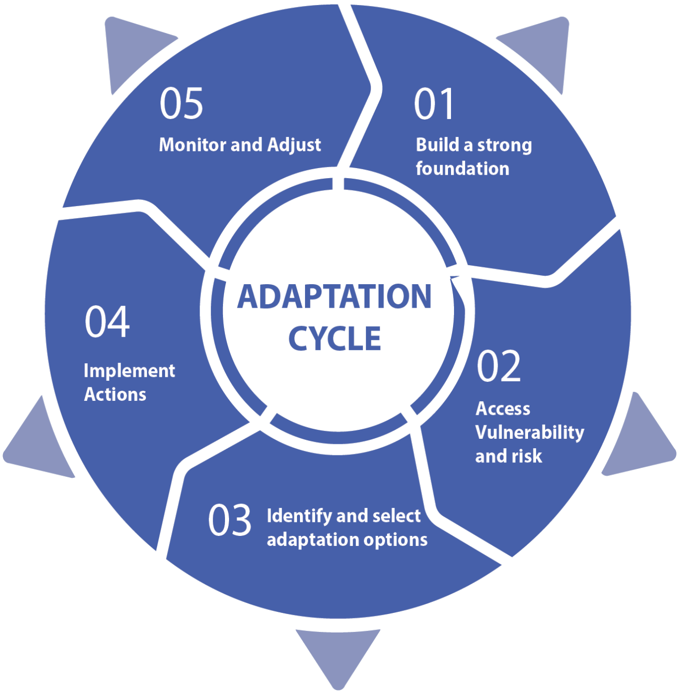
Step 4: Starting with the most appropriate initiatives

- First, take emergency response measures to prevent and / or mitigate short-term effects.
- Then consider adaptation measures where socio-economic benefits are clearly higher than costs.
- Track and evaluate the progress and effectiveness of adaptation measures (overall assessment of progress).

Step 5: Combine risk assessments and adaptation measures based on monitoring and the latest information

- Identify areas and items that require priority monitoring and consider and develop methodologies and regulations for them.
- Improve future projections using the latest research results and local monitoring data.
- Re-evaluation of risks, review and integration of compliance measures (Gross et al., 2016).

Figure 1: The general adaptation cycle consists of five basic steps and is an iterative process



Resource: Gross et al., 2016

2. WILL PARIS BE A TURNING POINT ON THE ROAD TO GLOBAL DECARBONIZATION?

It will be important to further stabilize and accelerate a downward trend in the energy intensity of the global economy. In addition, the most important condition for decoupling emissions from energy supply is decarbonisation of energy supply. Two major developments give hope that this will happen in the near future:

1. The global development of renewable energy is a great success story. Of the 58 countries included in the Climate Change Performance Index, 44 have double digit growth rates. Only four countries included in the Climate Change Performance Index have not increased their renewable energies. In more and more countries, the positive developments in the price development of renewable energies allow them to compete with other energy sources.

2. In order to enter the path of decarbonization, phasing out coal as the dirtiest energy source is essential. It is encouraging to observe that worldwide coal use is declining. Some of the most emitting countries have reduced coal use, and recent reports show that global coal consumption decreased in 2015. A new publication of the Institute for Energy Economics and Financial Analysis (IEEFA) reported that the changes in China led to a structural change in international markets. In most of the major coal countries, coal consumption is decreasing: USA (-11%), Canada (-5%), Germany (-3%), the UK (-16%), Turkey (-13%), China (-5.7%), Japan (-5%), South Africa (-2%). This dynamic structure led to a decrease in coal consumption of up to 4% in 2015 (Irena 2020).

3. THE SITUATIONS OF G 20 COUNTRIES

In 2018, global emissions grew once again, signaling that stronger efforts than ever are needed to reduce emissions to stop global warming at 1,5 °C. This means that G20 countries will have to increase their 2030 emission targets in 2020 and significantly increase their mitigation, adaptation and financing measures over the next decade.

3.1. Adaptation

Currently, extreme weather events cause about 16,000 deaths and $ 142 billion in economic damage in G20 countries each year. While less developed countries are generally more affected by industrialized countries, many G20 countries are among the 31 countries most affected by extreme weather events, with the highest annual death rates per population in the world.

Limiting the global temperature increase to 1,5 °C instead of 3 °C reduces the negative effects on the sectors in G20 countries by more than 70%. For example, if the average drought length is reduced by 68% and the number of days above 35 °C per year from 50 to 30, there may be considerable reductions in heat waves that destroy plants.

All G20 countries have adaptation plans except Saudi Arabia. Climate change adaptation is a seminal policy goal that is increasingly included in national adaptation strategies (Climate Transparency 2019).

3.2. Mitigation

Energy- related CO_2 emissions in G20 countries increased by 1.8% in 2018 due to high economic growth and even more fossil fuel energy sources. This increased sales of all fossil fuels and the gas industry profited the most. Energy supply increased at the highest rate in the USA and Canada as a result of strong growth and weather conditions. The energy supply of fossil fuels has grown in nine G20 countries (Australia, Canada, China, India, Indonesia, Russia, South Africa, South Korea and the USA), mainly due to increased fuel use in transport and higher electricity demand. The carbon density of the energy system has slightly decreased. 82% of the G20's energy mix is still fossil fuels. This should drop to at least 67% by 2030 and 33% by 2050 without carbon capture and storage to be globally 1,5 °C compliant.

G20 countries need to reduce their current greenhouse gas (GHG) emissions by at least 45% by 2030 (below 2010 levels) to comply with the global benchmarks set by the IPCC's 1,5 °C report. Industrialized G20 countries should reduce their greenhouse gas emissions to net zero a few years before the rest of the world (Climate Transparency 2019).

3.2.1. Nationally Determined Contributions (NDCs) - 2030 Emissions Target

Approximately half of the G20 countries (China, the EU and the G20 member countries, India, Indonesia, Russia, Saudi Arabia, Turkey) are foreseen to meet or exceed their national contribution targets for land use, land use change and meet forestry emissions. However, it is difficult to assess Saudi Arabia's progress. In addition, Saudi Arabia's contribution to national goals and objectives of Russia and Turkey, the Treaty of Paris, the temperature required to reach a long-term target is too far away. Indonesia is unlikely to meet national contribution targets, considering emissions from land use, land use change and forestry.

South Korea, Canada and Australia are the furthest G20 countries to implement their national contribution targets. Argentina, Brazil, Japan, Mexico, South Africa and the USA may also exceed their national contribution targets if they do not take additional action. To limit global warming to 1,5 °C, all G20 countries will have to increase their national contribution targets (Climate Transparency 2019).

3.2.2. Long Term Strategies - 2050 Emissions Target

There is an increasing trend that is accelerating net-zero emissions targets. France and the United Kingdom have a target of net zero emissions by 2050 stipulated by law. Germany has adopted a target of net zero emissions 2050 and it will be enacted soon. Argentina, EU, Italy and Mexico also announced that these targets were accepted.

Canada, France, Germany, Japan, Mexico, the UK and the USA submitted their long-term strategies for 2050 to the United Nations Framework Convention on Climate Change. Argentina, China, EU, India, South Africa, South Korea and Russia are currently preparing their strategies (Climate Transparency 2019).

3.2.3. Energy

Emissions in the energy sector, including electricity and heat generation, increased by 1.6% in 2018, similar to the annual average of the last decade. Indonesia and Turkey consume more coal than ever for the electricity - and their energy emissions are increasing most countries in 2018. South Africa continues to have the highest emission intensity in the G20. All three countries urgently need to develop coal staged generation plans and stop building more coal plants. 2030 for OECD countries and 2040 for the rest of the world are the deadlines for plans to phase out coal. However, it is also mandatory for Australia, India, Japan, Mexico, Russia, South Korea and the United States, which have not yet taken significant measures to phase out coal.

France, Brazil and the United Kingdom significantly reduced emissions in the energy sectors in 2018. Of the G20 countries, only Brazil and Germany have long-term renewable energy strategies, while France and the UK have 1,5 °C compliant coal phase-out plans alongside Canada and Italy. To slow global warming to 1,5 °C, all G20 countries must have zero-carbon electricity by 2050 (Climate Transparency 2019).

3.2.4. Transportation

Transport emissions of the G20 continued to increase in 2018 (1,2%). In order to keep global warming below 1,5 °C, the share of low-carbon fuels in the transport fuel mix (6%) for G20 countries will need to increase roughly ten fold by 2050. The US, Canada and Australia have the highest transport emissions per capita among the G20. For example, US emissions per capita are 24 times higher than India. All three countries are implementing inadequate policies for 1,5 °C compliant transport conversion. Australia, in particular, lacks important policies such as emissions or fuel-efficiency standards for light commercial vehicles. In addition, it does not implement policies that encourage public transport.

Canada, France, Japan and the UK plan to phase out fossil fuel cars by 2040/2050. However, the commitments of these four countries are still insufficient. A phased termination by 2035 is the latest possible date to be 1,5 °C compliant. China sold more than one million electric cars in 2018, almost twice that of 2017. China also has the most progressive public transport policy in the G20.

In G20 aviation emissions, Australia, USA and UK have the highest flight emissions per capita. For example, Australia emissions per capita are 53 times higher than India. G20 countries need to reduce government subsidies, lower jet fuel tax, reduce air transport, and invest in electro-fuels (Climate Transparency 2019).

3.2.5. Construction Sector

Although average emissions have stabilized over the past decade, G20 emissions in the construction sector grew more than any other sector in 2018 (4,1%). The USA, Australia, and Saudi Arabia had the highest construction sector emissions per capita in 2018. The three countries lack ambitious policies to significantly reduce emissions in the sector. There are building codes for new buildings, but there is no national strategy for all new buildings to be near zero energy and retrofitting existing buildings.

European countries are pioneering 1,5 °C compliant strategies for new zero-energy buildings. The EU, France and Germany are the only G20 members with long-term strategies for building retrofitting. In order to be 1,5 °C compliant, even these countries will need a deep renewal rate of 5% by 2020, while non-OECD countries will need 5% renewal rates per year (Climate Transparency 2019).

3.2.6. Industry

The G20's growth in industrial emissions in 2018 (+3.1%) remains highly problematic. Emission intensity in the sector is highest in Russia, India and China, partly due to the shift of heavy industry from developed to developing countries. At the same time, India and China are among the G20 countries with the most progressive energy efficiency policies. India's mandatory efficiency policies cover more than 26-50% of industrial energy use as of 2017, while China and Japan cover 51% to 100%. However, no G20 country has a long-term strategy to reduce industrial energy emissions by 75-90% from 2010 levels by 2050, which would be 1,5 °C compliant. (Climate Transparency 2019)

3.2.7. Agriculture and Land Use

Less consumption of animal products will reduce G20 emissions in agriculture. The high rates of deforestation in Argentina, Australia, Brazil and Indonesia must be stopped. G20 greenhouse gas emissions from agriculture continue to increase. Livestock is the main factor and accounts for 40% of agricultural emissions. The G20's four rainforest countries - Argentina, Australia, Brazil, Indonesia - need to develop a net zero deforestation strategy in the 2020s to be 1,5 °C compliant. At the UN Climate Action Summit in September 2019, Argentina announced that it would aim for net zero deforestation by 2030. India, China, and Mexico rank at the top of long-term deforestation policies. India is the only G20 country with 1,5 °C compliant forest policies (Climate Transparency 2019).

3.3. FINANCE

3.3.1. Financial Policies and Regulations

G20 economies lead the greening of the financial system. All G20 countries have begun to discuss green financial principles such as national green finance strategies, climate-related financial risks, and the taxonomy of green and brown investments. But the G20 developing economies leads the way in implementing policies that reduce climate-related risks for the financial system as a whole. Brazil, France, and South Africa have climate-related risk disclosure requirements for financial institutions. Canada and Indonesia have voluntary and mandatory climate-related risk assessments, respectively. China, India and Japan have set capital and liquidity requirements for financial institutions that prefer green loans and investments (Climate Transparency 2019).

3.3.2. Fiscal Policy Levels

The G20 countries, excluding Saudi Arabia, provided subsidies of US $ 127 billion for coal, oil and natural gas in 2013 compared to US $ 248 billion. This downward trend can be seen in the nine G20 countries: Argentina, Brazil, China, India, Indonesia, Italy, Japan, UK and USA. In general, subsidies to coal mining tend to decline, while subsidies to coal-fired power continue and in some countries natural gas infrastructure and generation subsidies are increasing. All G20 countries must eliminate fossil fuel subsidies by 2025 at the latest. European countries are already determined to phase this out in 2020.

A total of 18 G20 countries have implemented or are in the process of implementing explicit carbon pricing schemes such as emission trading systems and carbon taxes. The newcomers are South Africa, which launched Africa's first carbon tax in June 2019, and Argentina, which passed a carbon tax in 2018 for most liquid fuels (However, the size of the Argentine tax is negligible.) Australia and India do not have explicit carbon pricing plans and do not take them into account.

In 2015, an average of 71% of CO_2 emissions from energy in the G20 was not priced at a price of EUR 30 or more over the price of carbon taxes, certain taxes on energy use, or exchangeable emission permits. With the benchmark of EUR 60 per tonne, the price difference for G20 countries increases to 78%. Russia, Indonesia, Brazil, China and South Africa have the highest carbon pricing deficit (Climate Transparency 2019).

3.3.3. Public Finance

In 2016-2017, G20 public institutions financed coal and coal-fired power generation in the international arena with an amount of USD 17 billion and locally, on average, USD 11 billion. The largest G20 financiers abroad are China, Japan and South Korea. China's public financial institutions financed an average of USD 9.5 billion annually in 2016 and 2017, while Japan provided USD 5.1 billion and South Korea USD 1 billion. Development agencies and banks of Brazil, Canada, China, Germany, the UK and the USA restrict public coal spending. Germany and the UK are the only two G20 countries that have announced restrictions on coal financing as shareholders of multilateral development banks (to restrict coal-fired energy financing above the 2013 commitments of the World Bank Group, the European Investment Bank and the European Bank for Reconstruction and Development). G20 countries made 31 billion dollars of climate finance to developing countries in the period of 2015-2016. Per GDP, Japan (total amount: $ 12 billion), France ($ 4 billion), the UK ($ 4 billion) and Germany ($ 4 billion) provided the highest amounts. Japan, Germany and France remain the largest bilateral funders, while the UK provides the highest amount with multilateral funds. Under its current administration, the US did not submit a third biennial report to the UNFCCC, but instead only provided provisional data for these statistics (Climate Transparency 2019).

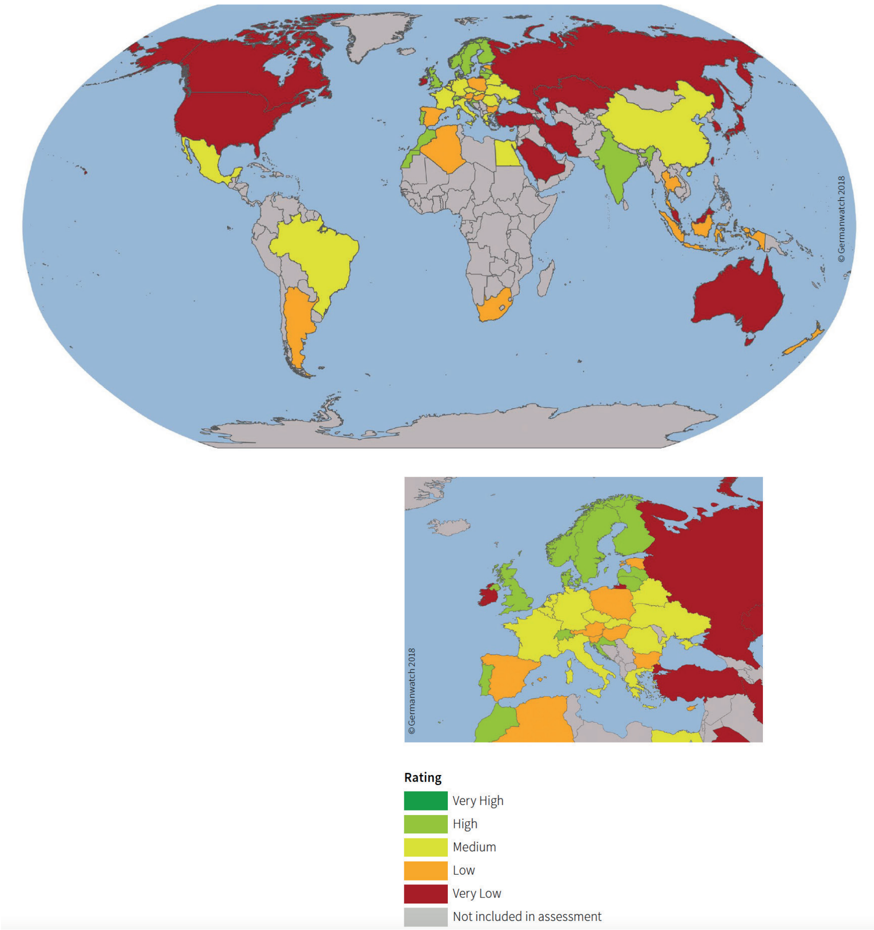
4. CONCLUSION

Ranking results in the Climate Change Performance Index are defined by the overall performance of the indicator in a globally unique policy segment for 14 indicators in the "Greenhouse Gas Emissions", "Renewable Energy" and "Energy Use" categories.

The Climate Change Performance Index 2019 results show the main regional differences in climate protection and performance within the EU and 56 evaluated countries. No country performed well enough to rank in the index in 2019, meaning no country ranked in the top three (Burck et al., (2019).

The world map (Figure 2) shows the aggregate results and overall performance of countries. Table 1 shows the overall ranking and shows how the countries performed in different categories.

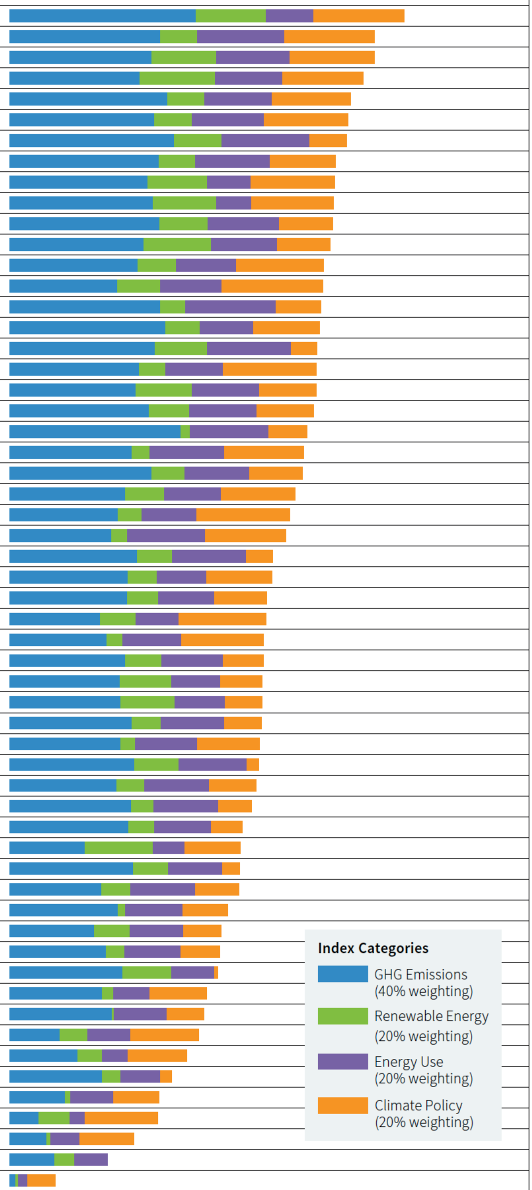
Figure 2: Countries' Climate Change Performance in 2019



Resource: Burck et al., (2019)

Table 1: Climate Change Performance Index Values of Countries

Rank		Country	Score**
1.*		–	–
2.		–	–
3.		–	–
4.	–	Sweden	76.28
5.	▲	Morocco	70.48
6.	▼	Lithuania	70.47
7.	▲	Latvia	68.31
8.	–	United Kingdom	65.92
9.	▲	Switzerland	65.42
10.	▲	Malta	65.06
11.	▲	India	62.93
12.	▼	Norway	62.80
13.	▼	Finland	62.61
14.	▼	Croatia	62.39
15.	▲	Denmark	61.96
16.	▲	European Union (28)	60.65
17.	▲	Portugal	60.54
18.	▲	Ukraine	60.09
19.	▲	Luxembourg	59.92
20.	▲	Romania	59.42
21.	▼	France	59.30
22.	▼	Brazil	59.29
23.	▼	Italy	58.69
24.	▲	Egypt	57.49
25.	▲	Mexico	56.82
26.	▼	Slovak Republic	56.61
27.	▼	Germany	55.18
28.	▲	Netherlands	54.11
29.	▼	Belarus	53.31
30.	▲	Greece	50.86
31.	▲	Belgium	50.63
32.	▲	Czech Republic	49.73
33.	▲	China	49.60
34.	▲	Argentina	49.01
35.	▲	Spain	48.97
36.	▼	Austria	48.78
37.	▼	Thailand	48.71
38.	▼	Indonesia	48.68
39.	▲	South Africa	48.25
40.	▲	Bulgaria	48.11
41.	▼	Poland	47.59
42.	▲	Hungary	46.79
43.	▼	Slovenia	44.90
44.	▼	New Zealand	44.61
45.	▼	Estonia	44.37
46.	▼	Cyprus	44.34
47.	▼	Algeria	42.10
48.	▲	Ireland	40.84
49.	▲	Japan	40.63
50.	▼	Turkey	40.22
51.	▲	Malaysia	38.08
52.	▲	Russian Federation	37.59
53.	▲	Kazakhstan	36.47
54.	▼	Canada	34.26
55.	▲	Australia	31.27
56.	▼	Chinese Taipei	28.80
57.	▲	Republic of Korea	28.53
58.	▲	Islamic Republic of Iran	23.94
59.	▼	United States	18.82
60.	–	Saudi Arabia	8.82



* None of the countries achieved positions one to three. No country is doing enough to prevent dangerous climate change. ** rounded

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Resource: Burck et al., (2019)

In the 2019 index, Sweden ranked first in Morocco and Lithuania. The group of countries with medium performance includes countries such as France, Mexico, Germany and the Czech Republic. Generally, underperformers include Indonesia, Austria and New Zealand. The bottom five countries in this year's Climate Change Performance Index Are Saudi Arabia, the USA, the Islamic Republic of Iran, the Republic of Korea, and Taiwan, and they scored low or very low in almost all categories (Burck et al., (2019)).

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POSSIBLE EFFECTS AND RISKS OF CLIMATE CHANGE ON SECTORS IN TURKEY AND WORLD

Prof. Dr. Mehmet Somuncu

1. INTRODUCTION

The most important result of the greenhouse effect which has become stronger as a result of gradual increase of the accumulation of greenhouse gases in the atmosphere after the industrial revolution due to human activities is that these create an additional positive radiational strain on the energy balance of the Earth, making the climate of the world hotter and more variable (Türkeş, 2019) The average temperatures in the world have increased by 0,87 °C from the Industrial Revolution up to date (IPCC, 2018). Both at the global scale and regional scale, climate change causes the occurrence of important changes in the frequency, magnitude, spatial distribution, length, and timing of extreme weather and climate conditions. For example, a significant decrease and increase trend has been observed in various regions of the world in the 1950-2011 period in the precipitation, which is characterized by a high variability both in spatial and timing terms. Besides, increases have been observed in precipitation events in various regions of the world and in Turkey and some extremities caused important changes (Türkeş, 2019)

It is foreseen that this temperature increase should be limited to 2 °C, that as a result of a warming of more than 2 °C, carbon stored at oceans, wet areas and tundra could be released to the atmosphere, and the greenhouse gas emissions could continue due to changes in natural processes even if the fossil fuel oriented emissions could be stopped. It is foreseen that if no precaution is taken by IPCC, the average temperatures could increased by 4 °C by the end of the 21st century. For that reason, in the Paris Climate Agreement which was held in Paris in 2015 and negotiated in the 21st Conference of Parties (COP21) and entered into force in 2016, it is stated that temperature increases connected with global heating should be kept limited at 2 °C, and if possible at 1,5°C. For that reason, a report was published, which is known as 1,5 °C Report, at the beginning of October of 2018 by IPCC. In this report, it was emphasized that why the temperature increase should be limited to 1,5 °C instead of 2 °C (IPCC, 2018; Tolunay, 2019).

According to the up to date findings which rely on analysis of long term climatologic observation series, changes in extreme weather and climate events are observed in Turkey particularly in the 1990s with significant increase in the number of summer and tropical days, significant decrease in the number of days with frost cases and snow, and extension in the part of the year when frost event is not observed. Whereas almost 50% of the records related to maximum air temperatures have been broken since 2000 in Turkey, this rate decreased to 10% in records pertinent to minimum temperatures. In other words, in the last 25-year period in Turkey, the temperature regime has significantly changed towards warmer and hotter conditions, and there occurred significant changes in the frequency and magnitude of hot weather waves.

In addition to the changes and trends observed, in connection with the climate model affinities, the increase trend seen in sub-troposphere and surface air temperatures in general, and the increasing thermal energy (positive radiational forcing) and accelerating and/ or strengthening hydrological cycle, it could be seen that there could be increases in the frequency and/or magnitude of extreme weather and climate events in many parts of the World in 21st century (Türkeş, 2019).

Climate change will increase the existing risks and create new risks for natural and human systems. Risks are distributed in an unequal way and generally are more for disadvantageous people and communities in countries at all levels of development. Increase of heating will increase the possibility of strong, widespread, and irrevocable impacts for human beings, species, and ecosystems. Ongoing high emissions will mostly lead to negative impacts on biodiversity, ecosystem services, and economic development and increase the risks for livelihoods and food and human safety (IPCC, 2014b)

IPCC Fifth Assessment Report (AR5) focuses on why the climate change is important and on human and natural systems and regional aspects in the same order. The report includes the impacts that currently occur and risks of future impacts, in particular how these risks change with the amount of climate change that occurs and the investments which do not adapt to climate change (IPCC, 2014a; 2014b).

Risks of climate change arise in environments where many interacted processes and stress factors are present. Climate change acts mainly by adding new dimensions and complications to the challenges that have been ongoing for long. Understanding the multiple stress factors context of climate change risks may open door to new understandings and solution approaches. For that reason, the increasing information on risks that arise from climate change could be a good starting point for understanding the opportunities and results of possible solutions.

The impacts of climate change, adaptation, and vulnerability cover various issues. With the deepening of information related to climate change, we see the changing connections of various areas, activities, and assets under risk. Early researches focused on the direct effects of temperature and precipitation on human beings, products, wild plants, and animals. New evidences point out the importance of understanding not only these direct impacts but also the potential indirect impacts including the impacts that could spread overall the world through trade, travel, and safety. As a conclusion, very few aspects of human efforts and natural ecosystem processes may remain outside the possible impacts of changing climate. The fact that the global system is interconnected makes it impossible to draw a limited line around climate change impacts, adaptation, and vulnerability. For that reason, IPCC Fifth Assessment Report (AR5) focuses on the basic elements and determine the points where the problem of climate change intersects with other issues, or where they connect with those. For that reason, the information in this report has been taken as basis in understanding the possible impacts and risks of climate change in the sectors overall the world (IPCC, 2014a; 2014b). These elements which are highlighted in IPCC 5th Assessment Report are summarized below.

2. POSSIBLE IMPACTS OF CLIMATE CHANGE ON GLOBAL SECTORS AND MAIN RISKS

Key risks are the potential severe effects related to Article 2 of United Nations Framework Convention on Climate Change, which means "dangerous anthropogenic intervention in the climate system". Risks are considered as important due to high danger of the exposed societies and systems or both, or their high vulnerability. Definition of key risks rely on expert assessment using special criteria. These are: degree of magnitude of risks, high probability or irrevocability of effects; timing of impacts; permanent weakness or exposure that contribute to risks; or limited potential for mitigating the risks through adaptation or mitigation (IPCC, 2014a).

2.1. Fresh Water Resources

Climate change risks related to fresh water significantly increase with the increasing greenhouse gas concentrations. Part of global population that experience water scarcity and the part that is affected from big river floods increase together with the heating level in the 21st century. It is foreseen that most of the climate change in the 21st century will significantly decrease surface water and underground water resources in dry subtropical region and increase competition for water among the sectors. Today the drought frequency in arid regions will increase at the end of the 21st century. As opposed to this, it is estimated that water resources will increase in higher latitudes. It is foreseen that climate change will decrease water quality and will create risk for the drinking water quality even in the traditional increase due to interactive factors (IPCC, 2014a).

It is foreseen that most of the climate change in the 21st century will significantly decrease surface water and underground water resources in dry subtropical region and increase competition for water among the sectors. Today the drought frequency in arid regions will increase at the end of the 21st century under RCP8.5. As opposed to this, it is estimated that water resources will increase in higher latitudes. Interaction of increasing temperatures, siltation, nutrient substance, and pollutant loads that increases with powerful rains; contaminant concentrations that increase during drought and failure of purification facilities during flood will reduce water quality and constitute a risk for drinking water quality.

2.1. Ecosystems and Biodiversity

Risks of hazardous impacts on ecosystems and human beings increase with heating, ocean acidification, increase of sea level and other dimensions of climate change. It should be noted that the future risk will be higher with the information that natural global climate change at lower rates than the existing anthropogenic climate change caused important ecosystem changes and extinction of species in the oceans and on the land throughout the last millions of years. Many plant and animal species will fail to locally adapt so as to follow suitable climates under the climate change rates at middle and higher interval (RCP4.5, RCP6.0 and RCP8.5) during the 21st century, or will fail to act sufficiently fast. Coral reefs and polar ecosystems are apparently defenseless (IPCC, 2014b)

A major part of land, fresh water and sea species face the risk of extinction due to climate change during and after the 21st century in particularly when climate change interacts with other stress factors. As a result of size and rate of climate change, in all RCP scenarios, the extinction risk increases compared to pre-industrial and current periods.

Marine ecosystems, in particularly coral reefs and polar ecosystems are under the risk of ocean acidification. Ocean acidification has impacts on physiology, behaviors and population dynamics of organisms. Impacts on individual species and the number of species affected from species groups increase from RCP4.5 to RCP 8.5. As a result of a series of chemical reactions that take place, carbon dioxide enters into oceans as carbonic acid. Carbonic acid that increases in oceans lead to many living things that use calcium for growth and creating shell, such as corals and escallops, fail to perform this due to increasing amount of acid. The reason is that every chemical reaction takes place in a certain pH interval. Highly calcareous Mollusca, echinoderms, corals created reefs, planktons and crustaceans are more sensitive than the fish Ocean acidification leads to interacting, complex and strengthened effects for species and ecosystems by moving together with local changes such as pollution, eutrophication and global changes such as heating, gradually lower ocean levels.

2.2.1. Land and Fresh Water Ecosystems

A high portion of both land and fresh water species, in particular when climate change interacts with other stress factors such as habitat change, excessive exploitation, pollution and invasive species, face with the risk of extinction under the effect of climate change foreseen during and after the 21st century. Extinction risk increases in all RCP scenarios and the risk increases with the climate change rate. Many species will not follow suitable climates under middle and high range climate change ranges (namely RCP 4.5, 6.0 and 8.5) in the 21st century. Less change rates (namely RCP 2.6) will create less problem. Some species will adapt to new climates. Those who cannot adapt with sufficient speed will decrease in number of extinct (IPCC, 2014a).

In this century, climate change sizes and rates related to middle and high emission scenarios (RCP 4.5, 6.0 and 8.5), bear the risk of sudden and irrevocable change in fresh water ecosystems including the wetland areas. Examples that will cause important effect on climate are the boreal-tundra North Pole system and Amazon forests. The carbon that is stored in land biosphere (for example in turf, permafrost and in forests) may cause damage to atmosphere due to stored carbon, climate change, deforestation and ecosystem distortion. It is foreseen that increase in death rates in trees depending in diseases and the disappearance of forests in connection with this will occur in many regions through the 21st century as a result of increasing temperatures and drought. Disappearance of forests in this way constitutes a risk for carbon storage, biodiversity, wood production, water quality and economic activities (IPCC, 2014a).

2.2.2. Marine Ecosystems

As a result of climate change foreseen in the middle and after the 21st century, redistribution of global marine species in sensitive regions and decrease of marine biodiversity and challenges in ensuring the fishery efficiency and ensuring the continuity of other ecosystem services. As a result of the projected heating, spatial shifts in marine species will lead to invasion of higher latitude species in tropical and semi-closed seas and high local extinction rates.

It is expected that acquiring species richness and fishery potential will increase at medium and higher latitudes on average and decrease in tropical latitudes. Gradual expansion of regions with minimum oxygen and anoxic "death zones" is projected to occur in a manner to further restrict the fish habitat. It is expected to globally decrease under all RCP scenarios by 2100 and under redistribution of open ocean network primary production. Climate change contributes in the threats of extreme hunting and other non-climate depression factors, thus making sea management regimes hard.

According to medium and high emission scenarios (RCP4.5, 6.0, and 8.5), ocean acidification constitutes significant risks for marine ecosystems and in particular polar ecosystems and coral reefs in relation to impacts on physiology, behaviors, and population dynamics of species from phytoplankton to animals. Highly calcareous Mollusca, echinoderms, and corals making reefs are more sensitive than crustacean animals and fish, causing potentially hazardous results for fishery and livelihoods. Ocean acidification acts together with other global changes (e.g. heating, lowering the oxygen levels) and local changes (e.g. pollution, eutrophication). Concurrent elements such as heating and ocean acidification may lead to interactive, complex, and strengthened impacts for species and ecosystems (IPCC, 2014a).

2.3. Food Security and Food Production Systems

Climate change has already affected food security /due to more frequent occurrence of heating, variable precipitation models, and some extreme events. Observations demonstrate that the yield of some products in most lower latitude regions (for example corn and wheat) is negatively affected from climate changes, and as opposed to this some products at most higher latitude regions (for example corn, wheat, and sugar beet) were positively affected in recent years. Climate change has caused insufficiency in animal development in pastoral systems in Africa, which ended up less yield. There are strong evidences that agricultural pests and diseases have already lead to increase and decrease in reactions to climate change. Based on local and native information, climate change affects food safety in the arid regions of Africa and high mountainous regions of Asia and South America (IPCC, 2019).

Increase of yield effect risk after 2050 in a stronger way depends on the heating level. It is foreseen that climate change will gradually increase the change in crop yield over years in many regions. These projected effects will arise within the context of rapidly increasing demand for product. Food safety is potentially affected from climate change, including food access, use, and price stability. Redistribution of sea fishery demonstrates the potential to shift towards higher latitudes, while in tropical countries creating the risk of decreasing supply, income, and employment that have potential consequences for food security in tropical countries. At the end of 20th century, global temperature increases of ~ 4 ° C or more will lead to great risks for global and regional food safety together with increasing food demand. Food security risks are generally more in lower latitude regions (IPCC, 2014a).

2.4. Coastal Systems and Lower Areas

As a result of increasing sea level during and after 21st century, negative impacts such as floods and coastal erosion will increase further on coastal systems and lower areas. Populations and assets which are estimated to incur risks on coastal areas and human pressures on coastal ecosystems will significantly increase in the coming decades as a result of population increase, economic development and urbanization. Relative costs of coastal adaptation demonstrate differences within and between regions and countries in the 21st century. It is expected that some low level developing countries and small island countries will face very high effects that could cause adaptation costs and loss at a few points of GDP in some situations (IPCC, 2014a).

2.5. Urban Areas

Most of the global risks of climate change intensify on urban areas. Steps that ensure resistance and provide for sustainable development could globally accelerate successful adaptation to climate change. Heat stress, extreme precipitation, interior and coastal floods, landslides, air pollution, drought, and water scarcity create risk for human beings, assets, economies, and ecosystems. It is expected that risks will increase for those who deprive of basic infrastructure and services or who live in low quality houses and open areas. Decrease of fundamental service gaps, improvement of houses, and creating flexible infrastructure systems could significantly mitigate the safety gap and exposure in the urban areas. Urban adaptation makes use of effective multi-level urban risk governance, harmony of policies and incentives, strengthening of local administrations and adaptation capacity of the society, synergy with private sector, and suitable financing and corporate development. Increasing capacities, voices, and impacts of low income groups and unprotected communities, as well as their partnership with local administrations, are beneficial for adaptation (IPCC, 2014a).

2.6. Rural Regions

In the near future and beyond, significant rural impacts are expected in the near future and future through effects on water existence and supply, food safety, and agricultural revenues, including the changes in the production areas of food and non-food products overall the world. It is expected that these effects will disproportionally affect the wealth of the poor living in rural areas who have limited access to modern agricultural inputs, infrastructure, and education. More adaptation could be possible for agriculture, water, forestry, and biodiversity by means of policies that take into account the rural decision-making contexts. Trade reform and investments could improve the market access for small-scaled farms (IPCC, 2014a).

2.7. Extreme Weather Conditions

Changes have been seen in extreme weather and climate conditions since 1950. It is highly possible that the number of cold days and nights will decrease and the number of hot days and nights will increase. The frequency of hot air waves in the wide regions of Europe, Asia, and Australia probably increased. It is highly probable that human effect has contributed in the changes at global scale observed in the frequency and intensity of daily temperature extremes since the midst of the 20th century. It is possible that the human effect increases the possibility of the occurrence of hot waves in some places more than twice. The number of places where the number of extreme precipitation events increased is more than those where the number decreased. In some basins, extreme precipitation means higher flood risk at regional scale. Effects coming from extremities related to climate such as hot air waves, drought, floods, cyclones, and forest fires demonstrate that some ecosystems and many human systems are significantly weak against and exposed to the current climate change (IPCC, 2014a).

Hot air waves, drought, forest fires, floods, strong storms, and dust clouds could affect human health and wealth and also cause widespread social and cultural conflict. Rapid change in temperatures may also affect the seasons and change the period of seasons. For example, shortening winters may lead to problems such as non-matching of elements which plan key roles in a certain ecosystem. Warms or insects may not be present in the nutrition periods of birds, the flowers may not have blossomed when the bees wake up. Whereas the drought and floods that become frequent will affect food production at local level negatively, these will also make communities that live in mountainous regions more exposed to flood risk to be caused by melting glaciers. In addition to this, diseases caused by floods and deaths due to diarrhea could increase in South and South East Asia. The fact that a specific region is open to being affected from such type of extreme weather conditions depends on both the dimension of climate change and on whether the countries develop solutions effective against possible threats. Tropical storms, such as hurricanes, energies of which increase due to heating, will become stronger and the storm ways will possibly change direction and head towards poles. This change of direction means that less rain will be seen on the south of Australia, north of USA and important part of south of Europe, and stronger winter storms will hit North Europe. Even a small increase in the temperature of the seas may lead to occurrence of hurricanes that threaten Australian coasts. For example, hot waves were experienced in Chicago in July of 1995 for five days, and the air temperatures reached to 38-41°C. Despite the fact that Chicago is a modern industrial city where A/C was widely used, the temperature wave claimed the lives for 500 people. Besides, since Chicago is located at the center of corn sowing region of the USA, this hot weather caused 15 % decrease in the corn yield of the USA and a loss of 3 billion US Dollars.

2.8. Human Health

By the half of the century, the climate change projected will strengthen the health problems that already exist and affect human health. During the 21st century, it is expected that climate change will lead to significant increase in health problems in the region and in particular in low income developing countries. Examples include possibility of more injury, disease and death as a result of more intense hot waves and fires; possibility of malnutrition in poor regions due to decreasing food production; lost job capacity and decreasing labor efficiency risks in defenseless population; increasing risks that arise from water and food borne diseases and vector borne diseases. Whereas it is expected that there will be moderate decrease in deaths and diseases connected with cold in some regions as a result of less cold extremes, geographical shifts in food production, and decrease in the capacity of the vectors to communicate some diseases, it is estimated that the size and severity of negative effects will overweigh the positive effects in the 21st century. According to high emission scenario RCP8.5, in the year 2100, it is expected that in some periods of the year the combination of high temperature and humidity in some regions could endanger the normal human activities including vegetative production or working in open air (IPCC, 2014a).

2.9. Safety

It is foreseen that climate change will increase the displacement of people in the 21st century. In both rural and urban areas, in particular in the low income developing countries, the risk of displacement will increase when exposed to extreme weather events more. Extending the mobilization opportunities could mitigate the safety gap for this type of population. Changes in migration models could be a response to both extreme weather events and long term climate change and variability and also migration could be an efficient adaptation strategy (IPCC, 2014a).

Climate change could indirectly increase the documented pushing powers of these conflicts like poverty and economic shocks, increasing the risk of civil war and severe conflict between groups. Numerous evidences associate climate change with these types of conflict. It is expected that the effects of climate change on the critical infrastructure and territorial integrity of many states will affect the national security policies. For example, the fact that the lands are covered by water as a result of increasing sea level constitutes a risk for the territorial integrity of states that have wide coastal band as well as of small island states. Some transborder effects of climate change such as sea ice, common water resources and changes in pelagic fish stocks have the potential to increase the competition between states, however, these may increase cooperation between strong national and intergovernmental institutions and manage most of these competitions (IPCC, 2014a)

2.10. Livelihood Sources and Poverty

It is foreseen that, during the 21st century, the effects of climate change will slow down economic growth, make it harder to mitigate poverty, further threaten food security and extend the current period, and in particular create new poverty traps in urban areas and at new hunger hot points. It is expected that most of the effects of climate change will increase poverty in the developing countries and also create new poverty pockets both in developed and developing countries and those where inequality increased. It is expected that poor households that are dependent on paid labor and are net food purchasers in urban and rural areas will be particularly affected from the increases in food prices, including the regions where there is high food insecurity and high inequality (particularly in Africa). In countries and regions where such shortcomings exist, if insurance programs, social protection measures, and disaster risk management handles the poverty and multi-dimensional inequalities, these could increase long term livelihood resistance among poor and marginal people.

3. POSSIBLE IMPACTS OF CLIMATE CHANGE ON TURKEY'S SECTORS AND MAIN RISKS

Turkey's National Climate Change Adaptation Strategy and Action Plan focuses on water resources management, agriculture, and food security, ecosystem services, biodiversity and forestry, natural disaster risk management, and human health sectors which are among the vulnerability areas that are accepted with participatory processes and supported by technical and scientific studies. (Çevre ve Şehircilik Bakanlığı, 2012; 2016; Republic of Turkey Ministry of Environment and Urbanization, 2018). Therefore, possible impacts of climate change on Turkey and the risks are evaluated within this framework.

3.1. Water Resources

Turkey's current water potential that could be used in a sustainable manner is 112 billion m^3, of which 94 billion m^3 is surface water and 18 billion m^3 is underground water. Around 50% of this potential is currently used in Turkey. The total water consumption which was 54 billion m3 in 2016, corresponds to 48% of Turkey's net water potential. 39 billion m^3 of the total consumption is covered from surface waters and 15 billion m3 from underground waters.

Water used in agricultural irrigation has the highest share with 74% and 13% of the water is used for domestic purposes and 13 % for industrial purposes (Figure 6.21) Therefore, in the year 2016, 40 billion m^3 water is used for irrigation, 7 billion m^3 for domestic use and 7 billion m^3 for industry in qualitative terms.

It is estimated that in 2023, Turkey will use all of the usable water, which is 112 billion m3. As water consumption amounts for the year 2023, 72 billion m3 is foreseen for irrigation, 18 billion m3 for drinking and usage water, and 22 billion m3 for industry, making a total of 112 billion m3. According to this data, it is foreseen that the share of water usage for agricultural irrigation will decrease to 64% in 2023, share of industrial use will increase to 20%, and the share of domestic use to 16%. (Republic of Turkey Ministry of Environment and Urbanization. 2018).

According to the projections of Turkish Statistics Institution (TUIK), it is foreseen that Turkey's population will reach to around 93 million in 2030. According to this, the amount of usable water per capita, which is 1.302 m^3/year today, will decrease to 1.204 m^3/year in 2030. It is possible to estimate the pressures that could be on water resources with the effects of such factors as the current growth rate of the country and change of water consumption behaviors. Besides, all these estimations are valid in case that the existing resources are transferred to this year without being destroyed.

In this regard, as opposed to the general belief, Turkey is not a country rich for water as regards the amount of usable water. According to Falkenmark Index which classifies the countries from the point of per capita water potential, turkey is a country with "water stress" since it has a water potential of 1.000-1.500 cubic meters per capita and the per capita amount of water is below global average. Taking the same index into account, if the amount of water per capita in the country decreases below 1.000 cubic meters, the country will be in water scarcity. Under the light of this reality, Turkey is under the risk of water scarcity in the near future) It is foreseen that this number will further decrease in the future without taking into account the effect of climate change.

Assuming that the amount of usable water will not change throughout the 21st century (namely without the effect of climate change), the amount of water per person will decrease more compared to today by 2050, because the population will increase. According to Turkey's population projections updated in 2018 by TUIK, it is foreseen that the population will be around 104 million in 2050 and 107 million in 2075. According to this, the amount of water per capita will decrease to 982 m^3/year in 2050 and around 957 m^3/year in 2075. These figures will place Turkey among countries with "water scarcity" (Şen, 2013).

It is scientifically foreseen that the most important effect of climate change will be on the water cycle and the climate change in Turkey will lead to a decrease in overall water resources in the future. Decreases in total precipitation are foreseen overall in Turkey, with particular effect in the aftermath of 2041. (Republic of Turkey Ministry of Environment and Urbanization, 2018).

3.2. Agriculture and Food Security

Turkey's climate and surface shapes enable cultivation of cereals, fruit, and vegetables of various species. Of the land assets of Turkey which is 77.9 million hectares, 23.7 million hectares comprise the agricultural areas. As of the year 2016, 31.4 % of the agricultural areas could be irrigated and dry agriculture is performed on the remaining 68.6%. For that reason, agricultural production is directly connected with precipitations.

It is thought that climate change could affect food production in the Mediterranean region where Turkey is located, in various ways. Direct effects could arise in the form of increase in the carbon dioxide amount in the atmosphere and increase in sea level. However, food production in many areas will be more affected from climate change due to such factors as desertification, increase in fire risk, rapid spread of diseases and pests, and changes to occur in global market. On the other hand, the possible impacts of climate change on food production are not fully known. Because, comprehensive integrated studies which will wholly demonstrate the effect of climate change at different levels, have not been carried out. A high majority of the studies carried out focused on limited number of food products, taking into account the conditions where 2 folds more of today's carbon dioxide will remain in the atmosphere with the earth processing methods of today. Together with this, the existing evidences demonstrate that the climate change will negatively affect food production overall the region, that the food prices will increase and the food security will be under threat in the whole region. (Republic of Turkey Ministry of Environment and Urbanization. 2018).

Stockbreeding in Turkey is mainly carried out based on pasture lands and in the form of extensive stock breeding. For that reason, stockbreeding takes place according to natural conditions. Climate change has direct and indirect effects on stockbreeding. Increase of events such as drought, floods, landslides, efficiency losses, and physiologic stress are a few of the direct effects. Indirect effects are the feed quality and amount, availability of drinking water, increase in contagious diseases, and increase of input prices. Observations demonstrate that there is an increase in temperatures, and the model projections show that there will be increases in the frequency, term, and scope of drought. When the temperature continues above 40°C, significant problems will arise for stockbreeding. Animals that crop and ruminate on natural areas such as pasture lands will be directly and more affected from the increasing air temperature than animals like goats and sheep. In particular, the decrease in the efficiency in natural grazing areas depending on drought could negatively affect the lives of animals due to nutrition, leading to a decrease in the production of feed plants needed such as corn and clover and an increase in feed prices. For that reason, it is considered that species and races that are resistant against hot will become more important in the future (Kadıoğlu et al., 2017).

Turkey is a country encircled with seas at three sides. For that reason, fishery, is an important economic activity due to the nutrition of the population and due to being one of the basic livelihood resources of the coastal regions. Fisheries on the coasts provide significant contribution to food security in addition to being able to be conducted at low cost and being an occupation of the population with low income and education level, and are also an important source of protein.

Production of fisheries and aquaculture in Turkey for the year 2017 is 630.820 tons. Of this amount, 322.173 tons comprise aquaculture, 276.502 tons capture fisheries and 32.145 tons products cultivated in waters at interior lands (TUIK, d. 2018). Fishery sectors provides employment opportunity for more than 250 thousand people. Despite high hunting power, the production of water products obtained from seas and internal water resources does not increase and therefore it is considered that the water products production figures are now at top limit. This situation is mostly a result of uncontrolled and excessive hunting. It is expected that climate change will further increase this shortcoming. While clime change leads to change in sea ecosystems on one hand, it will cause economic and social problems on the other. Since water products are very sensitive to changes in the aqueous media, it will become inevitable to cause damages in fishery and cultivation sectors.

3.3. Natural Disasters and Risk Management

Increasing number of studies in recent years point out that the climate change increases the power of destructive meteorological events. Projections related to future foresee that climate change will further strengthen such type of events. In this regard, the relationship between extreme weather events, climate change, and disasters is better understood in recent years. As a matter of fact, climate change leads to extreme weather events and extreme weather events lead to disasters at places where socio-economic conditions are unavailable. For that reason, works towards adaptation to climate change could contribute towards mitigating the disaster risks, and disaster risks mitigations works could contribute to climate change adaptation (Kadıoglu, 2012).

According to IPCC AR4, it is expected that in the 21st century, there will be more frequent, more powerful and longer lasting droughts, hot air waves and forest fires in South Europe, including Turkey. Besides, it is foreseen that significant increases will take place in sudden floods together with the increase in the number of days with short term but severe precipitation. As a result of this, climate change could lead to negative impacts on agricultural and water resources and could increase loss of properties and lives in connection with hydro-meteorological disasters Changes similar to global changes are expected in Turkey's climate which is located in Mediterranean Basin. In particular, the decreases in winter rains, increases in temperatures and droughts, floods, and overflows that we experience recently, could be counted among these. Results of regional climate model studies carried out for Turkey demonstrate that these changes will continue in the future. According to a study quoted in the report published by the World Bank, it is indicated that Turkey will be the 3rd country to be exposed to extreme climate events in the Europe and Central Asia Region towards the end of 21st century (Kadıoğlu, 2012).

Whereas there is no actual significant change in the number of occurrence of geologic and geophysical disasters in recent years, there has been significant increases in the number of occurrence of meteorological, climatic, and hydrologic disasters with the effect of global climate change. There have been continuous and significant increases since 1980 in the number of major scaled natural disasters which are named as "catastrophic" which have meteorological character as a result of global climate change (MGM, 2017). In our country, a total of 731 meteorological disasters were reported in 2015, whereas this number was 654 in total in 2016, 598 in 2017, and 871 in 2018 (MGM, 2016; 2017 and MGM, 2018; 2019).

Turkey is among the risk group countries in terms of potential effects of global climate change. Natural disasters which are foreseen to increase in connection with climate change in Turkey are: extreme weather conditions, forest fires, storms, floods, hail, hot air waves, landslide, and avalanche. Economic losses caused by floods due to climate change in our country have become equal to the economic losses caused by earthquakes. It has been determined by data that the lives lost due to lightnings seen with storms have increased tremendously in recent years, reaching to 400. Parallel to this, it was determined that the number of meteorological disasters that occurred in the 2000s increased by 3 folds compared to the 1960s, 15 folds in terms of insurance losses and 9 folds in terms of economic losses (Kadıoğlu, 2012).

It is hard to estimate the full scope, severity and tempo of the future effects of climate change, but it is still clear that climate change will affect social safety with events to occur at disaster level (Republic of Turkey Ministry of Environment and Urbanization, 2018).

3.4. Ecosystems and Biodiversity

Turkey has three biogeographical regions named as Europe-Siberia, Mediterranean, and Iran-Turan and their transition zones. The fact that the country is located between the continents and the altitudes, surface shapes, and climate characteristics change at short distances, let the country to have a rich characteristics in terms ecosystem diversity with living species and genetic characteristics. Turkey has forest, mountain, steppe, wetland area, coastal and sea ecosystems, as well as different forms and combinations of these ecosystems (Ministry of Environment and Forestry, 2008)

Since the most important factors that determine an ecosystem type are temperature and precipitation regime, changes in the climate will lead to changes in the ecosystem structure and functions. Impacts of climate change in recent years on species and ecosystems have been started to be felt even more. In particular, it is considered that species that have restricted living areas and sensitive ecosystems will be more affected from climate change. In this section where the effects of climate change on ecosystems and the figures related to national studies related to the issue are given, ecosystems are evaluated under three headings, being inland water, terrestrial and marine ecosystems.

3.4.1. Inland Water Ecosystems

Turkey has inland water resources that are very important for livening the biodiversity with its rivers and lakes that cover an approximate area of 10.000 km^2. The inland water potential of Turkey comprises 33 rivers, more than 120 natural lakes, and 825 dam lakes. The expected impacts of climate change on inland water ecosystems are summarized below.

The expected impacts of climate change on inland water ecosystems will lead to results such as area and volume losses of inland water masses, decrease in fresh water resources, decreases in stream and flow rates, and these effects will cause desertification, water scarcity and insufficiency, biodiversity and distortion in habitats, efficiency decreases in agriculture and food insufficiency.

Wetland areas are one of the ecosystems that are the most fragile against climate change. Terrestrial fresh water wetland areas will be affected from changes in precipitation and more frequent and more severe drought, storm, flood and overflows. The change in the time and amount of precipitation that feeds river systems will change water supply on coastal water areas such as deltas and estuaries.

Intensity of nutrient salts that increases as a result of lake water decreasing with temperature causes the extreme increase of algae (bursting) and in particular increase of phytoplankton mainly comprising cyanobacteria that produce toxins. The occurrence of extreme algae increased mostly comprising cyanobacteria in drought periods in the lakes of Turkey and of eutrophication totally coincides with the possible expectations on lakes in arid climate regions together with global heating. Since the nitrogen and phosphorus density which mixes from rivers feeding inland rivers to the lakes will increase as a result of increasing drought, the same situation will also be experienced in the lakes. The algae explosion to occur will damage the ecologic balance in interior lakes, causing a decrease in water plans, hunting fish and birds.

Narrowing on lake surface areas will be observed at a high rate on wetland areas in Central Aegean and Central Anatolia, and at relatively low rate on wetland areas in Marmara and East Anatolia regions. Although narrowing is expected on surface areas as a result of vaporization arising from temperature increase, there may not be much change on the status of delta and lagoons located at coastal areas as a result of the sea level expected to rise. However, as a result of increasing salinity and changing flora, an absolute change and losses will be observed in the fauna and bird species fed by these (Ministry of Environment and Forestry, 2008).

3.4.2. Terrestrial Ecosystems

The terrestrial ecosystems in Turkey comprise mainly agricultural ecosystems and steppe, forest and mountain ecosystems. Agricultural ecosystems (planted areas) comprise around 35% of Turkey's total surface area and most of these are located in steppe regions. Of total agricultural area, 70% comprise cereals, 5% fruit gardens, 2.7% vegetable gardens, 2% vinery and 2% olive trees.

Information related to projections which could be caused on air temperature and precipitation for three separate periods in the future and all basins in the country by climate change until the year 2100 is presented in the project report prepared by General Directorate of Water Management.

In the study, prospective data obtained from global climate change models and the days with hail, plant vegetation season and earth humidity balance analysis were conducted for 30 agricultural basins (General Directorate of Water Management, 2016; Kadıoğlu, 2017). Results demonstrate that the water amount will remain limited in a huge portion of Turkey in summer and spring months, and that the balance between precipitation and vaporization – sweating will change. Together with this, the biggest impact on ecosystem hydrology is in the length of plant growing season and the increasing growth day degrees and changes will occur in the flora in connection with it. The increase of vaporization – sweating rate in connection with the lack of snow and rain expected, will increase stress in water resources and thus in agriculture and forestry sectors. Thus, with the rapid increase in air waves and decrease in precipitation, it is expected that, starting from the year 2015 which is the start of the climate projections period, the possibility of agriculture, tourism, industry sectors, which are in competition for water, and the drinking and usage water sectors being affected is expected to be at high levels (Kadıoğlu, 2017).

One of the issues which affect agricultural ecosystems and are expected to affect in the future is drought and desertification. Taking the climate factors and the vegetation into account, the dry lands of Turkey that have tendency for aridification include a significant part of terrestrial inner and eastern regions, and South East Anatolian Region. A wide part of Mediterranean and Aegean regions is considered as semi-humid areas which could be more affected from the desertification processes in the future depending on wrong land use. This opinion is further supported by the fact that, in addition to long term and strong summer droughts and high air temperatures, the change tendencies towards arid conditions observed in the precipitation and aridity index series increase the strength of desertification of climate factors in the Mediterranean and Aegean regions.

In summary, whereas winter and spring rains in Aegean, Central Anatolia and Mediterranean regions decrease, both the air temperature in summer months and the vaporization- sweating increases. Despite this, due to the fact that the sawing of summer plants such as sunflower and corn and clover rapidly increases in Central Anatolia, the amount of irrigation water needed could be approximately doubled compared to now. Although irrigation is made, since the plants will incur higher and extreme temperatures in the blossoming and grain filling period, it is expected in particular that there will be decrease in the efficiency of summer plants (Kadıoğlu, 2017).

Whereas steppe ecosystems in Central Anatolia remain in the form of a narrow band at places that are close to forestry borders on the north and south, steppe areas that cover wide areas will easily turn into desert ecosystems on a wide area encircling Salt Lake. Since Central and South East Anatolia Regions are drought areas with tendency towards desertification with rare and sensitive flora, the fact of desertification will easily take place in these regions. However, since an improvement will be seen in line with semi-humid climate conditions on north areas of Central Anatolia, it could be expected that the existing forest border will descend towards south, though at a little rate (Republic of Turkey Ministry of Environment and Urbanization, 2018).

Forest Ecosystems comprise 28.6% of Turkey's surface area according to the data of 2015. The total forest areas are 22.34 million hectares (Forestry General Directorate, 2015). In addition to coniferous and leafed forests, there are bushes and scrubs, humid, semi-humid coniferous and dry forests (oak, black pine and Turkish pine) in Aegean and Mediterranean regions. Main possible effects of climate change on Turkey's forests are summarized below.

- 1°C increase in global average temperature will significantly increase the species composition and functions of forests. New forest species could occur with the formation of new type of compositions. Besides, effects such as disease and fire will increase depending on the increase of temperature. Northern forests will be more affected than tropical forests from the increasing temperatures.
- In particular, the living areas of species and ecosystems living at coastal regions and low altitudes will shift to higher altitudes.
- Increases are expected in the frequency, period and magnitude of forest fires with the increase of temperatures and decrease of precipitation. Besides, the area of regions that are very sensitive against fire, which is 60% of Turkey's forests today, will extend.
- Plant and animal species could migrate towards areas where there are suitable ecologic conditions for ensuring adaptation to climate conditions. The vegetation bands and forest limit that are observed at mountainous areas in Turkey could shift towards higher altitudes.
- With the increase of temperatures, the growing periods of plants will start earlier and last longer so as to include autumn. Some species will not adapt to changing conditions.

Turkey is a high altitude and mountainous country with an average height of 1132 meters. The mountain ranges that are an extension of Alpine – Himalayan mountain system extent parallel to coast on the south and north of the country. There are many high volcanic mountains in the interior parts, of which the highest is Agri Mountain (5137 m). The types of mountain ecosystems in Turkey change according to biogeographical regions, ways of formation and height. According to the researches conducted, significant amount of withdrawal is determined in the glaciers located at high mountains in Turkey. In the area where glaciers are located, long term atmospheric heating trend observed in the nearby meteorology stations is in compliance with the narrowing trend in the glacier (Republic of Turkey Ministry of Environment and Urbanization, 2018).

This data demonstrate that, in the coming years, it is possible that the magnitudes of climate change impacts observed in the mountain systems will increase. The decrease in precipitations and temperature increase will lead to significant changes in the mountainous hydrologic regime. As a conclusion, the availability of hydrogeologic risk and water resources will be significantly affected.

3.4.3. Marine Ecosystems

Turkey has a coastal length of 8.333 km including the coasts of Mediterranean, Aegean Sea, Marmara Sea and Black Sea, excluding the islands, and 22% of its coasts are under protection. Such long sea and coastal areas have different characteristics, hosting quite rich biodiversity values. Around 5000 plant and animal species have been determined in Turkey's territorial waters. Coastal ecosystems are special ecosystems due to the fact that they are important sudden transition regions (ecotone) where sea and land ecosystems intersect. 4.1% of the terrestrial resources that constitute country surface area comprises coastal ecosystems. The fact that the way mountains descent towards seas in coastal regions of our country and the coastal topography is different lead to the appearance of various coastal ecosystems such as dunes, fishponds, cave, delta, lagoon, travertine structures which differ among regions.

Among the seas of Turkey, Mediterranean which has the highest saltiness and temperature rate is the region where the biodiversity is the richest. There are 400 fish species in Turkey part of the Mediterranean, whereas there are 300 fish species in Aegean Sea, 200 in Marmara Sea and 151 in Black Sea. Coastal areas in Eastern

Mediterranean region are the rich ecosystems that have very high flora and fauna diversity (Ministry of Environment and Forestry, 2008).

Whereas the protected areas system in Turkey host numerous sea and coastal protection areas, these areas have terrestrial and sea connections. A sea area of 346.138 hectares on average is under protection in Turkey, and around 4% of territorial waters are being protected. Special Environmental Protection (ÖÇK) Regions are the areas that are taken under protection by national regulations under the scope of Barcelona Convention – Mediterranean Action Plan. A total of 11 areas on Mediterranean and Aegean coasts of Turkey are taken under protection as Special Environment Protection Region in order to ensure sustainability of sea and coastal biodiversity.

The effects of climate change in marine ecosystems appear in particular in the form of increase of sea water temperature, increases in sea water level, changes in salinity, density and streams and distortion of biodiversity, foreign species invasion and loss of natural resources.

Whereas Mediterranean has a rate of 0.82% over the global ocean surfaces, it has 4-18% of the global marine biodiversity. Despite being a closed sea, it is defined as "miniature ocean" by physical oceanography. Climatic modellings demonstrate that Mediterranean basin will be one of the regions which will be most affected from the global heating trend with the increase of extreme events. Many studies conducted in relation to risks which the Mediterranean biodiversity encounters with the increase of sea water temperature verify this evaluation. (Republic of Turkey Ministry of Environment and Urbanization, 2018).

The increase in water temperature as a result of tropical flow to Mediterranean from Gibraltar and the climate change in recent years, lead the water of the Mediterranean to become tropic. The increase in the number of foreign species that enter from Suez Canal plays an important role in this change. With the increase in the number of foreign species from Suez Canal in recent years, Mediterranean has become a sea which experienced the highest biodiversity change in the world and has become a region where the effects of climate change on biodiversity could be observed the best. Whereas the number of species that come from Suez Canal and enter into, settle in and spread overall the Mediterranean until the middle of 20th century was quite few as a result of temperature and saltiness differences/ barriers between Red Sea and Mediterranean, there has been very important increase in this number. This increase is directly related to the warming of Mediterranean water. Today, the number of species that entered from Suez Canal and settled in Mediterranean is over 600. Some of the alien species compete with local species in the media where they are newly carried and lead to irrevocable changes on biodiversity, collapse of fishery, distortion of stocks related to culture fishing, increase of production costs and effect on human health (Republic of Turkey Ministry of Environment and Urbanization. 2018).

3.5. Coastal Areas

The coast length in Turkey is 8333 km. There are 28 coastal cities in these regions. According to the data of 2009 census, around 54.7% of the Turkish population live in these cities. The population density of Turkey is almost double in coastal cities. In addition to this, the pressure on coastal cities further increase due to high immigration. It is foreseen that the climate change will effect more the coastal areas which demonstrate sensitive features and structure compared to inner regions. Coastal erosion, flood and water overflows that occur on our coasts, including in Central and Eastern Black Sea, Northern Aegean and Easter Mediterranean, are among important problems when we take the recent past into account. Cities which are touristic and located at the coastal line are particularly under threat.

There are studies on land losses that could be expected in Turkey according to sea level increase scenarios. Results of the studies indicate that places which will be affected the most from climate change on Turkish coasts are the coastal deltas where agricultural production is the highest, wet land areas and tourism regions at low altitude (Republic of Turkey Ministry of Environment and Urbanization, 2018).

3.6. Health

Climate change could have direct or indirect effects on human health. Whereas floods, extremely hot air waves, storms and other extraordinary climate events have direct impacts on human health, the climate change will cause long term problems in water food and shelter, thus having an indirect effect. Climate change distorts the ecosystems and could case changes in distribution of contagious disease bearing vectors and global population and thus increases in the frequency of vector borne diseases.

There has been a significant increase in the tularemia cases in recent years. According to the results of a comprehensive compilation made in this subject, 866 of 1441 patients diagnosed in the past 75 years from 1936 to 2011 (60%) have appeared in the last 10 years.

Malaria is the leading of diseases that are known to be related to climate change. However, the only factor that determines the number of cases is not the climate change, but also health services are also determinant. As a result of this, the number of malaria cases has significantly decreased in the last 10 years.

Crimean-Congo Hemorrhagic Fever is a diseases seen in the world particularly in Asia, Africa, Middle East and East Europe and was first seen in our country in 2002 in Kelkit valley. Turkey, 8742 people got sick according to official records in 2008-2017 period due to Crimean-Congo Hemorrhagic Fever and 409 people have lost their lives. Among the reasons for this disease to become such widespread are that the number of ticks that bear the disease virus has increased as a result of climate change, forest areas are converted into agricultural areas, and the number of rodents that act as source of blood for the ticks has increased as a result of climate change (Republic of Turkey Ministry of Environment and Urbanization, 2018).

3.7. Settlement Areas and Tourism

Cities are affected from climate change directly and they are indirectly affected from the events that occur in connection with the change (temperature increase, increase of sea level, changing precipitation regimes and wind speeds, hot air waves, heat island effect, disasters, tsunami, flood, overflows, erosion and landslide, drought). This influence has effects particularly on urban life quality and sustainable development. Starting from IPCC Third Assessment Report, the central role and importance of cities in the climate change has entered into issues with international priority. The potential that taking direct and indirect urban emissions under contract will decrease total greenhouse gas emissions is high (Ministry of Environment and Urbanization, 2016).

When the urbanization experience in Turkey is examined in relation to climate, the leading of urbanization problems related to climate change is the rapid increase of urban population, which is followed by unbalanced distribution of the increasing population between cities. Due to the fact that urban population absorbs general population increase and part of rural population, it is expected that the rural population will start to decrease overall the world after the coming decade.

The urbanization rate which was around 24% overall the country in the first years of the Republic, increase to 53% in 1985 and 78.5% in 2017 and it is expected that the urbanization rate will continue to rapidly increase on the west of the country in the coming period. According to the calculations made, the urbanization rate in Turkey will be 84% in 2023, and the urban population will be 71 million. There was an increase in the dimensional distribution of metropoles that have the highest population in particular in the year 2010 overall Turkey. When examined from the point of urban density, a significant part of the population prefers to settle in the provinces in western regions parallel to the difference in development level between the regions. Whereas population density increases in the west and coastal sections of the country, the population decreases on eastern and central parts.

Changes that occur in the trend of climate elements including temperature and precipitation in the cities in Turkey, in particular in metropoles, have lead to important problems and it is expected that these problems will further increase in the future. Urban heat islands, which occur as a result of the merger between urban structuring and increased temperatures without taking into account climate characteristics, is one of the leading problems. This situation means more cooling, more use of energy and eventually more emissions. Changes that occur in the period and amount of precipitation cause floods and overflows in cities when combined with insufficient urban infrastructure, leading to loss of lives and properties. In particular, during years 2018 and 2019, big cities including Istanbul, Ankara, Izmir and Antalya have experienced this shortcoming and will continue to experience the same. Problems that occur with temperature increase and precipitation change also negatively affect the socio-economic life in a severe manner.

Tourism sector is one of the economic sectors that are highly sensitive against climate change and are affected in negative direction. In addition to this, it has an important role in order to struggle against shortcomings caused and to be caused by climate change. However, climate change - tourism relationship has two different dimensions. Whereas tourism sector and all of its stakeholders struggle against the negative effects of climate change on one hand, they should also engage in actions and initiatives towards mitigating the impact of sector on the global climate change arising from carbon emission. When we look at the effects of climate on tourism within the contexts of struggle of tourism sector against climate change, adaptation to climate changes is seen as the most urgent path. However, when the effects of tourism on climate are examined, the fundamental discussions intensity on impact mitigation works. Therefore, since budget, time and other resources for resolving the problems are limited, it is necessary to handle impact mitigation and adaptation actions together. Besides, taking into account the fact that in general the environment and economy are contrary to each other, it is apparent that a progress in a direction is only possible with developments in the other direction.

Since tourism mainly relies on natural resources, Turkey is a country which will be most affected from and is under the risks to be caused directly by climate change. Various types of tourism such as coastal tourism and winter spots etc. are affected from climate change and it is expected that this effect will further increase in the future. For that reason, it is necessary and urgent that risks arising from climate change in Turkey's tourism should be identified and measures towards this should be developed, namely that the sector should adapt to climate change.

4. CONCLUSION

Climate change is no more a future scenario, it is already ongoing and its impacts are felt in many places of the world. Example such as heat waves and droughts, melting glaciers and permafrost, increases in intense precipitation and early start of growth seasons, which have become seen more frequently, are evidences of this situation. All of these are the indicators of our changing climate. For that reason, adaptation to climate change is vitally important both for human beings and for the future of the ecosystem. Recent studies demonstrated that even complete ending of greenhouse gas emissions will not prevent the increase in global temperatures. In the coming decades, despite all efforts and accomplishments towards mitigating climate change, challenges experienced in adaptation to climate change will increase.

A major part of Turkey is located in subtropical Mediterranean climate zone with drought summers. Therefore, Turkey is located among the countries with middle-high risk in terms of both current climate, climate change and variability and future climate. According to the observations and data of Meteorology General Directorate (MGM), precipitations are decreasing and temperatures are increasing in summer months in Turkey. In general, there is an increasing trend overall the country that affects maximum and minimum temperatures. Together with this, there are very complex patterns in precipitation changes. Despite the decrease in average annual total precipitation amount, maximum precipitation amount for one day increases. The length of growth season has already increased except for the coastal regions which are at high altitude. This results points out a significant increase in Turkey's temperatures. According to MGM, the annual total precipitation amount on the north of Turkey has increased, that there was a decline trend in Aegean, Mediterranean and South East Anatolia regions and the number of days with maximum precipitation, number of rainy days and day maximum precipitation had an increase trend in many stations outside Aegean and South East Anatolian Regions The effects of climate change have already been felt in Turkey. The most significant results are hotter winters, drier and hotter summers, changes in biodiversity and retracting of glaciers in mountains. Climate change has impact on terrestrial, sea and fresh water ecosystems and this increases the general pressure on environment. Social and economic losses that arise from extreme events and disasters arising from weather and climate, increase with variety over areas and years. It is expected that climate in Turkey will have significant changes over the next decades.

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POSSIBLE EFFECTS OF CLIMATE CHANGE ON HEALTH IN THE WORLD AND IN TURKEY

Prof. Dr. E. Didem Evci Kiraz

Before beginning to review the effects of climate change on health, it is useful to remind some classic information.

According to the Constitution of the World Health Organization (WHO) "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (WHO, 2020, a). According to Dr. Charles-Edward A. Winslow, "Public Health is the science and the art of preventing disease, prolonging life, and promoting physical health and efficiency through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of medical and nursing service for the early diagnosis and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health; organizing these benefits in such fashion as to enable every citizen to realize his birthright of health and longevity." (Fişek, 1983). According to WHO "City is a complicated organism with an internal dynamic that lives, breathes, grows and constantly changes (Petersen, 1996). Healthy City is a city that can improve its environment and expand its resources. A healthy city is not only a city that has achieved a certain level of health, but it is a city that has health awareness and spends effort to improve it." (WHO, 2020, b).

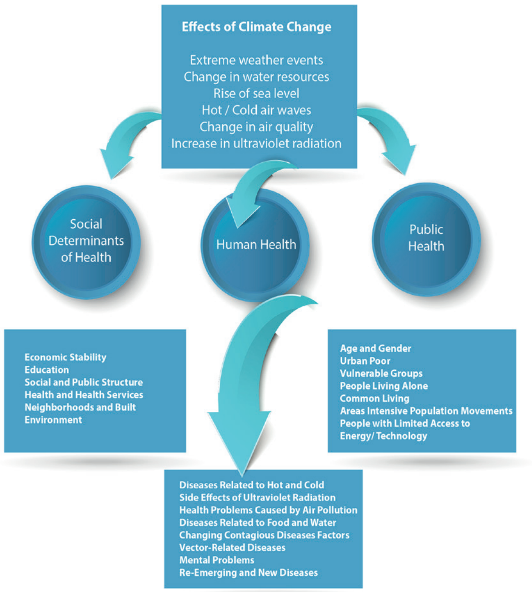
In the scenarios related with climate change, "cities" are considered the most fragile regions. When the investment plans and development plans made in recent years are examined, it is seen that the largest investments are made in cities. Forgetting the rural may come to mean for the arteries feeding the heart to be neglected and clogged. Then, there is a need to develop points of view to protect the health of the city, without making any discrimination between city and country. The local managements' vision of the future should be "to lead forth to increase the public health capacity in the city and to place health at the center in every policy (Tsouros, 2019). It may take time to change the personal characteristics, habits, and education information coming from the past to achieve these. The way to shorten the time passes through foreseeing new health emergencies and planning for the worst, presenting the city dwellers and visitors highest level of health and welfare, preventing, protecting, developing, res-structuring and working together for this.

The legal framework for working together is clear. The General Health Protection Law published in 1930 gives the general framework in detail (1593, 1930). WHO International Health Bylaw published in 2005 "has been accepted by 196 countries as a response to the increase in international travel and trade and new and re-emerging international disease threats and other health risks. This binding instrument of the international law has become effective on June 15, 2007" (WHO, 2008).

Climate and health relation is a "multivariate equation" (Evci Kiraz, 2020). According to WHO; 250,000 more deaths are expected between 2030-2050 due to malnutrition, malaria, diarrhea and heat stress caused by climate change. It is foreseen that 95,000 of these deaths will be as a result of childhood malnutrition, 60,000 of malaria, 48,000 of diarrhea and 38,000 of heat stress on elderly people (WHO, 2018).

Besides the individual and social health, all components determining the health are under risk. The following figure explains this sentence (Evci Kiraz, 2019).

Figure 1: Collective Look at Health Effects of Climate Change (Prof. Dr. E. Didem Evci Kiraz, 2018)



Effects of climate change are listed under six headings (Figure 1).

- Extreme weather events
- Change in water resources
- Rise of sea levels
- Hot/cold airwaves
- Change in air quality
- Increase in infrared radiation

There are social determinants at the target of every effect: economic stability, education, social and community structure, health and health services, neighborhoods and built-up environment will be affected the most.

Health problems associated with climate change are as follows:

- Diseases related with hot and cold
- Side effects of infrared radiation
- Health problems caused by air pollution
- Diseases related with food and water
- Changing contagious disease factors
- Vector-related diseases
- Mental problems
- Re-emerging and new diseases

Health problems will be seen mostly in places where population density is high. The first ones to be affected will be the most fragile region of a city and the most fragile groups. Common living areas must be handled without losing time. Critical infrastructures of the city and people who have related duties must be informed and they should be ready when the worst scenario is implemented.

The most discussed issue is the hot airwaves. However, cold and long days and nights must not be overlooked. Table 1 shows the health problems that may occur because of hot and cold weather (Evci Kiraz, 2019). As can be seen from the table, climate change cannot be associated with only one health issue. Levels of effects of other factors must be taken into consideration that may be mixing, changing and effect increasing or decreasing features.

Table 1: Hot and Cold Weather, Risks, Health Effects, Risk Groups

Risks of Hot and Cold Weather	Health Effects	Risk Groups That Early Warning Must Reach with Priority
Number of hot days and nights increases Frequency and intensity of hot waves increase Fire risk increases with the decrease of precipitation	Increase in deaths related with temperature Increase in heat stroke and sunstroke incidence More intense circulatory, cardiovascular, respiratory and kidney diseases especially in workers working outdoors, athletes and elderly people Increase in premature deaths due to ozone Injury because of fires especially those that broke out during hot airwaves, disease due to air pollution, increase in death rates Respiratory diseases due to ingincreasing in PM10 level	
Number of cold days and nights decreases	Decrease in deaths due to cold Decrease in cardiovascular and respiratory diseases in elderly people especially in cold and moderate climates	
Temperature and humidity increase Tendency of change and increase in Temperature increases at the sea surface and freshwaters	Pathogens' capability to reproduce, resist, spread and cause disease to increase/speed up Change in the geographic and seasonal distribution of cholera, schistosomiasis, harmful sea algae types Water shortage and personal/social hygiene problems Increase in water pollution as a result of water caused by floods and infrastructure damage and emerging of risk of diseases transmitted with water	

Risks of Hot and Cold Weather	Health Effects	Risk Groups That Early Warning Must Reach with Priority
Temperature and humidity increase Tendency of change and increase in evaporation	Increase in parasites and their power to cause harm Prolonged seasonal transition periods Re-emergence of old diseases Changing distribution and frequency of disease factors Increased risk of diseases transmitted with vector	Elderly people Elderly people living alone Bedbound people People with cardiovascular, lung, kidney diseases People whose accommodation conditions, socio-economic conditions are not sufficient Addicts Children People with diabetes Pregnant women People with disability and function loss People working outdoors Sportsmen Overweight Street children, homeless people
Temperature increases and evaporation changes	Decrease in food production in tropical regions Difficulty to access food due to decreased supply and increased prices Combined effect of insufficient nutrition and infections Short and weak children	
Temperature and humidity increase	Health problems in people working outdoors without protection Decrease in productivity and production	
Extreme and long term heat	Heat cramps Syncope due to heat Heat fatigue Heat stroke	
Temperature increases irregularly and extremely	Increase in deaths Increase in diseases	
Night temperature rise	Increase in air pollution and related health risks Increase in deaths	
CO_2 and temperature increase	Increase in pollen production and related health risks	
Temperature rise and precipitation distribution becomes irregular	*Change in the distribution of hazard that causes disease *Increase in following diseases: 1- Avian flue 2- Diseases caused by tick 3- Cholera 4- Ebola 5- Parasites 6- Plague 7- Lyme 8- Harmful sea algae 9- Red fever, malaria 10- Sleeping sickness 11- Tuberculosis 12- Yellow fever 13- Malaria 14- West Nile Virus 15- Chikungunya 16- Dengue fever	
Being threatened by cold weather	Rise in hypothermia risk Injuries Increase in deaths Increase in diseases	

Source: Evci Kiraz, 2019

Favorable effects of the sun provide relief to the health sector. Some of the infection agents lose their ability to cause disease with the effect of the sun or their effects decrease. Sun is needed for growth and development. However, the environment created with the human hand weakens the shield that the atmosphere forms against the harmful effects of the sun. International Agency for Cancer Research (IACR) reported in 2009 that UVR between 100-400 nm wavelengths cause cancer for humans (Goettsch et al., 1998). Infrared Index (UVI) was developed in 1995 by WHO, World Meteorological Organization (WMO), UNEP, International Non-Ionization Radiation Protection Commission (INRPC) (US EPA, 2016). Possible health effects that may be caused according to UVI index values are given in Table 2 (Evci Kiraz, 2019; US EPA, 2016).

Table 2: UV Index Value, Scale and Health Effects

UV Index Value	Infrared Index Scale	Health Effects
<2	Low	Lowest harm. Persons except for white, red-headed and very light-skinned people can stay under the sun without being burned for one hour between 10.00-16.00 hours when sun is at extreme values.
3-5	Moderate	Low risk. People may stay 20 minutes under the sun without being harmed. However, it is recommended to wear hats with wide visors and sunglasses.
6-7	High	Medium strength infrared radiation. Persons with normal skin can stay under the sun for 15 minutes. They must definitely use hats and sunglasses. Also, persons who will stay in the sun must protect their noses and ears and protective creams must be applied on the lips.
8-10	Very High	High infrared radiation. Persons must not stay under the sun longer than 10 minutes. Hats and sunglasses must be used; people who need to go outside must make use of shadows; pants and long-sleeved garments must be preferred. All kinds of outdoor sports must be avoided.

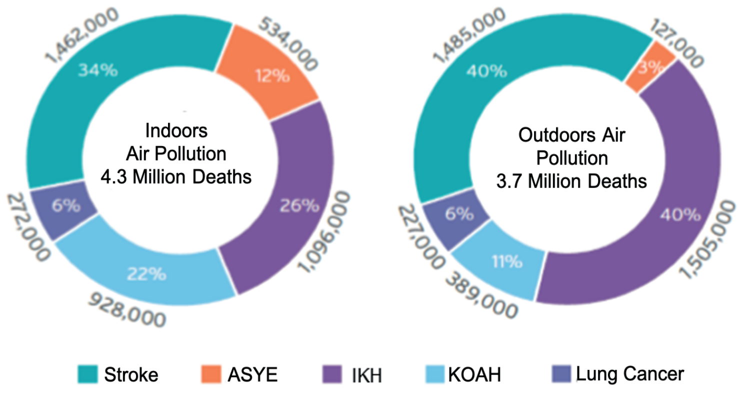
UV Index Value	Infrared Index Scale	Health Effects
11+	Extremely High	Values in this range show the highest risks of infrared radiation on living organisms. Time to stay under the sun is limited to 10 minutes. People must not go outside if possible. In the case where it is unavoidable to go outside, protection must be taken from the sun and measures must be taken for this purpose.
SHADOW RULE	The simplest way to read UVI is to look at your shadow.	If your shadow is taller than yourself (early hours of the morning or late hours of the afternoon) your UVR exposure is low. If your shadow is shorter than yourself (midday) your UVR exposure is high.

Source: Evci Kiraz, 2019; US EPA, 2016

The least studied health effect of climate change is mental problems. The evidence pool will be enriched with eco-anxiety, eco-worry studies and similar studies.

The health problems that are caused by increasing levels of air pollution are entirely avoidable. Everything will be restored when the cause, origin of the cause and the bad environment where the cause develops are eliminated. The role of air pollution in the relation of climate change with health can be summarized as the "triggering element". Air pollution is held responsible for seven million deaths every year (Figure 2) (Evci Kiraz, 2019). Most of these deaths occur at home (indoors). The most frequently observed health problems are stroke, acute lower respiratory tract infections (LRTI), ischemic heart disease (IHD), chronic obstructive lung disease (COLD), lung cancer (WHO & UNFCCC, 2015).

Figure 2: Distribution of Causes of Death Due to Indoors and Outdoors Air Pollution



Indoors Air Pollution 4.3 million deaths
Outdoors Air Pollution 3.7 million deaths
Stroke, acute lower respiratory track infection (ASYE), ischemic heart disease (IHD), chronic obstructive pulmonary disease (COPD), Lung cancer

Source: Evci Kiraz, 2019

At a time when multi-disciplinary approaches are being implemented by virtue of "Single Health", "Health for Everyone" diseases related with malnutrition and drought, changing contagious disease agents, vector-borne diseases, re-emerging and new diseases are the most expected outcomes of climate change. COVID-19(SARS CoV-2) pandemic that began in December 2019 and made the world another world in 2020 caused humanity, scientists and decision-makers to turn and look at these subjects again. Presently, there is no "data and evidence collection system to correlate the climate" change with diseases related with food, water and vectors, changing contagious diseases and re-emerging or new diseases.

According to the World Economic Forum "Global Risks 2019" report, the first five global risks regarding the possibility of occurrence are extreme weather events, failure in mitigation and adaptation of climate change, natural disasters, data fraud and theft and cyber-attack (WEF, 2019). Actions to be taken for mitigation and adaptation may take time. However, it is not necessary to wait for tomorrow to achieve the manpower, time and budget to manage the health effects of climate change as a whole and to begin with sustainable political determination. Scientific studies must be started very rapidly aimed at events at neighborhood, city, region and country levels and that exhibits international transition. For this purpose, it is considered useful to establish "Regional Climate and Health Research Centers". WHO started the 11th Version of the International Classification of Diseases (ICD). WHO is collecting expert opinions. "Disease codes related with climate change" must be started to be used with ICD11. The first responses were given to the experts who expressed their opinions to WHO in this regard state that this coding cannot be entered into the system yet because there is no evidence based on scientific studies. There is a need for scientific studies.

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MODELING AGRICULTURAL PRODUCTION, AGRICULTURAL DROUGHT AND LAND USE

Prof. Dr. Zeynep Zaimoğlu

1. INTRODUCTION

When it comes to Climate Change, agriculture is one of the sectors where the effects can be seen most easily and instantly.

As a result of intensive studies in recent years, according to the climate models of 2099, we will not be able to produce the varieties of plants we grow today at the same latitude and longitude and with the same varieties. Almost all climate models foresee that a significant portion of the subtropical zone, including the eastern Mediterranean basin and Turkey, will see reduced winter precipitation. Therefore, in addition to the long-term summer drought, the Mediterranean climate zone will be the region most affected, especially as a result of the long-term decreasing trends in winter precipitation. Apart from this, Konya closed basin will be another of the basins most affected by the change of drought and rainfall regimes. As a result of the modeling studies carried out for agricultural productivity in addition to the Mediterranean and Konya basins, while decreases are expected in the flows of the Euphrates and Tigris rivers, the effect of this decrease on productivity is discussed, especially in terms of the amount of irrigation water, and the number of hydrometeorological disasters is expected to increase.

In the Eastern Black Sea region, it is a known fact that agricultural production will be affected by the expected increases in rainfall and floods.

In fact, these negative effects have already been observed by our farmers in the last five years and their effects are reflected on consumers.


SPORT

2. CLIMATE CHANGE AND MODEL USE IN AGRICULTURAL PRODUCTION

The impact of climate change is a growing concern for decision-makers. Crop production in agriculture is affected by any combination of climatic, physiological, technological, hydrological, and economic factors. Since all these effects cannot be expressed in a single model, combining different models in a single modeling system offers various advantages and can enable us to plan the future according to more variables.

It predicts the agricultural impacts of climate change in the future, and modeling systems enable planning for the future, including the impact of climate change on agriculture, the differences in crop yield, and their impacts on national economies. In the use of these models, integrated models are generally used at the first stage. However, before deciding on the use of the model and the model, it is necessary to decide which adaptation method will be used, as well as "whether to use adaptation technique with short-term and local outputs or long-term national and later international ones". This decision mechanism is called the adaptation method.

A: Short Term, Incremental, Autonomous, Reactive, and Localized Adaptation Method:

Types of A adaptation may include changes in planting dates, field or crop selection, and adaptation of water, nutrient, residue, and canopy management. By changing the planting date, farmers can take advantage of the expanded growing season associated with the climate. In addition, planting date shifts provide the possibility of avoiding exposure to certain climatic stresses such as heat or drought during sensitive phenological stages. If the growing season is prolonged, there may be a chance of multiple harvests; therefore, climate change may be suitable options to increase land productivity, as more than one crop can be planted in the same year or multiple harvests can be made from the same crop (Liang et al., 2015). Switching to varieties or crops that are more tolerant of the most dominant stressors can help reduce climate risks.

B: Long Term, Transformative, Strategic Expectation and Large Scale (Regional, National or International) Adaptation Method

Type B adaptation aims to plan spatial changes in production areas, structural changes in farming activities, or the cultivation of new crops and varieties in the long term. For farmers, this adaptation method can mean investment over time, in new production systems and the necessary infrastructure (Nicotra et al., 2010; Bloomfield et al., 2014.), while at the public level, incentive systems can help steer incentive systems towards transformative adaptation and adapting to support the adaptation efforts of farmers. Government support to be given to agricultural industries should come to the fore in the development of new technologies and the cultivation of new varieties. Examples of specific breeding targets include resistance to high temperatures that cause altered phenology.

Thus, harvesting systems and harvest numbers can be rearranged for agroecological regions as climatic conditions change (Rosenzweig et al., 2013; Chenu et al., 2017). For adaptation, tolerance to floods, drought, or increased salinity as well as water and water efficiency are taken into account.

2.1. Agricultural Models and Components

Climate change in agriculture, crop production, will be affected by the complex interactions between several factors (climatic, physiological, technological, hydrological, economic). In this regard, combining different models in a single modeling system offers several advantages.

Main Components of Agricultural Models

- CLIMATE: Supports the preparation of scale-free climate data.
- HYDROLOGY: It predicts water resources under future climate projections.
- CROPS: It simulates crop yields under future climate projections and technological advancement scenarios.
- ECONOMY: Evaluates the economic impact of future crop yields and water resource projections.

These components include models and utilities for performing the successive steps of impact assessment. It allows several different user profiles to manage data flow and production as well as users design work.

The data exchange between models should consistently address different aspects of climate change impacts. In addition, the model should allow users to conduct impact studies in different areas and achieve comparable results.

The models must allow for a group study that defines the interactions between each component and the required output from each model, in order to use the ideal model output. The model should be able to interact with end-users and allow for impact studies tailored to their needs.

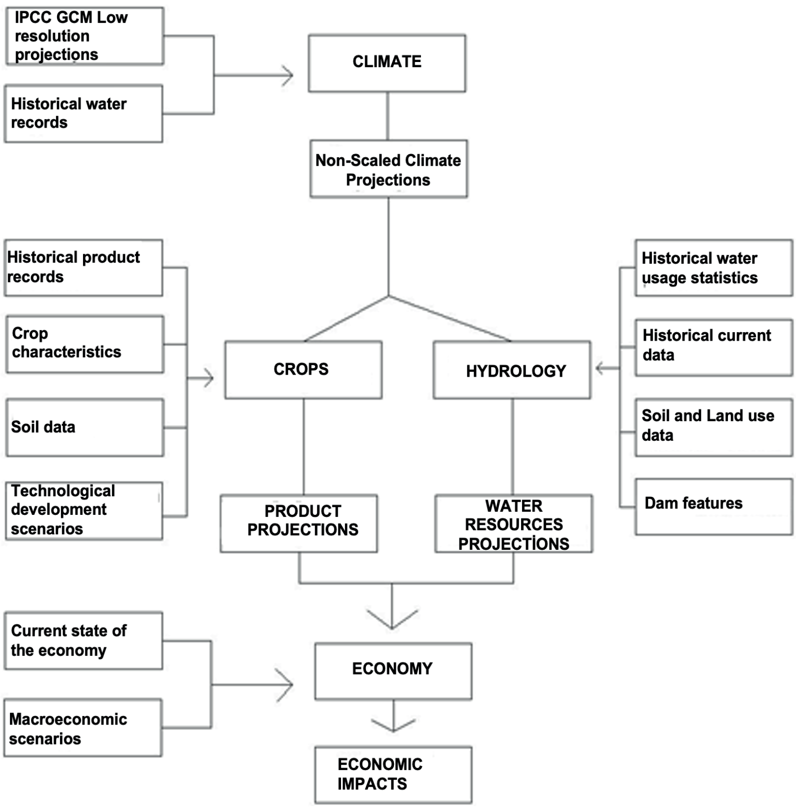
If we look at the models with climate, plant and water variables used in the world and their characteristics, the most used agricultural product and agricultural climate models are:

CropSyst (Cropping Systems Simulation Model) (Hoogenboom et al., 1994), CERES (Crop Environment Resource Synthesis) (Arnold et al., 1998.), SWAT/SWIM (Soil Water Assessment Tool/Soil and Water Integrated Model) (Food and Agriculture Organization of the United Nations (FAO), 1992), CROPWAT/ AquaCrop (FAO product model) (Keating et al., 2003), APSIM (AgriculturalProduction Systems simulator) (Jones et al., 2003), DSSAT (Decision Support for Agrotechnology

Transfer System) (Williams et al., 1989), EPIC (Erosion Efficiency Impact Calculator) (Brisson et al., 2008), STICS (Simulateur multidisciplinary pour Les Cultures Standard) (Bondeau et al., 2007), LPJmL (Lund-Potsdam-Jena managed Terrain model) (Abbott et al., 1986), MIKE (Modeling System for Rivers and Channels) (Renaud-Gentié et al., 2015).

The climate and agriculture models used and the flow chart between the inputs and outputs used in the model are given in Table 1.

Figure 1: Data Exchange Between Four Main Components Used in the Model



Resource: (Food and Agriculture Organization of the United Nations (FAO), 2016)
Models differing in spatial scale, integration and complexity levels:

While APSIM, CropSyst, CERES, DSSAT, CROPWAT / AquaCrop, STICS, and While

APSIM, CropSyst, CERES, DSSAT, CROPWAT / AquaCrop, STICS, and EPIC are designed to simulate biophysical processes at the field level, LPJmL, SWAT / SWIM, and MIKE are spatially distributed models that are often applied at a regional or even global scale. Land scale models mostly focus on representing different plant growth processes. The heavily used CROPWAT / AquaCrop approach is designed to simulate water limitations to potential crop yields. STICS, CERES and product modeling, DSSAT (combining CERES with other product models) simulates product responses to the dynamics of the soil water budget, nutrients, and soil carbon. EPIC and CropSyst simulate crop growth processes with similar complexity, while also integrating the effects of climate and management on soil erosion. A very detailed representation of the growth processes of the crop is integrated into the APSIM model, which differs between plant components (leaf, stem, head, and root) and also allows to simulate competition between species in crop mixes.

The results of model studies conducted in Turkey have important work on behalf of agricultural production and future planning. According to the results of these studies, the global circulation model called ECHAM5 was combined with the RegCM3 climate model and the model was run. As a result of this study, it was determined that the agricultural yield would reach an 11% decrease in climate scenarios where rainfall decreased by 30%, according to the simulation results, which were made primarily considering the plant water consumption, in the period covering the years 2011-2099 (Cline, 2007; Dudu, 2013). Again, in studies using agricultural yield and water consumption, and hydrometeorological data, the amount of rainfall in winter will increase until 2035 and there will be an irregular rainfall regime in the 2035-2060 time interval, and there will be a decrease in precipitation throughout the country in the 2060-2099 interval. Unfortunately, these decreases are accompanied by temperature increases, and the need for irrigation water increases and makes productivity variable.

The use of models is the first tool used for agricultural production in climate change adaptation studies both in the world and in our country.

3. CLIMATE CHANGE, AGRICULTURAL DROUGHT, WATER AND LAND USE

3.1. Climate change and Water Management

It is known by everyone that water has gained as much value as oil in the 21st century, in fact, a large part of the total amount of water made available by the hydrological cycle is concentrated in certain regions, while other regions already have water shortages (Pimentel et al., 1999). Due to the unbalanced distribution of water resources and population densities around the world, 40% of the population, currently in about 80 countries, has more water demand than supplies, and water resources are unable to meet the need (Bennett, 2000). The annual average minimum water requirement per capita for food production is 0.4 × 10 6 l (Postel, 1996), which is about four times less than the amount consumed in America (1.7 × 10 6 l). Likewise, for 50% of the world's population, as far as human health is concerned, including drinking water, the daily minimum amount of water used per person is eight times less than that used for this purpose in the United States (Gleick, 1996). Although the availability of freshwater per capita worldwide decreased by approximately 60% between 1960 and 1997, a 50% decrease in per capita water supply is expected in the future by 2025 (Hinrichsen, 1998).

When compared to the total water reserves in the world, the amount of freshwater can be compared to a spoonful of water. This is because 97% of the world's water comprıses ocean waters that have an electrical conductivity (EC) of about 55 dS m −1 (total dissolved solids≈35 000 mg l −1), and a sodium concentration of more than 450 mmol l −1 (Suarez and Lebron, 1993) (Turner, 2001). Groundwater accounts for more than 98% of fresh water, while rivers and lakes feed 2% of groundwater. After the runoff and evaporating water is deducted from total precipitation, the remaining rainwater infiltrates deep into the soil and eventually permeates groundwater formations or aquifers. (Bouwer, 2000). The total amount of precipitation associated with groundwater is primarily affected by climatic conditions. For example, 30-50% of precipitation goes into groundwater in humid areas. This value varies between 10-20% in the Mediterranean climate. The amount of precipitation reaching groundwater is the lowest in hot and arid climates and may be 2% or even less (Tyler et al., 1996). Although it is difficult to estimate the actual natural recharge rates (Stone et al., 2001), the above estimates reveal the approximate amount of water that can be pumped from the aquifer under different climatic conditions without consuming groundwater resources. Pumping, as a general practice in many arid and semi-arid regions of the world where groundwater is the main water source, creates a significant problem for the future by dangerously lowering the groundwater level (Pimentel et al., 1999). Two Asian countries where groundwater levels are particularly falling are the Punjab and North China Plains of India (Seckler et al., 1999). In fact, the situation is even more frightening in the Middle East and parts of Africa, which could not meet their nutritional needs from usable water resources by consuming their water decades ago. Many other countries are just getting acquainted with the water deficit (Allan, 2001).

All these worldwide water, drought, and freshwater challenges will become more problematic for many parts of the world with climate change. Climate change agricultural drought will be a more troublesome issue, as more than half of the freshwater used in our country and in the world is used in agricultural production for irrigation purposes.

All these world-wide water, drought and freshwater challenges will become more problematic for many parts of the world with climate change. Climate change agricultural drought will be a more troublesome issue, as more than half of the fresh water used in our country and in the world is used in agricultural production for irrigation purposes.

The cornerstone of water management is the development and protection of water basins. Therefore, the development and protection of water resources and their subsequent use depends on both a disciplined organization and the provision of sufficient financial conditions. This is because water can be properly taken from the source and supplied to the usage areas in the desired quantity and quality with large investments such as dams, ponds, water transmission, and distribution networks. However, while making the necessary regulations for water, taking into account the socio-economic conditions and sectoral developments in the country will help increase the security of the water supply (Zaimoğlu, 2019).

In today's world, Integrated Water Resources Management practices have been observed since the early 1990s. With this method, it aims not to harm ecosystems while developing water resources and to ensure sustainable socio-economic and environmental development. The term "holistic" in the concept refers to the relationship between many goals (Star, 2013). Globally, while water management frameworks are being formed today, organizations such as the World Bank and the IMF are helping countries with serious incentives and suggesting that countries have no other choice but to do this (Sword, 2008).

Although there is a prominent weight of the public sector in water services around the world, important changes started to occur after 1980. After 1980, the private sector started to take part in the provision of water services besides the public. In this process, efforts to move away from the fact that water services are a public service and to make it accepted as an "economic good" draw attention. One of the basic principles adopted in the Dublin Conference is “accepting water as an economic good” as a proof of this issue (Salihoğlu, 2006; Kılıç, 2008).

3.2. Agricultural Drought and Climate Change

Water scarcity is the inability of water resources to meet average long-term needs. A drought is a natural event that negatively affects the land, water resources, and production systems as a result of the precipitation significantly below the recorded normal levels and causes serious hydrological imbalances.

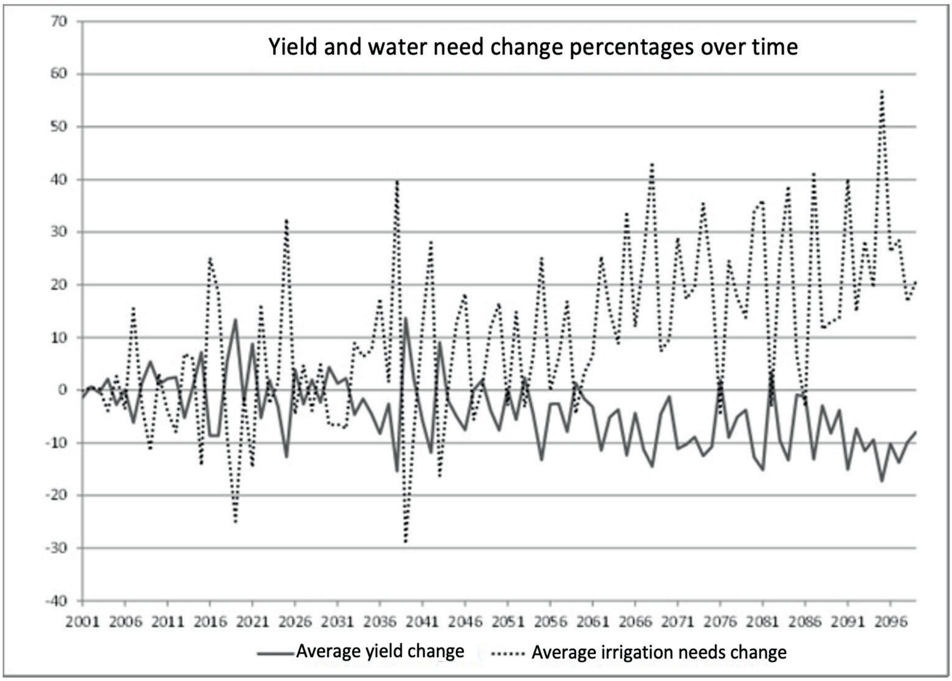
In other words, "drought" means a temporary decrease in water conditions due to low rainfall, while "water scarcity" means that water demand exceeds the capacity of available water resources under sustainable conditions. In this sense, turning the drought into a disaster becomes easier with the interventions of humanitarian activities on natural balance. The concept of drought can be expressed in different ways (Bayramin, 2008).

- Drought: A drought is a natural event that negatively affects the land, water resources, and production systems as a result of the precipitation significantly below the recorded normal levels and causes serious hydrological imbalances.
- Meteorological Drought: It is expressed as the deviation from the normals (usually at least 30 years) for a certain period of precipitation.
- Agricultural Drought: The lack of sufficient water in the soil to meet the needs of the plant indicates agricultural drought.
- Hydrological Drought: Reductions in the hydrological system such as resource levels, runoff, groundwater, and soil moisture due to a long-term lack of rainfall indicate hydrological drought.
- Drought Management Plan: It refers to the management plan that includes the measures to be taken before, during, and after the drought to control the adverse effects of possible drought risks and to solve drought problems (Türkeş and Yıldız, 2014).
- Crisis management: It is a temporary management style implemented during the crisis, aiming to return the situation to normal (National drought management strategy document and action plan, 2007-2013).

Various studies have been carried out within the framework of drought management in our country. Most of these studies were carried out on the agricultural drought axis. In addition, works were conducted to meet the drinking water needs of provinces in case of drought (opening groundwater wells, water transfer between basins, etc.) The most important feature that distinguishes a drought disaster from other natural disasters such as earthquakes is that it is very difficult to accurately determine the start and end times. For this reason, early warning systems should be developed in our country in order to reduce the damages of drought disasters and to take necessary measures.

Climate change and climate models reveal that the amount of water needed for irrigation will increase linearly with the difference in irrigation water and plant water need over time.

Figure 2: Yield and Water Need Change Percentages Over Time



Resource: Dudu and Çakmak, 2017

As can be seen in Figure 1, irrigation water needs will increase inversely with precipitation in the Mediterranean basin in 2096, and combating agricultural drought will become very important.

In line with this known reality, Turkey Agricultural Drought Action Plan was established.

Short, medium, and long-term measures are taken to combat agricultural drought throughout the country, and action plans are put in place to reduce the effects of drought in a sustainable manner. Turkey Agricultural Drought Strategy and Action Plan was implemented between 2008-2012 and in 2013, it was revised to cover the years 2013 to 2017. Combating agricultural drought alone is not enough to reduce the damages of drought. Meteorological, agricultural and hydrological drought should be handled as a whole and institutional capacity should be developed accordingly. In this way, sustainable solutions can be developed for every sector affected by the drought disaster and economic and social benefits can be obtained. In this sense, it is necessary to ensure that the measures that are complementary to each other are implemented by the relevant institutions and organizations (Zaimoğlu, 2019).

4. AGRICULTURAL DROUGHT COMBATING STRATEGY AND ACTION PLAN ACTIVITIES

The activities included in the Action Plan have been prepared by grouping them under the basic development axes and priorities on the basis of the strategy mentioned above.

A. Drought Risk Estimation and Management

- Crisis management based on agricultural drought forecasts will be implemented.

B. Ensuring Sustainable Water Supply

- Potential water holding capacity will be increased.
- Water transmission channels will be modernized, maintenance and renewal investments of water storage and transmission channels will be made on time. Measures will be taken for the collection of wastewater and reuse of treated wastewater in agriculture and industry.
- Effective management of groundwater will be ensured.

C. Effective Management of Agricultural Water Demand

- By determining agricultural basins, the most suitable growing areas of agricultural products will be determined taking into account the water resources, and water use in agriculture will be reduced.
- Irrigation transmission systems will be modernized.
- Effective use of groundwater for agricultural purposes will be ensured.
- Crop and animal production policies will be implemented considering the drought risk.

D. Accelerating Supportive R&D Studies and Increasing Training / Extension Services

- R&D studies supporting the fight against drought will be accelerated.
- Training and extension services for relevant segments, especially farmers, will be increased.

E. Developing Institutional Capacity

- Legal arrangements will be made and institutional structuring will be strengthened to effectively combat agricultural drought.
- Developing the necessary institutional capacity in combating non-forest fires

4.1. Measures Determined Within the Action Plan

4.1.1. Studies to be Done Before the Drought

- Determining basic needs for institutional and technical capacity in order to ensure drought management,
- Determining the drought index and indicators to be used in determining the severity of drought, taking into account the characteristics of the river basin and land use,
- Establishing drought prediction and early warning systems,
- Preparation or development of drought maps and drought management plans for each basin,
- Preparation and development of the legal legislation regulating the structuring of drought management at basin scale,
- Establishing and developing the drought inventory,
- Taking into account the effects of drought in the preparation or development of physical plans foreseeing various land uses within the river basin,
- Developing measures to minimize the negative effects of possible drought events on the sectors,

- Preparation and development of agricultural product yield insurance system,
- Training, informing and ensuring the participation of the relevant personnel and the public involved in every stage of drought management,
- Training activities for the efficient use of water,
- Developing water pricing and prioritization policies in order to regulate the imbalance between the expected water supply and demand in case of drought,
- Preparation of emergency action plans of institutions and organizations to be implemented during drought,
- Considering the droughts experienced in the basin during the preparation of water transfer projects between basins,
- Establishing hydrological monitoring stations, forecasting and monitoring systems,
- Promoting and expanding the use of rainwater harvesting and gray water,
- Switching to modern irrigation systems that save water in agricultural irrigation systems,
- Opening sufficient number of observation wells to monitor groundwater levels in basins,
- Encouraging less water consuming plant species,
- Ensuring the selection of the appropriate plant pattern for the basin,
- Increasing the number of treatment facilities, ensuring efficient operation and recycling of wastewater,
- Extending the use of conventional wastewater for irrigation purposes by passing it through advanced treatment systems and modernization of treatment facilities,
- Carrying out the activities included in the Agricultural Drought Fight Strategy and Action Plan,
- Prevention or reduction, if possible, of losses and leakages in water transmission and distribution systems,
- Ensuring the supply of quality and sufficient amount of drinking water,
- Making studies on the current status of water supply and storage facilities to be used in dry periods,

- Developing medium and long term forecasting capacity and carrying out similar studies,
- Increasing animal drinking water ponds,
- Disciplining the terms of agricultural irrigation subscriptions.

4.1.2. Studies to be Done During the Drought

- Estimating the course of the drought and making warnings,
- Implementation of Drought Emergency Action Plans prepared by institutions and organizations,
- Implementation of operation plans prepared in accordance with the drought situation of water supply and storage facilities,
- Training, informing and ensuring the participation of the relevant personnel and the public involved in every stage of drought management,
- Health and assistance services,
- Carrying out the activities included in the Agricultural Drought Fight Strategy and Action Plan,

4.1.3. Studies to be Done After the Drought

- Determination of the damage on the sectors,
- Providing necessary support to the sectors affected by drought, taking into account the extent of the effects
- Training, informing and ensuring the participation of the relevant personnel and the public involved in every stage of drought management,
- Preparation of Post-Drought Improvement Plans that concern all institutions, organizations and sectors in order to improve the serious and destructive damages that may occur after a drought,
- Review of water supply and storage systems,

4.2. Strengths Wherein Conditions Affecting Drought Management Are Systematically Examined

- The existence of well-established organizations with a strong organizational structure,
- The authority of the Ministry of Forestry and Water Affairs regarding drought management,
- Our country has expert human resources in different disciplines,
- The Ministry of Forestry and Water Affairs being a national and international focal point in drought-related fields of activity,
- Having a dynamic structure that is open to innovations,
- Communication and technological infrastructure is strong,
- Making plans based on basin integrity recently,
- Beginning of basin-scale drought management plans,
- Basin protection action plans are ready and river basin management plans are being prepared,
- The increase in financing provided by the state for basin investments in recent years,
- Implementation of the "Combating Agricultural Drought Strategy and Action Plan" by the Ministry of Food, Agriculture and Livestock.

4.3. Weaknesses Wherein Conditions Affecting Drought Management Are Systematically Examined

- Difficulties in accessing data,
- Coordination problems,
- Gaps in legal legislation,
- Inadequacies in policies and strategies related to basin management and lack of coordination between basin-based sectoral investment policies,
- Insufficient stakeholder participation and local ownership,

- Lack of data information system at basin level,
- Inadequacies in the criteria and methods of prioritizing watershed projects and activities,
- The high-level plans that will form the basis for the coordinated execution of watershed studies are not completed,
- Insufficient data on the effects of past droughts,
- Lack of drought-related units in most of the relevant and responsible organizations.

4.4. Possible Opportunities in Action Plans

- Preparation of Basin Scale Drought Management Plans
- Increasing public awareness on sustainable drought management in the world and in our country,
- Supporting modern irrigation systems that save water in agricultural irrigation systems,
- Within the scope of the Program for Enabling Water Use in Agriculture, the studies started after the determination of agricultural supports in line with the product pattern on the basis of agricultural basins, taking into account the existing water resources
- Climate change is on the agenda,
- Increasing scientific and academic research on drought management,
- Reducing human-induced pressures due to migration in the upper basins,
- Access to information and the opportunity to benefit from developing information technologies (GIS, etc.),
- Increasing awareness of natural resources and environmental protection in society,
- Increase of contributions and activities of non-governmental organizations,
- Increasing political interest and support,
- Developing a participatory approach in institutions,
- The importance of water basin management,

- 1Regulations within the scope of urban transformation law,
- Integrated watershed management of stakeholders other than public institutions (NGOs, scientific institutions, etc.).

4.5. Possible Threats in Action Plans

- The conflict between public goals and private sector interests,
- Irregular structuring in river basins and catchment basins of rivers,
- Excessive consumption of surface and groundwater by farmers in agricultural areas,
- Excessive water consumption and not saving water in urban and rural areas due to lack of education and knowledge,
- As a result of industrialization, the increase in natural environment (air-water-soil) pollution adversely affects global warming and consumable water resources,
- Opening of river basins for construction and insufficient protection of rivers' water catchments,
- Destruction of natural habitats as a result of the necessity to create more residential areas due to population growth and rapid urbanization,
- The increase in the urban population as a result of the migration of the agricultural population to the cities,
- Opening agricultural land for the use of different sectors,
- Decrease in aquifers, decrease in resource flows, decrease in stream flows-drying and withdrawal of water in lakes and swamp areas,
- Water quality deterioration in water resources,
- Failure to provide ecological flow due to the unplanned use of water, deterioration of river and wetland ecosystems (MFAL, 2018).

Turkey is continuing its policies to struggle with drought with its action plans and acts effectively with the 2018-2022 action plan.

5. THE NEED OF YIELD AND IRRIGATION WATER IN OUR COUNTRY

When it comes to climate change, the increase or decrease in irrigation water needs should be taken into account as well as yield changes. The yield of the agricultural basin is a sensitive factor in terms of both climate change and its economic contribution to the country. It should not be forgotten that even if soil is fertile, potential water need is of great importance for both of the mentioned factors. The cultivation of a crop with high irrigation costs can cause both climate change due to inefficient use of water resources and economic losses. In the studies carried out, it draws attention that especially the provinces and basins located in the Mediterranean climate zone are the regions that will be most affected by the changes in climate, both in terms of efficiency and irrigation needs. The interruption of agricultural activities in this region may cause irreparable problems for our country in terms of both food availability and economic factors.

The sustainability of agriculture is under serious threat due to the anticipated temperature increases and rainfall irregularities in our inner parts, where the yield is relatively lower and the need for irrigation is higher. It should be kept in mind that even our Northeast Anatolian basins, which do not need extra irrigation in most cases, may become dependent on irrigation over time. The yield change and the percentages of irrigation water need over time are shown in Figure 6. While yield increases and decreases in irrigation need are observed in the western regions in the first observed time intervals, yield changes and irrigation needs show minor changes in the middle sections, while serious yield losses and irrigation needs increase in the second and third observation intervals (Dudu & Çakmak, 2018).


New Holland

6. CLIMATE CHANGE AND LAND USE

6.1. Measures Against Decreasing Forest Amount

Forests and trees store carbon. When they are burned or cut down - as a result of this process called deforestation - this stored carbon is released back into the atmosphere as carbon dioxide and contributes to climate change. Deforestation contributes about 12% of carbon dioxide emissions from human activities. This figure rises to 15% when tropical peat is included, which is now highly degraded and may contain ten times more carbon than forests (DeFries, 2016). In the last decade, the greatest deforestation has occurred in the tropics. Although difficult to measure, current global estimates show an annual loss of about 13 million hectares (an area half the size of the UK) between 2000 and 2010. It is known that the purpose of the population destroying the forest is to feed their families and to turn the agricultural land into monoculture farms that produce high-value products such as soy (Koglo, 2018). Scientists know the value of protecting forests in combating climate change.

6.2. Land Consolidation and Its Effects

Countries that will be highly affected by climate change and food supply hazards are primarily developing countries, which are known to be fragmented and serving small family businesses.

Multi-part lands are one of the topics that should be handled indirectly in terms of land use in climate changes since they are inefficient in terms of both infrastructure and natural resource use.

Land consolidation provides significant benefits in terms of the consolidation of small and irregular agricultural lands. As small parcels will be brought together with consolidation, the distance between the business center and the parcels is shortened, and consequently, emission reduction and fuel savings are achieved in on-farm transportation. In addition, as the number of parcels decreases, their shapes improve and their size increases, productivity increases, and losses in agricultural inputs such as seeds, fertilizers, and pharmaceuticals decrease. The reduction of these losses means that the emission generated during the production of each agricultural input decreases.

As the parcels will get bigger, there will be a border to the road and the canal, which will increase the water used and transportation efficiency as a result of irrigation. For the rural area: All services such as environmental protection, erosion prevention, afforestation, village renewal, planning of all kinds of roads, making village development plans, preparing land use plans can contribute to rural development and climate change simultaneously as a result of the planning and implementation of all services together with consolidation projects.

In non-consolidated irrigation projects, the planning and implementation of channels and roads remain dependent on the parcel boundaries and cross borders as much as possible. As the plots are small and irregular in shape, the channel lengths become too long, which increases the cost of the facility; whereas, if irrigation projects are implemented in consolidated terms, the most economical way of irrigation, road, and evacuation planning is made regardless of the parcel boundaries, saving up to 40% in investment costs. Water waste is minimized, and irrigation rate and efficiency increase (Türker, 2015).

7. CONCLUSION

The most controllable indicators of climate change agriculture interaction are water use and land use.

In terms of sustainable agriculture, the main decision point is to determine the correct plant selection, correct variety, and correct coordinates with the help of models.

Later, the use of land and water and planning according to these constraints are the main issues that both farmers and policymakers should combine on common ground.

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EFFECTS ON CLIMATE CHANGE: LAND COVER / USE

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1. INTRODUCTION

Land cover is the (biological) physical cover covering the ground surface. When evaluating land cover in its purest sense, it is necessary to define vegetation cover and man-made features. As a result, areas where the surface consists of bare rock or bare soil define the land itself rather than land cover. It is also discussed whether water surfaces are true land cover (FAO, 2000). Land use is defined by the regulations, activities that people undertake to produce, change or maintain a particular type of land cover.

Ecosystems have two important components, abiotic (inorganic) and biotic (organic). Abiotic components; consist of non-living factors such as water (hydrosphere), air (atmosphere), soil (pedosphere), geomorphological structure and parent material (lithosphere). Biotic components, on the other hand, consist of living factors such as plants (flora), animals (fauna) and humans, and together these elements are called the biosphere. The two main characteristics of ecosystems are that they have components (structure) and processes (functions). Ecosystem efficiency is an indicator that combines ecosystem processes and dynamics. Ecological efficiency and production are two different concepts expressing the rate and amount of organic matter accumulation on a specific temporal-spatial scale, respectively. Ecological efficiency is generally expressed in three different organizational levels: plant, ecosystem and biome. The practical measurement of these three ecological efficiency classes is based on the expression of organic matter accumulation and losses in terms of carbon (C) (Meydan, 2008).

When the carbon distribution is examined on a global scale, there are four major reserves of the carbon component: atmosphere, hydrosphere, lithosphere and biosphere. These reserves move between oceans and terrestrial ecosystems and the atmosphere during the year, and these changes occur at the level of billion tons. The carbon cycle begins with the binding of the carbon dioxide in the atmosphere by plants and some algae through photosynthesis (Güler and Çobanoğlu, 1997).

Terrestrial ecosystems connect 1.7 billion tons of carbon per year to the atmosphere, including vegetation and soil. However, by releasing 1.4 billion tons of carbon back to the atmosphere as a result of changes in land use, it holds 0.3 billion tons of carbon in the system. The amount of carbon that passes from the atmosphere to the terrestrial ecosystem annually by respiration and photosynthesis is 61.7 billion tons. The total amount that passes into the atmosphere from terrestrial systems reaches 60 billion tons (Meydan, 2008). Approximately 3.2 billion tons of carbon accumulate in the atmosphere every year with the contribution of the oceans (Reichle et al., 1999). Carbon can be stored in soil and plant structure for a long time under suitable conditions. However, the carbon stocks in the forest and soil are decreasing significantly with the effect of change in land use in agriculture, intensive tillage techniques, erosion and climate change.

With the change in land use, the amount of organic carbon in the soil decreases to the lowest level in the first 20 years, while a time period of about 100 years is required to maximize the amount of organic carbon in the same soil (FAO, 1992). Organic carbon can be stored in soils for a long time under suitable conditions. However, the carbon stocks of soils decrease significantly with the change in land use and intensive cultivation techniques in agricultural use, erosion, and different silvicultural practices in forests (Başaran, 2004) (Table 1.2).,

Table 1: Carbon Stocks Retained in Vegetation and Soil (1 m depth) in the World.

Land cover		Carbon Stocks in the World (Gt C)		
		Vegetation	Soil	Total
Tropical Forests	1.76	212	216	428
Temperate Forests	1.04	59	100	159
Humid Forests	1.37	88	471	559
Savannahs	2.25	66	264	330
Temperate Pastures	1.25	9	295	304

Land cover		Carbon Stocks in the World (Gt C)		
		Vegetation	Soil	Total
Desert and Semi Deserts	4.55	8	191	199
Tundras	0.95	6	121	127
Wetlands	0.35	15	225	240
Planted Areas	1.60	3	128	131
TOTAL	15.12	466	2011	2477

Resource: IPCC, 2000

In Table 1.3, land covers and biomass potential rates in the world are given. Changes in land use/cover/will directly affect biomass and carbon sequestration.

Table 2: World Biomass Potential Ratios

LAND USE/COVER	Area (%)	Biomass Production (%)
Forests	11	44
Groves	5	1
Herbs-Meadows	5	9
Agricultural Areas	3	5
Desert	5	0
Lakes and Rivers	1	3
Oceans	70	38

Resource: IPCC, 2000

2. INTERNATIONAL PROGRAM ON LAND USE /COVER

2.1. GMES and Copernicus

GMES (Global Monitoring for Environment and Security) is a program started in 1998 aiming to provide fast and effective information flow for environmental management, to avoid climate change impacts and to protect civil security. Later, it is named Copernicus and continues to work.

It operated in partnership with the European Commission, the European Space Agency (ESA) and the European Environment Agency (EEA). It manages the Sentinel family satellites.

Copernicus Land Monitoring Service

The Copernicus Land Monitoring Service started its operations as part of the GMES Initial Operations (GIO) program in mid-2011 and became operational in 2012. The Copernicus Program is managed in partnership with institutions such as ESA, EEA, EUMETSAT (European Organization for the Exploitation of Meteorological Satellites).

It provides geographical information on land /use/cover and changes by years, of vegetation status and the water cycle. It has three components: global, pan-European and local. The Pan-European component is coordinated by the EEA and provides the CORINE data.

2.2. CORINE and CLC Program

CoORdination of Information on the Environment (CORINE) land cover studies first started in 1985 and the first mapping was concluded in 1990. Studies were carried out by the European Commission from 1985 to 1990, its terminology and methodology were developed and accepted at the European Union level. By the decision of the Council of Europe, the EEA has established the European Environment Information and Observation Network (EIONET); besides, tasks involving processing and updating the CORINE databases are:

- Collecting information on the state of the environment according to priority issues determined for all member states of the European Union,
- Data collection and harmonization of information for member states or internationally,
- Ensuring consistency of information and compatibility of data,
- The gathering of studies at different levels (international, national and regional) in order to monitor the changes in environmental information collected, taking into account the temporal processes.

The CORINE Project Land Cover Classification consists of three hierarchical levels determined by the European Environment Agency. At the first level;

- Artificial areas,
- Agricultural areas,
- Forest and semi-natural areas,
- Wetlands,
- Water bodies,

These are 5 main groups, 15 at the second level and 44 subclasses that must be used at the third level. It is stated in the CORINE Technical Manual that additional national classes derived from the third hierarchical level can be used, but this should be added to the fourth and fifth levels for the integrity of the European data standard. The naming system is specified as "CORINE Land Cover 1990 (CLC1990)". CLC2000, CLC2006 and CLC2012 were produced in the following years. This organization is run by the European Environment Agency (EEA), but the work is directly run and funded by the member countries. CLC2000 and CLC2006 are carried out under the Global Monitoring for Environment and Security (GMES) program, while the last completed CLC2012 was carried out within the scope of the Copernicus program, which is a continuation of GMES. Although the CORINE land cover is produced by different countries with a higher resolution, the final product has been created at a resolution of 25 hectares and at a scale of 1: 100.000. This coarse resolution brought with it class mixes and many land covers were underrepresented. Some countries (eg. Finland, Sweden) have completed land cover mapping with higher resolution semi-automated approaches, but integration into CORINE has been 25 hectares.

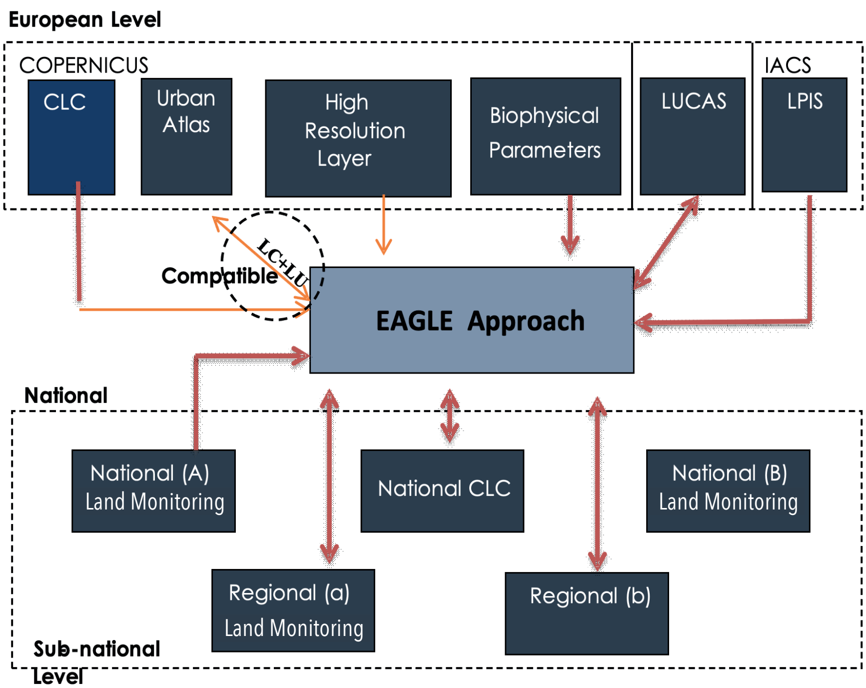
CLC1990 and CLC2000 maps were produced with Landsat TM / ETM data, while SPOT-4 and IRS LISS III data were used for CLC2006. With CLC2006, the European Space Agency (ESA) provided SPOT 4-5 and Indian Remote Sensing (IRS) P6 satellite data in the GMES / Copernicus framework. In CLC2012, in addition, RapidEye data was put into use. From 2016 onwards, classifications will mostly be carried out with Copernicus Sentinel 2. After the CLC2000 data, change analysis "CLC Change" (CLCC) was started. In change analysis, the minimum area has been reduced to 5 hectares. All changes in classification and analysis were conducted by 39 member states, including Turkey.

2.3. Other National Land Cover / Use Classification Studies

Most of the member states have developed their national mapping systems (eg. Norway, Finland, Sweden, Netherlands, Spain). These countries have found it ineffective to produce their land cover maps in parallel with the CLC. However, 30 of the 39 member countries do not have a national mapping program other than CLC.

The EAGLE group (EIONET Action Group on Land Monitoring in Europe), supported by the EEA, is a network of experts from different countries on land cover /use (Figure 1). While operating in harmonizing national studies with EU CLC studies, their most important achievement is the application of the object-based modeling approach. It supports the precise separation of land cover and land use concepts on the basis of classes.

Figure 1: EU land monitoring main framework with EAGLE approach



The main results of the EAGLE group:

- EAGLE matrix; it is a tool for semantically comparing class definitions in different classification systems. Separates land cover and use components and tables in excel format.
- EAGLE data model; UML (Unified Modeling Language) is a model that can be displayed conceptually and graphically in model presentation.

The EAGLE approach separates the landscape units into building blocks and enables their transformation into different classification systems, it is an interface at the national and EU level that provides data collection, harmonization and distribution. All of these initiatives address the need to revise the CLC and develop more representative classification definitions in the short and medium-term. This situation can be compensated by the development of levels 4 and 5.

HRL

The production of high-resolution layers named HRL (High-Resolution Layers) has been prepared under the GIO (GMES Initial Operations) program as an aid to CLC components. First level CORINE has five classes: impermeable surfaces, forest, meadow, water body and swamps. Pixel resolutions are 20 m for the intermediate product and 100 m for final product. The minimum mapping unit is 0.5 ha. The forest layer includes a closed percentage value ranging from 10 to 100 and a broadleaf / coniferous classification. It is prepared every three years.

LUCAS

LUCAS (Land use/cover area frame survey) is a project carried out by EUROSTAT, whose main task is to provide harmonized information on agriculture and the environment. LUCAS records land cover and use the information and digital field pictures in a two-dimensional regular grid. The grid size is 2 km x 2 km. It is used for CORINE authentication. The target accuracy of 85% is aimed. Secondly, it is determined which classes are less accurate and which are relatively high. The reasons for the wrong evaluation are investigated. Classifications in LUCAS are different from CORINE and are more detailed. It covers 28 European countries which do not include Turkey.

Urban Atlas

It is a local component of the Copernicus Land Monitoring Service program. It is aimed to create 27 classes of land use and land cover information for residential areas with more than 100 thousand people. The minimum mapping unit is 0.25 ha for 17 artificial site classes and 1 ha for 10 natural area classes. In the change maps, a resolution of 0.1 ha for transformation to artificial area and 0.25 ha for transformation to natural area is determined. The minimum mapping width is 10 meters. Its resolution is 100 times higher than CORINE. It works on 1: 10,000 maps. The first map was created across Europe in 2006 and updated in 2012.

LPIS

LPIS (Land Parcel Information System) is a pan-European database funded by the European Community Directorate of Agriculture and Rural Development, organized at national level, such as CORINE. It is the land parcel identification system that constitutes one of the basic elements of the Integrated Administration and Control System for land-based supports. It is aimed to produce LPIS data set on a yearly basis and this set contains information on what purpose all agricultural lands are used for the relevant year on an individual polygon basis. Studies in Turkey started within the body of Ministry of Food, Agriculture and Livestock Agricultural Reform General Directorate on 10.01.2014. It is aimed to keep records of all agricultural areas. Studies are conducted on 1: 10.000 maps.

Inspire Directive

In 2007, the European Parliament and the EU Council decided to establish INSPIRE (Infrastructure for Spatial Information in the European Community). The main purpose is not mapping, but the integration of data from different sectors and the coordination between data producers and users. One of the important tasks of this is to support CLC. INSPIRE does not include any mapping tool. Member countries can develop their databases voluntarily through national INSPIRE portals.

3. LAND USE/COVER CHANGE

Change analysis includes a number of applications aimed at determining qualitative and quantitative changes in data sets belonging to different times. Image extraction, principal component analysis, post-classification comparison studies are the most frequently used methods in change analysis studies (Lu et al., 2004). Different change analysis methods have different assessment methods and a single approach cannot be applied in all situations.

Areas where land use and land cover change analysis applications are commonly performed using remote sensing techniques: Can be grouped as vegetation change, forest losses, forest productivity, regeneration, forest fires, change of wetlands, topograph changes, changes in urban areas, changes in agricultural land use pattern.

In terms of suitability, change analysis methods are collected in 7 categories. (1) algebra, (2) transformation, (3) classification, (4) advanced models, (5) geographic information systems approach, (6) visual analysis, (7) other approaches. Techniques in the seventh category are change analysis techniques that are not suitable for grouping into the other six categories and are not used much in practice. Therefore, this category is not explained in detail.

3.1. Algebra

The Algebra category includes image extraction, image proportioning, image regression, vegetation index extraction, Change Vector Analysis (CVA) and background extraction techniques. These algorithms have common features such as selecting threshold values to detect areas of change. It is based on the detection of the reflection difference between more than one date and the principle that pixels above the threshold value are areas of change. Threshold values are determined experimentally. These methods (other than CVA) are simple, easy to implement and interpret, but do not provide a complete matrix for change information. In other words, it does not contain information about conversion from what to what, for this change pixels must be classified separately. The CVA approach, on the other hand, can define much more comprehensive changes than defined threshold values and provides very detailed information about the change.

3.2. Transformation

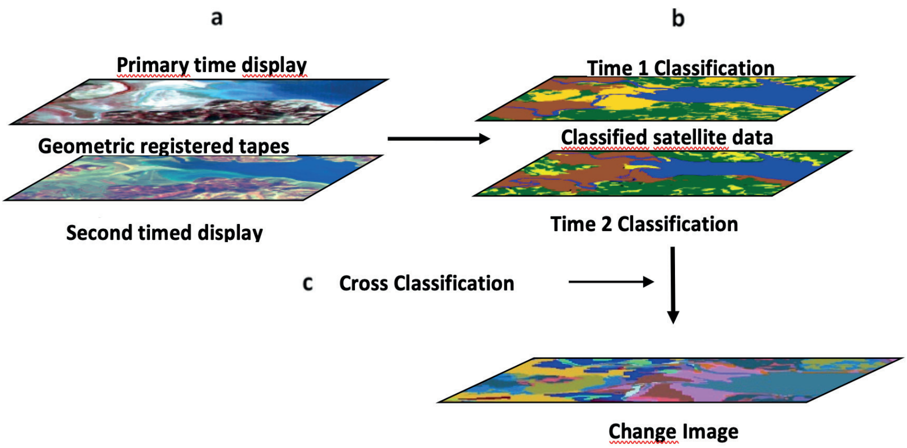
The transformation category includes principal component analysis (Principle Component Analysis (PCA)), KT, Gramm-Scmidt (GS) and Chi-square transformations. The advantage of these methods is that additional information can be generated between the bands and the information extracted from the components can be highlighted differently. However, they do not give a detailed change matrix and require a threshold value to define the study area. One disadvantage is that it is difficult to interpret and classify on the transformed image.

3.3. Classification

Post-classification comparisons are among the methods frequently used in change detection studies. This method is based on classifying the images belonging to different dates separately and collecting them and creating the change map in this way. Post-classification comparisons are among pixel-based methods. Therefore, in order to produce correct change analysis results, the geometric registration between the images must be made well. The margin of error (RMSE) obtained during geometric correction in the study is approximately 1 pixel on average.

This method, which is also important for change studies, is also important in terms of obtaining classified images belonging to different dates and at the same time giving the "from-to" information about the change (Figure 2). The main advantage of these methods is that they provide a matrix of variation information while reducing the effects of the atmosphere and different environmental factors between multi-time images.

Figure 2: General Flow Chart of Post-Classification Comparisons



Images of different dates are classified and compared independently, but classification error in each image can lead to an exponentially increasing error in comparisons. Especially the difficulty encountered in classifying old data generally affects the results of change analysis.

Cross-Classification

In post-classification comparisons, the most valid way to compare two images is cross-classification. Cross-classification calculates logical ' AND ' values for all possible combinations in the two maps. In cases where two maps represent the same categorical information on two dates, the method provides information on whether the fields fall into the same class on both dates or whether the fields changed to a new class. This is expressed by the cross-classification matrix, in other words, the error matrix compares the cells in the diagonal with the cells that fall outside the diagonal (Table 1).

Table 1: Cross Classification Matrix

		Time 1				
		A	B	C	D	TOTAL
Time 2	A	n_{AA}	n_{AB}	n_{AC}	n_{AD}	n_{A+}
	B	n_{BA}	n_{BB}	n_{BC}	n_{BC}	n_{B+}
	C	n_{CB}	n_{CB}	n_{CC}	N_{CD}	n_{C+}
	D	n_{DA}	n_{DB}	n_{DC}	n_{DD}	n_{D+}
	TOTAL	N_{+A}	n_{+B}	n_{+C}	n_{+D}	n

3.4. Advanced Models

Advanced models cover Li-Strahler reflection model, reflectance mixture model, biophysical parameters estimation methods. In these models, image reflectance values are converted into values dependent on physical parameters with the help of linear and nonlinear models. Transformed parameters produce more understandable information by interpretation, for example, it is easier to extract vegetation-related information than using reflection values alone. The disadvantage of these methods is that they take a lot of time and it is difficult to correlate the image reflectance values with the biophysical parameters of the land cover.

3.5. GIS

The advantage of using GIS is the ability to combine different source data in change analysis applications. Many previous studies on the GIS approach focused on urban areas. This is probably because traditional change analysis techniques produce poor results in urban areas with a complex landscape. Thus, it becomes a useful tool in multi-source data processing and application of change analysis techniques.

3.6. Visual Analysis

Visual analysis category includes visual interpretation of multi-time image components and digitization of change areas on the image. Among the visual analysis, the structure, size and shape structure of the image are the key factors in defining the land cover-land use change. These features are mostly not used in digital change detection analysis because it is difficult to determine the features by automatic methods. Successfully analyzing and combining these features in visual interpretation helps to reach a conclusion about the land cover-land use change. The disadvantage of this method is that change analysis studies involving large areas require a lot of time and it is difficult to update the change analysis results.

4. THE EFFECT OF LAND USE / LAND COVER CHANGE ON ECOSYSTEMS

Deforestation is the destruction of forests for different reasons, turning them into deforested areas. Converting forest lands to agricultural lands or rural and urban settlements can be shown as an example of deforestation. Deforestation destroys species by damaging the natural cycle of the ecosystem on the one hand, and an increase in greenhouse gas emissions due to human activities on the other.

The causes of deforestation differ between countries. Expansion of agricultural lands, overgrazing, livestock farming, road and similar construction works and logging are among the main causes of deforestation worldwide. While these reasons stem from both the increasing population of countries and the uncontrolled increase in consumption demand on a global scale, unplanned management and improper land use also increase deforestation.

Failure to adequately determine the land cover changes in forest ecosystems on a global scale causes the carbon emission rate resulting from deforestation and forest degradation in the global carbon cycle to not be clearly revealed and thus the carbon storage are calculated to be lower than their real value. Deforestation, which has been increasing at a steady rate in the last two decades on a global scale, is predicted to cause 10 Gt of release per year in the next 50 to 100 years. Since forest areas are carbon stores, the increase in forest areas on earth reduces greenhouse gas emissions. However, this positive effect is insufficient for the contribution of deforestation to CO_2 in the atmosphere. Therefore, although it is beneficial to establish forests with afforestation, trying to reduce deforestation in all forest areas on earth, especially tropical forests, should be one of the primary goals of countries (WWF, 2009).

Within this scope, Land Use, Land Use-Change and Forestry - LULUCF and "Reducing Emissions from Deforestation and Forest Degradation - REDD" programs have been developed. These programs are mechanisms to reduce human activities impacts on forest land and carbon stocks in these areas. Again, both aim to highlight sustainable development (see Article 2 of the Kyoto Protocol and the Cancun Agreements).

Forest areas, which are a carbon sink area where CO_2 is absorbed, have been considered as one of the carbon removal options in the Kyoto Protocol in order to reduce the rate of greenhouse gases in the atmosphere. The protocol is of great importance for decision makers in developing countries to determine climate strategies with the REDD Program, which was developed to accurately and precisely determine emissions from land use change on a global scale (FAO, 2010).

Using remote sensing technologies, especially in regions with rich forest ecosystems in terms of species diversity, mapping forest areas and modeling Reference and Carbon Emission Reduction Scenarios within the scope of REDD Project are very important in terms of making future planning decisions. Land cover mapping of different years is important in determining how and in what direction the changes in forest areas occurred, as well as how the landscape dynamics affected these changes.

The concept of LULUCF, which was brought to the agenda for the first time with the Kyoto Protocol, was defined by the United Nations Framework Convention on Climate Change (UNFCCC) as a whole aiming to determine the impact of human intervention in land use and land use over time on greenhouse gas emissions and reductions, and brought some obligations:

- Determining the current land use situation and integrating it into geographical information systems,
- Determination of sinks and emissions absorbed by sinks to calculate net carbon dioxide emission,
- For the reduction of greenhouse gas emissions by land use change, taking

into account economic and social conditions, the necessary legal regulations, incentive mechanisms, and developing suggestions.

- It includes studies to reduce greenhouse gas emissions caused by agriculture and animal husbandry activities.

With the recognition of the role of terrestrial ecosystems in climate change, the concept of "Land use, land use change and forestry (LULUCF)" has emerged. Living biomass, decaying organic matter and terrestrial ecological systems in which they are held play an important role in the global carbon cycle. Carbon naturally moves between these systems and the atmosphere through photosynthesis, respiration, decomposition, and combustion. Changes in land use cause changes in this cycle (IPCC, 2000).

From 1850 to 1998, it was determined that approximately 270 Gt (Gigatonnes) of carbon was released into the atmosphere globally from fossil fuels and cement production. Due to the change in land use, about 136 Gt of carbon was released into the atmosphere. This resulted in an increase of 176 units of CO_2 in the atmosphere. Ecosystem models show that atmospheric CO_2, resulting from indirect human activities (eg CO_2 fertilization and nutrient loading), will continue to be taken from forest ecosystems by land for many years on a global scale. However, this may gradually decrease and forest ecosystems may even become a source of emissions (IPCC, 2000).

Carbon is released into the atmosphere when plants photosynthesize, by storing and then by inhaling, destroying or burning the plant. It is also exposed by grazing animals, plowing the soil, and agricultural activities.

It is currently estimated that around 2.3 Gt of carbon or anthropogenic emissions are removed by terrestrial ecosystems annually. On the other hand, emissions from the carbon pools of terrestrial ecosystems due to land use change account for more than 20% of 1.6 Gt of carbon or anthropogenic emissions per year. However, when 4.6 Gt of the total 7.9 Gt of carbon released into the atmosphere each year is retained by terrestrial ecosystems and oceans, the remaining 3.3 Gt remains in the atmosphere (IPCC, 2000).

Human activities under LULUCF as specified in the Kyoto protocol;

- Afforestation
- Deforestation
- Forest management
- Management of agricultural lands and pastures
- Re-planting (Decision 16 / CMP.1, Kyoto Protocol)

The annual carbon amount accumulated in forests and the annual variation of this amount are calculated with the help of the amounts in a total of five carbon pools separated above and below ground. Studies show that tropical forests are the largest carbon deposits on the earth in terms of above-ground accumulation and 80% of the total carbon accumulation is found in tropical forests. Tropical forests are followed by a temperate zone with 17% and a boreal forest belt with 3% (Brown, 1997).

Forests are superior to other ecosystems because of their ability to retain the carbon they bind for sometimes hundreds of years. For example, agricultural areas return the carbon they have stored for 3 to 6 months, either directly at the end of the production period, or by being consumed by humans and animals, depending on the type of the plant. This period is also valid for pasture ecosystems. The carbon bonded in forests returns to nature as CO_2 , even in energy forests that provide fuel to thermal power plants for at least 10 years. These periods can extend up to 3-4 centuries depending on the usage area and production period of the wood product (Asan 2007; Asan et al., 2008).

In this context, due to the significant impact of forest areas on the carbon balance sheet, the member countries involved in the Rio-Helsinki process and signing the Kyoto Protocol are given the obligation to explain the carbon stock changes in their forests every year, and how their countries affect the world carbon cycle and global warming, according to a standard format. This format is referred to as Good Practice Guidance for Land Use, Land Use Change and Forestry (GPG - LULUCF) among IPCC documents (IPCC, 2003). In the guide, the method for calculating the amount of greenhouse gases emitted into the atmosphere and the amount absorbed from the atmosphere is explained optionally according to the forestry level of the relevant countries, inventory records of forest resources, original research data and their capacity to use modern information technology.

There are 3 methodological methods for estimating greenhouse gas emissions and removals in the guide.

- Identification of total areas for each land use category, but detailed information on changes between categories is not available. General and rough data are generally used, such as national or global forest and agricultural production statistics and global land use maps.
- Monitoring land use changes and including country-specific data. The emission factors / activity data defined by the countries are considered to be more appropriate than the climate zones and land use systems of that country. High-resolution data are used against country-specific coefficients for regional and specific land use categories.
- Land use and land use change require spatial inventory information. Data is generated according to the national inventory by sampling geographically located points. High-resolution activity data are processed through GIS, including segregated, subnational scaled models. Quality control, inspection and conformity inquiries are made to the models.

3 important documents for LULUCF in the international platform; Framework Convention on Climate Change, Kyoto Protocol and Marrakech Decisions. In the text of the contract, "any process, activity or mechanism that removes any greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere is defined as sink" (see 1.8). However, the term sink is used in a broader sense for LULUCF for

all land use, land use change and forestry activities where greenhouse gas emissions and removals occur.

Turkey has become a party to UNFCCC as of May 24, 2004 pursuant to Law No. 4990 came into force on 16.10.2003. For this purpose, the İDKK was established under the Presidency of the Minister of Environment and Forestry with the Prime Ministry Circular No. 2004/13. This committee which is constituted with the participation of undersecretaries of the various ministries, Turkey Trade and Industry Chambers, Maritime Trade and Commodity Exchanges Association (TOBB) and other civil society organizations, created eight working groups for carrying out the works as a whole and ensuring cooperation, one of which is named "Land Use, Land Use Changes and Forestry"

Turkey has to make some reporting under the UNFCCC. These reports; I. National Greenhouse Gas Inventory Report (NIR): In this reporting, the period from 1990 to 2 years before the reporting year is calculated and reported annually. For this purpose, the annual greenhouse gas inventory report is sent to the secretariat on 15 April each year as CRF (spreadsheets) and NIR (ie the written part where the methods and data are explained). II. Biennial Report (Biannual Report- BR): A new reporting system has emerged since 2014. In this reporting system, which is called as bi-annual reporting, the main purpose is to reveal the extent to which the reporting party country is close to its targets. For this purpose, targets, mitigation measures and policies towards achieving this target and the effects of these policies are presented. This reporting system also includes projections. The projections of the current situation (Bussines as Usual) and With Measures scenarios are explained. Turkey is still at the beginning of the work in this reporting system which started in 2016 particularly in relation to the effects of measures and projections (Serengil, 2018).

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POSSIBLE EFFECTS OF CLIMATE CHANGE ON INDUSTRIAL PRODUCTION SECTOR AND RISKS IN THE WORLD AND TURKEY

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1. INTRODUCTION

The direct impact of climate on industry is not as strong and pronounced as in nature-based or nature-dependent sectors such as agriculture or tourism. However, the industry is indirectly affected by the climate, especially the components of the industry such as raw materials, water, transportation, energy, and the choice of location for some industries. For example, industries that depend on agricultural raw materials are indirectly affected by the effects of climatic conditions on these materials. In contrast, the effect of climate on the aircraft industry is direct. For example, whereas the plants producing parts such as aircraft engine, propeller, etc. in the USA operate in the northeastern part of the country, factories and combination facilities that produce body are located on the south east where mild climate conditions prevail in order to have most of the works in open air, have the test flights under good weather conditions for a long period of time, and for storing certain materials openly at a cheaper charge. In this site selection, the desire to minimize costs plays a role in the heating of large facilities that cover millions of square meters (Tümertekin & Özgüç, 2015).

The same can be said for the ship looms in the USA. The cessation of shipbuilding activities in the severe cold in the northeast of the country and the warming of the iron and steel parts in the summer heat making the work conditions harder, have affected the gathering of such facilities in the northwest, where there are better working conditions in terms of climate for most of the year.

During the operation of factories, hot or cold climatic conditions affect employees. Severe hot temperatures reduce efficiency and production, while severe cold creates heating problems and increases costs (Tümertekin & Özgüç, 2015). Energy-dependent heating and cooling systems such as air conditioning have made it possible to eliminate both negative conditions in the factory, but these systems that use high levels of energy cause other problems.

There are direct and indirect costs that have a very important effect on the establishment and development of the industry. Direct or indirect costs include raw materials, energy, fuel, labor, water supply, waste material availability and delivery to markets. Indirect costs include "site" costs, buildings, moving equipment (machines and hand tools), taxes, administrative expenses, advertisements, loans (investment capital, etc.) (Tümertekin & Özgüç, 2015). It is necessary to consider these factors that form the basis of the establishment and development of the industry not alone, but in combination with each other and with other factors. It should also be added that the role of these factors may vary from field to field, from time to time, from industry to industry, and may give different results in different types of economy. The most important group of factors affecting the establishment and development of the industry is the factors associated with the processing, assembly of raw materials and the distribution of finished products (Tümertekin & Özgüç, 2015). Therefore, the structure of the industrial sector should not be considered as production in industrial facilities in a closed environment. Undoubtedly, this stage constitutes the most important stage in industrial production, but there are other stages related to the production processes of enterprises before and after the industrial production process. As will be explained in detail below, each link of this chain, also known as the value chain, has a direct relationship with climate and climate change.

As explained briefly above, it is inevitable that the industrial sector affected by the climate in raw material procurement, production and distribution processes will be affected by climate change. This impact is expected to increase further in the future. However, it is known that most of the greenhouse gas (GHG) emissions that trigger climate change in the world are caused by activities related to energy and industry. Indeed, according to the figures provided by the Intergovernmental Panel on Climate Change (IPCC), 25% of total global emissions are caused by electricity and heat generation, 21% by industry, 14% by transport and 10% by other energy-related activities. (IPCC, 2014).

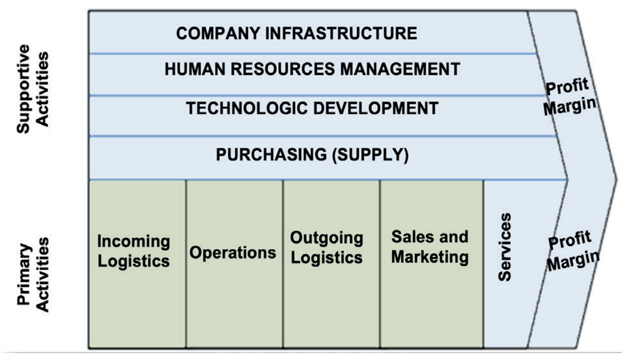
Historically, most of the world's greenhouse gas emissions have originated from industrialized countries. However, as the developing countries have undergone a rapid industrialization process in the last decades, the responsibility of these countries in causing climate change has increased significantly. Currently China is the country that produces the most greenhouse gas emissions in the world, although it is still considered a developing country. In 2012, the share of developing countries in total emissions in the world was 59% and the share of all developed countries was 41%. As a result, many developing countries around the world are currently pursuing policies aimed at low-carbon growth, and developing world countries will need to make additional mitigation efforts to limit global temperature increases to safe levels. This requirement raises questions about the compatibility of development policies with climate policies, as these countries also have important development obligations to address. According to the International Energy Agency, about 1.2 billion people in the world still do not have access to electricity, and about 2.7 billion people still use traditional biomass resources for cooking. The main challenge that new industrial policies will face will be to realize environmentally sustainable growth paths without harming the development needs of the countries where they are implemented (Bavbek, 2016).

The industrial sector is affected in many different ways by climate change in the world and Turkey. These effects can be negative or there may be opportunities to create. Climate change can affect the way businesses operate, affect the profitability of their operations or create opportunities. Therefore, businesses may be exposed to different risks as a result of climate change. These risks could be both direct and indirect. These risks may be physical risks, supply chain and raw material risks, reputation risks, financial risks, product demand risks, regulatory risks. Companies' exposure to these risks will vary depending on their commercial activities and the industry in which they operate (Agrawala, et al., 2011).

2. IMPACTS OF CLIMATE CHANGE ON INDUSTRY SECTOR

When industrial production is considered in a holistic manner, in general it is carried out starting from the supply of raw materials, production, marketing within the framework of a concept that is interconnected and qualified as a value chain. Value chain, which is a strategic concept developed by Porter (1985), is a model towards how an added value appears in an enterprise, also explaining all operations starting from the point where a service or a product is conceptually developed through various production processes (including the contribution of physical change and many different producer services) up until the access to final consumer and the period after use (Eraslan et al., 2008). Each stage or link of the value chain is associated with other rings and aims to add more value to the product at each stage based on customer needs-oriented thinking. In other words, every link in the value chain should aim to provide competitive advantage. Compared to its competitors, it should aim to achieve either lower cost or higher quality or differentiation at every stage. In this context, the value chain is a good analysis tool to reveal the contribution of each activity (procurement, marketing, etc.) to creating competitive advantage (Figure 1).

Figure 1: Value Chain Model



Source: Eraslan et al., (2008) from Porter (1985).

The value chain has been designed to provide a framework for evaluating the overall contribution of internal processes to customer value in order to support analysis conducted at a functional level. However, based on the fact that an industry value chain is a physical representation of the process processes in the goods (and services) sector starting with the raw material and ending with the delivered product (also known as the supply chain), the impact of climate change on the industrial sector will be analyzed within this framework.

The concept of value chain is an improved vision of the conveyor belt in the Ford production model where joint specialization and common location enable a manufacturing firm to achieve economies of scale and scope. A traditional concept of value chain represents a modularized version of the Fordist manufacturing process, based on an interconnected set of modularized production processes and business functions, each adding value to a firm's final output individually. Global value chains make up almost 50% of global trade today. For example, the bicycle is the world's most popular mode of transport. Bicycles, invented in Germany at the beginning of the 19th century, were mass produced by the Dutch at the end of that century, sometimes with frames imported from England. Global production then increased from about 10 million units in 1950 to more than 130 million today.

Bicycles are bought and sold heavily. They are assembled using parts and components from all over the world, especially Asia and Europe. For example, Bianchi performs all design, prototyping work in Italy and then assembles most of her bikes in Taiwan, China, using parts and components from China, Italy, Japan, Malaysia and many other places. Each component manufacturer has niche expertise - for example Shimano from Japan, brakes for Bianchi, and handlebars are made in Taiwan, China. Assembling a bike from parts and components produced worldwide increases efficiency and results in a cheaper and better quality bike for the consumer. The bicycle frame requires steel, aluminum or carbon fiber tubing and welding. The wheel must be straightened in both radial and lateral directions to ensure even tension. A quality saddle requires technical knowledge to produce a high-tech gel. Due to the wide bicycle value chain, the bicycle parts business has increased the bicycle trade by 15-25% in recent years (World Bank, 2020).

2.1. Possible Reflections of Variability and Difficulties Occurring in Raw Material or Commodity Supply to the Industrial Sector

According to the IPCC 5th Assessment Report, climate change will affect production through different channels. First, climate change will affect primary economic activities. Second, the supply chain or the quality of the product will also be affected (IPCC, 2014). It is likely that precipitation variability increases due to climate change and increases in drought and flood frequency will reduce yield in general. Although higher temperatures can improve crop growth, studies have documented that crop yields drop significantly when daytime temperatures exceed the specific level for a particular product. Higher temperatures and less reliable water sources will pose serious challenges to small-scale livestock breeders, especially in arid and semi-arid pastures and low latitudes in pasture ecosystems. Temperature increase and water scarcity will have a direct impact on animal health and decrease feed and feed quality and supply. There is some evidence that global warming is affecting the distribution of some marine fish species. Changes in temperature and precipitation will cause the distribution of inland fish species to also change. Therefore, climate change, especially agricultural raw materials, also affects the commodity industry with its different manifestations. Heat waves, floods, hurricanes, and rising sea levels and sea temperatures destroy crops or reduce crop yields and fish production (FAO, 2016; 2017; UNCTAD, 2019). For example, hot waves were experienced in Chicago in July of 1995 for five days, and the air temperatures reached to 38–41 C. Despite the fact that Chicago is a modern industrial city where A/C was widely used, the temperature wave claimed the lives for 500 people. Besides, since Chicago is located at the center of corn sowing region of the USA, this hot weather caused 15 % decrease in the corn yield of USA and a loss of 3 billion US Dollars. The cited article below reveals the raw material-industry relationship of climate change quite strikingly (Box 1).

Box 1: Climate Change Risks in the Fashion Industry

There is widespread consensus among the international scientific community that the world's climate is affected by anthropogenic (i.e. human-induced) greenhouse gas emissions (GHGs) into the atmosphere. In addition, it is predicted that climate change will accelerate if we do not significantly reduce greenhouse gas emissions. So there is an urgent global call to radically transform established ecologically unsustainable production and consumption patterns among industries.

The fashion industry is extremely resource-intensive with too many adverse environmental (e.g. extensive water consumption and greenhouse gas emissions) and social impacts (e.g. Child labor, unsafe working conditions) along the value chain. While the fashion industry contributes significantly to global greenhouse gas emissions, it is sensitive to the feedback from climate change (e.g. global warming) due to its dependence on natural resources. For example, agricultural inputs (especially cotton) and the farming systems that provide them are highly sensitive to climate change and thus pose a risk to global fashion value chains.
In the era of 'low-cost and fast fashion', as the apparel manufacturing industry faces increasing supply chain challenges based on commodity price fluctuations and availability of resources, the scientific community acknowledges more than ever that current and future global supply chain risks related to climate change are greater. In particular, climate change risks emerge as changing weather patterns and extreme weather events, causing garment producers to experience uncertainty in the supply of agricultural inputs, disruption of distribution networks and damage to production facilities. In addition, increased temperatures and consequently less reliable traditional seasonal cycles cause changes in consumer behavior. It is also argued that increasing consumer environmental awareness will affect purchasing behavior.

"Low cost, resource intensive and fast fashion" is an old and unsustainable production and consumption model. In a future where there is a significant shortage of natural resources, "business as usual" will not be. To remain competitive, fashion brands will need to improve their business models. Ultimately, the garment industry as a whole requires a new economic narrative backed by a radical improvement in overall productivity.

As a starting point, the identification and assessment of climate change and social risks will become strategic factors driving new investments. The evolution of the fashion industry will have a stronger attraction for more sustainable production and consumption patterns (e.g. Circular economy models - reuse, remanufacturing and end-of-life solutions) and the use of more environmentally friendly materials (e.g. Organic cotton, hemp, bamboo)" (Sealand, 2020).

Undoubtedly, climate change and associated extreme weather events will adversely affect not only the agricultural sector but also other sectors. One of the most important of these is the mining sector, which provides industrial raw materials. Climate change-induced adversities such as rising temperatures, extreme weather events, floods can also destroy or damage infrastructure in the mining industry, reduce profitability or make projects less attractive. This will undoubtedly reflect directly on the industrial sector in the raw material procurement process, especially in costs (UNCTAD, 2019).

2.2. Possible Restrictions and Difficulties in Production Due to Changes in Water Quality and Water Availability

97.5% of the total water in the world is salt water and it constitutes the water in oceans and seas. The remaining 2,5% water is fresh water on land. This amount consists of glaciers, groundwater, freshwater lakes, atmospheric water, rivers and water from other sources. Only 0.5% of fresh water can be used. 70% of the 0.5% usable water is used in agricultural irrigation, 20% in industry and 10% in homes. When considered as a whole, water use in the industry has an average of 20% of the total amount of water consumed in the world. However, this rate has increased to 50-80% in industrialized countries. For some developing and less developed countries, this rate is around 10-30%.

It is known that water resources that can be used in water resources in many countries due to climate change are at critical thresholds, and even some have difficulties in this regard. For example, Turkey's current water potential that could be used in a sustainable manner is 112 billion m^3, of which 94 billion m^3 is surface water and 18 billion m^3 is underground water. Around 50% of this potential is currently used in Turkey. The total water consumption which was 54 billion m^3 in 2016, corresponds to 48% of Turkey's net water potential. 39 billion m^3 of the total consumption is covered from surface waters and 15 billion m^3 from underground waters. Water used in agricultural irrigation has the highest share with 74% and 13% of the water is used for domestic purposes and 13 % for industrial purposes. Therefore, in the year 2016, 40 billion m^3 water is used for irrigation, 7 billion m^3 for domestic use and 7 billion m^3 for industry in qualitative terms. It is estimated that in 2023, Turkey will use all of the usable water, which is 112 billion m^3.

As water consumption amounts for year 2023, 72 billion m^3 is foreseen for irrigation, 18 billion m^3 for drinking and usage water and 22 billion m^3 for industry, making a total of 112 billion m^3. According to this data, it is foreseen that the share of water usage for agricultural irrigation will decrease to 64% in 2023, share of industrial use will increase to 20% and the share of domestic use to 16%. According to the projections of Turkish Statistics Institution (TUIK), it is foreseen that Turkey's population will reach to around 93 million in 2030. According to this, the amount of usable water per capita, which is 1.302 m^3/year today, will decrease to 1.204 m^3/year in 2030. It is possible to estimate the pressures that could be on water resources with the effects of such factors as the current growth rate of the country and change of water consumption behaviors. Besides, all these estimations are valid in case that the existing resources are transferred to this year without being destroyed. In this regard, as opposed to the general belief, Turkey is not a country rich for water as regards the amount of usable water. According to Falkenmark Index which classifies the countries from the point of per capita water potential, turkey is a country with "water stress" since it has a water potential of 1.000–1.5000 cubic meters per capita and the per capita amount of water is below global average. Taking the same index into account, if the amount of water per capita in the country decreases below 1.000 cubic meters, the country will be in water scarcity. Under the light of this reality, Turkey is under the risk of water scarcity in the near future) It is foreseen that this number will further decrease in the future without taking into account the effect of climate change. Assuming that the amount of usable water will not change throughout 21st century (namely without the effect of climate change), the amount of water per person will decrease more compared to today by 2050, because the population will increase. According to Turkey's population projections updated in 2018 by TUIK, it is foreseen that the population will be around 104 million in 2050, and 107 million in 2075. According to this, the amount of water per capita will decrease to 982 m^3/year in 2050 and around 957 m^3/year in 2075. These figures will place Turkey among countries with "water scarcity". (Republic of Turkey Ministry of Environment and Urbanization. 2018; Şen, 2013). It is scientifically foreseen that the most important effect of climate change will be on water cycle and the climate change in Turkey will lead to a decrease in overall water resources in the future. (Şen, 2013; Su Yönetimi Genel Müdürlüğü, 2016; Kadıoğlu et al., 2017). Decreases in total precipitation are foreseen overall Turkey, with particular effect in the aftermath of 2041 (Republic of Turkey Ministry of Environment and Urbanization. 2018). As a matter of fact, the industrial sector is aware of these negativities. The following text is taken from the Istanbul Chamber of Industry website (Box 2):

Box 2: Impact of Climate Change on Economy and Industry is Discussed in ISO Assembly

The ordinary July meeting of the Istanbul Chamber of Industry (ISO) took place on July 26, 2017 in Odakule with its main agenda "Global Climate Change, Our Industry; Production, Sustainability, Efficiency and Competitiveness Effects". The guest of the meeting, chaired by ISO Assembly Vice President Hasan Büyükdede, was Istanbul Technical University Faculty Member Prof. Dr. Mikdat Kadıoğlu. In his speech on the agenda of the Board of Directors of ISO, Erdal Bahçıvan pointed out that the drought and deviations in the precipitation regime caused by climate change pose a threat to the water resources, one of the most important inputs of the industry, and said, "If the measures are not taken, the days when we will not find the necessary water for our industrial production may be waiting for us." "Istanbul Chamber of Industry, 2020

2.3. Problems in the Transportation Sector and Their Possible Reflections on the Industry

Infrastructure is the backbone of social and economic development. Especially the transportation infrastructure has enabled the development of civilizations since ancient times in order to transport goods and meet the travel needs of people. Because transportation systems increase the flow of people and products, strengthen inter-regional connections, provide access to basic welfare and social opportunities, and increase economic development. However, the transportation sector, which is so important in the economic and social life of people, is deeply affected by climate change. In fact, the relationship between transportation and climate change is two factors that affect each other mutually, just like our subject in the industrial sector. As a matter of fact, as stated above, the transportation sector is responsible for 14% of global atmospheric emissions. However, extreme weather events such as hurricanes, storms, floods, lightning and sea level rise have negative effects on the transportation system (Gelete and Gokcekus, 2018). In addition to negatively affecting the transportation sector, these negativities directly affect the industrial sector and all stages of the production and distribution processes in this sector.

Transport design, construction and operation depends on climatic and weather conditions. Climate change affects the transport sector, or floods, bridges, roads and ports, either permanently or temporarily, through sea level rise. Climate change can also disrupt maintenance costs and services by damaging transport infrastructure or increasing wear and tear. It is clear that reliable transport is essential for economic development and healthy communities. As a result of its impact on transport infrastructure, climate change can have far-reaching implications for development programs, particularly those which depend on transport to gain access to the population they serve. Changes in precipitation and temperature due to climate change may have a negative impact on various transportation resources (Gelete and Gokcekus, 2018). Therefore, it is clear that climate change deeply affects all modes of transport. Because extreme weather events with increasing frequency and duration due to climate change (storm, lightning, flood, etc.), rise in sea level or on the contrary, factors such as decreasing water level or shallowing in inland waters such as lakes, rivers and canals due to rising temperatures. Affect transportation negatively. All these cause disruptions and delays in transportation and this situation is directly reflected in the industrial sector. As a matter of fact, according to a study conducted by the World Bank on the adaptation of transportation infrastructure to climate change, it was concluded that the cost of new transportation infrastructure increased due to the high standards of expensive construction materials and design to adapt to climate change (Gelete and Gokcekus, 2018). Undoubtedly, these costs will also reflect on the industrial sector.

89.6% of the goods transportation in world trade in 2008 in terms of volume, and 70.1 % in terms of value, was realized by sea transportation (Rodrigue et al., 2013). Considering the vulnerability of maritime transportation, which has such a large volume in terms of volume and is the most important form of transportation for the industrial sector, both in the raw material supply chain and at the marketing stage, it will be better understood what risks a wait in the future in terms of the sector's relationship with transportation. As a matter of fact, it would not be wrong to say that these effects have occurred in some parts of the world today.

In a study conducted in North America for the Great Lakes Region, an important inland waterway for North America, located on the border of Canada and the United States and consisting of five interconnected freshwater lakes, in nearly all scenarios of future climate change, it is predicted that water levels in the lakes and connection channel flows will decrease due to increased evaporation, which arises as a result of higher temperatures. It is reported that as a potential economic impact, ship cargo capacity decreases and this may lead to an increase in transportation costs. It has been determined that lower water levels, estimated as a result of doubling atmospheric CO_2, could increase annual transportation costs by 29%, while milder climate change could cause a 13% increase in annual shipping costs. In this respect, it is also one of the results of the study that the effects will vary between commodities and routes (Millerd, 2010).

Ports will be affected by climate change, including higher temperatures, increasingly violent storms and increased precipitation. According to various sources, the presence of more than $ 3 trillion of port infrastructure in 136 of the world's largest port cities is reported to be vulnerable to weather events (CCSP, 2008; UNCTAD, 2009; UNECE and UNCTAD, 2010). For example, the Canadian coast supports a number of ports, harbors and marinas found in cities, towns and villages. Larger ports under the jurisdiction of individual maritime Port Authorities transport more than $ 160 billion per year. Small boat harbors in towns and villages contain more than $ 2 billion in infrastructure, vital for the fishing and transportation industries, and about 90% of all fishing in the country takes place in the small boat port. Aware of the potential significant economic impact of climate change on the coastal industrial infrastructure, the authorities have started a study to assess the vulnerability of the infrastructure used for fishing and aquaculture activities. As a matter of fact, there are many examples of damage recently to the maritime transportation infrastructure and transportation delays caused by extreme weather events and seasonal conditions in Canada. Severe weather conditions caused damage and delays for ferries and cargo ships, and in some cases resulted in isolation periods (for example, Îles de la Madeleine ferries stuck in ice in the winter of 2014-2015). Many coastal roads have been built to closely follow coastal roads and rivers, and bridges and intersections are often used to complete their connections. These transport systems have proven to be particularly vulnerable to extreme climatic events, especially when higher sea levels and storm surges are combined with heavy rainfall (Lemmen et al., 2016).

Transportation via increased storm on certain routes, additional security measures or longer roads with less storm tendency will increase the cost of transportation. If storms destroy the port infrastructure that connects the supply chains to the road or rail, transportation costs increase or new roads are sought. Increasing storm may also affect the passage through areas such as the strait or canals, which are defined as key systems. Increased storms due to extreme weather events can increase maintenance costs for ships and ports and cause more frequent weather-related delays. It is inevitable that these negativities will directly reflect on the industrial sector in different dimensions.

2.4. Infrastructure Damages and Operation Disruption Due to Extreme Weather Events and Flood

Depending on the climate change, weather events such as heat waves, storms, hurricanes, excessive rainfalls and disasters such as floods, etc. can have direct or indirect impacts on the industrial sector. For example, more intense and frequent heatwaves can affect the energy supply. This will cause difficulties in energy supply, one of the fundamental elements of the industry. The frequency and duration of extreme weather events will increase the threats to physical energy infrastructure, such as overall energy transmission and distribution.

Climate risks are also affected by a number of dependencies between different industries, between businesses and infrastructure, between climate and resource availability, and between business activities and socio-economic processes. They contribute to a complex network of interactions and relationships based on clustering around business centers, sharing the same resources, and near and distant services and goods. This can create multiple pressure points and lead to gradual effects. For example, co-located companies (such as organized industrial zones or business parks) all rely on the same infrastructure and are exposed to greater risks if the resulting risk of infrastructure flooding occurs. This dynamic has gained some recognition after the Thai Floods in 2011. Flood in the specified area caused a total damage of $ 45 billion and 9,859 factories faced the threat of closure due to the direct effects of the flood. Indeed, business dependencies in the specified area were extensive, and the flooding caused significant travel disruptions with Don Mueang Airport being closed for six months. Also, the disruption in hard disk production, with Thailand accounting for 45% globally, has caused the global hard drive price to double. Therefore, the complexity of dependencies related to the effects of climate for businesses and industries has begun to be realized with more frequent similar events both in our country and in the world (Surminski et al., 2018).

In our country, the irregularity in the rains experienced especially in recent years causes excessive precipitation and floods and overflows. As a result, it is a fact that there are industrial zones damaged by rains and floods in large cities, especially in metropolises such as Istanbul, Ankara and Izmir, and it is possible to read a lot of news on this subject when looking at the press archives.

2.5. The Effects of the Problems to be Experienced in Energy Resources, which are the Driving Force of the Industry, on the Industry Sector

It is the driving force of the energy industry. Today, the energy sector, which is responsible for approximately 35% of greenhouse gases that cause climate change, faces serious problems in terms of mitigation and adaptation. Another aspect of the subject is the problems that arise or may arise in the energy sector due to climate change and how this will affect the industrial sector. These are briefly explained below.

Power plants:

Thermal plants will be affected from the decreasing efficiency of thermal transformation as a result of increasing environmental temperatures. Decreased water for cooling and increasing water temperatures could lead to low power processes or provisional closures.

Pipelines:

The energy transportation infrastructure in cold climates is under risk with the thawing of permafrost and oil and gas pipelines at coastal regions that are affected from increasing sea levels. New land zoning codes and risk based design and construction standards and structural improvements on infrastructure could be necessary.

Power lines:

Extreme weather conditions, in particular powerful wind, could damage power lines. Standards may change in order to implement suitable adaptation measures, including lines to direct to remote from high risk areas.

Renewable Resources:

Changes in regional air conditions have the threat to affect the hydrologic cycle that supports hydroelectric energy. While cloudiness increase in some regions affect solar technologies, an increase in the number and magnitude of storm could damage the equipment.

Nuclear plants:

Water scarcity and extreme weather conditions could distort the processes of critical equipment and processes and threaten the nuclear plants.

When this brief explanation about energy resources is evaluated in its entirety, it shows that the problems that may arise due to climate change may have problems in the energy supply of the industrial sector. These risks can cause a series of problems, especially production disruption.

2.6. Possible Effects of Climate Change on the Workforce

Good living conditions have become a very prominent cultural factor in the industrial location and production process, and at the same time, it gains importance in the old industrial countries and redefines the industrial areas. Good living conditions are desirable qualities of the environment - a subjective assessment of both the physical and the cultural environment. Good living conditions include climate, terrain, cost of living, recreational amenities, and cultural attractions. The most obvious good living condition is climate. Temperate climates, especially those with low humidity and plenty of sunlight, are very attractive to people. A location with good climatic conditions is the best choice in industries where traditional location factors are less important, as well as industries where a highly mobile, highly educated, skilled workforce and the power to attract researchers are important (Tümertekin & Özgüç, 2015). As a matter of fact, in a study conducted by Kjellstrom et al., (2009) in the

IPCC 5th Assessment Report, it is stated that by using a biophysical model of the human body, it is predicted that the labor productivity based on manual labor will decrease especially in humid climates and it is pointed out that only a few studies are measuring these effects (IPCC, 2014).

2.7. Summary for Current and Possible Effects of Climate Change on the Industrial Sector

A summary can be made as follows for the current and possible effects of climate change on the industrial sector, which are described under main headings above:

- Possible changes in the availability of raw materials and intermediates due to changes in temperature and precipitation could affect the entire value chain.
- Potential increase in extreme events and extreme weather conditions can cause major damage to operational infrastructure and production (risk of liquidity shortage for businesses and insurance companies).
- Impacts on intra-company logistics resulting from the escalation of extreme events and their adverse effects on transport and storage infrastructure.
- Higher temperatures and heat waves will increase the demand for refrigeration for storage and transportation of various products.
- Changes in consumer behavior will occur due to increased temperatures and longer hot periods at these temperatures.
- Reduced availability of cooling water during heat waves and droughts may hinder cooling intensive production
- Regional differences in water availability may occur due to changes in precipitation and seasonal distribution.
- Higher temperatures and heat waves will adversely affect working conditions. This situation will create risks for decrease in productivity and occupational health and safety.

3. CONCLUSION

The direct impact of climate on industry is not as strong and pronounced as in nature-based or nature-dependent sectors such as agriculture or tourism. However, the industry is indirectly affected by the climate, especially the components of the industry such as raw materials, water, transportation, energy, and the choice of location for some industries. According to the figures provided by the Intergovernmental Panel on Climate Change (IPCC), 25% of total global emissions are caused by electricity and heat generation, 21% by industry, 14% by transport and 10% by other energy-related activities. (IPCC, 2014). In this respect, there is a mutual influence between the industrial sector and the phenomenon of climate change. The industrial sector is affected in many different ways by climate change in the world and Turkey. These effects can be negative or there may be opportunities to create. Climate change can affect the way businesses operate, affect the profitability of their operations or create opportunities. Therefore, businesses may be exposed to different risks as a result of climate change. These risks could be both direct and indirect. These risks may be physical risks, supply chain and raw material risks, reputation risks, financial risks, product demand risks, regulatory risks. Companies' exposure to these risks will vary depending on their commercial activities and the industry in which they operate (Agrawala, et al., 2011). When industrial production is considered in a holistic manner, in general it is carried out starting from the supply of raw materials, production, marketing within the framework of a concept that is interconnected and qualified as a value chain. In this context, the industrial sector will be affected from climate change; variability and difficulties in sourcing raw materials or commodities; possible restrictions and difficulties in production due to changes in water quality and water availability; problems to be experienced in the transportation sector and possible reflections to the industry; infrastructure damage and operational disruption due to extreme weather events and flooding, and potential impacts of climate change on the workforce.

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POSSIBLE IMPACTS OF CLIMATE CHANGE ON SOCIETY IN THE WORLD AND IN TURKEY AND THE RISKS

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

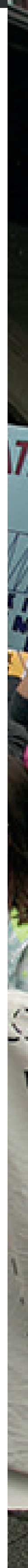
Since the last quarter of the twentieth century, one of the most fundamental problems in the field of environment is the negative effects of climate change. In this respect, the concept of climate security can be considered as a subtitle of the concept of environmental security. The physical effects of global climate change put pressure on the main elements of sustainable development such as water, agriculture, health, energy and environment, leading to a re-evaluation of the concept of security. In this context, the concept of climate security includes the effects of climate change, which manifests itself with droughts, heat waves, floods and fires, on security perception, assessments and applications.

2. CLIMATE CHANGE AND HUMAN HEALTH

2.1. Future Increases in Temperature-Related Deaths

Increasing concentrations of greenhouse gases cause both average and extreme temperatures to rise. This is expected to lead to an increase in deaths and illness from heat and a potential decrease in deaths from cold, particularly for a number of communities especially vulnerable to these changes, such as children, the elderly, and economically disadvantaged groups. Days warmer than the average seasonal temperature in summer or cooler than the average seasonal temperature in winter cause an increase in morbidity and mortality by reducing the body's ability to regulate its temperature or leading to direct or indirect health complications.

Loss of internal temperature control, heat cramps, heat exhaustion, heat stroke and hyperthermia, and extreme colds can cause a range of diseases such as hypothermia and frostbite (USGCRP, 2016).



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Extreme temperatures can also worsen chronic conditions such as cardiovascular disease, respiratory disease, cerebrovascular disease, and diabetes-related conditions. Prolonged exposure to high temperatures can result.

2.1.1. Changing Tolerance Against Extreme Temperature

Over time, an increase in population tolerance to temperature extremes has been observed. These changes in tolerance have been associated with increased use of air conditioning, improved social responses, and/or physiological conditioning, among other factors. Expected increases in this tolerance in the future will reduce the projected increase in heat-related deaths.

2.1.2. Population at Great Risk

Older adults and children are at a higher risk of dying or getting sick from extreme heat. People working outdoors, socially isolated and economically disadvantaged people, those with chronic illnesses are particularly vulnerable to death or illness.

2.2. Impact of Air Quality

Changes in climate affect the air we breathe both indoors and outdoors. The changing climate has affected the levels and location of outdoor air pollutants such as ground-level ozone (O_3) and particulate matter. Increased carbon dioxide (CO_2) levels also stimulate the growth of plants that release airborne allergens (aeroallergens). Finally, these changes in outdoor air quality and aeroallergens also affect indoor air quality as both pollutants and aeroallergens leak into homes, schools and other buildings. Poor air quality outdoors or indoors can adversely affect the human respiratory and cardiovascular systems. Higher pollen concentrations and longer pollen seasons can increase allergic sensitization and asthma attacks and thus limit productivity at work and school (USGCRP, 2016).

2.2.1. Health Effects of Increased Ozone

Climate change will make it difficult for any regulatory approach to reduce ground-level ozone pollution in the future as meteorological conditions become increasingly conducive to ozone formation in most countries.

2.2.2. Increased Health Effects from Forest Fires

Fires emit fine particles and ozone precursors that increase the risk of premature death and adverse chronic and acute cardiovascular and respiratory health consequences.

One of the risks that we will face with climate change is mega fires. Fires, which are normal to be experienced in areas where drought will occur, will not only be limited to natural areas, but may reach mega-dimensions by including human settlements. Mega fires, where the height of the flames exceeded 70 meters, started in Australia. After the start of September 2019, 33 people died due to fires that have affected forest and grassland areas in Queensland, Victoria and South Australia states and sometimes spread to settlements, a total of around 11 million hectares of land and more than 3,000 houses, mostly in New South Wales. were destroyed. The damage caused by mega fires to urban areas and settlements will be at a level that will force our dreams. In many cities and towns in Australia, people have been evacuated and people have left their homes in a mega fire with their own hands.

In August 2010, 557 separate forest fires occurred in Russia on a total of 174 thousand hectares. Most of Russia was covered with smoke due to fires, 76 of which were large. The situation in Moscow, which was covered with a gray layer due to "peat", that is "peat" fires in the marshes, reached an alarming level in every sense. The rate of carbon monoxide in the air increased 7-8 times above normal. The number of deaths in Moscow, where 360 people died in a day, reached 700.

2.2.3. Chronic Allergy and Asthma Conditions

Climate change, particularly rising temperatures, altered precipitation patterns and increasing atmospheric carbon dioxide concentrations are expected to contribute to increases in levels of some airborne allergens and associated increases in asthma attacks and other allergic diseases.

2.3. Effects of Extreme Weather Events on Human Health

While climate change projections show that some extreme events will arise and continue to increase in their severity by the end of the century, the linkages to climate change at other ends are less clear. Some parts of the United States have suffered significant economic losses as well as lost lives due to changes in the frequency, intensity or duration of some extreme events.

Having health effects such as death or injury during an extreme event (for example, drowning during floods) requires individuals to undertake risk prevention training to protect their health. However, the health effects of extreme events are not limited to the sequence of events. Health effects can occur before or after an extreme event. Health risks increase long after the incident or outside the area of the incident, due to damage to property, destruction of assets, loss of infrastructure and utilities, social and economic impacts, environmental degradation, and other factors.

Extreme events pose unique health risks if multiple events occur at the same time or in a row in a particular location. The severity and extent of health effects associated with extreme events depend on the physical effects of the extreme events themselves, as well as the individual, social and environmental conditions at the time and place of the events (USGCRP, 2016).

2.3.1. Increasing exposure to extreme events

Health effects include death, injury or illness when exposed to extreme events associated with climate change; exacerbation of underlying medical conditions; and its negative effects on mental health

2.3.2. Basic Infrastructure Disruption

Many types of extreme events related to climate change cause infrastructure degradation, including power, water, transport and communication systems necessary to maintain access to health and emergency response services and protect human health.

2.3.3. Security Gap Against Coastal Flood

Coastal populations that are more vulnerable to health impacts from coastal flooding include people with disabilities or other access and functional needs, ethnic groups, older adults, pregnant women and children, low-income populations, and certain occupational groups.

2.4. Vector-borne diseases

Vector-borne diseases are those transmitted by vectors containing mosquitoes, ticks, and fleas. These vectors can carry infective pathogens such as viruses, bacteria and protozoa that can be transferred from one host (carrier) to another. Seasonality, distribution and prevalence of vector-borne diseases are significantly affected by climatic factors, especially high and low temperature extremes and precipitation patterns.

Climate change is likely to have both short and long-term impacts on transmission of vector-borne diseases and infection patterns. Although climate variability and climate change alter transmission of vector-borne diseases, it is related to many other factors, including how pathogens adapt and change, the availability of hosts, changing ecosystems and land use, demography, human behavior and capacity. These complex interactions make it difficult to predict the effects of climate change on vector-borne diseases (USGCRP, 2016).

2.4.1. Varying Distributions of Vectors and Vector-borne Diseases

Climate change is expected to change the geographic and seasonal distribution of existing vectors and vector-borne disease.

2.4.2. Earlier Tick Activity and North Spread

Ticks that can carry bacteria that cause Lyme and Crimean Congo Hemorrhagic Fever (CCHF) disease and other pathogens will show earlier seasonal activity and generally expand northward in response to increased temperatures associated with climate change. The longer seasonal activity and expanding geographic spread of these ticks will increase the risk of human exposure to ticks.

2.4.3. Changing the Mosquito-borne Disease Dynamic

Increasing temperatures, changing precipitation patterns and the more frequent occurrence of some extreme weather events associated with climate change will affect the distribution, quantity and prevalence of mosquitoes that transmit West Nile virus and other pathogens by altering the availability of their habitat.

2.4.4. The Emergence of New Vector-borne Pathogens

Vector-borne pathogens are expected to emerge or reappear due to the interaction of climate change factors with many other factors such as changing land use habits.

2.5. Seasonal and Geographical Changes in Waterborne Disease Risk

Climate change is expected to affect fresh and marine water resources in a way that increases people's exposure to water-related pollutants that cause disease. Water-related diseases include waterborne diseases caused by pathogens such as bacteria, viruses and protozoa. Water-related diseases are also caused by toxins produced by some harmful algae and cyanobacteria and chemicals released into the environment by human activities. It occurs through exposure, inhalation or direct contact with contaminated drinking or recreational water and consumption of contaminated fish and shellfish. Climate change-related factors - including temperature, precipitation and associated runoff, hurricanes, and storm surge - affect the growth, survival, spread and virulence or toxicity of agents (causes) of water-related diseases. Whether the disease is caused by exposure to contaminated water, fish or shellfish depends on a complex set of factors such as human behavior and social determinants of health that can affect a person's exposure, sensitivity, and adaptive capacity (USGCRP, 2016).

Increases in water temperatures associated with climate change will alter the geographic area and seasonal growth periods of the habitat suitable for the breeding of some naturally occurring Vibrio bacteria and harmful marine algae and harmful freshwater algae. These changes will increase the risk of exposure to waterborne pathogens and algae toxins that can cause a variety of diseases.

2.5.1. Water Infrastructure Insufficiency

Increases in some extreme weather events and storm surges will increase the risk of drinking water, wastewater and storm water infrastructure being insufficient, especially in areas with aging infrastructure, due to damage or exceeding system capacity.

2.6. Food Safety, Nutrition and Distribution

A safe and nutritious food supply is a vital component of food security. The effects of climate change on food production, prices, and the US and global trade have been extensively examined in the recently published "Climate Change, Global Food Security and US Food System" report. A general finding of the report is that climate change is likely to affect global, regional and local food security by disrupting food availability, reducing access to food and making use more difficult.

Increasing CO_2 concentration and climate change have two different effects on food safety, food supply and distribution. First, it relates to rising global temperatures and subsequent weather events and changes in extreme climatic events. Current and expected changes in climate and physical environment have consequences for contamination, spoilage and deterioration of food distribution. The second is the direct CO_2 "fertilizing" effect on plant photosynthesis. Higher concentrations of CO_2 stimulate growth and carbohydrate production in some plants, but can reduce protein and essential mineral levels in many consumed products, including wheat, rice, and potatoes, which have potentially adverse effects for human nutrition (USGCRP, 2016).

A safe and nutritious food supply is a vital component of food security. Climate change is likely to affect global, regional and local food security by disrupting food availability, reducing access to food and making use more difficult.

2.6.1. Foodborne Disease Risk Increases

Climate change, including rising temperatures and changes in extreme weather conditions, is expected to increase the exposure of foods to certain pathogens and toxins. This will increase the risk of adverse health effects.

2.6.2. Chemical Pollutants in the Food Chain

Climate change will increase people's exposure to chemical pollutants in food in a variety of ways. Elevated sea surface temperatures cause more mercury to accumulate in seafood. Increases in extreme weather events will bring pollutants into the food chain. Increasing CO_2 concentrations and climate change will alter the prevalence and distribution of pests, parasites and microbes, leading to an increase in the use of pesticides and veterinary drugs.

2.6.3. Rising Carbon Dioxide Reduces Food's Nutritional Value

As atmospheric carbon dioxide levels continue to rise, the nutritional value of agriculturally important food crops such as wheat and rice and the protein and essential mineral concentrations which need to be received to body from outside, of most plant species will decrease.

2.6.4. Extreme Weather Conditions Limit Access to Safe Food

Increases in the frequency or intensity of some climate change-related extreme weather events will increase disruptions in food delivery by damaging existing infrastructure or slowing food shipments. These barriers increase the risk of food damage, spoilage or contamination that limits the availability and access to safe and nutritious foods due to the flexibility and deterioration of the food delivery infrastructure.

2.7. Mental Illness and Peace

The effects of global climate change on mental health and well-being are an integral part of general human health impacts on climate. The mental health consequences of climate change range from minimal stress and distress symptoms to clinical disorders such as anxiety, depression, post-traumatic stress and suicidality. Other results include impacts on the daily life, perceptions and experiences of individuals and communities trying to properly understand and respond appropriately to climate change and its impacts. The mental health and healthy consequences of climate change impacts rarely occur in isolation, but often interact with other social and environmental stressors. The interactive and cumulative nature of the effects of climate change on health, mental health and well-being are critical factors in understanding the overall consequences of climate change on human health (USGCRP, 2016).

2.7.1. Results of Exposure to Disasters in Mental Health

Many people are exposed to climate and weather-related disasters experience stress and serious mental health consequences. Depending on the type of disaster, these results include post-traumatic stress disorder, depression, and general anxiety that often occurs at the same time.

2.7.2. Certain Groups of People are under High Risk

Certain groups of people are at higher risk of distress and other negative mental health consequences of exposure to climate and weather disasters. These groups include children, the elderly, women (especially pregnant and postpartum women), people with pre-existing mental illness, the economically disadvantaged, the homeless and first responders.

2.7.3. The Consequences of Climate Change Threats on Mental Health and Social Impacts

Many people will experience the negative mental health consequences and social impacts of the climate change threat due to the direct experience of climate change and changes in one's local environment. Effects of climate change in the media and popular culture affect stress responses, mental health and well-being.

2.7.4. Extreme Heat Increases the Risk of People with Mental Illness

People with mental illness are at higher risk for poor physical and mental health from extreme heat. Increases in temperature extremes will increase the risk of illness and death for older populations and people with mental illness using prescription medications that impair the body's ability to regulate temperature.

2.8. Populations of Concern

Climate change is already causing a range of health effects that vary across different population groups, and this is expected to continue to do so. The vulnerability of any group is a function of its sensitivity to and exposure to health risks associated with climate change and their capacity to respond to or cope with climate change and variability. The vulnerable groups of people defined here as populations of concern include those with low incomes, some ethnic communities, immigrant groups, local populations, children and pregnant women, older adults, vulnerable occupational groups, people with disabilities, and people with pre-existing or chronic medical conditions (USGCRP, 2016).

3. INEQUALITY, DISPLACEMENT AND CULTURAL CHANGE

Climate change will force massive population movements and this will change our societies in a way that has never been seen before.

3.1. Uncertainty and Powerlessness

For elderly people or families, the possibility of their homes being taken over by the rising sea level is a major problem. They know it will happen, but the unknown is when it will happen. There is hope that efforts to reverse global warming could be successful and the time frame could go beyond their lives. But they feel powerless because the results are largely based on the actions of politicians and scientists. Long-term uncertainty about their homes and livelihoods can weaken the physical and mental health of these communities.

Women, children and the elderly, who already tend to be a vulnerable group in society, will be even more affected by the negative effects of climate change. In rural areas of developing countries, collecting firewood and bringing water is often the responsibility of women and children, but reducing supply now results in more jobs and more time, because people in these regions now have to travel more to find supplies. Children and elderly people are more susceptible to health concerns such as heat-related ailments from higher temperatures, increased pressure on food supply / increased prices, malnutrition, and also disease associated with increased flooding. In many countries where women do not have equal access to land, capital and other resources (but generally household heads), women have difficulty accessing climate-resilient technology or products necessary for climate change adaptation. In addition, the increasing pressure on families due to the difficulties in meeting basic necessities due to climate change (both for men and women) causes various psychological and physical effects.

3.2. Justice and equality

One result of the Climate Change summit in Paris was the determination of developed countries to financially support the efforts of third world countries. This is fair, as it is heavy industry activity in developed countries that cause rapid increase in global warming. Some people in developing countries react to this aid decision by being biased. Some third world countries do not have the resources to meet their climate change targets, and most are the countries most affected by this situation. They already need support to mitigate the effects of rising temperatures and rising sea levels. They do not have the resources or capacity to meet global targets for carbon reduction.

Developing countries that do not contribute significantly to the increase in the amount of greenhouse gases in the atmosphere will be even more disadvantaged in dealing with the effects of climate change. Developing countries are struggling with the lack of infrastructure, weak technological and financial resources in their social lives, as well as concerns about finding alternative solutions to hinder adaptation skills. In addition, these countries already have scarce resources as they have to deal with high rates of poverty and income inequality. The distribution of scarce resources between social development and prosperity and climate adaptation will cause a dilemma. For example, some public funds initially spent on education will now have to be spent on seawalls, increased irrigation or rainwater systems for adaptation. Although this fact is discussed as part of the United Nations Framework Convention on Climate Change (UNFCCC), technological and financial assistance to developing countries is still not sufficient.

3.3. Anger and Conflict

Our world is already in conflict. Global climate change can increase this even more. There is a fine balance between global climate change mitigation efforts and also efforts to cope. Populations that have become impoverished and heavily affected by the climate change resulting from the business activities of developed countries feel anger and frustration. If they have to migrate later, they will feel displaced and weakened. This will cause an increase in global resentment and conflict processes.

3.4. Unemployment

Unemployment is another consequence of climate change in rural and urban areas. The agricultural area becomes inefficient due to the effects of continuous droughts and carbon emissions and remains out of agriculture. This causes many small farmers, who rely on the sale of the products they grow from these small fields, to become unemployed and migrate to urban areas. They sell the vegetables and fruits grown by these small farmers to small tradesmen in nearby cities. However, the fact that small farmers are excluded from agriculture due to climate change causes a decrease in the income of small craftsmen in the cities and the arrival of products from longer distances causes the prices of agricultural products to increase.

Small farmers are currently forced to compete with large-scale agricultural holdings in order to obtain a fair price for their goods, protect their crops from extreme weather events and pests, and survive. With climate change, a change in climate and agricultural regions, changes in production patterns due to higher temperatures, and more extreme and changing precipitation patterns threatening crops, farmers' plight is getting worse. Such a situation has the potential to destroy families' livelihoods and main source of income, as well as damaging entire communities that buy, sell and consume the products they have obtained as a result of intensive labor. Small farmers are an integral part of our societies, and as a result, the effects of climate change on farmers can threaten food supply and security as well as increase volatility in global food prices.

In 2015, 1 billion people were living in extreme poverty. The survival of many of these people depends on the natural resources around them. Poverty and inequality that have been worked to improve for decades is exacerbated by climate change, as disadvantaged groups do not have sufficient resources to cope with impacts such as extreme floods or drought that could destroy them or change their way of life. Poor neighborhoods in the world's cities are already suffering from the poor environmental conditions. However, the increase in temperature will cause these bad conditions to become even more unbearable. Even in US cities, research shows that poor neighborhoods are at increased risk of heat-related ailments as temperatures rise. People in the poor neighborhood are less likely to use cooling systems to counter the rising temperature, and they are not willing to use it when needed simply for cost reasons. In addition, the construction of the buildings in these slums from unsuitable materials instead of heat-preserving materials increases heat stress.

3.5. Migration

The United Nations Environment Program (UNEP) predicts that climate change will affect migration flows in three ways. The first of these is the migration that will occur as warming reduces agricultural productivity in some regions and causes a decrease in ecosystem services such as clean water and fertile land. The second is migration, which will push people to displace massively due to the increase of extreme weather events, such as flashfloods or fluvial floods, especially in tropical regions. The third is migration, which will force millions of people to relocate when the coastal areas below the level disappear due to the rise in sea level.

Many communities will be forced to migrate as they are exposed to rising sea levels, extreme drought that puts pressure on resources, and even extreme rainfall that has become normal. Small island states are particularly vulnerable and are at the forefront of feeling the effects of climate change. At the beginning of 2014, it was the first village in Fiji to relocate for this reason as part of the country's climate change program, as marine water advance of up to 1 km began to flood the homes of residents in the village of Vunidogoloa. The Fiji state has also planned to move 34 villages dealing with eroded beaches and increased flooding. The nation of Kiribati, a small island state in the Pacific, is expected to become uninhabitable due to sea level rise, and the country has recently purchased land in Fiji to move into.

4. CLIMATE CHANGE AND EMPLOYMENT OPPORTUNITY

The business world is closely related to the natural environment. About a third of jobs in the G20 countries are directly linked to the effective management and sustainability of a healthy environment. Although it is known that climate change and other forms of environmental degradation have negative impacts on jobs and work productivity, these impacts are expected to become more pronounced in the coming decades. For example, temperature increases can make heat stress more prevalent, thus reducing the total number of working hours (ILO 2018).

Differences in social and economic roles and responsibilities increase the vulnerability of women, migrants, youth, people with disabilities, indigenous peoples and tribal peoples who have poor access to resources such as land and agriculture and credit for adaptation to climate change. For the majority of these vulnerable groups working in the informal economy and small businesses, the support of decision-making bodies, technology, social insurance, access to education is also limited. Therefore, it is particularly difficult for these people to recover from the effects of disasters (ILO 2018).

Adaptation measures include, but are not limited to, the development of infrastructures to protect individuals and communities against natural disasters. Depending on their design, such infrastructures can create employment opportunities far beyond the construction industry. Adaptation measures should be designed to take into account gender equality concerns. Moreover, community engagement and social dialogue in the design and implementation of these measures can help strengthen local development and employment creation (ILO 2018).

Social protection and skill development policies increase adaptability; it can protect individuals and communities that face natural hazards against income and food insecurity.

These policies can also assist displaced workers and workers directly affected by climate-related hazards. More generally, climate change will bring about new regulations in the workforce, ways of dealing with environmental stress at work, policies to deal with environmental migration, and above all, supporting the challenge of providing compensation and protection for workers in all climate-related job losses, as well as diversification of economic activity and new jobs (ILO 2018).

4.1. Negative effects of climate change and extreme weather conditions on employment

Some forms of environmental degradation can have a direct negative impact on business. Considering the relationship between business and climate change, the following key points should be considered:

- Generally, things depend on the services provided by ecosystems. Climate change threatens the provision of many of these vital ecosystem services.
- Both work and ensuring safe, healthy and good working conditions depend on the absence of environmental hazards and the preservation of environmental stability (ILO 2018).
- The risks and hazards associated with environmental degradation tend to affect vulnerable workers the most.
- The increasing frequency and intensity of various environmental hazards caused or increased by human activity has reduced labor productivity. Between 2000 and 2015, 23 million years of work per year were lost worldwide due to such hazards.
- Among the G20 members, China, Brazil and India are the countries most affected by this situation; they lost 8,7, 3,2 and 1,5 working years per person per year, respectively, in the 2008-2015 period.
- Projected temperature increases will have a greater impact on agricultural workers and workers in developing countries, by making heat stress more

prevalent, reducing the total number of hours worked in G20 countries by 1.9 percent by 2030.

- Currently, 34 percent of jobs in G20 countries rely directly on ecosystem services and therefore on effective and sustainable management of the environment. This includes jobs in agriculture, fisheries and forestry that rely on natural processes such as air and water purification, soil renewal and fertilization, pollination, pest control, measurement of extreme temperatures, protection of natural infrastructure such as environmental degradation against storms, floods and strong winds, threatening these ecosystem services and affiliated jobs (ILO 2018).

4.2. Adaptation measures can create new jobs and protect workers and income

The transition to a low greenhouse gas economy can reduce the impacts of climate change, keep future adaptation costs low, and lead to net employment creation through massive reallocation of labor. However, regardless of the climate change mitigation efforts that can be taken, climate change related events already have a profound impact and are expected to continue. Therefore, adaptation to climate change requires immediate action (ILO 2018).

Adaptation measures can lead to employment increases and prevent job losses. Evidence suggests that around 500,000 additional jobs (about 0.2 percent of the working population) will be created directly and indirectly in 2050 in Europe as a result of an increase in adaptation-related activities (ILO 2018).

Investment in adaptation infrastructure is likely to have a positive impact on employment due to the increased demand for construction works, particularly in projects aimed at mitigating climate related risks. The direct, indirect and induced employment effects of investment in adaptation infrastructure vary between countries. For every US $ 1 million invested in the construction sector, 650 jobs are expected to be created in India, 200 in China, 160 in Brazil and Indonesia, and close to 120 in the Russian Federation (ILO 2018).

Three out of four jobs in the world are heavily or moderately dependent on water. Adaptation measures, such as investment in infrastructure for water conservation, purification and supply, can increase the number and quality of jobs across the economy.

Afforestation and reforestation are more effective adaptation measures because of their ability to regulate water flows of forests, barrier against storms, and protect against erosion and mudslides. At the same time, many other ecosystem services provided by forests create jobs and economic value.

Skill development is also an adaptation strategy. It helps migrated workers to move into employment growth sectors; thus protecting them against loss of income and other negative effects of climate change. Lack of skills can be an obstacle to the implementation of adaptation and mitigation measures in any case.

Social protection policies are another form of adaptation to climate change. Two two such instrumentsare cash transfers and public employment programs. By 2030, expanded social transfers are expected to increase employment by 0.2 percent in developed countries and 0.6 percent in developing countries.

It requires meeting and enabling policies to maximize the positive employment impact of the transition to a climate resilient economy.

The following measures are among the measures that can be implemented to increase the positive effects of climate resistance on employment:

- A national legal framework that integrates the environment with labor-related targets can go a long way towards ensuring that climate change adaptation and mitigation measures are also employment-friendly.

- Social dialogue can play an important role in maximizing the employment impact of climate change adaptation. It is important to give due value to international labor standards when designing climate change adaptation policies.
- Micro, small and medium enterprises are important partners in climate change adaptation; because they are in a good position to develop relevant and effective compliance solutions locally.
- Sharing best practices and developing tools and methods to identify employment benefits, particularly attributable to compliance investments, will help ensure that such investments lead to productive and inclusive growth. For example, the employment results of investments with a compliance component can be compared systematically with the results of investments that do not. Another possibility is that green jobs in labor force surveys include jobs involved in mitigation and adaptation related activities. Developed by the Green Job Evaluation Agencies Network (GAIN), there are several methods available to assess employment effects accordingly (ILO 2018)

All kinds of environmental degradation directly and negatively affect the business world. Environmental degradation jeopardizes the provision of ecosystem services and the jobs that depend on them.

In particular, the frequency and intensity of natural disasters caused or exacerbated by human activity reduce labor productivity. An increase in temperature in the coming years will have a similar effect. Although mitigation strategies can help limit future adaptation costs, climate change adaptation is a priority issue that needs to be addressed without delay. Adaptation measures can prevent job losses by increasing employment. These measures include natural and physical infrastructure as well as skills development programs and social protection policies. There is a need to urgently examine the relation between the number of works on one hand and adaptation to climate change on the other hand. In any case, social dialogue that brings governments, employees and employers together can increase the local relevance and effectiveness of adaptation plans. Investment in adaptation infrastructure is likely to have positive employment effects by increasing the demand for construction work in projects aimed at reducing climate-related risks. Infrastructure arrangements are generally not made for adaptation purposes alone; it is not easy to identify the specific impacts of climate change on employment in this area. Climate change protection activities tend to be integrated into existing infrastructure as part of periodic maintenance and improvement activities, making it difficult to track employment impacts. Therefore, it is difficult to determine the specific contribution of climate change adaptation to employment and the relationship between the two needs to be analyzed in more detail. Social protection and skills development policies should also be taken into account in this area. Because by increasing adaptive capacities, they can protect individuals and communities facing natural hazards against income and food insecurity (ILO 2018).

These policies can also assist displaced workers and workers directly affected by climate-related hazards. By providing food and income security, such policies encourage economic activity and employment, albeit indirectly. More generally, the labor regulatory framework, the issues of dealing with environmental stress and migration at work, the challenge of providing compensation and protection for workers, as well as the diversification of economies are important. More research is needed to understand which adaptation measures provide the best employment outcomes in a variety of environments and with different levels of vulnerability to climate change (ILO 2018).

People need to take into account not only the various adaptation measures but also the social, economic and institutional contexts that support positive employment outcomes. In some countries, for example, investment in adaptation infrastructure may produce better results in times of economic downturn. Existing platforms such as GAIN and the Partnership for Action for the Green Economy (PAGE) should be used to develop tools and methods to share best practices and identify employment benefits, in particular attributable to cohesion investments (ILO 2018).

5. SOCIOECONOMIC IMPACTS OF CLIMATE CHANGE IN TURKEY

5.1. Health

Change in the atmosphere conditions of Turkey, which is located in Mediterranean Basin and increase in the frequency of extreme weather conditions and epidemic diseases as a result of increasing heat level, higher heat stress is expected to face the effects of such changes in commonly consumed foods nutritional value. It is necessary to underline the following five points regarding public health:

1. As a result of the fact that vectors (carriers), especially mosquitoes and ticks, can reproduce in new geographies, the transmission mechanisms of these vectors will strengthen.
2. Increase in drought and deterioration in the water cycle will make it difficult to protect water resources from the risk of epidemics, and water-borne diseases will increase as a result of problems in accessing clean water.
3. In some regions, as a result of the increase in the level of heat stress and air pollution, which will reach up to 4 °C, there will be an increase in temperature-related mortality and public health concerns will arise.
4. As a result of the increase in the amount of pollen in one cubic meter of air, the allergic problems of the general population will increase and the allergy periods will be prolonged.
5. According to the scenario in which the necessary steps are not taken regarding emission reduction and adaptation in deaths due to heat stress, an increase of 200-450 percent is predicted, although it varies according to different climate scenarios. Assuming that the average increase in annual maximum temperatures will reach 4 °C, heat stress deaths are expected to increase by 400 percent (Gündoğan et al., 2017).

5.2. Social Impacts

This makes an integrated approach that addresses integrated indicators essential to assessing climate change impacts on overall economic activities. The macroeconomic analysis conducted within the scope of the study reveals the effects of changes in total factor productivity due to temperature changes, additional productivity and international price effects on the agricultural sector. The main findings of the analysis are as follows:

1. It is predicted that climate change will cause a decrease in national income compared to the reference scenario:

    - The analysis predicts that if there is a 1,5-2,5 °C increase in temperatures during 2018-2050, if additional measures are not taken for adaptation and special environmental policies are not designed, there will be a decrease in Gross Domestic Product (GDP) between 9.8 and 26.8 according to the reference scenario.
    - Under a scenario where the temperature increase is higher and the necessary steps for adaptation to climate change and emission reduction are not taken, the decrease in national income will increase to 50% in 2050 according to the reference scenario. Under this scenario, we are likely to face an economic shrinkage between 2040 and 2050.

2. It is anticipated that there will be a decrease in registered employment and salaries as a result of the negative shock to the economic activities. It is estimated that the said decrease will affect especially low income regions and trigger migration to high income regions:

    - The "negative shock" to which economic activities will be exposed as a result of the effects of climate change will cause many employees to shift from formal labor markets to informal labor markets. The rate of decrease in salaries as a result of informal employment will be higher in low-income regions than in high-income regions. Limited opportunities to find employment, even with falling salaries, will trigger migration from low-income regions to high-income regions.

- The negative shock on economic activity is thought to cause a very strong decrease in the level of total employment in the low income region, and a decrease of up to 28 percent is predicted in the employment level compared to the reference scenario.
- It is predicted that most of the remaining employment in low-income regions will be shifted off the record, and the rate of registered employment

3. The global price increases in the agricultural sector and the decline in agricultural productivity will cause considerably higher increases in the prices of agricultural products compared to the price level of the whole economy. Under a scenario where the temperature increase reaches high levels and is progressing, and where the necessary steps are not taken for adaptation to climate change and emission reduction, the increase in food prices can reach 250% according to the reference scenario.
4. The simple (heuristic) approach used in the study reveals that there is a need for more holistic analyzes to be carried out in order to evaluate the physical effects such as agricultural production loss due to climate change, impacts in coastal areas, damage to physical infrastructure as a result of extreme weather events, changes in energy demand, possible increases in morbidity and mortality rates.

Finally, in our country, which is one of the geographies where the effects of climate change will be felt the most, holistic questions about the costs of these effects are not yet asked. Until now, it could be said that no study has been conducted specific to Turkey towards functionalizing the "common socio-economic paths" by handling integrally the demography, human development, economy, lifestyles, institutions, politics, technology, environment and natural resources dimensions. This applies to both sub-sectors and nationally. This gap should be seen and studies should be carried out in this context (Gündoğan et al., 2017).

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POSSIBLE EFFECTS OF CLIMATE CHANGE ON URBAN ECOSYSTEMS AND RISKS IN THE WORLD AND IN TURKEY

Prof. Dr. İhsan Çiçek

1.INTRODUCTION

It requires great effort to adapt and mitigate the severe weather conditions caused by current climate change in both Europe and the World. According to the research of NOAA (National Oceanic and Atmospheric Administration), 2020 will be the hottest year with a 74.67% probability within the measured years. The institution predicted the probability of 2020 being in the hottest 10 years to be higher than 99.99%, and stated the probability of being in the hottest 5 years measured as 99.94%. The increase in temperature causes an increase in global discomfort, economic loss, migration and death rates. In addition, some parts of the Earth are also estimated to be affected by multiple climate change-related extreme weather events (e.g. Heat and cold weather waves, floods, droughts, forest fires and severe storms) which are expected to increase (Emilsson T., Ode Sang A. 2017).

While there is a global phenomenon of climate change on the one hand, there is a rapid urbanization process on the other hand. Half of the world's population lived in urban areas in 2007, and it is estimated that 66% of the world's population will live in urban areas by 2050. Urban climate differs from rural areas in that it is generally more polluted, warmer, more rainy and less windy. This indicates that the impact of climate change with the expected increase in temperature and more extreme weather events will be more experienced in urban areas than in rural areas. Events such as changing climate, rising urban temperatures, and floods can also increase the negative effects of current urbanization (Emilsson T., Ode Sang A. 2017).

Still, increasing urban densities are seen as a way forward towards sustainable urban development. Across Europe, a sustainable development approach prevails that promotes efficient use of resources, efficient transport systems and a vibrant urban life. In this development model, development usually takes place through redevelopment in areas seen as underused land (such as green areas) or in previous industrial sites. However, this approach is also questioned for its threat to urban green spaces. Because green spaces are potentially important to offer climate change adaptation solutions along with urban brown areas. Establishing, rebuilding, rehabilitating and maintaining existing vegetation systems and developing an integrated urban green infrastructure network are the main nature-based solutions to cope with the local effects of climate change. Dual urban development can be seen here as a constructive path forward. The approach combines the intensification of existing residential areas with a mix of conservation actions, increasing the existence, quality and usability of green spaces while also strengthening other green infrastructure such as street trees, green walls and roofs (Emilsson T., Ode Sang A. 2017).

2. GENERAL EFFECTS AND RESULTS OF CLIMATE CHANGE FOR URBAN AREAS

Urban areas around the world are facing the reality of climate change. Hazards such as floods, storms and the slow rise of sea level affect human, economic and environmental assets. The knowledge gained about the effects of climate change mitigation and adaptation strategies in the housing sector is critical in making policies and decisions about improving the quality of life, developing in cities and eliminating inequalities in living spaces in cities (Rosenzweig, C. Vd. 2018).

Climate change will have far-reaching implications and consequences for urban areas. The impact will range from the direct impact of rising temperatures and changing precipitation dynamics, to indirect effects from events related to degradation and climate change elsewhere (Emilsson T., Ode Sang A. 2017).

A wide spectrum is taken into consideration in the processes and applications related to the housing sector. The focus of processes and practices related to urbanization is on housing and slum settlements in middle and low-income countries due to their increased exposure to the impacts of climate change and their vulnerability. Approximately 80% of the world's urban population consists of the population in middle and low-income countries. This rate will increase further in the next 10-20 years, depending on the increasing population growth in the world. It is inevitable that this population increase will have negative consequences in an environment where global and regional climate change is experienced. The lack of capacity to cope and adapt to the effects of climate change in urban areas of low- and middle-income countries increases the risk of flooding, storm surge and sea level rise. Urbanization trends in coastal areas offer increased economic opportunities for both formal and informal economies. These economic opportunities cause the poor to be more exposed to climate-related hazards and increase vulnerability (Porio, 2014).

The 2014 World Risk Report discusses urban risk and vulnerability in light of sensitivity, coping and adaptive capacity. While vulnerability is a feature of exposed communities, coping and adaptive capacity depends primarily on the ability of government agencies to respond to current and long-term human needs. In cities in middle and low-income countries where 30-70% of the population do not have access to clean water or basic health services, this failure in governance leads to increased effects of climate change (Rosenzweig, C. Vd. 2018).

The UN Office of Economic and Social Affairs (UNDESA) estimates that there are around one billion slum dwellers in the world today, with growth potential by 2050. (2013). The population of people living in slums in Asia and Africa is estimated to be from 30% to 70% of the urban population. Slum dwellers often live in areas that are undesirable or would be too expensive to develop commercially. For this reason, those who live in these shantytowns are faced with the dangers of climate change. Table 1 shows the possible effects of climate change on cities. Therefore, risk reduction in slum areas requires a dynamic contextualization at certain intersections between social and physical geography characteristics of each city (Revi 2014 et al.,). However, localized decision-making strategies should also be appropriate to global political and economic conditions that directly affect human development. Moreover, this can only be achieved by a change in conceptualizing disasters as systems rather than as independent sequences. In addition, risk reduction strategies in slum areas can only yield positive results when conceptualizing disasters as systems rather than events. This approach puts both human exposure and vulnerability at the center of the risk debate. This ensures that innovative and strategic approaches are included in policies and practice. Integrated decision support systems can then be applied to those who live in slum areas with economic, social, health and environmental aspects. Finally, this approach should be effectively transferred to national and local development programs that need to cascade their needs both horizontally and vertically.

Table 1: Impacts of climate change on urban areas

Climate Change	Possible impact on urban areas	5 deprivation and possible impacts on slum areas
Changes in averages		
Temperature	Increasing energy demands for heating / cooling	Disease, morbidity and mortality
	Air quality deterioration	Health and life expectancy
	Temperature increased by urban heat islands	Access to water and purification
Precipitation	Risk of flooding increases	Life expectancy
	Increased risk of landslides	Access to water and purification
	Distress migration from rural areas	Access to adequate living space
	Downtime in food supply networks	Durability of residences
		Safe utilization period
Increase of sea level	Coastal flood	Durability of residences
	Low income from agriculture and tourism	Access to water and purification
	Salination of water resources	Safe utilization period
		Labor and employment
Changes in extremes		
Heavy rain	More intense flood	Durability of residences
	Risk of landslide increases	Disease, morbidity and mortality
	Deterioration of livelihoods and urban economies	Life expectancy
	Damage to homes and workplaces	Access to adequate living space
		Safe utilization period
		Labor and employment
Drought	Water shortages	Access to water and purification
	Higher food prices	Safe utilization period
	Hydroelectric disturbance	Disease, morbidity and mortality
	Distress migration from rural areas	
Heat or cold waves	Short-term increase in heating / energy demands / cooling	Life expectancy
		Disease, morbidity and mortality

Climate Change	Possible impact on urban areas	5 deprivation and possible impacts on slum areas
Sudden climate change	Deniz seviyesinin hızlı ve aşırı yükselmesinden kaynaklanan olası önemli etkiler	Suya erişim ve arındırma
	Possible significant effects from rapid and extreme temperature change	Durability of residences
		Labor and employment
Exposure changes		
Population movements	Movements in stressful rural living spaces	Safe utilization period
		Access to adequate living space
Biological changes	Expanded vector habitats	Access to water and purification
		Disease, morbidity and mortality

Resource: Revi et al., 2014

Note: Access to clean water, access to a healthy and clean toilet, access to durable housing, safe use of life, adequate living space 5 are defined as deprivation ((UN-Habitat 2003).

2.1. Impact on Urban Temperatures

Changing urban temperatures are controlled by both large-scale climate change and ongoing urbanization. A global agreement has been reached with the Paris Agreement that the current changing climate should be kept well below an average global increase of 2 °C in order to avoid future climate-related disasters. Urban temperature is related to global climate change, but the urban heat island effect, which is generally seen as the main problem of urbanization, becomes more pronounced. According to Taha (1997), there are three urbanization parameters that have a direct impact on the urban heat island: (1) increased dark surfaces such as low albedo and high acceptance asphalt and roofing material, (2) reduction of vegetation covered areas and permeable surfaces such as gravel or soil that contribute to shading and evaporation, and (3) human activity (cars, air conditioning, etc.), the release of heat generated. These factors are not evenly distributed throughout the urban area and therefore in certain areas the urban heat island emerges at a higher level. Urban temperature rise will be higher, for example, in highly residential areas and in areas with little green space than in suburbs with green vegetation. Therefore, the urban heat island affects the population in an urban area in different ways (Emilsson T., Ode Sang A. 2017). The urban climate is expected to increase the heat stress experienced by people during the night, especially during periods of high temperature when the urban heat island is greatest. Studies show that there is an adaptation factor related to heat and that heat waves cause more negative consequences in regions where heat waves are less common or at the beginning of the season when the warm period starts but there is no heat wave. This suggests that people living in areas that have not previously experienced dangerously high temperature periods are less adapted to cope with the rise in temperature. In other words, the increase in the period of high temperature will reduce the temperature comfort of people. Health problems will be experienced in these areas due to high temperatures and heat waves (Emilsson T., Ode Sang A. 2017).

2.2. Impact on Urban Hydrology

It is estimated that the frequency of flood peaks will increase with a changing climate. Forecasts suggest that by 2045, severe flood peaks will double on average within Europe with a 100-year return period. In addition, these floods will match an increase in sea level and cause coastal flooding with an estimated increase in windstorm frequency. Most of them will have a major impact on floodplains or urban areas located along the coast. Climate changerelated sea level rises in certain regions will also cause more frequent flooding in flood plains and low coasts (Emilsson T., Ode Sang A. 2017).

The impact of changing climate will differ across Europe, and Northern Europe is expected to experience more annual average precipitation than Southern and Central European countries, which are predicted to experience a reduction in precipitation. A few models point out that the total summer precipitation will decrease with increasing gusts interrupted by drought. A similar pattern of precipitation changes will be seen modeled in Europe and in Turkey. It is foreseen that in Turkey's precipitation there will be an increase in the amount of precipitation throughout the country for the winter season in all periods, a decrease in the amount of precipitation in all periods except the coastal and northeast parts of the country in the spring season, a decrease in the amount of precipitation in all periods except the western coasts and the northeast parts of the country in the summer season and a decrease in the amount of precipitation in the autumn season in general. Although there is no regular increase and decrease tendency in the amount of precipitation during the projection period (2016-2099), the irregularity of the precipitation regime is remarkable (Demircan et al., 2017). Increased heavy rainfall events will mean that the existing urban drainage system will exceed the capacity more often and cause economic loss, increased disturbance and even loss of life. Rising urban temperatures will also have a strong effect on evapotranspiration, which is largely limited by precipitation. Therefore, there may be an increase in evapotranspiration in areas with more precipitation, but there may also be an increase in drought times in areas with reduced precipitation (Emilsson T., Ode Sang A. 2017).

2.3. Indirect Impacts on Urban Habitats and Biodiversity

Climate change will affect many important factors for habitat quality and the development of urban biodiversity. The predicted change in temperature, precipitation, extreme events and increased CO_2 concentrations will affect a number of factors related to single species (e.g. physiology), population dynamics, species distribution patterns, species interactions, and ecosystem services as a result of spatial or temporal restructuring. Increasing urban temperatures and changing precipitation dynamics will affect the development of the species by limiting the availability of water during the growing season and changing food dynamics (Emilsson T., Ode Sang A. 2017).

Urban areas already have in many cases a higher plant richness compared to their natural counterparts due to influx of alien plant material, more nutrient-rich systems, a larger habitat heterogeneity and more continuous land use or directed management. With a change in urban climate, there is likely to be a change in invasion of alien species as well as an increase in the spread of diseases and pests (Emilsson T., Ode Sang A. 2017).

3. ADAPTATION TO CLIMATE CHANGE USING GREEN INFRASTRUCTURE AND NATURE-BASED SOLUTIONS

Adaptation to actual or expected climate change impacts includes a set of measures or actions that can be taken to reduce community vulnerability and increase resilience to the expected changing climate. Possible adaptation measures to address climate change can take many forms and be effective at various spatial and temporal scales, either proactively planned or as a result of socio-political drivers such as new planning regulations, market demand, or even social pressure (Emilsson T., Ode Sang A. 2017).

3.1. Urban Green Infrastructure and Nature Based Solutions

Vegetation can play a really important role in bringing the urban climate closer to a pre-development state. Urban green infrastructure and nature-based solutions are a concept stemming from planning, and therefore the focus is on the strategic role of integrating green spaces and their associated ecosystem services in urban planning at multiple scales. The European Commission and the Directorate-General for Research and Innovation define nature-based solutions as nature-inspired, continuously supported and utilized solutions designed to address various societal challenges from resources in an efficient and adaptable manner and simultaneously deliver economic, social and environmental benefits. It is suggested to be seen as an umbrella term that includes urban green infrastructure and ecosystem-based adaptation and ecosystem services (Emilsson T., Ode Sang A. 2017).

3.2. Reducing Urban Temperature with Green or Blue Infrastructure and Nature-Based Solutions

Urban temperatures can be strategically addressed through the planned urban green space network. This includes the selection of suitable surfaces, their spatial organization and management.

Studies show that urban parks have a cooling effect in the range of 1 °C during the day, while larger parks, trees as well as systems have a greater effect. Surface type will also affect the cooling effect of the blue or green infrastructure. For example, surface water temperatures are lower than in vegetative areas that are noticeably cooler than streets and roofs. This means there is a greater cooling effect per unit surface water compared to a vegetative parking system. This effect varies according to the time of day, with the greatest difference between parks and water bodies during the day. Various studies therefore suggest that in order to maximize the use of space for urban cooling, an alternative approach to smaller parks distributed throughout the city requires a greater focus on including water bodies and concentrating these surfaces in urban centers. There is also an important seasonality in the influence of urban vegetation, which is stronger in summer than early spring. While these wide variations in cooling occurred, differences were also found depending on the level of soil impermeability and the amount of vegetation that could explain microclimatic effects (Emilsson T., Ode Sang A. 2017).

The impact and importance of vegetation systems also depend on the organization of the urban texture as well as the structure and type of structure. It has been shown that the temperature reduction potential with the use of vegetation is greater in areas with high building density compared to areas with less frequent building density depending on the prevailing wind direction and time of day (Emilsson T., Ode Sang A. 2017).

Each of the urban trees can have an impact on urban temperatures by contributing to the reduction of the urban heat island. The effect of reducing the temperature of trees depends on tree characteristics such as leaf organization and canopy shape where large-leaf sparse crowns have a higher cooling capacity. New vegetation systems such as green roofs and green walls are changing the energy balance of urban areas. The direct advantage of these systems is that they can be added as a complement to existing blue and green infrastructure and make it possible to use areas that are normally not green. Green walls have been shown to reduce wall temperatures close to 10 °C during the day and street canyon temperatures in truly hot and arid climates. The performance of vegetation depends on different cooling capacity and different cooling modes, i.e. the composition of species with evaporative cooling (taking heat from the air by evaporation of water) or shade cooling, as well as management variables such as irrigation and soil water levels (Emilsson T., Ode Sang A. 2017).

3.3. Urban Vegetation Selection and Management in Changing Climatic Conditions

It is important to remember that a changing climate will have positive and negative effects on existing plant material, but in many cases it will experience increased stress and therefore lower survival and performance rates. Choosing the right tree is important to have limited maintenance requirements and to maintain high temperature efficiency while at the same time performing other ecosystem services such as habitat creation and aesthetic values. Current plant material selection and planting design should be adjusted to suit a changing climate. For example, tree distances of 7.5 m can achieve a moderate planting design, good cooling and low water stress in combination with bare soil extending into a permeable pavement or canopy extension. Changing precipitation patterns can increase the need for irrigation during prolonged drought periods. Xeric trees will have higher performance in relation to cooling and survival under water-limited situations and can also contribute to urban cooling through shading but does not have the same effect as other vegetation types such as perennial plantations and in particular lawns when it comes to increasing humidity. (Emilsson T., Ode Sang A. 2017).

Stressful, unhealthy or declining vegetation will also cause a decrease in ecosystem function. Speak et al., (2013) showed that green roofs can reduce the air temperature above the system by approximately 1 °C. This effect is increased by 50% at night, when the urban heat island was at its strongest. Yaghoobian and Srebric (2015) have reached similar conclusions showing that green roof performance, i.e. the decrease in surface temperature, is associated with the increase in vegetation. High vegetation, high albedo, shading, and vegetation will result in reduced solar radiation due to evaporation. In a declining vegetation system, albedo will be worse, especially if a dark ground is used and the efficiency of the green roof depends only on evaporation. For this reason, it is essential that these nature-based solutions are designed to provide good vegetation over time, installed and maintained in a way that actually provides the targeted ecosystem services during installation. There is also some evidence that plant composition and species or functional diversity can affect the level of evapotranspiration and reduction of urban stormwater. Some of the most common impact species can have high survival rates on green roofs and usually make up a significant portion of the total cover, but due to their water conservative physiological adaptation, they have extremely low evapotranspirationrates and hence a lower cooling capacity. Using plant characteristics to select plants from natural dryland habitats that optimize water use strategies for evaporation during humid periods as well as drought tolerant may be one way to optimize green roof cooling capacity (Emilsson T., Ode Sang A. 2017).

Vegetation can also be used to directly change the energy balance of buildings. The modeling results show a high reduction in energy use and low maximum temperatures in buildings close to vegetation compared to traditional sunblocking materials such as blinds and panels. The maximum temperature reduction inferred from green roof vegetation has been shown to be close to 20 °C compared to using blinds or physical shading panels. In modern buildings, insulation is generally thicker, making the surface properties of the outer layer less important. However, roofs reinforced with green roofs can have a significant positive effect on winter energy cost if they are installed in poorly insulated buildings and thicker substrate depths are used (Emilsson T., Ode Sang A. 2017).

3.4. Green Infrastructure, Nature Based Solutions and Urban Hydrology

Green infrastructure and nature-based solutions such as green roofs, rain gardens and bio-stores have been shown to reduce local flooding, economic loss and discomfort during storm events with medium or frequent return periods. Still, it is important to remember that these small-scale structures have little impact on large-scale rain events such as river floods, sea floods or heavy downpours that pose the greatest danger to urban infrastructure and communities. Therefore, work on multiple spatial scales is needed to adapt to changing precipitation dynamics focusing on both the installation of local solutions and the development of zoning arrangements for residential developments and the planning of safer proactively planned floodplains creating an integrated and multifunctional urban drainage system (Emilsson T., Ode Sang A. 2017).

Green roofs have been shown to have a major impact on annual stormwater runoff as well as on peak flows. Thin green roofs have limited storage capacity, which means these systems reduce efficiency during very long or heavy rain events. Green roofs and other vegetative systems can adversely affect the water quality of running water if conventional fertilizers are used or contain nutrient-rich compost without the addition of substances such as biological coal. Biosstools, biofilters or rainbeds or other erected retention beds are alternative solutions for treating stormwater if space is available. Ground-based systems can be built with thicker surfaces compared to roofs, which simplifies the use of shrubs and small trees. Functionally, these systems also have a potential for infiltration and evapotranspiration (Emilsson T., Ode Sang A. 2017).

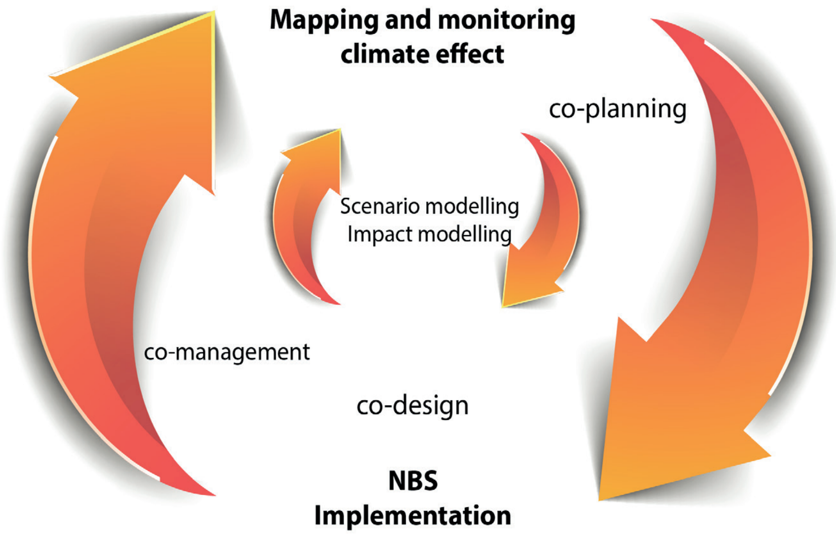
4. PLANNING AND DESIGN ASPECTS OF GREEN INFRASTRUCTURE AND NATURE-BASED SOLUTIONS FOR ADAPTATION TO CLIMATE CHANGE

The introduction and development of urban green infrastructure provides a local impact for the microclimate, both by providing the "cool island" effect and by contributing to an overall global climate impact through CO_2 binding.

When it comes to where to invest in nature-based solutions for climate change adaptation, it is important to look at the urban space at a strategic level, taking into account the character of urban morphology and information on population details. The following questions are important to achieve the most cost-effective, highest return and take into account environmental justice to mitigate the negative effects of climate change: (1) Where does the urban heat island have the greatest impact? (2) Where do vulnerable population groups live (e.g. the elderly and high population density)? (3) Where is the current lack of green and blue infrastructure? Here, strategic documents such as green infrastructure plans can provide a valuable tool for working with nature-based solutions at a strategic level. Norton et al., (2015) offers a new approach between temperature reduction, morphology, urban green infrastrucutre to reduce high temperature using a hierarchical process to prioritize and strategically select nature-based solutions (in this case, green open spaces, shade trees, green roofs and vertical greening systems). (Emilsson T., Ode Sang A. 2017).

There are many different modeling techniques that differ in complexity and accuracy that can assist in the strategic planning and design of nature-based solutions for climate change adaptation. However, there are strong calls for the local population to be included in different co-planning, different co-design and different co-management processes to ensure environmental justice. Environmental justice is defined as an essential component of the concept of nature-based solutions, as it has the potential to ensure the applicability of different solutions and provide processes for field adaptation. By incorporating scenario and impact modeling techniques into a collaborative process, it is possible to implement nature-based solutions that provide both climate-effective and environmental justice (Figure 1).

Figure 1: Application process in a common process with the integration of modeling techniques into nature-based solutions



5. CONCLUSION

Nature-based solutions play an important role in achieving a future compact city that is livable and sustainable. Vegetation in different forms can contribute to climate adaptation to varying degrees, depending on the type and quality of nature-based solutions, climatic and socio-ecological contexts. By integrating modeling techniques with collaborative processes, we can provide a strategic planning of greenfield interventions that ensure climate-efficient and environmental justice (Emilsson T., Ode Sang A. 2017). Adaptation to urban climate can increase resilience and ensure sustainable development.

Action in urban centers is crucial to successful global climate change adaptation. Urban areas more than half of the world's population and most of their resident assets and economic activities. They also harbor a high proportion of the population and economic activities most at risk from climate change, and a high proportion of global greenhouse gas emissions are generated by urban-based activities and residents.

Most of the emerging global climate risks are concentrated in urban areas. Rapid urbanization and the rapid growth of large cities in low- and middle-income countries have been accompanied by the rapid growth of highly vulnerable urban communities living in slums, many of which are at high risk due to extreme weather conditions.

Cities consist of complex interdependent systems that can be used to support adaptation to climate change through effective city governments supported by collaborative multi-level governance. This can create synergies with infrastructure investment and maintenance, land use management, livelihood creation and ecosystem services protection.

Urban adaptation action, which brings common benefits to mitigation, is a powerful, resource-efficient tool to address climate change and achieve sustainable development goals.

Urban climate change risks, vulnerabilities and impacts are increasing worldwide in city centers of all sizes, economic conditions and field characteristics.

Risks associated with urban climate change are increasing, and widespread negative impacts are occurring on local and national economies and ecosystems and people. These risks are increasing for those living in slums and dangerous areas, or for those who lack basic infrastructure and services, or who lack adequate means for adaptation.

Climate change will have profound impacts on a wide range of infrastructure systems, services, construction sites and ecosystem services. These interact with other social, economic and environmental stressors that exacerbate and increase risks to individual and household well-being.

Urban climate adaptation provides opportunities for both incremental and transformative development. Urban cohesion provides opportunities for incremental and transformative adjustments in development trajectories towards resilience and sustainable development through effective multi-level urban risk governance, harmonization of policies and incentives, strengthened local government and community adaptation capacity, synergy with the private sector and appropriate financing and institutional development.

Urban adaptation can increase economic advantage and reduce risks to businesses, households and communities. City-based disaster risk management with a central focus on risk reduction provides a strong foundation for addressing increased exposure and vulnerability and thus adaptation. Combining local, national and international development policies with the closer integration of disaster risk management and climate change adaptation can provide benefits at all scales.

Ecosystem-based adaptation makes an important contribution to urban resilience. Adaptation measures for effective urban food security (including social safety nets, as well as urban and urban agriculture, local markets and green roofs) can reduce climate vulnerability, particularly for low-income urban residents.

Quality, affordable, well-positioned housing provides a strong foundation for urban climate change adaptation, as they minimize existing exposure and loss. Possibilities for stock adaptation are owned by property owners and public, private and non-governmental organizations.

Reducing key service gaps and building resilient infrastructure systems can significantly reduce exposure to the threat and vulnerability to climate change, especially for them. For many of the main hazards associated with climate change in urban areas, risk levels are increasing from now (with current adaptation) to near term, but high adaptation can significantly reduce these risk levels. It is less possible to do this in the long run, especially under the global average temperature rise of 4 °C.

Effective urban adaptation can be implemented and accelerated. Urban governments are at the center of successful urban climate adaptation. Because urban climate adaptation depends on local assessments and integration into local investments, policies and regulatory frameworks.

Building human and institutional capacity for adaptation in local governments accelerates implementation and improves urban adaptation outcomes, including the scope for reflection on increasing and transformative ways of adaptation. Horizontal learning benefits urban adaptation through coordinated support from higher-level governments, the private sector and civil society, and networks of cities and practitioners.

Leadership within local governments, as well as at all scales, is important for achieving successful adaptation, building and maintaining a broad base of support for the urban adaptation agenda.

Addressing political interests, mobilizing institutional support for climate adaptation, and providing voice and influence to those most at risk are important strategic cohesion concerns.

Activating the capacity of low-income groups and vulnerable communities and their partnerships with local governments can be an effective urban adaptation strategy. City centers around the world face severe constraints on increasing and allocating resources to implement adaptation. In most low- and middle-income cities, lack of infrastructure, lack of competencies, and lack of financial and human resources severely constrain adaptation action. Because small urban centers have relatively low national and international profiles, they often lack economies of scale and local operating capacities for adaptation investments.

International financial institutions provide limited financial support for adaptation in urban areas. There is limited existing commitment from different levels of government and international organizations to finance urban adaptation.

Information and data are needed to take into account local risk and vulnerability assessments and current and future risk and adaptation and development options for effective adaptation action. Dealing with the uncertainty associated with climate change forecasts and balancing them with actions to address current vulnerabilities and adaptation costs helps to assist implementation in urban areas (Revi et al., 2014).

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CLIMATE CHANGE AND URBAN FLOODS

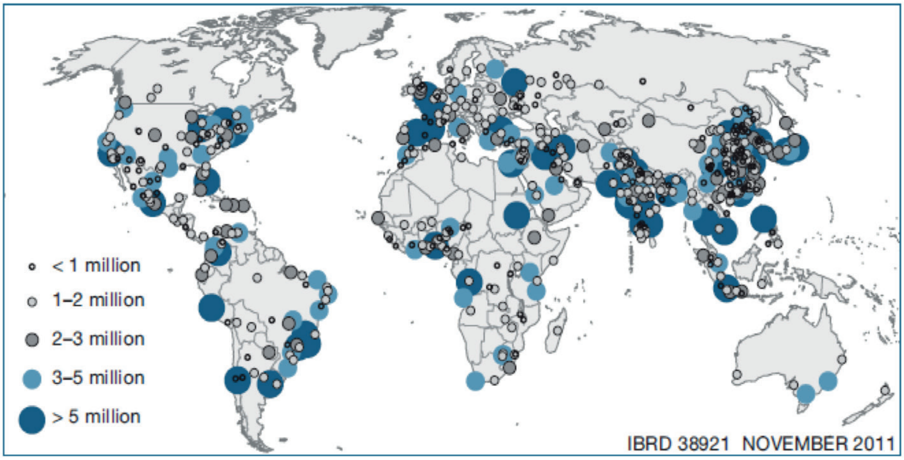
Prof. Dr. İhsan Çiçek

1. INTRODUCTION

Floods are the most frequently occuring of all natural disasters. Especially in the last two decades, the number of reported incidents has increased significantly. Figure 1 illustrates this trend. The number of people affected by floods and financial, economic and insured losses also increased. In 2010 alone, 178 million people were affected by these floodss. Total losses in years when flood events were high, such as 1998 and 2010, exceeded $ 40 billion (Jha et al., 2012).

Flood is a global event that causes widespread devastation, economic damage and loss of human life. In August 2010, devastating floods occurred in the Indus River basin in Pakistan. Floods occurred in Queensland, Australia, South Africa, Sri Lanka and the Philippines in late 2010 and early 2011; with earthflows in the Serrana region of Brazil in January 2011; after the earthquake-induced tsunami on the northeast coast of Japan in March 2011; along the Mississippi River in mid 2011; as a result of Hurricane Irene on the US East Coast in August 2011; in the southern state of Sindh in Pakistan in September 2011; in large parts of Thailand, including Bangkok, in October and November 2011. This situation highlights floods in terms of frequency and prevalence compared to other disasters. Especially in the last two decades, the number of reported incidents has increased significantly. The number of people affected by floods and financial, economic and insured losses also increased. In 2010 alone, 178 million people were affected by flood-related diseases.

Figure 1: Urban agglomerations with more than 750,000 inhabitants



Resource: Cities and Flooding A Guide to Integrated Urban Flood Risk Management for the 21st Century (2012)

Urbanization is an indicator of the world's demographic growth. This process causes the natural risks to increase and more people to be affected by these risks. In 2008, for the first time in human history, half of the world's population lived in urban areas, while two-thirds of them lived in low-income and middle-income countries. It is predicted that the urbanization rate will increase to 60 percent in 2030 and 70 percent in 2050, and a total of 6.2 billion people will live in cities. This projected figure corresponds to twice the estimated rural population at that time. As the urban population represents a larger proportion of the world's population, the proportion of urban floods will increase proportionally to other floods. Therefore, urban floods become more dangerous and more costly due to the large population exposed to floods in urban settlements. By 2030 the majority of urban dwellers, in fact, will live in towns and cities with populations of less than one million where urban infrastructure and institutions are least able to cope.

In the last 200 years, the global population has increased sevenfold. While the population in the world was 1 billion in 1800, it has increased to over 7.5 billion in 2020. In the same period, the proportion of people living in urban areas increased from 3% to 50%. With the increase of the population in the cities, there has been an intense change in the landscape. Its impact on environmental systems, including the atmosphere, is profound, and this impact is very strongly transmitted to regional and global systems. Urban effects on the environment are present in every city to a greater or lesser extent. In urban climates, it is essential to define and measure the impact of urban growth on atmospheric processes and the resulting development of different urban climates.

Urban climates are a prime example of climate change that results from the unwanted effect of human activities on the atmosphere. Cities contribute to climate and atmospheric composition changes on a local, regional and even global scale. In contrast, while cities try to cope with extreme weather events such as storm, flood, drought, they also try to minimize the effects of these extreme weather events on infrastructure, health and safety in cities. Such undesirable and minimized events need to be understood and modeled correctly to understand their mutual interactions and to maximize their beneficial aspects. Ultimately, this provides the essential scientific data needed to design, manage and operate safer, healthier, more sustainable and more resilient settlements.

2. ENVIRONMENTAL IMPACTS OF URBAN DEVELOPMENT

2.1. Urban Pedosphere and Lithosphere

Urban development can change the surface form of the landscape (geomorphology) and cause changes to the original soil of the settlement area. Bulldozers and similar earthmoving equipment are emotional symbols of urban development and precisely for this reason their impact is fundamental and permanent. In preparing the ground to construct roads, bridges, houses, etc., it is considered necessary or at least convenient, to flatten hummocks, fill depressions, excavate large openings, fill or straighten water courses, remove, rearrange and compact topsoil and so on. Such activities can completely destroy small ecosystems (e.g. a pond, marsh or stream can be obliterated by the dumping of rubble and refuse);. Behind a dam built to provide water to the city, all the valleys are filled with water and completely new islands or beaches can be created by land reclamation. These changes may be less disturbing than such events as land subsidence caused by mining or melting permafrost , or accelerated soil erosion as a result of vegetation destruction. The deterioration of the top layer of the soil destroys the natural structure of the soil. These changes add externally added materials such as sand, gravel, clastic materials, topsoils and mulches to the original soil materials. These materials can likewise be transported later by wind and water erosion. These processes radically change the composition and horizons of urban soils, and this causes significant changes in soil fertility and hydrology in an urban ecosystem (Oke et al., 2017).

2.2. Urban Hydrosphere

The hydrological effects of land degradation can also be profound. Land is often unloaded and wetlands, ponds and lakes are in-filled. When impervious materials such as asphalt and concrete roads, parking lots and buildings are built, the water regime is severely interrupted. Thus, it partially seals the surface and greatly reduces the infiltration of water into the soil. Even if the soil is not completely impermeable, changes in the terrain distort the patterns and rates of both surface and underground drainage. This reduces infiltration into deeper layers and increases the speed and amount of surface runoff.. Lack of drainage in deeper layers affects the underlying ground and reduces groundwater storage. Increased surface runoff increases the likelihood of damage by flash floods. Unfortunately, all these changes in the amount and orientation of water are accompanied by degradation of water quality. As a result of urbanization, many negative features such as increased turbidity in urban waters, more chemical and biological pollutant loads and increased water temperature are added (Oke et al., 2017).

2.3. Urban Biosphere

Urban development accelerates or even eliminates vegetation loss as a result of trenchs initiated on land used for agriculture or other activities before settling on a land. Original native plants are removed or replaced with exotic species of plants and weeds, except for those that are often unsuitable for construction or remain in patches in areas specially protected for the park. The process is a combination of the more preferred urban plant species (grass, flowering plants and shrubs, vegetables, ornamental trees, fruit trees, shade and shelter trees, etc.), with the gradual rapid loss and replanting of native vegetation. All these effects on the biophysical environment of cities affect the ecology of wild and domestic mammals, birds, reptiles and insects. In general, wildlife habitat and food resources (particularly vegetation) are threatened by loss of vegetation and pollution.

Of course, some animal species can adapt to urban life, and some may even develop as a result of finding new habitats and food supplements (cockroaches, seagulls, mice, foxes) (Oke et al., 2017).

2.4. Urban Atmosphere

In broader perspective, there are two groups of urban features that change the atmosphere. These are those related to changes in surface properties and those resulting from anthropogenic releases. The first is related to the urban form, the second to the urban function. While this distinction provides a useful classification of factors that create urban climate, this duality is a fundamental principle in architecture and urban planning. This classification helps us to discuss the role of climate in urban design and the effect of the city on the atmosphere (Oke et al., 2017).

2.5. How Urban Form Affects the Atmosphere

The overall dimensions of a city, its area, diameter, shape (i.e., circular, radial, linear or cellular), landscape, and whether its core is central, ex-central, or multicenter can play a role in urban climate in spatial form. At more precise scales, the shape of any urban area affects the atmosphere as follows:

- **Fabric:** Natural and construction materials that make up urban elements such as buildings, roads, and vegetation determine the radiation, thermal and moisture properties of a surface, and thus their ability to absorb, reflect and emit radiation, accept, transfer and retain heat and water.
- **Surface cover:** It creates different textures such as the surface interface, built-up, avenues and streets, vegetation, bare land, water cover. Cover fractions cause differentiation of heat especially in the urban area. For example, a dry urban surface gets very warmt on a sunny day because it cannot dispose of solar energy through evaporation. Patches with vegetation remain relatively cool because plants and soil use solar energy to evaporate water.
- **Urban structure:** 3-D configuration of urban elements: This includes the dimensions of the buildings and the spaces between them, street widths and street spaces. Structure matters at two scales. Albedo and its aerodynamic roughness help determine the structure of the whole city and individual buildings and streets where it controls radiation exchange and airflow patterns

(Oke et al., 2017).

3. HOW DOES THE URBAN FUNCTION AFFECT THE ATMOSPHERE

Metabolic cycles in the urban ecosystem as a result of urbanization work at different time scales. The most prominent is the rhythm of the work day and work week that modulate traffic, domestic water use, space heating and cooling, industrial activity and similar systems. Many cities also have characteristic weekday-weekend cycles and seasonal variations in human activity. Anthropogenic emissions include the release of pollutants such as water vapor, heat and liquid, gas or particulate matter etc., all of which can be thought of as waste by-products of urban metabolism. There are fluctuations of building and other infrastructure construction, transformation, demolition and reconstruction over much longer periods. These dynamics stem from human occupation, activity and decision-making processes in settlements. The effects of anthropogenic releases are direct or indirect. Direct effects are condensation in the clouds as a result of heat losses from building or automobiles heating the nearby air or vapor injections from cooling towers. Indirect impacts include processes where air pollutants interfere with radiation transfer in the atmosphere or generate condensate nuclei around which cloud droplets grow, or greenhouse gases that alter the Earth's radiation budget. Anthropogenic emissions mean that people are actors of all scales in the climate system. Human decisions constantly influence the spatial and temporal nature of these effects. Examples include planning the workday and the week, commuting to work at home, watering the garden, using air conditioning, setting a thermostat, driving or public transport, etc. (Oke et al., 2017).

4. FUNDAMENTALS OF SURFACE HYDROLOGY AND WATER BALANCE

4.1. Hydrologic Cycle

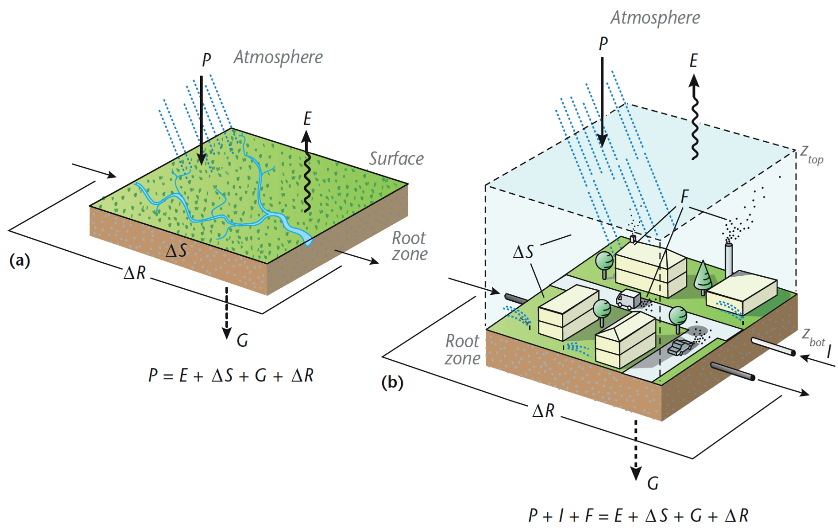
The global hydrologic cycle continually recycles components such as water, ice, liquid water or water vapor through components of the Earth-Atmosphere system. The cycle is supported by the global surface energy balance with meteorological processes such as evaporation of water from moist surfaces (e.g. vegetation, soils, lakes, oceans), vertical mixing, wind transport, condensation such as clouds, and eventually return to the surface. It restocks water reserves (soil moisture, groundwater, snow cover, glaciers, lakes, oceans) by falling as precipitation in various ways (snow, rain, dewfall, fog drip). The hydrological cycle carries water between the components of the system. These include convection and advection in the atmosphere, glaciers, runoff on land, rivers and oceans.

A surface water balance for a given part of the landscape refers to all the water that has passed through the system or stored underground over a period of time. The ability to evaluate and predict the components of the surface water balance is essential for urban water management. Water in the atmosphere exists as solid (ice, snow, etc.), liquid (eg cloud droplets, rain droplets) and gas (water vapor). A complete calculation of the water cycle includes all phases that depend on temperature and involve receiving or releasing energy and hence the surface energy balance. Surface water balance for the atmospheric boundary layer is a basic boundary condition of atmospheric humidity (Oke et al., 2017).

4.2. Surface Water Balance

The surface water balance is the easiest way to delineate a natural basin. The basin boundary is defined as the landscape area where all precipitation falls, with a depth extending from the top of any surface landscape (eg vegetation) to permanently saturated soil or rock (Figure 2a). Topographic irregularities in the natural landscape, together with the influence of gravity, define basins just as they describe river networks (the spatial extent of Figure 2a cannot provide sufficient topographic relief to show the effect of elevation differences in the formation of a river basin) (Oke et al., 2017).

Figure 2: Natural surface water balance and (b) equivalent surface water balance of urban hydrological unit; e.g. a city and its associated volume of air and moist soil in the root zone.



Source Urban Climates (2017)

Most precipitation (P) that reaches the ground seeps into the soil and seeps into the deeper layers. Some are stopped by vegetation, where some is held for a short time before evaporation returns to the atmosphere and the rest reaches the ground. If the soil near the surface is unsaturated, the water at the surface enters the soil by infiltration, the ratio of which is governed by the gravitational potential and the two forces that qualify as matrix potential. The gravitational potential is due to gravity acting on water in the soil column and is most effective on water trapped in large pores that are easy to drain. Matrix potential arises because water is attracted by surface tension to solid surfaces (eg soil particles, stones) it adheres to. The infiltrated water moves towards the groundwater region consisting of the unsaturated (vados) zone located above the saturated (phreatic) zone where the voids are filled with water. The water table defines the upper level of the phreatic layer. The water table is often irregular, following the topographical structure. The speed of any horizontal movement of soil water is governed by the slope (gradient) of the water table and the hydraulic conductivity of the layer. The conductivity of compact clay can be only about 0.0001 m day -1, while for fine sand about 3 m day-1 and for coarse sand and gravel it can be as much as 300 m day-1. However, given a typical water table slope of 0.005, horizontal movement in this region is very slow (Shanahan, 2009). The layers may contain many different layers, some of which are almost impermeable and act to confine groundwater and thus form an aquifer; that is, groundwater can be extracted by drilling a well in a water-bearing permeable rock area. The spatial spread of the groundwater zone is generally greater than an individual basin, so water extraction can respond to changes occurring outside the immediate area (Welty, 2009).

Surface runoff (R) is water passing over the surface, exiting the catchment through a stream channel fed by a series of branching tributaries. R contains water from a variety of sources, including: P refers to the water directly entering the channels. The surface flow if the P ratio exceeds the infiltration rate; it is related to the groundwater that emerges in a channel where the water in the unsaturated layer and the water table intersects with the land, moving from the slope down to a channel. Because the water from each source follows a different route (and time) to reach the stream, the flow at any given time represents a combination of water collected at different time scales. Base flow in a stream during dry periods comes from groundwater stored by rainfall events over long periods. The level in groundwater is determined during a dry period when the precipitation is negligible. In urban areas, the base runoff is generally lower than in rural areas because precipitation is diverted to runoff; as a result, less water seeps into the soil, feeding the groundwater. R shows a transient response to precipitation depending on the magnitude and intensity of the event, the characteristics of the basin (depth of soil, slope, underlying layers, etc.), and permanent effects from pre-existing conditions. After a dry period, P can fill depleted tanks leaving little room for R, but after a wet period the reservoirs may be full, so R responds quickly to P. Surface water balance for a natural basin;

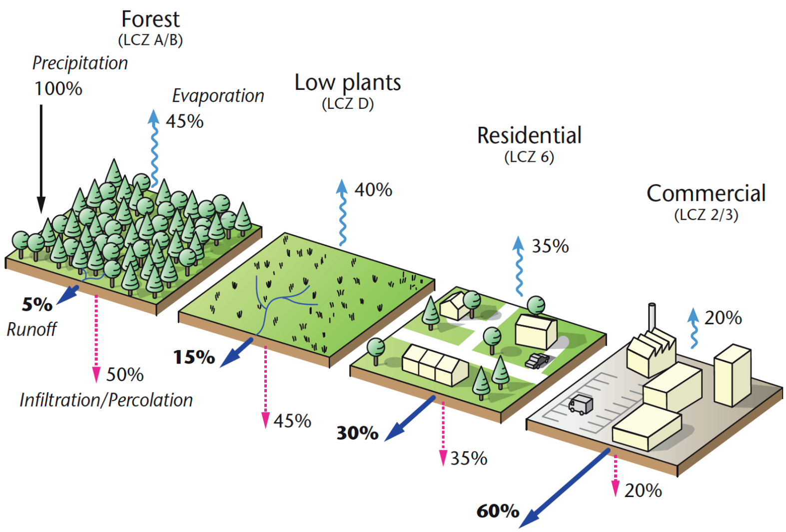
$$P = R + E + \Delta S \ (\text{mm day}^{-1}; \text{kg m}^{-2} \text{ day}^{-1})$$

Here ΔS is the change in storage including soil water, groundwater and any surface water reservoir (eg lakes, streams, snow cover, vegetation-interception). It is positive after a precipitation event (or in the wet season) and negative in the dry period. Measuring a complete surface water balance is often difficult due to mismatches between the scales of time and space at which different conditions operate in the equation above. For example, ΔS can be active for days or weeks. If the time frame for analysis is long (many years), it may be possible to capture all the wetting and drying processes in a catchment, in which case ΔS approaches zero. In contrast, P occurs periodically, often intermittently for hours or days, it can be active perhaps for a month or more with no input. Evaporation (E) is a semi-continuous process with the availability of energy and efficiency of convection in as little as seconds and plant transpiration within hours. In addition to these incompatibilities, receiving rain and snowfall even during a single storm can be very spatially irregular (Oke et al., 2017).

4.3. Surface flow

Figure 3 shows how four ecosystems can cause P to split. Together, these four ecosystems illustrate a typical transition of a landscape from rural areas to urban uses and consequently its impact on flow. Forest and pasture and scrub plant environments stop P quite effectively and water is stored. In the medium term, this means that there is water left in the soil for E. Generally, this slows the flow of water and produces relatively less flow (R). Urban cover types are less permeable, so water is easily repelled and this increases flow (Oke et al., 2017).

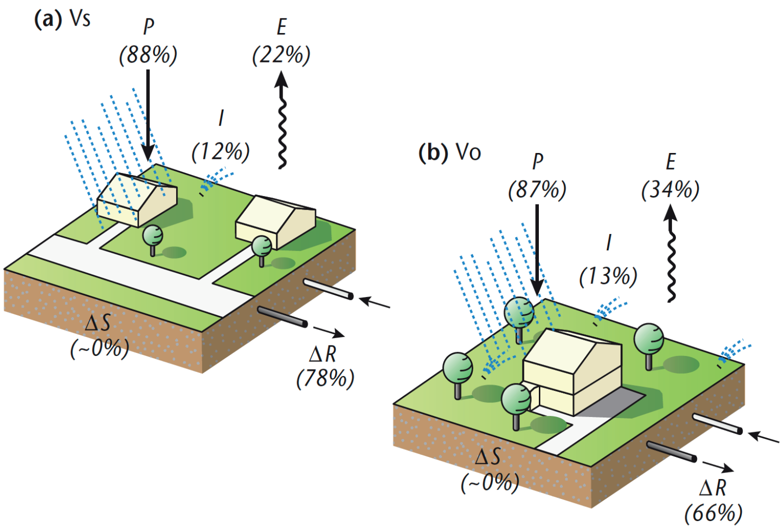
Figure 3: For the effect of land cover on the splitting of precipitation (100%) between evaporation, seepage and runoff, generally the storage change in the root zone for about a year is neglected.



Resource: Urban Climates (2017)

The results in Figure 4 follow this pattern. For example, in Vancouver, in places with different construction textures (two single-storey buildings Vo and double-storey single buildings Vs) in the same area, approximately 12% more flow occurs on a larger impermeable surface, but 12% less evaporation occurs in this area. As the magnitude of R (runoff) increases with urban development, the ratio of R/E also increases. Critical control is the total impervious surface cover fraction that includes both pavement and asphalt and buildings. In Figure 4, the R/E increases from about 1.9 to 3.5. In addition to land cover, the connectivity of the river/sewer network and the presence of additional water resources above P (eg I, F) exert control over R. For example, have rivers been diverted or rerouted to create sewers and have new network connections or canals been established. Have drains been raised so that leakage and groundwater flow change? Is the sewage system consolidated or separated?

Figure 4: *Calculated using the Surface Water Balance Program - Surface Water Balance Program with inputs (P and I) measured in suburbs of two residential areas in Vancouver, Canada in 2009. Percentages are by total water input (P + I). (P: Precipitation (mm) I: Tubular water supply per unit horizontal area (kg m^{-2} s^{-1}), E: Evaporation or evaporation + perspiration (kg m^{-2} s^{-1}), ΔR: Net flow (mm), ΔS Net water change (kg m^{-2} s^{-1})*



Resource: Urban Climates, 2017

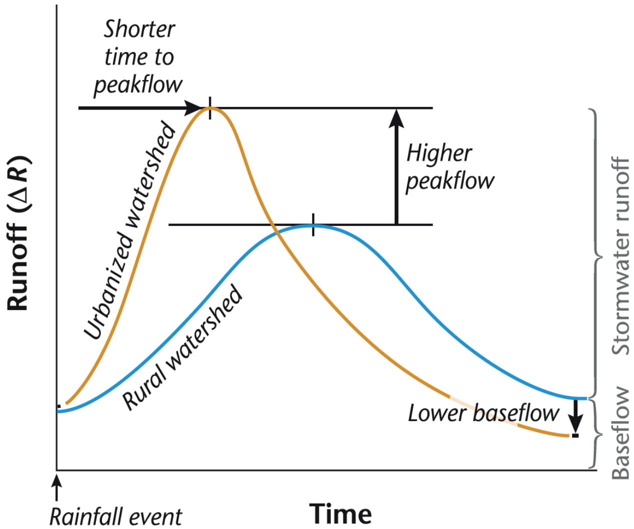
4.4. Discharge Curves in Urban Systems

The main result of urban development on streamflow is threefold (Figure 5):

- Much more high volume flow occurs after a storm event.
- The time taken before water input appears in gutters, drains, culverts, streams and rivers is shortened. In other words, it takes very little time for the surface flow to reach the main stream.
- The base flow is generally lower because less water infiltrates into the substrate.

Both the rising and the decreasing limbs of the flow curve are steeper than the previous flow curves after urban development (Figure 5). This is because the flow is faster than those passing through and through natural soils and vegetation on impervious and relatively smooth surfaces found in cities (e.g. roofs, roads and asphalt areas). The flow, flowing both faster and faster in volume, is stronger and increases the probability of flooding (Oke et al., 2017).

Figure 5: Typical storm hydrograph showing the relationship between the current discharge (R, left axis) and time, beginning with a large rainwater inflow (P) due to a storm event. One curve is the typical flow after a rural basin and the other after urban development.

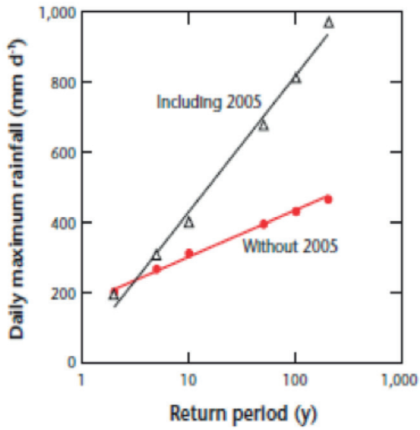


Resource: Urban Climates, 2017

4.5. Floods

In cities, flooding can occur due to intense and/or long-lasting rainfall events (pluvials), river discharge (fluvial) exceeding canal capacity, and sea level rise (shore). London, United Kingdom has an excellent inventory of the development of many urban areas and the floods that occurred there. It develops in the floodplain of the River Thames, where flooding occurs as a result of both fluvial events and tidal surges. A number of flood defenses have taken place over time in response to individual events. A flood management system was put into operation in 1953 after an extraordinary tidal surge caused by a major storm in the North Sea. The center of this system is the Thames Barrier, a series of gates that can be opened or closed to manage water levels. In line with other obstacles and 337 km of walls and embankments, these defenses protect a floodplain in which 1.25 million people live and work. The design standard is built with a 0.1% chance of flooding in any year. Based on an 8 mm year^{-1} sea level rise, its estimated life is 50 years. This allowed urban development on the land to be flooded according to the flood risk and the amount of sea level rise (Lavery and Donovan, 2005).

Figure 6: Return periods of rainfall events at Santa Cruz Airport, Mumbai, India, showing the effect of including the 24:00 hour heavy rain event in July 2005 in the recurrence estimates



Resource: Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai, 2010

The design capacity of urban rainwater systems has to cope with expected events such as a hundred-year rainstorm. Figure 6 shows a graph of recurrence times for varying intensities of precipitation events in Mumbai, India, a city of over 18 million. The region's macroclimate is monsoon, and more than 2,000 mm of precipitation per year is concentrated in summer. In July alone, it falls on average more than 680 mm, usually in the form of heavy rainstorms. However, a single event can change the statistics on which these design curves are based. On July 26-27, 2005, a heavy rainstorm occurred over the city for 24 hours. At the meteorological station at the nearby airport, 944 mm was recorded in 24 hours. The result was a widespread flood that damaged more than 175,000 homes and 40,000 commercial buildings and 400 dead, and then disrupted the functioning of the city for weeks. The inclusion of this event in the historical record has led to the recalculation of the maximum 24-hour precipitation frequency curve and the amount of precipitation that will fall every 100 years from around 400 mm to 1000 mm of precipitation (Hallegatte et al., 2010).

4.6. Flooding

There are three types of floods that affect cities: shore (due to sea level rise or storm surges); fluvial (river) and pluvial (precipitation). For the former, protection measures can only be addressed by using direct barriers. These should not be built (or towed) in coastal areas that are likely to be flooded. In cities, these areas should be vacant for recreational purposes to provide a buffer zone between the settlement and the coast. In the areas where the building is built, measures should be taken to raise the buildings as an architectural precaution, so that the ground floors will be above the possible flood level and / or the ground floor of the buildings will be used such as car parks.

Urban impacts on pluvial and fluvial flooding are interrelated, as both are reinforced by the waterproof surfacing that causes water to accumulate on the surface or too quickly damages the drainage capacity of the channel.

One way to reduce vulnerability is to increase the capacity of the drainage infrastructure to cope with heavy rainfall events by increasing the size of pipes and channels. Another approach is to avoid building construction by providing suitable buffer zones around river channels, creating guard bands in areas likely to be flooded. Naturally, these measures are easiest to take at the outset, since recycling in riverside areas where dense buildings are built around requires a costly and very important response to comply with flood measures.

However, it is often not possible to store significant amounts of water on roofs due to its considerable weight. This is especially true for large, low-rise neighborhoods (eg warehouses). In such places, increased storage capacity and ground level permeability are the only ways to reduce R / P. However, minimization of the total impermeable fraction of a city (part of the building plan area + part of the impermeable surface plan area) also means reducing the footprint of large low-density neighborhoods. Stone (2004) studied suburban developments of varying densities in the United States and found that building on larger plots were located furthest from the road network and needed long paths that increased total impervious coverage. Limiting only the size of building areas has been proposed as an effective tool to control impervious cover (Oke et al., 2017).

6. CONCLUSION

6.1. Each risk scenario is different: There is no flood management plan

Understanding the type, source and probability of floods, assets exposed and their vulnerability is important if appropriate urban load risk management measures are to be identified. The measures must be appropriate to the context and conditions: A flood barrier in the wrong place can worsen floods by blocking rain from flowing into the river or pushing water downstream into more vulnerable areas. Therefore, flood early warning systems may have limited impact on mitigation.

6.2. Designs for flood management must be able to cope with a changing and uncertain future

The impact of urbanization on site management is and will continue to be significant now. But this will not be completely predictable into the future. In addition, even the best weather models and climate forecasts result in a large measure of uncertainty, now and in the long run. This is because the future climate depends on people's unpredictable actions on the climate and the climate approaches scenarios that have never been seen before. Therefore, flood risk managers need to consider measures that resist uncertainty and different flood scenarios under climate change conditions.

6.3. Rapid urbanization requires the integration of existing risk management into regular urban planning and governance

Urban planning and management that integrates land risk management is a fundamental requirement that includes land use, shelter, infrastructure and services. The rapid expansion of urban areas offers an opportunity for the development of new settlements, which initially included integrated vehicle management. Adequate operation and maintenance of immovable management assets is also an urban management problem.

6.4. An integrated strategy requires the use of both structural and non-structural measures and good measurements to "get the balance right"

The two types of measures should not be considered to be different from each other. Rather, they complement each other. Each measure contributes to flood risk reduction, but the most effective strategies usually combine several measures that can occur of both types. It is important to identify different ways to reduce risk in order to choose those that best meet the desired goals now and in the future.

6.5. Heavy engineering structures can transfer risks up and down

Well designed structural measures can be quite effective when used properly. However, while it characteristically reduces the risk of flooding in one area, it increases in another. Urban flood managers have to assess whether such measures are in the interests of the wider collection area.

6.6. It is impossible to completely eliminate the risk of overflow

Harsh engineering measures are designed to defend a predetermined level. They may fail. Other non-structural measures are often designed to minimize rather than prevent risk. There will always be a residual risk to be planned. The measures should be designed in such a way that, if unsuccessful, they do less damage than would have occurred without action.

6.7. Many field management measures have multiple benefits

Links between flood management, urban design, planning and management, and climate change initiatives are useful. For example, the greening of urban areas is of primary value, increases biodiversity, protects against the urban heat island, and can provide urban food production and evacuation space. Improved waste management has health benefits as well as maintaining drainage system capacity and reducing the risk of overflow.

6.8. It is important to consider the wider social and ecological consequences of business management expenditure

While costs and benefits can be defined purely in economic terms, decisions are seldom based solely on economics. Some social and ecological consequences, such as loss of social adaptation and biodiversity, cannot be easily measured economically. Therefore, qualitative judgments should be made by city managers, communities at risk, urban planners and flood risk experts on these wider issues.

6.9. Clarity of responsibility is important in setting up and running flood risk programs

Integrated urban flood risk management is often among and may include decision-making dynamics and different incentives at the national, regional, municipal and community levels. Strengthening the flood problem by the relevant institutions and individuals and mutual ownership will lead to positive actions to reduce risk.

6.10. Implementing flood risk management measures requires multi-stakeholder collaboration

Active participation with people at risk at all stages is a key success factor. Participation improves compliance, increases capacity, and reduces conflict. This needs to be combined with strong, determined leadership and commitment from national and local governments.

6.11. Continuous communication is required to increase awareness and strengthen preparedness

Constant communication eliminates the tendency of people to forget the risk of flooding. Even a major disaster has a half-life of less than two generations, and other more immediate threats often seem more urgent. In less than three years, less serious events can be forgotten.

6.12. Plan for a quick recovery after flood and use it to increase recovery capacity

It is important to plan a speedy recovery as flood events will continue to devastate communities despite best practices of flood risk management. This includes planning for the right human and financial resources to be available. The best recovery plans take the opportunity to rebuild to build safer and stronger communities with the capacity to better withstand future floods (Jha vd (2012).

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POSSIBLE EFFECTS OF CLIMATE CHANGE ON INCREASE OF DISASTERS AND RISKS IN THE WORLD AND IN TURKEY

Prof. Dr. İhsan Çiçek

1. INTRODUCTION

Climate change adds a new dimension to the centenary problem of natural disasters. The link between anthropogenic greenhouse gas (GHG) emissions and global temperatures has resulted in linking climate change to human actions. Anthropogenic climate change depends more on the character of natural influences than on the nature of the physical world, on the phenomena shaped and influenced by human activities - in particular the high carbon lifestyle.

Energy-intensive and carbon-intensive human activities have increased greenhouse gas emissions in the atmosphere and its main component, carbon dioxide (CO_2). This, in turn, has been associated with an increase in the long-term average temperatures of the seas and the atmosphere, and increased extrem temperatures and heavy precipitation (IPCC 2012, 2013).

This relationship shifted the focus of disasters from purely natural events to human induces events. This understanding emphasizes climate change mitigation and adaptation, as well as being prepared for and preventing natural disasters. All this highlights how human decisions and actions affect the frequency and severity of climate-related disasters (Thomas, V. 2017).

2. DISASTERS IN TURKEY AND IN THE WORLD

According to the World Bank and many other data, the economic losses of disasters are increasing rapidly. The reason for this cannot be attributed to the increase in disasters. Although there are periodic increases, the information that disasters are increasing gradually is not very reliable. The problem is not that disasters increase but that disasters become more damaging. Main reasons include the ineffective use of existing resources, inappropriate disaster strategies, erroneous plans to eliminate or reduce the conditions that will turn hazards into disasters before the disaster occurs, and the rapid increase in the population of the urban settlements. But the main reason is poverty. Unfortunately, disasters love the poor! It is impossible to cope with disasters without dealing with poverty in the world. Undeveloped countries are more at risk than developing countries (Ersoy 2013). Regional income distribution increases vulnerability in disasters. 83 million people live in Turkey, which is both a European and an Asian country. 75% of the total population lives in urban areas. The GDP of Turkey, which is among upper medium income level countries, is 1 trillion 24 billion 226 million TL. 18.1% of the country's population live below the poverty line. Life span is 75 years. The per capita income is 9,127 (2019) US dollars. Private sector and global resources are at great risk due to the large amount of investments. All public and private institutions should take the necessary responsibilities in order to prevent the national resources from being melted. Disaster damages have increased to an extent that they can no longer be sustained by helping civilian victims or volunteering services. It has become a business and service sector. Some countries have significantly reduced the loss of lives in disasters with well-implemented plans and measures. Risk that are not properly managed may lead to a shrinkage in the global assets, leading the countries to face with the risk of poverty. (Ersoy 2013).

Risks such as antibiotic resistance, deforestation, desertification, drought, economic depression, global climate change, famine, stopping of the Gulf Stream, increasing frequency of tropical cyclones, a new ice age, asteroid impact, mass extinction, earthquake, tsunami, nuclear war, excessive consumption, rapid population growth, global epidemic risk, oil leakage in the seas, sea level change, volcanic eruptions and water crisis are important problems that will threaten the world in the future (Ersoy 2013).

While taking into account the sudden occurrences of natural disasters such as earthquakes, tsunamis, landslides and floods, in the near future, dangers such as global climate change, drought, desertification, deforestation, hurricane etc. will be faced. In addition, dense housing in coastal areas where streams reach the sea is an important problem. The flood bases of river beds and the places with unplanned construction on the coasts will have a higher probability of encountering disasters in the future compared to other areas (Ersoy 2013).

Dangers such as earthquake, tsunami, landslide, debris flow rock fall, earth flow, subsidence, floods and overflows with heavy rainfall, extreme winter conditions, frost, avalanche, heat wave, tornado, water shortage, drought and desertification, forest fires, erosion, deforestation, epidemics, soil, rocks and water-related diseases, climate change, sea level changes and even volcanic activity can be seen in Turkey and are the cases that could turn into disaster.

While handling disasters comprehensively, all dangers and risks should be taken into consideration, all phases of the disaster management system and all stakeholders should be included in the planning. Disaster measures should be planned holistically. Disasters need to be managed more than ever NatCatSERVICE from Munich Re recorded approximately 1,900 incidents of natural origin in 2016. 750 of them are classified as disaster-sized. Of the 750 disasters, 130 (17%) were classified in the category of very severe and serious disasters. The remaining 83% are medium and minor loss events. There have been significant changes in the number of wind storms and floods compared to previous years. When the distribution according to "danger groups" is analyzed, a significant difference occurred in 2016. For example, 33% of all recorded events are meteorological events, well below the long-term average of 40% for the period 1980-2015. In contrast, the rate of hydrological events increased from 39% to 50%; in other words, fluvial floods, flash floods and mass movement accounted for half of all relevant events worldwide in 2016. 7% of all events are of geophysical origin. In 2016, a total of 9200 people died in 750 catastrophic incidents. Only 15% of these losses are related to geophysical disasters, 21% to meteorological and 10% to climatological disasters. The share of hydrological raleted disasters in total losses is 54% (Munich Re 2017).

From the perspective of Turkey in 2016, disasters, especially earthquakes are fairly quiet in terms of history. The number of natural disasters that occurred in 2016 in the territory of Turkey is 323. The percentage distribution in terms of types is as follows: 25% flood / overflow, 22% severe storm, 20% landslide, 18% tornado, 7.4% lightning, 4.3% ripcurrent, 0.9% avalanche, 0.9% meteor impact, 0.6% heat wave / extreme heat, 0.3% collapse. Although the most disasters occurred in September, the most casualties were experienced in July and November (Ersoy et al., 2017).

The loss of life in nature disasters in Turkey in 2016 is 83. The distribution of these according to disaster types is as follows: 24 people as a result of floods, 24 people drowning, 22 people landslides, 8 people lightning, 4 people avalanches and 1 from storm (Ersoy et al., 2017).

Floods and landslides in Turkey are increasingly causing more damage. Unplanned urbanization plays a major role in this. Even in the flood disaster in Mersin alone, there was a loss of more than 1,5 trillion TL. In this respect, urban areas with lack of infrastructure are increasingly damaged (Ersoy et al., 2017).

The effects of global climate change are seen both in the world and in Turkey with an increase. There is a serious increase in severe storm, dust storm, tornado and lightning cases, severe winter conditions or heat waves with extreme temperatures (Ersoy et al., 2017).

Risks against natural hazards in Turkey is increasing due to human-induced reasons. In the World Risk Report, Turkey ranks 12 out of 12 countries with the highest risk. When considered from the point of "Risk Level and Trends " Turkey remains in the 10 countries with high and increasing risk (Wayne et al., 2017).

3. INCREASE OF CLIMATE-RELATED NATURAL DISASTERS

There is a relationship between global warming and the increasing frequency and severity of climate-related events. Although this relationship has not been scientifically proven, there is a consensus that global warming increases the frequency and severity of extreme climatic events. For example, it appears that the frequency of tropical cyclones is increasing. The strength (duration and intensity) of Atlantic cyclones has doubled over the past 30 years. The increasing frequency and severity of cyclones is associated with the warming of ocean surface water, a result of global warming. There is also an increasing trend in floods and overflows (Alper and Anbar 2006).

As the severity and number of climate-related events increase, the monetary cost of damages also increases. Small changes in the severity of extreme events can cause 4-5 times more increase in damage. In 2016, 27% of global US $ 175 billion overall losses were related to geophysical events, including the costliest natural disaster of the year, which occurred in mid-April near the city of Kumamoto on the island of Kyushu in Japan. In 2016, 31% of economic losses due to natural disasters were caused by meteorological events and 32% from hydrological events. These losses were caused by floods in the USA, Europe and China. Besides the burden of damage from Hurricane Matthew and the earthquake in Japan, the five costliest events in 2016 were caused by these floods. 10% of the losses incurred in 2016 were attributed to climatic events. Wildfires in Canada, months of drought in China and India and winter losses in East Asia left their mark. Overall, there were 32 incidents in 2016 that caused a loss of at least $ 1 billion. These included heavy stormy weather and flash floods in the USA and Europe, as well as typhoons in China, Taiwan and the Philippines. These accounted for about 70% of the total amount of losses (Munich Re 2017).

When insured losses were subtracted from general losses, the insurance deficit reached US $ 125 billion. More than half of the insured losses in 2016 were related to storms. 18% of the damages were caused by floods, 20% by earthquakes and 12% by droughts and other climatic events. Among 14 separate events each costing insurance companies $ 1 billion or more, there are earthquakes in Japan and New Zealand and four hail storms in the USA. 62% of insured claims occurred in the USA, only 21% in Asia and 11% in Europe (Munich Re 2017). The cost of the heat wave in 2003 in Europe was € 10 billion. It is not entirely possible to make an accurate estimate of future costs. (Alper and Anbar 2006).

As the number and severity of major climate-related disasters increase, the social and economic costs of these events will also increase. Less developed and developing countries are more vulnerable to climate-related events and disasters. Because these countries will be affected more by such disasters because they cannot take the necessary precautions or have insufficient infrastructure. For example, according to the World Bank, 1.3 billion people live on a daily income of less than $ 1, and three-quarters of them live in agriculture. Climate-related disasters such as floods, storms and droughts will adversely affect agriculture, and therefore these people engaged in agriculture. The economic costs of natural disasters will place heavy burdens on the budgets of lessdeveloped or developing countries. Even in small countries located in high-risk regions, the cost of climate-related disasters may exceed 100% of the GDP of those countries (Alper and Anbar 2006).

3.1. Agriculture and Forestry

At local average temperature increases up to 1-3 °C, crop productivity is expected to increase slightly at mid-high latitudes (regions), but decrease at higher temperature increases. At lower latitudes, especially in seasonally arid and tropical regions, crop yields are expected to decrease, even with small temperature increases (1-2 °C). Increasing the frequency of drought and floods will negatively affect local crop productivity (Alper and Anbar 2006).

Drought will pose the most important risk for agriculture in developed countries such as Australia and Europe. Farming accounts for 1.7% of the EU's total GNP and 4.2% of total employment is employed in the agricultural sector. In Europe, a temperature increase of up to about 2 °C can lead to an increase in crop yields. However, depending on the temperature increase, there will be problematic years and problematic areas. For example, the heat wave experienced in Europe in 2003 caused a yield loss of 30-40% in grain products (Alper and Anbar 2006).

Lessdeveloped and developing countries whose economy is relatively dependent on agriculture will be more affected by the depletion of water resources and drought. For example, the agricultural sector accounts for 21% of Africa's GDP on average, up to 70% in some countries. In Africa, it is estimated that by 2080, agricultural yields will decrease by 12%. Problems in the agricultural sector in African countries will increase the risk of food insufficiency or hunger (Alper and Anbar 2006).

Forests are very important in terms of biodiversity capacity. Globally, the productivity of commercial forest products is expected to increase slightly due to climate change in the short and medium term. However, there will be significant differences between regions. In Northern Europe, water shortage and temperature increase will cause drought, forest fires, erosion and desertification. Some tropical rainforests, such as the Amazon, are predicted to be adversely affected by drought (Alper and Anbar 2006).

3.2. Energy Supply

Global warming affects energy supply and demand. For example, in 2006, heat waves in Europe and the USA forced energy producers to reduce their production and led to an increase in energy prices. Water supply will be a major problem in electricity generation. Because thermal and nuclear power plants need water to achieve steam and cooling functions. In particular, hydroelectric power plants are very sensitive to water resources. The decrease in water resources and drought will adversely affect energy production (Alper and Anbar 2006).

Energy needs are met mainly from fossil sources. Over the last 150 years, the burning of carbon-containing fossil fuels such as oil, natural gas and coal has significantly increased the atmospheric concentrations of carbon dioxide and other greenhouse gases. Carbon dioxide emissions from the burning of fossil fuels increased from 6 Gt in 1950 to 40.2 Gt in 2019. According to the International Energy Agency's forecast, global carbon dioxide emissions due to energy use will increase rapidly by 2030, and developing countries will be responsible for three-quarters of this increase (Alper and Anbar 2006).

It is certain that carbon dioxide emissions arising from the use of fossil energy sources are one of the important causes of global warming. For this reason, efforts are being made to reduce the use of fossil resources and increase the use of renewable energy resources. The renewable energy market is growing rapidly. Energy produced from renewable energy sources increased by 41% in 2019. Thus, the amount of energy produced by renewable energy sources exceeded nuclear energy for the first time. According to the BP 2020 World Energy Statistics Report, as a result of the increase in renewable resources, electricity production from coal decreased by 240 terawatt hours. In 2019, China was the leader in renewable energy production with 732.3 terawatt hours, while the USA ranked second with 489.8 terawatt hours. Germany came third with 224.1 terawatt hours, India fourth with 134.9 terawatt hours and Japan fifth with 121.2 terawatt hours.

The increase in electricity generation from renewable sources on a global scale has outpaced other sources. Electricity generation from clean sources ranked first in 2019 with an increase of 340 terawatt-hours compared to the previous year. Thus, in 2019, a total of 2,805 terawatt-hours of electricity was generated from renewable sources.

The energy sector is exposed to emission reduction liabilities and legal risks, as it has an important role in the emergence of the global warming problem and in slowing down the global warming. Another risk that the energy sector is exposed to is the possibility of depletion of fossil resources after a certain period. Therefore, large companies such as BP and Shell invest in renewable energy technology, thinking that their core products could be in danger within 50-100 years (Alper and Anbar 2006).

3.3. Tourism

One of the sectors sensitive to global warming is the tourism sector. Countries in which the tourism sector has an important place in their GNP, especially developing countries, will be more affected by the negative effects of global warming on tourism. For example, tourism accounts for about 39% of the Bahamas' GDP. In Australia, the tourism industry is one of the industries with the highest export income. In the European Union, the tourism and travel sectors account for about 4% of the EU's GDP, and most European resorts could be adversely affected by global warming. The negative impact of global warming on the tourism industry is increasing, as travel costs will increase due to the rise in energy prices. Due to the high number of employees in the sector, there will be social impacts. Some regions may be positively affected by global warming in terms of tourism. For example, depending on the increase in temperature, the period of "sun and sand" tourism may be extended in some regions, and ecological tourism may come to the fore in some regions (Alper and Anbar 2006).

3.4. Other Effects of Global Warming

Global warming will also cause changes in the ecosystem. If the increase in global average temperatures exceeds 1,5-2,5 oC, the risk of extinction of approximately 20-30% of plant and animal species will increase. If temperatures increase by 1,5-2,5 °C and this is accompanied by carbon dioxide concentration in the atmosphere, significant changes are expected in the structure and function of the ecosystem, ecological interactions of species and geographical distribution of species. Ecosystems that are especially at risk are glaciers, coral reefs and coral islands, northern forests and tropical forests, and polar and Alpine ecosystems (Alper and Anbar 2006).

Changes made by global warming in climatic conditions, environment and ecosystem will also affect people's lives. For example, there will be migrations from regions where the effects of global warming are intense to other regions. These migrations will bring other problems with them. People will be able to accept lower salaries to work in regions with more favorable climates. In these regions, real estate prices and house rents will tend to increase. Depending on the effects of climate change, the expenses of individuals may increase (Alper and Anbar 2006).

Increasing differences between regions or countries may lead to an increase in unrest, fights and conflicts, apart from migration. Terrorist incidents may increase; regional or inter-country conflicts may occur in the sharing of water resources. Apart from sectors such as agriculture, energy and tourism, global warming will affect many other sectors directly or indirectly. Sectors most sensitive to emission reduction policies will be energy-intensive sectors such as cement, aviation, metals and mining, as well as those producing fossil fuel consuming products such as the transport sector and automobiles. Except those, food, construction, insurance and banking sectors will also be affected by global warming. Not only producers but also consumers may be adversely affected by global warming. The most important risk for consumers due to global warming will be price increases in food and energy products. In some products or areas there will be tax increases. The use of energy-efficient vehicles and equipment will be encouraged or made mandatory. In the construction of new buildings, it may be mandatory to use methods that provide efficiency and savings in energy consumption (Alper and Anbar 2006).

4. OTHER EFFECTS OF GLOBAL WARMING

Global warming has significant effects on the economies of developed and developing countries, and it is inevitable that these economic effects will reach large dimensions unless necessary emission reduction and adaptation measures are taken. Today's calculations show that the estimated economic impacts of just 1 °C of global warming could reach $ 2 trillion annually in 2050. In a study conducted within the European Union, it is stated that if effective measures are not taken against global warming, the cumulative global economic cost of global warming, with today's monetary value, can be € 74 trillion. It is predicted that the economic effects of global warming will be more severe in underdeveloped and developing countries compared to developed countries. Table 1 shows the economic effects of global warming on developed and developing countries according to the size of the temperature increase. As seen in Table 1, although a temperature increases up to 2 °C is not expected to affect developed countries negatively, temperature increases below 2 °C will adversely affect the economies of developing countries. As the temperature increase reaches high values, in other words, as the extent of global warming expands, developed countries, especially developing countries, will be affected more negatively (Alper and Anbar 2006).

Table 1: Macroeconomic Impacts of climate change

	Temperature increase	Effect of Temperature Increase
Developing countries	Temperature increase in any degree	In general, as temperatures rise, net economic loss
Developed Countries	A temperature increase of up to 2 °C	Net economic gain
	A temperature increase between 2 °C - 3 °C	Neutral or lost gain
	A temperature increase above 3 °C	Net loss

Resource: Alper and Anbar, 2006

Various studies have been carried out in order to reveal the cost of global warming on a country, region or world basis. Integrated assessment models are used, combining a simplified climate model with a global economic system model. In these models, different assumptions were used regarding temperature change levels and adaptation levels. For example, in Mendelsohn's study in 2000, the temperature increase level was assumed to be +2,5 °C and adaptation was included in the model. However, in its 1995 calculations, the IPCC hardly considered adaptation. As GNP will continue to grow over time, the same amount of costs, expressed as a percentage of future GNP, will decrease. Only in Mendelsohn (2000) the shares of costs in future GNP are taken into account. Costs and losses can be expressed in different ways. For example, costs in each region can be weighted by regional output or population to get a global figure. Costs can also be expressed using the "weighting to share" approach. According to this approach, a higher weight is given to the costs incurred by low-income countries, as costs will constitute a greater proportion of incomes in low-income countries than in rich countries. For example, in the case of a temperature increase of +2,5 °C, the global loss amount could be between 1,5% and 1,9% of the world's GNP. This ratio approaches 4% for Africa and 5% for India. In less developed and developing countries, the share of the cost of global warming in GNP is higher. If effective measures are taken against global warming, damages may be reduced and some secondary benefits may arise. For example, restricting traffic to reduce carbon dioxide emissions can prevent traffic congestion, increase regional air quality and save fuel (Alper and Anbar 2006).

There is a close relationship between economic growth and greenhouse gas emissions. The majority of greenhouse gas emissions are emissions from the use of fossil fuels. For example, in the USA, approximately 90% of the total energy used in the 20th century was met by fossil fuels and approximately 851% of the energy used in 2016 was met from fossil resources. Although OECD member developed countries and countries belonging to the former Soviet bloc account for approximately 80% of historical emissions, these countries account for only close to 20% of the world's population. In OECD countries, the annual carbon emission amount per capita due to the use of fossil fuels is approximately 3 $MTCO_2$ -eq, while the annual average carbon emission per capita in developing countries is 0.5 $MTCO_2$ -eq. There are also important differences between OECD countries. For example, whereas the US annual per capita carbon emissions in 2018 was 16.1 $MTCO_2$ -eq, this figure is 5.1 in Turkey and 3.5 $MTCO_2$ -eq in Mexico. Despite the increase in emission per capita in Pakistan, this value is 1.0 $MTCO_2$ -eq due to its high population. Overall, it can be said that people living in developed countries emit roughly 10 times more carbon emissions than people living in developing countries, and are therefore 10 times richer. It is expected that the greenhouse gas emission amounts of developed countries will decrease over time, while the greenhouse gas emissions of developing countries are expected to continue to increase. Especially, greenhouse gas emissions of developing countries such as China, India and Pakistan are increasing significantly (Alper and Anbar 2006).

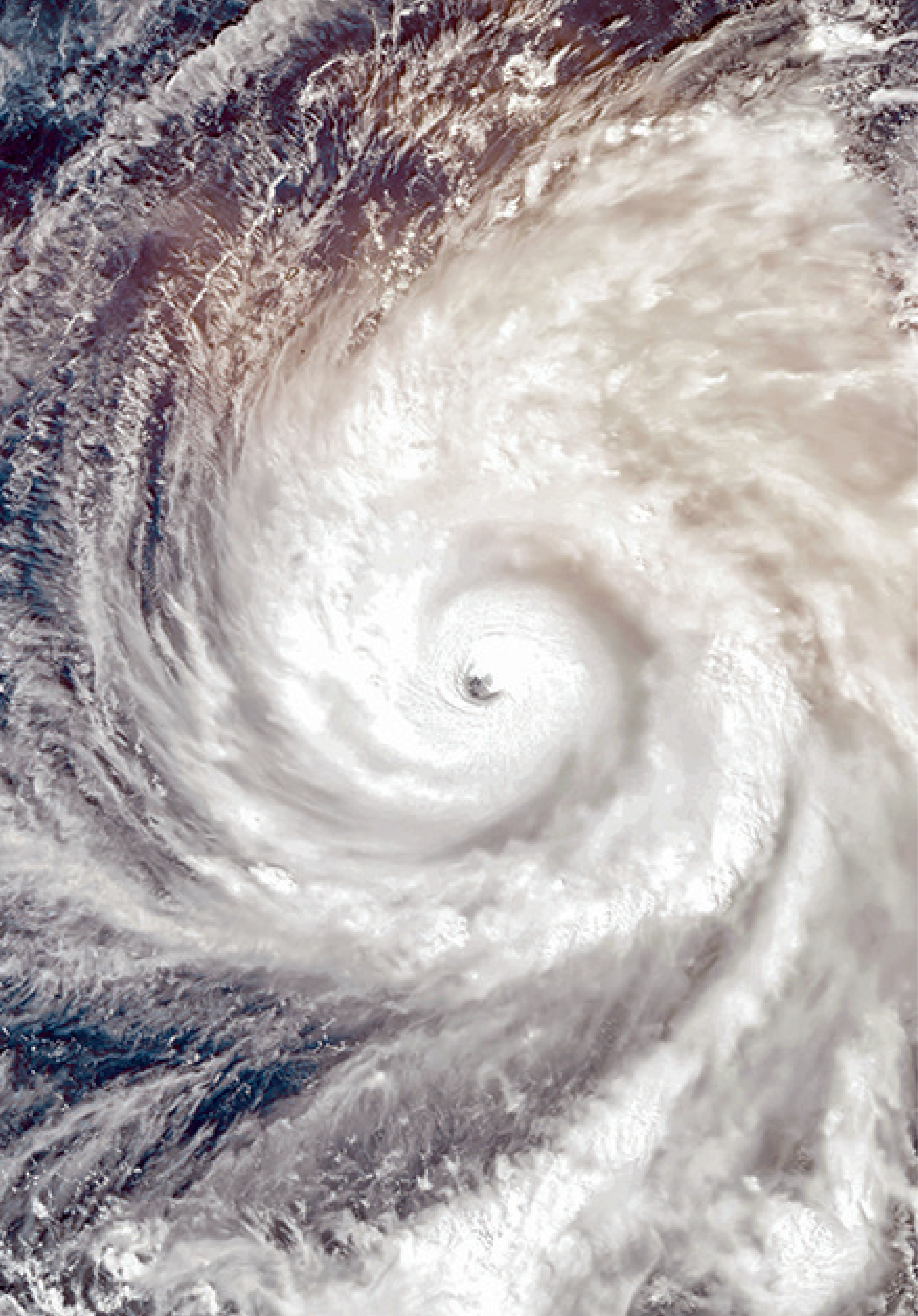
5. THE EFFECTS OF GLOBAL WARMING ON THE TURKISH ECONOMY

Although global warming is a global problem that affects and will affect all regions of the world, the effects of global warming will be different in different parts of the world. Located in a macro climate zone named as Mediterranean climate, Turkey is among the countries that will be disproportionately affected by global warming. The most important reason of this is that there is a arid zone on the east of Turkey and this zone is progressing towards north with warming. The increase in temperature of 1-3,5 ^{o}C will cause the middle latitudes to shift towards the poles by 150-550 km. But since naturally it is surrounded by sea on three sides, it has fragmented topography and due to its orographic characteristics, different regions of Turkey will be affected differently and in varying degrees by climate change (Alper and Anbar 2006).

Turkey will be affected by global warming from negative aspects such as reduction of water resources, forest fires, drought, desertification and ecological degradation related to these Depending on the growth of greenhouse gas concentrations in the atmosphere, the environmental, social and economic impacts that could be caused by global warming in Turkey are as follows:

- Turkey may be under the influence of a warmer and drier climate that prevails in the Middle East and North Africa today. The seasonal distribution and intensity of precipitation will change.
- Depending on the increase in the length and severity of the warm and dry period, the frequency, impact area and duration of forest fires may increase.
- Agricultural production potential may change (this change may be in the form of an increase or decrease according to species, with regional and seasonal differences)

- Natural terrestrial ecosystems and agricultural production systems will be damaged by increases in pests and diseases.
- New problems will be added to water resources problems in the arid and semi arid areas of Turkey, especially in urban areas; water requirement for agricultural and drinking purposes may increase even more.
- The cost of investment projects will increase as there will be "uncertainties" in the water supply systems.
- In addition to the expansion of arid and semi-arid areas, increases in the duration and severity of summer drought will support desertification processes, salinization and erosion.
- Increases in the frequency of extremely hot days can affect human health and biological productivity.
- Infections caused by changes in water availability and heat stress can increase health problems, especially in large cities. Increasing migration as a result of increasing environmental disasters, nutritional deficiencies associated with the decrease in water and food resources and increase in water-borne diseases will be important problems in terms of health.
- Parallel to the increase in the number and intensity of floods and overflows, the damages caused by them will increase.
- There may be some changes in sea currents, marine ecosystems and fisheries that can also cause significant socioeconomic problems in terms of their consequences.
- Depending on the sea level rise, the coasts of Turkey, tourism and agriculture sectors, lower delta plains and coastal plains estuarial and ria type coasts may be flooded (Alper and Anbar 2006).



6. CONCLUSIONS

▸ The global climate is already changing and will continue to change over the next decades and centuries. In many places, local trends in average temperature and precipitation due to climate change have become significant today. These significant trends allow for quite reliable projections for the future (van Aalst 2006).

▸ However, climate change is not just about gradual or linear changes. The main impacts of climate change will result from changes in climate variability and extreme weather conditions, such as those listed in Table 2 (van Aalst 2006).

Table 2: Examples of predicted changes in extreme climatic events with examples of predicted impacts

Twenty-first-century changes in extreme climatic events and their likelihood	Representative examples of predicted effects
Higher maximum temperatures; warmer days and heat waves (most likely) in almost all terrestrial areas	• Increase in mortality and serious illness among the elderly groups and the poor in urban areas • Increased heat stress in livestock and natural life • Shifts in tourist destinations • Risk of further damage to a range of products •Increased electric cooling
Higher (rising) minimum temperatures; fewer cold days, frost days and cold waves (most likely) in almost all terrestrial areas	• Decrease in morbidity and mortality rates • Less risk of damage to a range of products • Extended range and activity of some pest and disease vectors • Decrease in demand for heating energy
More heavy rain events (possibly in many areas)	• Increased flood, landslide, avalanche and mudslide damage • Increased soil erosion • Increased flood flow may increase feeding of floodplain aquifers • Increasing pressure on government and private flood insurance systems and disaster relief
Increased summer evaporation and associated drought risk (possibly) in the central parts of most latitudes far from the sea	• Decreased crop yield • Increased water resource quantity and quality • Increased forest fire risk

Twenty-first-century changes in extreme climatic events and their likelihood	Representative examples of predicted effects
Increase in tropical cyclone wind densities and increase in average and maximum rainfall intensities (possibly in some regions)	• Increased risks to human life, risk of infectious disease outbreaks and many other risks •Increased coastal erosion and damage to coastal buildings and infrastructure •Increased damage to coral ecosystems such as coral reefs and mangroves
Intense droughts and floods (possibly) associated with El Niño events in many different regions	• Decrease in agriculture and pasture productivity in drought and flood-prone areas • Decrease in hydroelectric potential in drought prone areas
Increase in Asian summer monsoons precipitation variability (possibly)	• Increase in flood and drought magnitude and damage in temperate and tropical Asia
Increased intensity of mid-latitude storms (little agreement between existing models)	• Increasing risks to human life and health • Increased property and infrastructure losses • Increased damage to coastal ecosystems

Resource: IPCC 2001a Table SPM-1.

▸ In order to benefit from more accurate information about such local knowledge on climate change, they will need to establish new collaborations between national meteorological organizations working on disaster risk reduction and development and global expertise centers on climate research. In addition, new methods and tools for disaster risk assessment may need to be adapted to identify trends that are more accurate and reliable (van Aalst 2006).

▸ However, while general patterns and trends can be reflected with reasonable confidence, some information will remain relatively uncertain, particularly regarding precise changes in risks to local scale and small-scale atmospheric events. It will be difficult to determine them in advance and to take precautions. Climate change will not only cause changes in known danger risks, but also increase the level of uncertainty and create surprises (van Aalst 2006).

▸ Disaster risk reduction and stronger development planning are crucial in adapting to the increased risks associated with climate change. This is particularly important in terms of the increasing number of people affected and the increased vulnerability to natural hazards, as reflected in increased levels of economic damage. In almost all cases, climate change is an important factor that can be incorporated into existing risk reduction strategies (van Aalst 2006).

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METEOROLOGICAL DISASTERS AND INSURANCE SECTOR

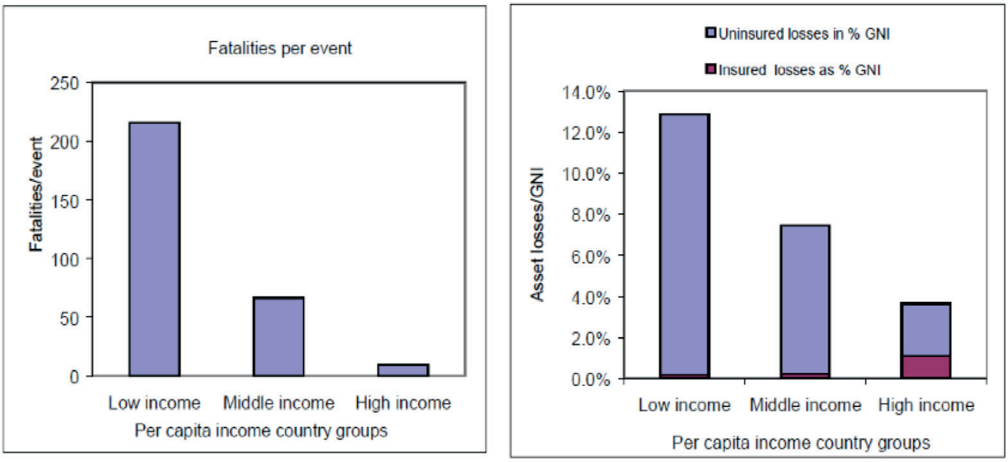
Prof. Dr. İhsan Çiçek

1. INTRODUCTION

The impact of natural hazards due to weather variability, climatic extreme conditions and geophysical events on economic well-being and human losses has increased alarmingly. More than three-quarters of recent casualties can be attributed to other hazards related to climatological and meteorological events such as windstorms, floods, and drought (UNISDR, 2020). This trend can largely be attributed to land-use changes and vulnerable areas, such as coastal areas exposed to windstorms, fertile river basins exposed to floods, and urban areas subject to earthquakes (Mileti, 1999). Climate change also has appears to be playing a role. The Intergovernmental Committee on Climate Change (IPCC, 2007) predicts that climate change will increase the intensity and frequency of weather variability and climate-related extremes (Linnerooth-Bayer, Mechler, 2009).

Low- and middle-income countries, and especially vulnerable communities in these countries, are the most affected by the harms related to loss of life and property. In the last quarter century (1980-2004), more than 95% of deaths from natural disasters occurred in developing countries, with direct economic losses averaging US $ 54 billion annually (Munich Re, 2005). This loss is constantly increasing and reached $ 175 billion in 2016 (Munich Re, 2017). During this period, deaths per event were higher in low-income and middle-income countries than in high-income countries. Again in the same period, losses as a percentage of gross national income also showed a high negative correlation with income per capita (Figure 1).

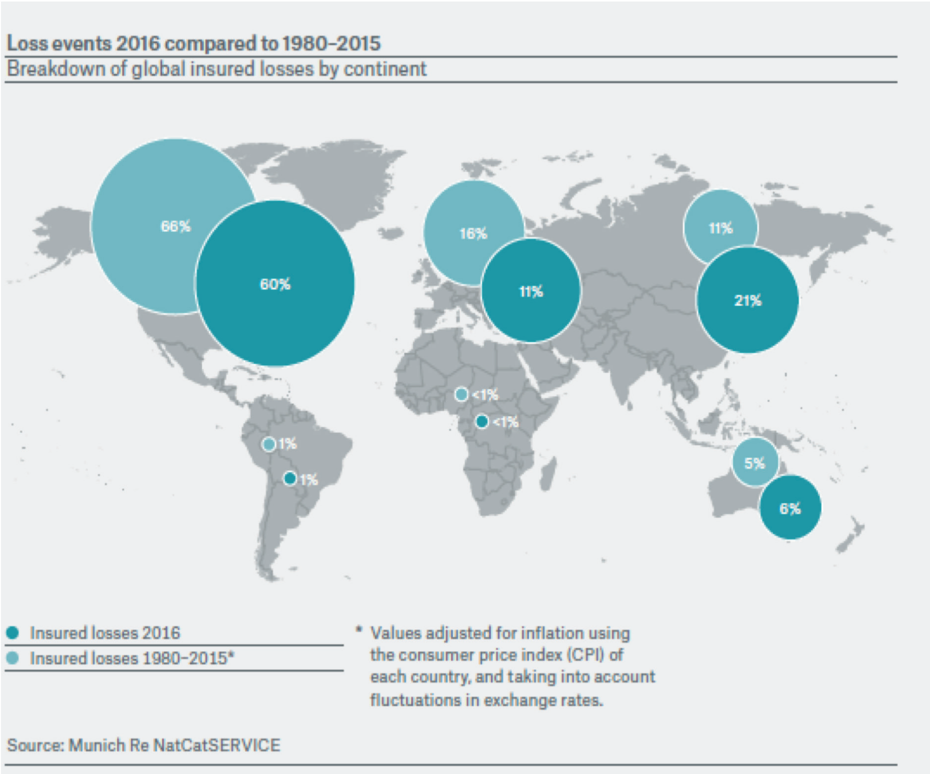
Figure 1: Differential burden of natural disasters



Resource: Munich Re, 2003

Developed and developing countries differ not only in the human and economic burden of natural disasters, but also in insurance coverage. In rich countries, around 30% of losses (about 3.7% of GNP) were insured during this period. In contrast, only 1% of losses (12.9% of GNP) in low-income countries were insured. It should be noted that these losses do not usually include long-term indirect losses, which can be very important, especially in countries with low capacity to cope with natural disasters. Along with the lack of insurance, tax bases, high level indebtedness, and limited donor support assistance, many developing countries exposed to a high degree of natural disaster are unable to raise enough capital to replace or repair damaged assets and regain livelihoods after major disasters (Gurenko, 2004). While the rate of losses due to natural disasters in North America is 60% of total losses, this rate is less than 1% in South America and Africa. In Asia, especially due to the economic development in China, the amount of goods and property insured has increased. Accordingly, there was an increase in losses insured in 2016 (Figure 2).

Figure 2: Comparison of insured losses between 1982 and 2015 with 2016



Resource: Munich Re, 2017

The problems created by the post-disaster capital gap and disaster risks are priced in global financial markets and the emergence of new insurance tools for the transfer of losses. This situation motivates governments of many developing countries, development institutions, NGOs and other donor organizations to think financial instruments more seriously as a component of pre-disaster risk management (Linnerooth-Bayer, Mechler, 2009). Donor-supported pilot insurance programs already demonstrate their potential to combine different policies to reduce economic losses and reduced revenues caused by weather variability, climate extremes and geophysical disasters. These programs provide insurance to farmers, property owners and small businesses, as well as transfer the risks faced by governments to global capital markets. Below are some examples of this.

- In Mongolia, herders can purchase an index-based insurance policy to protect them against livestock losses due to extreme winter weather. Small losses that can be covered by herders are protected, while larger losses are transferred to the private insurance sector, and catastrophe-sized losses are supported by the government (transferring some of this risk to the global financial markets).
- The owners of apartments in Turkey are required to purchase insurance to cover some of their losses from the earthquake. Policies are made affordable by the World Bank, which absorbs risk layers partially through contingent loan. This is the first project that the international development community has provided proactive risk financing support to a developing country.
- Caribbean Island States have recently created the first multi-country disaster insurance pool to receive reinsurance in capital markets to provide instant liquidity to governments after a hurricane or an earthquake.
- Since many of these and other recent insurance programs are still in pilot phase and none have experienced a major and widespread catastrophe, it is too early to fully assess their effectiveness in reducing economic insecurity. However, even if it is based on a short operating history, its effectiveness and sustainability need to be carefully studied. Disaster insurance systems in developed countries are frequently brought up by recent experience, particularly in the widespread inefficiencies of agricultural insurance systems, and insurance disputes following the Katrina cyclone that harms poor communities. Whether developing countries will follow the path of the developed world in establishing public-private partnerships against catastrophic events and which insurance tools and changes are appropriate to better tackle the developmental dimensions of natural disasters is the most important issue (Linnerooth-Bayer, Mechler, 2009).

2. DISASTER RISK MANAGEMENT

Insurance tools are just one of many options for managing natural hazards. The first and arguably highest priority in risk management is investing in preventing or reducing human and economic losses. Disaster prevention can take many forms. Methods such as reducing exposure to risks (eg land use planning), reducing vulnerability (eg retrofitting high-risk buildings) or creating institutions for better response (eg emergency planning) are effective disaster prevention methods. Today, risk management includes insurance and other risk financing strategies to provide timely relief and effective recovery. Disaster risk management therefore consists of risk reduction and coping processes (Linnerooth-Bayer, Mechler, 2009).

2.1. Disaster risk reduction

Even though families and institutions have high returns, only a small part of it is used for disaster prevention activities. In the United States, various studies show that only 10% of households in earthquake and flood-prone areas adopt mitigation measures (Kunreuther, 2006). Kunreuther attributes this lack of precaution mainly to social myopia, which seems difficult to be affected by public policies. Even with large public awareness campaigns in earthquake-prone California, there has been little change in risk perception. Policymakers facing nearsighted voters appear reluctant to allocate public resources to reduce disaster risks. This is especially true for development support institutions and donor organizations (Linnerooth-Bayer, Mechler, 2009).

According to some estimates, bilateral and multilateral donors currently allocate 98% of disaster management funds for relief and reconstruction and only 2% for proactive disaster risk management. With a few exceptions, the projects reviewed showed high benefit-cost ratios. However, assessing the costs and benefits of disaster risk reduction is difficult and complex. Because it is difficult to objectively evaluate the tools such as evaluating the risk which is one of the tools of this and making money from the benefits made from the investments made by expressing this (Linnerooth-Bayer, Mechler, 2009).

Increasing evidence of high returns on prevention investments in developing countries with high levels of disaster exposure is an important case for prioritizing disaster risk reduction. The major hurdle in this context is the lack of necessary political will, as clearly stated by Kofi Annan (1999). Creating a disaster prevention culture is not easy. While prevention costs are currently being paid, its benefits are realized in the distant future. Also, benefits are not always tangible (Linnerooth-Bayer, Mechler, 2009).

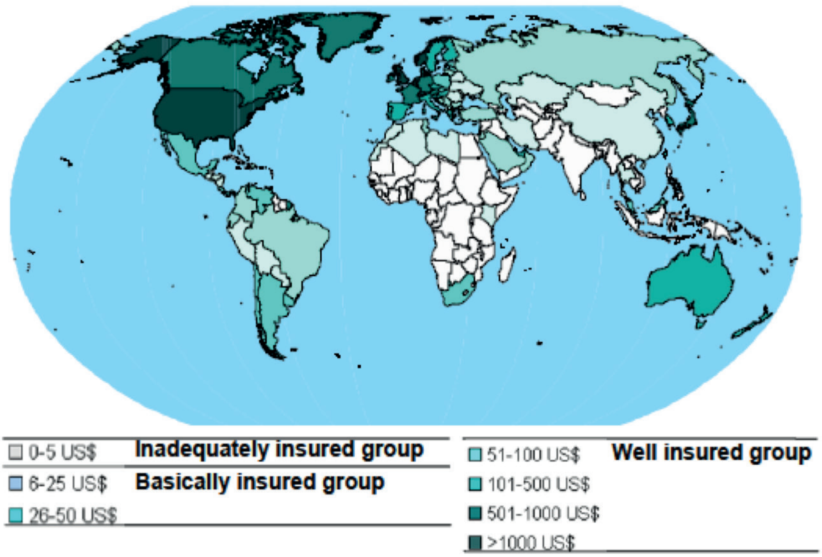
2.2. Disaster risk coping

Coping with risk through insurance and other hedging tools spread and pool risks, thus reducing the variability of losses, but not directly. Insured victims benefit from the contributions of many unaffected people by providing compensation in return for premium payment. Therefore, in the event of a disaster, they receive a larger contribution than their premium payments. However, in the long run, insured individuals or governments can expect to pay significantly more than their losses. This is due to the financial return required to absorb risks, as well as the insurance transactions and the capital allocated by the insurance companies for potential losses (or reinsurance). The "load" can be as much as 500% of the pure risk (expected losses). Still, people buy insurance because of avoiding large losses. Insurance and other risk transfer tools are justified by the concept of risk aversion (Linnerooth-Bayer, Mechler, 2009).

Globally, insurance companies have different penetration methods for disaster risks. In the United States, in parts of Europe and Australia, the average person pays more than \$ 500 annually compared to parts of Africa and Asia where less than \$ 5 premium is invested per person for disaster coverage excluding life insurance

(Figure 3). However, the averages differ greatly even within the regions themselves. For example, in Africa, while some countries have almost no coverage, in South Africa the per capita premium described above is $ 160 (Munich Re, 2003; Swiss Re, 2007).

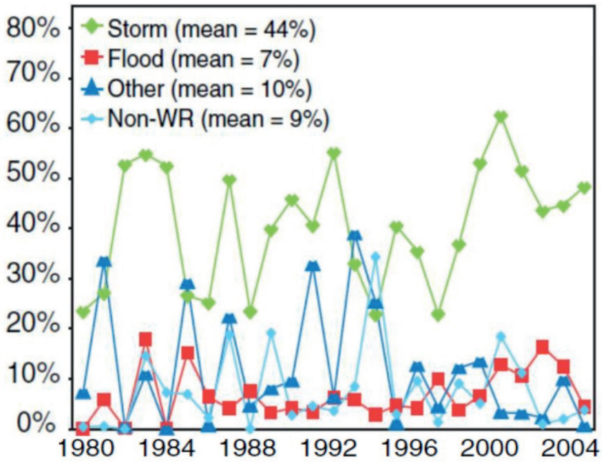
Figure 3: Global distribution of insurance premiums per capita, excluding life insurance



Source: Munich Re, 2003

The share of insured economic losses increased from about 10% in the 70s to about 25% in 2004; however, general insurance initiatives for many hazards are relatively low (Figure 4). Globally, storm risk (as it is often packaged with real estate insurance) currently covers around 50% of losses absorbed by insurance, followed by insurance for flood risk at around 10% of losses. These two disasters are the most penetrated by the insurance industry. Insurance companies have less penetration into other dangers such as earthquakes, forest fires, lightning strikes, etc. (Linnerooth-Bayer, Mechler, 2009).

Figure 4: Global disaster insurance density for different dangers



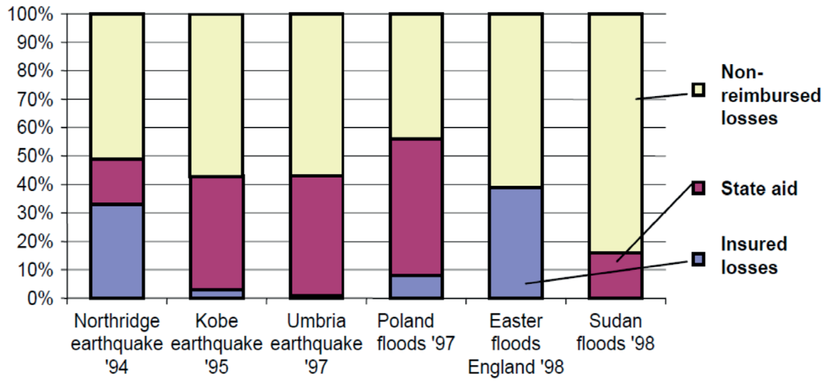
Resource: Mills, 2005

As the major disasters of recent times show, even in high-income countries, compensation for households and businesses relies heavily on public aid (Figure 5). Despite a national public-private earthquake insurance system in Japan, only 4% of damaged or destroyed homes were insured after the 1995 Kobe earthquake, so government assistance was needed for damage recovery and rehabilitation. In another example, the United States, about 30% of the total direct private and public losses from the 1994 Northridge earthquake were absorbed by private insurance companies. The federal government provided comprehensive assistance to victims and states' public infrastructure repair. In contrast, in the United Kingdom, which claims to have a 75% flood insurance rate, the government gave practically no assistance to victims after the 1998 Easter floods (Linnerooth-Bayer, Mechler, 2009).

In the least developed countries such as Sudan, where the insurance sector is not practically in place, they themselves covered more than 80% of the victims' losses from the severe flood in 1998. The state could only afford the rest with outside help (Linnerooth-Bayer & Mechler, 2007). Outside donor aid and financial assistance are temporary. Except for highly widespread disasters (eg the 2004 Indian Ocean

Tsunami), assistance is usually only a small fraction of what is needed. In the 1990s, humanitarian aid reported by the Organization for Economic Co-operation and Development (OECD) Development Assistance Committee accounted for less than 10% of disaster losses in recipient countries (Freeman et al., 2002). Post-disaster relief arrangements are not sufficient to meet relief and reconstruction needs. They also tend to be temporary and inefficient (Cardenas et al., 2007).

Figure 5: Insurance and state aid for disasters selected as a percentage of direct damages



Source: Linnerooth-Bayer, Mechler, 2007

In the absence of state aid and international assistance, pre- and post-disaster arrangements (often innovative) are needed to fund the recovery of poor victims. Insurance is just one of many different methods for this purpose (Table 1). The most usual financial method is to increase the capital needed after a disaster: Individuals rely on emergency loans from families, microcredit institutions or money lenders, selling or mortgaging assets and land, or public and international assistance. Likewise, governments raise post-disaster capital by diverting money from other budgeted programs, borrowing money domestically, or borrowing from international financial institutions (Linnerooth-Bayer, Mechler, 2009).

Many sources of funds on a local basis, for example borrowing from neighbors or family, appear to work quite well for small local events (Cohen & Sebstad, 2003), but are problematic for disasters affecting large areas or many at the same time (as co-variant or systemic risks). To guard against co-variant risks, households can deliberately exclude family members from harmful means or diversify their livelihoods. They can also organize activities, conditional savings, or food supplies that temporarily spread risks. Alternatively, households / businesses and farms can purchase property or crop insurance that temporarily and spatially spread risk. Insurance can be provided by micro insurance programs that differ from other insurance types by providing affordable coverage to low-income customers. Like individuals, governments can spread risks temporarily and spatially by establishing reserve funds or regional pools and purchasing insurance or hedging instruments (eg catastrophe bonds or contingent credit) respectively.

Table 1: Pre and post-disaster risk finance regulations

	Security for loss of assets (households / businesses)	Food safety for crop / livestock loss (farms)	Security for relief and reconstruction (governments)
Post-disaster			
	Emergency loans, lenders, public assistance	Sale of productive assets, food aid	Loans from World Banks and other IFIs
Before the disaster			
Out of market	Kinship arrangements	Voluntary mutual arrangements	International aid
Intertemporal	Micro savings	Food storage	Catastrophe reserve funds, regional pools, contingent credit
Market-based risk transfer	property and life insurance	Crop and livestock insurance (also index based)	Insurance or catastrophe bonds (also index-based)

Resource: Linnerooth-Bayer, Mechler, (2009)

Many of these risk financing methods are conventionall. Still, most importantly, index insurance and catastrophe bonds are fairly new and have been made possible by new advances in modeling risks and financial transactions. While conventional insurance is written against actual losses, index-based (parametric) insurance is written against physical or economic triggers. Index-based insurance is against events that cause damage, not against loss. For example, crop insurance may be based on a loss index determined by insufficient rainfall at key points in the growing season or by correlation between past weather events in a region and crop yields. The insurance company pays if precipitation, measured by a rain gauge, falls below a certain level regardless of crop damage. The major advantage of index-based insurance is the significant reduction in transaction costs, which hinders the development of insurance mechanisms, especially for developing countries. Th e major disadvantage is the underlying risk, which is the lack of correlation of the trigger with the loss occurred. If the rainfall measured at the weather station is sufficient, but insufficient for isolated farmers, they will not receive compensation for crop losses (Linnerooth-Bayer, Mechler, 2009).

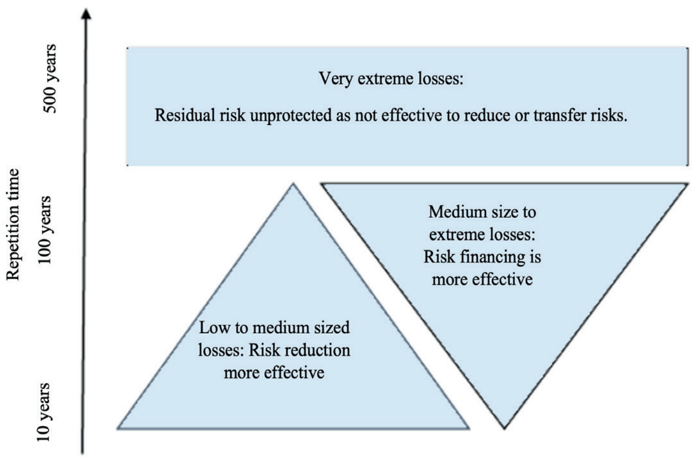
As another new insurance mechanism, a catastrophe link is a tool (can be parametric or indemnity-based) in which disaster risks are packaged (securitized) in financial markets. When a particular catastrophe does not occur in a certain time, the investor receives an over-market return but sacrifices some of the interest or principal following the event. Disaster risk is thus transferred to international financial markets, which are folds the capacity of the reinsurance market. Another advantage accrues to investors. By adding catastrophe risk to investment portfolios, the required diversification increases as natural disasters are not associated with stocks and other investments linked to economic performance. There are risks for these and other new financial instruments, especially if they are not under national or international regulations and oversight (Linnerooth-Bayer, Mechler, 2009).

2.3. Prevention and coping

How much should be invested in insurance to prevent disaster losses? This is a complex question that ultimately depends on the cost, benefits of both types of activities and their interactions (eg, through incentives, financial instruments affect prevention activities). Costs and benefits also depend on the nature of the hazard and the losses (for example, the likelihood of occurrence and exposure). One way to think about prevention and insurance is shown with the layering approach in Figure 6. In general, prevention costs increase disproportionately with the severity of the consequences (Linnerooth-Bayer, Mechler, 2009).

Therefore, for relatively frequent low and medium loss events, preventing is likely to be more cost effective in reducing losses than insurance. Moreover, individuals and governments can often fund low impact events (catastrophes) using their own means and international assistance, such as savings or disaster reserve funds. Conversely, costly risk-dealing insurance tools are often disaster bonds and contingent credit arrangements. Therefore, it is advisable to use these instruments mainly for low probability hazards with economically debilitating consequences (catastrophes). Finally, as shown in the uppermostlayer of Figure 6, most individuals and governments consider it too costly to insure against extreme risks that occur less frequently, for example, every 500 years (Linnerooth-Bayer, Mechler, 2009).

Figure 6: A layering approach for risk reduction and coping



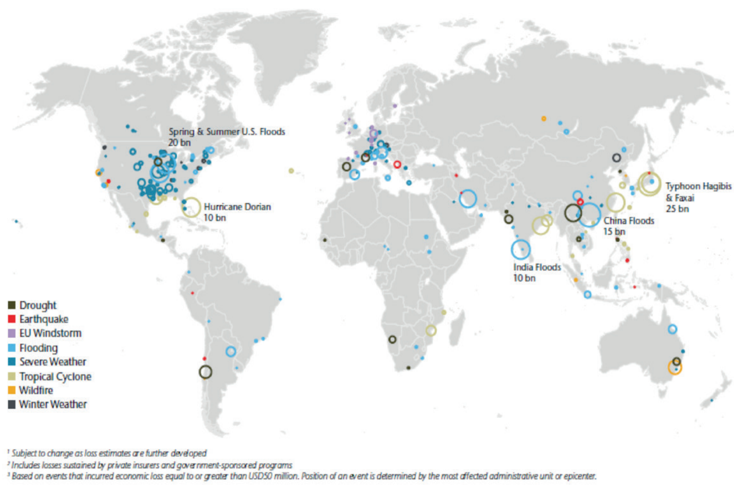
Resource: Linnerooth-Bayer, Mechler, (2009)

3. SAFETY AND NATURAL HAZARD TRENDS

In 2019, more than a thousand natural hazard events resulted in losses of US $ 232 billion worldwide. Over 90 percent of natural disasters in 2019 were linked to weather-related events, but only a third ($ 71 Billion) of resulting losses were insured (Figure 7) (Aon 2020). From 2004 to 2014, insurance companies covered 30 percent of global catastrophic losses, according to insurance company SwissRe. During this period, governments, companies, and people lost about US $ 1.3 trillion (EMCompass 2016).

Empirical evidence from the insurance industry shows that damage costs from weather-related disasters have been increasing over the past 30 years and will continue to grow as climate change increases storm, drought and flood intensity. These figures only detail economic losses and financial losses and do not capture the devastating human costs of natural disasters (EMCompass 2016).

Figure 7: Distribution of natural losses in 2019



Resource: Aon (2020).

4. CLIMATE CHALLENGES FOR INSURABILITY

İAs climate scientists are still trying to understand the physical and ecological processes affected by climate change, estimates about the magnitude and timing of expected damages vary widely, with some regions being better understood than others. Uncertainties remain regarding how sensitive climate and biological systems will be due to increasing greenhouse gas concentrations and the timing of significant changes. Even as predictive models advance rapidly, unpredictability is a major obstacle to developing an insurance approach that addresses climate risk.

Some additional factors further complicate the development and pricing of climate change insurance products, including the increasing frequency and severity of natural disasters, rapidly expanding populations, and higher wealth densities in vulnerable areas. It becomes difficult to insure the existing infrastructure built without taking into account the climate risks. These factors are important for policy markets and the insurance industry, which should be considered when developing insurance markets and other measures to manage climate change.

Nevertheless, given the early stage of insurance markets in emerging economies, there are significant opportunities to develop tools and financial products that can help manage and mitigate climate-related risks in the short and medium term and absorb the economic and financial shocks of those exposed to these risks (EMCompass 2016).

5. INNOVATIVE INSURANCE PRODUCTS AGAINST CLIMATE CHANGE

The World Bank and International Finance Corporation are making great efforts to create innovative insurance products that will be crucial for economic growth in emerging markets. They also participated in the "Global Innovation Lab for Climate Finance", which supports the identification and piloting of the latest climate finance instruments, including programs to develop new insurance mechanisms. While many of these initiatives are at an early stage, they could soon offer insights and strategies for using insurance to promote climate risk management.

5.1. Index insurance for small farmers

Index insurance can help offset 2,5 billion smallholder income by paying aid money on the basis of a predetermined index. The index used for this insurance tracks objectively determined indicators such as precipitation or animal mortality rates to estimate asset and investment losses from weather or other catastrophic events. Eliminating the need for traditional damage assessment makes the resolution process simpler, faster and more objective. Index insurance initiatives are being tested all over the world. The biggest effort is the effective implementation of the Global Index Insurance Loan, which operates in 31 countries supported by the International Finance Corporation and the World Bank, providing insurance to a total of 1.3 million farmers (EMCompass 2016).

In India, a favorable regulatory environment and effective access have led to a dramatic increase in small farmers using index insurance. As of 2012, 22 million farms are covered by a yield-based index and three million farms are covered by weather index insurance. The Syngenta Foundation in India offers farmers a product that combines weather index insurance with high-value hybrid maize seeds. Seeds sown by farmers are insured for monsoon failure with a re-cultivation guarantee.

Syngenta has a similar program in Kenya. The expanded scope of mobile phone banking also makes it possible to combine crop insurance with phone services to reduce transaction costs and reach more farmers (EMCompass 2016).

Establishing a successful, commercially sustainable index insurance program still faces many challenges, including the need for reliable local weather information, a resource many poor countries lack. Without this, payments may be wrong and farmers may not want to participate. Another challenge is that smaller farmers are unwilling to pay premiums. This results in the need for public subsidies for a program, even if it is economically viable and attractive (EMCompass 2016).

5.2. Dominant risk programs for disaster response

Disaster relief programs are primarily the responsibility of the state, and donor aid is often provided after major weather events such as tropical cyclones and floods. However, the insurance industry also plays an important role in designing and managing publicly supported post-disaster relief programs (EMCompass 2016).

For example, Africa Risk Capacity is a program that supports pre-approved disaster relief programs for participating African countries and is based on risk pooling and risk transfer. Payments are made when a pre-agreed threshold event occurs, such as a sufficiently severe deviation from normal rain levels. This approach gives countries quick access to capital when they need it most, without lengthy trading. In its first year, Africa Risk Capacity earned US $ 30 million in response to severe drought events. The World Bank Group, along with private insurance companies, supports similar programs in the Caribbean and the Pacific regions. Private insurance companies benefit from participating in these programs. Although mostly directed at governments, these programs benefit the local private sector by reducing losses to the national economy and accelerating recovery (EMCompass 2016).

5.3. Uruguay insurance for energy, drought and oil imports

As Uruguay generates a significant amount of energy through its rain-based hydroelectric power plants, energy production in the country decreases during periods of lower than normal rainfall levels. In 2012, hydroelectric production fell due to a prolonged drought, forcing the government to generate electricity from expensive fossil fuels. Another drought in 2008 caused crop losses of $ 900 million and threatened the availability of energy.

In 2013, Uruguay adopted climate insurance facilitated by the World Bank and managed by Swiss Re to insure against drought. Throughout the country's main water basins, 39 stations measure precipitation and produce daily indexes. When precipitation falls below the re-established minimum index level every few months, the insurance contract comes into effect. The amount of money used varies depending on the severity of the drought and also the oil price at the time the insurance was activated (EMCompass 2016).

CONCLUSION

Insurance products are one of many approaches that offer innovative methods to manage and reduce the economic development risks of climate change, especially in developing markets. Insurance can also help businesses and consumers withstand financial shocks caused by climate-related events, as well as be an important component to managing the impact of climate change on growth. Nevertheless, challenges remain in establishing insurance markets in these economies and developing products that manage climate change risks (EMCompass 2016).

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CLIMATE MIGRATION

Prof. Dr. İhsan Çiçek

1.INTRODUCTION

Climate change will cause population movements by making certain parts of the world less livable by increasing the frequency and intensity of floods and storms, causing food and water supplies to become more unreliable.

By 2099, the world is expected to average between 1,8°C and 4°C than it is now. Large areas are expected to be drier - the constant constant rate of dry land is expected to increase from 2 percent to 10 percent by 2050. Meanwhile, the proportion of land exposed to extreme drought is estimated to increase from 1 percent to 30 percent by the end of the 21st century. As the hydrological cycle becomes more intense, precipitation patterns will change. In some places, this means that rain will be more likely to fall into floods (washing away top-soil and causing flooding) (Brown 2008). Changing rainfall patterns and a more intense hydrological cycle are expected to become increasingly frequent and severe of extreme weather events such as droughts, storms and floods. For example, the South Asian monsoons are predicted to cause up to 20% stronger rainfall in eastern India and Bangladesh by 2050. Conversely, less rain is expected in low and mid latitudes; it is estimated that by 2050 there will be up to 10% less annual rainfall in the interior of sub-Saharan Africa. Less rain will have particularly serious implications for agriculture in Sub-Saharan Africa, which is largely rain-fed: The 2007 IPCC report of the Second Working Group estimates that yields from rain-fed agriculture could fall by as much as 50 percent by 2020. "It is predicted that agricultural production, including access to food, will be seriously affected by climate variability and change in many African countries and regions," the report said.

Climate change is predicted to worsen a variety of health problems that lead to more widespread malnutrition and diarrheal diseases and the distribution of certain disease transmission vectors such as malaria mosquitoes. Meanwhile, melting glaciers, predominantly in the Indian subcontinent, China and the Andean regions, which make up one-sixth of the world's population, will increase the risk of flooding during the wet season and reduce dry seasonal water supplies. Melting glaciers will increase the risk of glacial lake outburst floods, especially in mountainous countries such as Nepal, Peru and Bhutan (Stern 2006).

Global average sea level is estimated to rise between 8 cm and 13 cm by 2030, between 17 cm and 29 cm by 2050, and between 35 cm and 82 cm by 2100, after taking into account the uplift and subsidencel of coastal lands (depending on the model and the scenario used). Large delta systems are particularly at risk of flooding. The coastal wetlands are projected to decrease as a result of the rise in sea level. For the high emissions scenario and high climate sensitivity, wetland loss could be as high as 25 percent and 42 percent of the world's existing coastal wetlands, respectively, by the 2050s and 2100s (Brown 2008).

Depending on the future emissions scenario, the number of people affected by flooding per year is expected to be between 10 and 25 million per year in the 2050s and between 40 and 140 million per year in the 2100s. The avalanche of the above statistics becomes a simple fact - in current trends the "carrying capacity" of large parts of the world, ie the ability of different ecosystems to provide food, water and shelter for human populations, will compromise climate change (Brown 2008).

2. CHALLENGES OF CLIMATE-BASED MIGRATION

A subject that has taken a lot of media coverage is that many small island countries such as Tuvalu, Kiribati, and the Pacific island countries such as the Republic of the Marshall Islands and the Maldives in the Indian Ocean are under risk of practically being uninhabitable (or economically uninhabitable) and completely submerged. However, small island nations believed to be at greatest risk from climate change include a small portion in a larger scheme of climate-induced migration. The four island countries mentioned above have a population of about 500,000 people. The United Nations Secretary-General of Human Rights for Internally Displaced Persons has produced a useful report on situations that could cause climate-induced migration. Factors causing migration in this report are listed as: (1) "sudden-onset catastrophes" such as floods or storms, (2) "slow-onset disasters" such as sea level rise and increased salting of freshwater, (3) sinking "small island states", perhaps a specific example of a slow-onset disaster (4) "high risk areas that are very dangerous for human settlement" due to environmental hazards, and (5) "severely disturbing public order, violence, and even armed conflict" caused by the depletion of natural resources such as drinking water (Kalin, W., 2010).

There is some debate as to whether climate change will result in large numbers of migrants. More skeptical argues that estimates are based on uncertain foundations, considering that we do not know enough about the impacts of climate change and that people can adapt without having to migrate. Others object to attributing large numbers of immigrants to climate change, often due to various factors that trigger immigration decisions. These factors often include 'push' factors (such as economic conditions) that encourage immigrants to leave their homes, 'pull' factors that encourage them to choose a specific destination (such as better economic conditions and the presence of the current family), and other factors (travel cost and facilitating or including deterrent government policies). Climate change or environmental conditions more generally fit into the category of "push factors". In this context, the question arises whether, for legal or policy purposes, climate change is the sole or fundamental factor in the decision to migrate to be accepted as a cause of migration. In tort law, something is a cause of the result, if not the only reason for the outcome to occur (Leal-Arcas R.2012).

Most climate migrants are expected to move within their home countries, which may attribute at least some migration to climate change. However, some climate-related migration is likely to require international action. For example, if small island nations become uninhabitable or in severe danger, their citizens will have to settle in other countries. In other countries, people may face situations where habitable land masses or resources are severely depleted due to climate change and therefore must be transported internationally. In general, it is the extremely poor that will be most severely affected by the climate. They are all more vulnerable because of the poor, as poverty makes them less resilient and impedes their ability to adapt. Poverty also makes relocation difficult, especially due to relocation to other countries, as they lack access to resources, support and information that make cross-border travel much easier. If climate change victims are forced to relocate from elsewhere as climate migrants, unprecedented questions arise under traditional international law about the legal status of both nations and their citizens. For example, can a deteriorating State maintain sovereignty in international law if its citizens live within the borders of another country? How would this problem change if the land was completely submerged and simply uninhabitable? What about the citizens of a corrupt nation? Will they have access to a second citizenship in any new destinations? In international systems, there is limited precedent for displaced states. Australia and New Zealand have already agreed to take people from neighboring countries exposed to the consequences of climate change. On the other hand, India is concerned about the large number of Bangladeshi climate migrants coming to India in the future (Leal-Arcas R.2012).

2.1. Refugee Law

According to the definition of refugees in the 1951 UN Refugee Convention, climate change migrants are unlikely to qualify as refugees. Therefore, they cannot enjoy the protections offered by the Convention or claim refugee status under national immigration laws that follow the definition of the Convention and may provide permanent residence to refugees.

The definition of a refugee in the Refugee Convention means that he does not want to benefit from the protection of that country because of his fear of being persecuted due to race, religion, nationality, membership of a certain social group or political opinion, or because of such events a person who is not abroad, who is not willing to return because of such fear. "(1951 Refugee Convention, Article 1 (A2). Therefore, those who migrate as a result of climate change are unlikely to be considered refugees under this definition, as they are unlikely to be seen as under "persecution". Five causes of persecution are listed in the Refugee Convention: race, religion, nationality, membership of a particular social group and political opinion. So even if climate change is seen as a form of persecution, it is unlikely that migrants will be persecuted. In addition, the definition of the Convention also states that those who claim refugee status are outside the country of their nationality. Therefore, even if climate change survivors could demonstrate that they were persecuted on one of the grounds listed, they would have to leave their country to claim refugee status under the Refugee Convention (Leal-Arcas R.2012).

3. CLIMATE MIGRATION EXAMPLES

3.1. Migrations Occurring Due to Fast and Sudden Effects of Climate Change

An average of 335 weather-related disasters per year recorded by the EM-DAT (International Disasters Database) between 2005 and 2014; while it corresponds to an increase of 14% compared to 1995-2004, it corresponds to almost twice the level recorded between 1985-1994. According to the report of the World Meteorological Organization in the UN Climate Summit held in Marrakech, more than 50% of the major extreme weather events between 2011 and 2015 bear the fingerprints of human-induced global warming. According to the organization, 300,000 people lost their lives in disasters caused by climate change in the 2011-2015 period. The main ones are the drought in West Africa between 2010 and 2012, the tropical cyclone that occurred in the Philippines in 2013, and the heat waves that hit India and Pakistan in 2015 (Hood 2016). Similarly, sudden-onset disasters triggered most of the internal migration recorded in East Asia and the Pacific in 2017, with the displacement of 8.6 million people due to disasters, accounting for 46% of the global total for the same year (IDMC 2018b, Ilık Bilen 2019).

3.1.1. Floods Related Migration Movements

Climate change increases the frequency and amount of intense rainfall events. Occurring floods can cause great damage to agricultural products and livestock, and sometimes cause people to lose all their means of life and livelihoods. Similarly, floods, sewage etc. cause economic difficulties due to damage to infrastructure systems, the spread of related diseases, and the loss or damage of livelihoods. In the post-flood recovery and recovery survey, looking at long-term migration cases, it is seen that 10% of households have migrated since floods and 57% of these migrants see floods as the main cause of migration (Oudryvd. 2016, Ilık Bilen 2019).

Asia Pacific is one of the regions where migration due to floods experienced as a result of excessive rainfall is observed. In the Asia and Pacific region, migration occurs due to many factors such as labor mobility, income diversity, family reunification, as well as environmental changes, and climate change is thought to increase environmental change significantly. It is predicted that migration cases will increase even more as a result of recurrent floods to which Asian megacities will be exposed due to climate change, such as the displacement of 42 million people as a result of rapid and sudden weather events and environmental disasters in the 2010-2011 period (ADB 2012). The justification of these predictions is understood better every year. Because the Hunan floods disaster that occurred in southern China between June and July 2017 triggered the region's largest displacement, displacing more than 1,620,000 people. It is known that 547,000 people were displaced in southern provinces due to other floods (IDMC 2018b, Ilık Bilen 2019).

In Thailand, where many effects of climate change were observed, such as increasing temperature, increasing frequency of intense rain events, decreasing the number of rainy days and amount of rainfall, increasing the frequency and intensity of extreme weather events, 51 provinces were declared disaster zones in 2010 due to severe drought and water shortage. More than a few million people were affected by floods as a result of heavy rains in 2011 (Sakdapolrak 2014). In this context, the TransRe project examines the relationship between climate change, migration and social resilience in rural communities in Thailand and tries to increase empirical evidence on the current migration (Sakdapolrak 2014, Ilık Bilen 2019).

On the other hand, the International Organization for Migration states that Bangladesh has been subjected to "six severe floods in the last 25 years that displaced 45 million people" (Khatun 2013). The 1998 floods flooded 61% of Bangladesh and left 45 million homeless, displacing 650,000 by Sidr Cyclone in 2007 and 862,000 by Bijli and Aila Cyclone in 2009 (Mortreux and Adams 2015). After such disasters, migration movements are short-distance but are carried out by large groups of people, and people think that it is difficult to regain livelihoods such as fishing and farming, they prefer to migrate as a means of adaptation and migrate to urban areas in search of employment (Mortreux and Adams 2015). Field studies in Bangladesh show that floods exacerbate basic livelihood and food security difficulties for households. Currently, the practice of migration of a family member to cope with rural poverty is further increasing the environmental changes brought about by climate change. Supporting this, another study found that one-third of rural-to-urban migration in Bangladesh was caused by increased floods causing loss of arable land, and climate change contributed to economic migration as a secondary factor (Ilık Bilen 2019). In Sri Lanka, 135,000 people were displaced as a result of flood and landslide disasters in 2017, and the country's disaster management center found it difficult to accommodate people in official shelters in many regions. Undoubtedly, most of these displaced people have no homes to return to. Because, after 6 months after the flood in Nepal in 2008, it was determined that 25,000 people are still staying in camps and camp-like places (IOM 2009). On the other hand, in the field study conducted in Nepal, which was severely affected by fluvial floods, intense rainfall, decreasing water resources and landslides; sampled households do not perceive climate change as a direct trigger of migration, but it appears that uncertainties in livelihoods, which may be a manifestation of the effects of climate change and environmental degradation, may indirectly cause human mobility (IOM 2017, Ilık Bilen 2019).

In Africa and the Middle East, although drought is by far the leading edge among the effects of climate change, increasing floods also cause significant human mobility. One of the regions where floods are experienced due to strong rainfalls as a result of climate change are the eastern and southern parts of Angola. In Angola, which tries to respond to developments with methods such as disaster risk management, emergency response and disaster risk reduction, it is possible to say that the type of migration that occurs is internal migration (IOM 2009). In 2009, the third year when rainfall above normal levels fell, houses were destroyed by floods and fluvial floods that occurred as a result of intense rainfall, there were problems in access to food, social networks were weakened and many people were displaced. The steady increase in precipitation reveals the need to think of new ways to ensure food security by creating safer places to shelter and adapting agricultural activities (IOM

2009, Ilık Bilen 2019).

Ethiopia is another region that suffers from intense rainfall and periodic floods. Flood disasters caused by sudden and intense rainfall cause rivers to flood overnight and people have to leave their settlements. As a result of this changing rainfall regime, 170,000 people have been displaced, 2750 animals perished, and over 6500 hectares of land have been lost in the last five years (IOM 2009). On the other hand, floods in the Zambezi River as a result of intense rainfall in Mozambique caused the migration of 220,000 people in 2001, 110,000 in 2007, and 80,000 in 2008 (Faistve Schade 2013). Climate extremes in Mozambique cause prolonged delayed or episodic rainfall, which puts pressure on families producing along riverbeds and increases flood exposure (IOM 2009, Ilık Bilen 2019).

In August 2007, Ghana experienced an unprecedented flood that devastated the country's products and infrastructure and displaced 330,000 people (Hamro-Drotz 2014). As a result of the tropical storms and floods that occurred the following year, in the preliminary examination conducted by the United Nations Country Teams (UNCTs) in Yemen, it was determined that 700,000 people migrated (IOM 2009). As can be seen, floods and overflows are sudden disasters affecting certain areas and damaging buildings, agricultural land and infrastructure, as opposed to slow-onset disasters such as drought affecting livelihoods and large geographic areas. In the Sahara, drought-induced displacements occur gradually and mainly affect farmers and shepherds, while floods and flood displacements are more abrupt and affect both rural and urban areas (McLeman et al., 2016, 70), Of the 1.1 million displacement caused by sudden-onset disasters in Africa in 2016, 97% were due to weather-related disasters, consistent with what has been recorded since 2008. Floods accounted for 90% of the disasters and displaced a total of 977,000 people (IDMC 2017). It is seen that climate change, which increases the frequency and intensity of extreme weather events, does not complicate humanitarian emergencies in the continent only due to drought (Ilık Bilen 2019).

Similarly, even though 2014 was one of the driest years ever recorded in Brazil and water reservoirs in the most populous parts of the country are almost extinct, floods and landslides continue to increase (Ramos et al., 2016). Throughout 2017, many displacements occurred across the continent in Argentina, Bolivia, Canada, Guatemala, Nicaragua, Paraguay, Peru, Uruguay and the USA, among the countries most affected by multiple floods in the Americas. The flood in Peru, dubbed the worst of the last 20 years, is known to displace around 295,000 people (IDMC 2018a). Similarly, while rainfall in England was above average in October and November 2013; the amount of rainfall in January 2014 broke a record in the values recorded since 1910, and the amount of rainfall in February recorded since 1923, and as a result of the floods, regions still inundated in early April 2014 were seen (Gemenne et al., 2014). As a result, thousands of households had to be evacuated, some temporary and some permanent displacement (Gemenne et al., 2014). In the following year 2015, 518,000 people had to leave their homes in May due to floods that were experienced as a result of intense rains in 9 cities in the south and east of China (IDMC 2016). In the same year, 8.3 million people worldwide were displaced by floods (IDMC 2016). Floods that occurred between 1995 and 2016 affected 2.3 billion people in total (Ilık Bilen 2019).

3.1.2. Migration Movements Related to Storms and Tropical Cyclones

Although the limited strength of evidence due to the lack of long-term records in unmanaged basins makes it difficult to associate increases in the frequency and magnitude of floods with anthropogenic climate change, its role in increasing the frequency and size of storms and tropical cyclones is clearer. Global warming affects tropical cyclones by creating changes in water vapor, which is the main energy source. “Both theoretical and computer models suggest that a warmer ocean can increase the strength of tropical cyclones. Because, with additional evaporation, more water vapor is added to the atmosphere”. Storms, the deadliest type of weather-related disasters between 1995 and 2016, killed more than 242,000 people. While a longer time interval is required to determine whether an event is attributable to climate change, the current sequence of events matches the projections of the IPCC claiming that more frequent and more intense extreme weather events will occur due to global warming (Ilık Bilen 2019).

The Mitch and Katrina Cyclone, which took place in 1998 and 2005 in the Caribbean basin, where tropical cyclones with the potential for large-scale destruction are prevalent, are two well-known examples of large-scale displacement and a range of migrations. Cyclone Mitch displaced 2 million people, while after Cyclone, Texas alone admitted 150,000 displaced people (McLeman, Hunter 2010). In the study conducted by Landry et al., it was seen that after the Katrina Cyclone, about 70,000 poor black residents could not leave New Orleans, and among those who left, blacks were the smallest group that could return; similarly, Smith and McCarty's study of those who were displaced after the Andrew Cyclone that hit part of Florida in 1994 found that people living in the rich southern part of the state migrated much more than people living in the poor northern part (Faist and Schade 2013) . Another example is at the other end of the American continent. After the storm that occurred in Alaska in 2007, 250 residents had to leave their places, government funding began to be allocated to start the relocation planning process (Afifi and Jäger 2010).

Similarly, cyclones Harvey, Irma, and Maria broke many records in the Atlantic and Caribbean in 2017 (IDMC 2018b, Ilık Bilen 2019). Florida governor asks millions of people in Miami to evacuate the city as the Irma cyclone approaches; the Harvey cyclone caused unprecedented floods in Texas and displaced tens of thousands of people in Texas and 848,000 people across the United States (IDMC 2018b). Maria cyclone, which hit the Puerto Rico island in particular, is seen to have destroyed city centers and displaced tens of thousands of people (IDMC 2018b, Ilık Bilen 2019).
The Haiyan cyclone displaced approximately 4.1 million people in different parts of the Philippines, with only two percent (100,000) being resettled in one of the 381 evacuation sites, while about 4 million people remained outside these evacuation facilities and took refuge in relatives or neighboring shelters (Gemenne et al., 2014). They are the poorest and least developed regions of the country hit by the cyclone, and migration from these regions, which have very low capacity to cope with the crisis, increased after a week and the number of people leaving Tacloban reached

10,000 per day according to the report of IOM (Gemenne et al., 2014). Even a year and a half after the cyclone that killed more than 7,000 people, the government determined that 205,128 households' homes were located in unsafe areas (Sherwood et al., 2015). Similarly, as a result of the Durian cyclone, which previously occurred in the Philippines and affected 2.19 million people, 20,788 families, ie 101,000 people, applied for asylum in 338 evacuation centers (IOM 2009). In 2015, the Philippines suffered from increased weather- related disasters, similar to previous years, many cyclones occurred and the three strongest storms displaced two million people. The most severe, the Koppu cyclone hit Luzon, the largest and most populous island in the country, in October, displacing approximately 938,000 people, causing serious crop damage. The Melor cyclone resulted in 743,000 people leaving their homes on the Bicol Peninsula and Romblan Islands in December, while the Goni cyclone in August displaced more than 318,000 people in the north of the country (IDMC 2016). Three large-scale cyclones and one flood triggered 75% of the displacement in China that same year. Chan-Hom, Soudelor, and Dujan cyclones entered the four eastern provinces between July and September, destroying homes, causing landslides and flooding, and displacing more than 2.2 million people (IDMC 2016, Ilık Bilen 2019).

We see a series of cyclones in South and East Asia and the Pacific displacing large numbers of people in 2017 as well. For example, the Mora cyclone displaced people from South Asia, Bangladesh, India and Myanmar, as well as people from the Rohingya refugee camp in Bangladesh (IDMC 2018b). That same year, the tropical storm Tembin hit 865,000 people in Vietnam and the Philippines; Kai-tak displaced 765,000 people in the Philippines and Malaysia (IDMC 2018b). In Vietnam, which is highly risky and vulnerable to sudden weather events, a total of 633,000 people were displaced in 2017 as a result of 10 weather events, including the Tembin storm, the Doksuri cyclone and the Damrey cyclone (IDMC 2018b). Although most of the displacements associated with the disasters in Vietnam have been achieved in the form of preventive evacuation, the government's predictions that the intensity and unpredictability of cyclones occurring in the south of the country will increase due to climate change (IDMC 2018b). The results of a study examining the effect of extreme weather events, which are increasing in the country, on internal migration movements show that the increase in temperature and increasing cyclone activities increase migration, but the increases in precipitation do not have a consistent effect (Bohra-Mishra et al., 2017). Due to the negative effects of increasing typhoons on paddy production, migration from regions with high rural population is seen more, and it was revealed that the migration decisions of young people and individuals with high education levels are more sensitive to cyclones (Bohra-Mishra et al., 2017, Ilık Bilen 2019).

In Madagascar, one of the most vulnerable countries in terms of tropical cyclones in Africa, 340,000 people were displaced as a result of cyclones that occurred 3 times in 2008 (IOM 2009). Approximately 2.4 million people were affected by the Nargis Cyclone, which occurred in Myanmar in early May of the same year, and 240,000 displaced people settled in rural camps where humanitarian aid was delivered in the third week of May (IOM 2009). In 2015, the effects of the Komen cyclone displaced more than 1.6 million people in Myanmar in July and August; the country's twelve provinces have suffered widespread damage; the government declared the worst affected Chin and Rakhine states and Magway and Sagaing regions as disaster areas (IDMC 2016). In the same year, it is seen that the trigger of the biggest displacements in Bangladesh was the Komen cyclone. The cyclone displaced 331,000 people in the southeast of the country at the end of July (IDMC 2016). In November of the same year, intense rains and flash floods associated with a weak tropical cyclone tracked across the Bay of Bengal resulted in the displacement of 1.8 million people in the states of Tamil Nadu and South Andhra Pradesh (IDMC 2016). Thus, it is seen that the number of people who were in place due to sudden air disasters reached 6.3 million in 2015 (IDMC 2016, Ilık Bilen 2019).

Similarly, 800,000 people were directly affected by a series of tropical cyclones that took place in Haiti in 2008, of which 100,000 had to migrate (IOM 2009). Although not as many as cyclones, storms create serious migration movements. It is known that in Cambodia, which has flat plains and plateaus, the frequency of storms will increase and the costs associated with floods will increase accordingly (Oudry et al., 2016). Parallel to other examples, as a result of the storms in Cambodia, more temporary migrations are seen to occur, and more scientific evidence is needed to determine the circumstances in which temporary migration from rural to rural, rural to urban, or international temporary migration turns into permanent migration (Oudry et al., 2016).

3.2. Migrations Occurring Due to Slow and Gradual Effects of Climate Change

It is possible to give many examples of the slow and gradual effects of climate change such as sea level rise, rising temperatures, ocean acidification, glacial retreat, salinization, soil and forest degradation, biodiversity loss and desertification. It is not easy to distinguish the migrations that occur as a result of these effects from other types of migration. The slower manifestation of the effects also causes them to be intertwined with different dynamics. In such cases, climate change acts more like a threat multiplier. However, it is thought that the number of people displaced may be higher than those displaced due to sudden disasters due to the slow onset and gradual effects (Gemenne et al., 2014). There are also highly vulnerable areas that are exposed to more than one of these effects simultaneously. For example, countries within the MECLEP (Migration, Environment and Climate Change: Evidence for Policy) Project are good examples of rapid and sudden emerging effects, as well as slow and gradual effects. In five of the six countries surveyed (Dominican Republic, Haiti, Kenya, Papua New Guinea and Vietnam), the link between impacts and migration has been identified (Kelpsaite and Mach 2015). While these migrations occur mostly in the Dominican Republic, Haiti and Kenya from rural to urban; they occur in the form of displacement-resettlement in Papua New Guinea and Vietnam (Kelpsaite and Mach 2015, Ilık Bilen 2019).

Drawing a clear picture of displacements associated with slow onset events; this phenomenon is difficult because of the wide range of effects, drivers, types of movements it causes and the regions it affects. For this reason, it is very important to understand how displacements occur in different situations based on concrete examples, in order to develop appropriate policies (IDMC 2018a). Based on this, in the following sections, migration movements related to sea level rise and drought-desertification, which have a wide impact, have been examined (Ilık Bilen 2019).

3.2.1. Migration Movements Associated with Sea Level Rise

The melting and volume loss in the snow cover and glaciers, which manifest itself in the Northern Hemisphere, and the retreat trend in the cover glaciers continue. Additionally, the Antarctic ice sheet is expected to gain mass due to more precipitation, while the Greenland ice sheet is expected to lose mass. The glacial melting, which occurs as a response to the rise in the mean temperature of the earth, combined with the expansion created by the warming in the oceans, makes sea level rise inevitable. The problem is that the ocean level will continue to rise in the following centuries, even if the mean temperature of the world stabilizes in 2100, due to the expansion and long-term melting that will occur as warming penetrates to the deeper layers of the ocean over time (Denhez 2007). This increase causes the loss of fertile soil and land, makes agriculture difficult in the soil with increasing salinity, causes the loss of fresh water and ecosystem (Stabinsky and Hoffmaister 2012, Ilık Bilen 2019).

In addition to the advantages of being a developed country, with the knowledge and experience of having to overcome the water management for centuries in the context of the economic and social sustainability of the country (Van Koningsveld et al., 2007) the Netherlands, as a country under threat from sea level rise, follows successful adaptation policies implemented with the conscious support of public in the fields of water management, protection against floods (fortification of existing embankments on coasts and river banks, addition of new embankments and weirs etc.), management of drinking water supply and protection of Rotterdam Port (Kwadijk et al., 2010). However, it is not that easy for many other developing countries (Ilık Bilen 2019).

Due to sea level rise by 2050, 37.2 million in India, 27 million in Bangladesh, 22.3 million in China, 20.9 million in Indonesia, 13.6 million in Philippines, 9 in Vietnam, 5 million and 9.1 million people in Japan are seen at risk (ADB 2012). In addition, according to the report of the Climate Center named "Map of Preferences: Carbon, Climate, Sea Level Rise in Our Global Heritage", if global warming is 4 ˚C, the increase in sea level will cause 570 to 760 million people worldwide, and 130 million if 2 C, to be affected. Thanks to local assessments on migration patterns, climate impacts and vulnerability, it is possible to identify the areas where climate-related migration may occur and the processes through which these migration flows will occur. It is predicted that less than 15% of the populations of countries such as Thailand, Myanmar, Cambodia, Philippines, Indonesia, China, Malaysia, Korea and Papua New Guinea will be affected from a sea level rise between 1 and 5 meters, while about 40% of the Vietnamese population is predicted to be affected (ADB, 2012). On the other hand, sea level rise and coastal erosion threaten 86% of coastal villages in Alaska (Piguet et al., 2011). When sea level rise is added to the melting of the permafrost layer, it is stated that the inhabitants of parts of Alaska may be America's first climate immigrants (Ilık Bilen 2019).

Undoubtedly, the most prominent actors of the literature on migration due to sea level rise are small island states whose habitats are in danger of being completely submerged, namely the modern Atlantis case (Cameron 2018; Locke 2009; ADB 2012; Kelpsaite and Mach 2015; Allgood and McNamara 2017) Stojanov et al., 2018). Most of Kiribati, one of the lowest areas in the world, is only one to two meters above sea level, and the rate of increase in sea level in the Western Pacific is four times the global average, as World Bank research indicates that most of the capital will be flooded by 2050 (Ni 2015). It has been observed that a planned migration will be most beneficial for both Kiribati and neighboring countries that accept immigrants (Ni 2015). In this context, the slow and gradual effects of climate change in the Pacific offers a unique opportunity to plan, develop and implement migration strategies, and lead the formation of regional, national and international laws and policies (Ni 2015, Ilık Bilen 2019).

In Kiribati, where sea level rise makes long-term sustainability of life very difficult, a study reveals that the most important problem for the island people to maintain their livelihoods is climate change (Allgood and Mc Namara 2016). Because of the rising sea level, salt water leaks into freshwater aquifers, which increases the pressure on the already limited water and food resources. It is precisely for this reason that projections of how much of the island will be inundated in how many years do not mean much because life became unsustainable long before that time. Stating that they are currently forced to move temporarily or permanently and demand assistance from the state to adapt to the local impacts of climate change, they state that they will migrate as a long-term adaptation strategy against climate change (Allgood and Mc Namara 2016). The Kiribati government aims to keep its population in balance with 125,000 people through population planning and largely inter-island displacement by 2025 as part of its climate change adaptation strategy (Locke 2009). Similarly, the government of Papua New Guinea has allocated funds to evacuate the Carteret Islands due to sea level rise in 2003 and gradually relocate elsewhere by 2020, mostly in the surrounding area of Bougainville (Challen 2010, Ilık Bilen 2019).

Another group that sees slow onset effects of climate change, such as sea level rise, as one of the main problems affecting their livelihoods, is the inhabitants of the Maldives. However, it is seen that the island people approach the issue differently at national and individual levels. They acknowledge that sea level rise is a serious problem at the national level and migration from the islands to other countries may be a potential option, but it seems that they pay more attention to cultural, religious, economic and social factors rather than this problem in their individual migration decisions (Stojanov et al., 2017). Tuvalu, another place affected by sea level rise, planned to immigrate to Australia and New Zealand in 2001 as a result of the danger it faced; while Australia denies this due to strict immigration policies, New Zealand (Cameron 2018), which has emerged with projections of high adaptation capacity to climate change, has accepted to take 75 Tuvalu residents every year (Locke 2009). The 75- person quota each year is not a long-term solution because at the recommended rate, Tuvalu will not be evacuated for more than 100 years. However, if the negotiations with New Zealand continue in a positive way, it is foreseen that the Tuvalu people will move to New Zealand permanently without serious negative effects (Locke 2009, Ilık Bilen 2019).

Although it is seen that the small island states have more coverage in the media due to the sea level rise and the region is concentrated in the literature, the effects are of course not limited to this region. On the contrary, some regions face very serious problems, especially in terms of population density. For example, another area affected is the Nile Delta in Egypt. As a result of the effects experienced in this region, internal migration is experienced and there is a potential for regional and international migration. It is estimated that a 50 centimeter increase in sea level by 2025 will displace 2 million people and flood 1800 square meters of agricultural land, threatening the coastline on the Red Sea and adversely affect the tourism sector (IOM 2009). In this context, migration strategies that will reduce existing vulnerabilities and increase resilience are focused on as an adaptation strategy (Ilık Bilen 2019).

In Bangladesh, it has been accepted that environmental degradation and disasters due to climate change will be followed by population movements (Hillmann et al., 2015). Islam et al., (2014) examined how climate change migration affects vulnerability and adaptation, comparing a coastal fishing community resettled in Bangladesh due to sea level rise and increased floods with a community that did not migrate but remained in place. In 2010, 2011 and 2013, surveys, interviews, and focus group surveys were conducted on two communities that were equally vulnerable before relocation in the 1990s and had equal adaptation capacity. The findings reveal that migrant communities are less affected by climate shock and stress, have more livelihoods, benefit from higher income opportunities, health and education services, and access technology more easily. These findings demonstrate the function of migration in increasing the capacity for adaptation to climate change and reducing vulnerabilities (Islam et al., 2014, Ilık Bilen 2019).

3.2.2. Migration Movements Associated with Increasing Temperatures, Drought and Desertification

Although there is much emphasis on the potential of climate change to cause international displacements, studies show that this is largely at the level of internal displacement. Because long-distance migrations require serious resources and climate change effects such as drought increase the pressure on resources considerably (IDMC 2017, Ilık Bilen 2019).

As known, one of the effects of climate change that develops slowly and gradually is increasing temperatures. As temperatures increase, fertile soils disappear, decreasing rainfall and increasing evaporation result in losing soil moisture and decreasing agricultural productivity brings livelihood problems, and temperatures pose a threat to human health (Stabinsky and Hoffmaister 2012). The loss of productive land that comes with drought and desertification causes livelihood difficulties, making migration the primary option (Stabinsky and Hoffmaister 2012, Ilık Bilen 2019).

One of the places where droughts increasing due to the effects of climate change are most clearly observed is North Africa and the Middle East Region. According to the results of a qualitative study of households in five countries (Algeria, Egypt, Morocco, Syria, Yemen) in this region, more than three-quarters of households reported that rain became more episodic and almost three-quarters had higher temperatures, with about two-thirds of households going back to five years, there is less rainfall than the land, the land is dry or less productive, the rainy season starts later, lasts shorter and ends earlier, and droughts are more frequent (Wodon et al., 2014). Immigration is one of the mechanisms used to cope with the effects of climate change, indicating that three out of ten households are immigrants, since in parallel with the effects, most of the migration took place in the last five years (Wodon et al., 2014). The study shows that worsening climatic conditions increase temporary and permanent migration in the region, climatic factors affect migration between one tenth and one tenth of the regions most affected by climate change, but this rate will increase as the climate conditions continue to cause deterioration (Wodon et al., 2014; Ilık Bilen, 2019).

Israel, Jordan and Syria, which are part of the Eastern Mediterranean, experienced prolonged droughts in the 2000s as regional climate change models predict that the frequency and duration of severe drought in the Eastern Mediterranean will further increase as a continuing consequence of climate change (Weinthal et al., 2015). It is known that 40,000-60,000 families living in drought-affected areas across Syria migrate in search of better living conditions due to water and food shortages after a long drought (IOM, 2009). It started with a peaceful demonstration and announced that more people lost their lives to a bloody conflict and then the civil war, an estimated more than 9 million people were forced to flee their homes, more than 2,5 million people applied for refugees to neighboring countries, and over 6,5 million domestic and abroad displaced population has exceeded 40% of the country's population (GAR, 2015; Ilık Bilen, 2019).

Increasing urbanization rate and economic growth, as well as regional trends such as environmental degradation, water scarcity and the impact of climate change, all have an impact on inland migration flows in Africa (IDMC, 2017). However, addressing climate change and environmental degradation in rural and marginal areas offers an opportunity to capture the root causes of displacement in slow-onset crises (IDMC, 2017). The results of 13 separate case studies conducted in Africa show that migration during drought periods mostly occurs within the country (Jónsson, 2010). Kniveton et al., cite the first studies revealing the link between drought and migration in their study prepared for the International Organization for Migration. The first of these is about the migration from rural Mali, which experienced drought between 1983-1985. Findley (1994) found in this study that while short-distance migrations by children and women to find jobs to contribute to household income during drought periods increased, long-distance migrations decreased due to rising prices and resources spent on basic needs due to food shortages. In another study, Haug (2002) stated that those who did not migrate as a result of the drought in Northern Sudan in the 1980s had to stay behind because they did not have animals to migrate, even if they faced the danger of starvation, and in this case, socio-economic factors determined the migration decision. Similarly, Meze-Hausken's (2004) study in Northern Ethiopia reveals that drought alone does not cause migration thanks to the adaptation mechanisms that people in marginal regions have created. In a study by Henry et al., (2004) investigating the effects of changing rainfall patterns on migration in Burkina Faso, it was found that people living in regions with low precipitation have a higher rate of participating in short-distance migration compared to people living in other regions (Kniveton et al., 2008, 33), Another more recent study shows that the increase in heatwaves in Burkina Faso lowers the rate of international migration (Nawrotzki et al., 2016b, Ilık Bilen 2019).

As a result of the long-term drought in Mali in the 1980s, Faguibine Lake was completely destroyed in 2006 and 100,000 people migrated as a result of the climate change in this system, and 300,000 refugees and internally displaced people emerged to be displaced as a result of Tourag Rebellion caused by lessening resources (IOM 2009). According to the research conducted by Abu et al., (2014) in Ghana, more than half of the participants (54%) stated that they have a tendency to migrate in the next 5 years due to droughts and fires largely due to rainfall irregularities. The study shows that rural-to-rural migration is not preferred due to the fact that drought is seen in almost all rural areas and it will lead to similar food problems and livelihood difficulties, rather than rural to urban migration is seen as rational (Abu et al., 2014). The impact of decreasing rainfall due to climate change on agricultural productivity in the region turns into food insecurity and economic difficulties in the region, which is a big problem considering the large population of households (Hillmann et al., 2015). Gemenne et al., (2014) stated that the drought trend that started in Angola in 2011 with the decrease of the amount of rainfall below the average has been exacerbated by the precipitation amount falling below 60% of the normal since 2011-2012, and this decreasing trend continued in 2013 and almost Angola and neighboring countries with no rainfall because the International Organization for Migration (2013) thinks that 227,000 people have become internally displaced people after what happened in 2011 (Gemenne et al., 2014, Ilık Bilen 2019).

Another study conducted in South Africa reveals that migration flows increase during periods of maximum temperature anomalies, negative rainfall anomalies and increased moisture loss in the soil (Mastrorillo et al., 2016). The study also shows that the relative impact of climate change varies significantly among immigrant groups, with black and low-income South Africans in particular being the most affected (Mastrorillo et al., 2016). Severe drought combined with intense political violence and general administrative errors in 2011 caused widespread distress, which also led to famine declaration in some parts of Somalia, followed by high levels of domestic and overseas forced migration resulting in displacement of a quarter of the population (Lindley 2014). In a study conducted by the Food Safety and Nutrition Analysis Unit in Somalia in 2011, 60% of the participants stated that they were displaced due to drought (Lindley 2014, Ilık Bilen 2019).

The research conducted by Afifi (2011) on people who migrated from Niger and tried to determine the root causes of their migration shows that almost all participants were affected by environmental factors in their decision to migrate. Although it was understood in the interviews that migration was mostly carried out for economic reasons at the beginning, it is seen that the direct environmental factors, increasing drought and the shrinkage of Lake Chad lie at the bottom of them (Afifi 2011). Chad Basin is a good example of the link between climate change, water and displacement, due to the increasing temperatures due to climate change and Lake Chad, which shrinks by more than 90% as a result of population growth. Because of their livelihoods, more than 20 million people from Cameroon, Chad, Niger and Nigeria rely on Lake Chad and shepherds, farmers and fishermen are increasingly forced to migrate (IDMC 2017, Ilık Bilen 2019).

In the study of Barrios et al., (2006) investigating whether climate change, which manifests itself as a decrease in precipitation, can explain the various urbanization patterns in sub-Saharan Africa, it was revealed that urbanization rates increased during periods of decrease in precipitation. In addition, this ratio increased with the independence following the colonial process that prohibited the free intra-continental movement of indigenous Africans. Conflicts due to dwindling resources are not new in Sudan, but drought, one of the long-term effects of climate change, also acts as a threat multiplier here. For example, the crisis in Darfur displaced 2 million people and led to the construction of camps for hundreds of internally displaced people (IDPs) (IOM 2009, Ilı Bilen 2019).

As mentioned in many studies, climate change causes mobility as well as the inability of some groups to move in any way. For example, the results of the study by Nawrotzki and DeWaard (2018) examining the relationship between adverse climatic conditions and migration flows in 55 districts in Zambia reveal that the relationship between adverse climatic conditions and migration is only positive for the rich regions sending immigrants, and on the contrary, the poor regions are characterized by inactivity associated with climate. Especially in terms of slow onset impacts, the thesis demonstrates itself that climate change is not always a driving factor for migration, but on the contrary, the most vulnerable groups are too poor to migrate. However, the findings of the study reveal that access to migrant networks provides climate-related mobility in the poorest regions and that these networks are a viable way to overcome mobility constraints (Nawrotzki and DeWaard 2018, Ilık Bilen 2019).

As is known, in labor migration, it is very common for one of the households to send the money earned by migration to those who remain behind. It is possible to see that adapting to climate change and migrating households have a similar function. For example, a field study in northern Kenya, where climate change affects rural residents in arid and semi-arid areas, shows that migration and agricultural innovations complement each other in the face of shocks from weather events, one not being preferred over the other. At least one individual migrating from the household helps the household to overcome the high costs of agricultural innovations needed, thereby ensuring that the household protects itself against shocks caused by climate change (Ng'ang 2016, Ilık Bilen 2019).

It is quite possible to come across mobility examples due to drought and desertification in Asia, too. For example, a 21-year (1991-2012) long-term field study by researchers from the International Food Policy Research Institute and Carolina Population Center in rural Pakistan reveals the link between extreme climatic events and migration. According to the research, while both men and women are more active in periods of extreme temperature compared to normal periods, there is not much difference in periods of extreme precipitation (Bremner and Hunter 2014, 7). Similarly, in the field study conducted in Hindu Kush Himalayas, 80% of the migrating households stated that the threat of water is an important factor in their decision to migrate (Faist and Schade 2013). Among the multiple causality characteristics of migration, water threats that increase as a result of climate change appear to play an important role (Ilık Bilen 2019)

Central Mongolia, another region whose rate and scale of environmental degradation has increased with the increasing effects of climate change, faced problems such as desertification, pasture degradation, soil erosion, drought and water scarcity in the last decade (Gemenne et al., 2014). Within the framework of the Tenth National Five-Year Plan, a 6-year migration plan was prepared, which designed the displacement and resettlement of 650.00 people in environmentally fragile regions and affected by desertification, water and soil degradation, and between 2006 and 2010, 304 thousand people were resettled in Central Mongolia (Gemenne et al., 2014). In general, in Mongolia, there has been rural poverty and urban migration due to a 2 °C warming trend and continuous drought since 1940. Climate change makes it economically impossible to adapt to climatic challenges, and here also acts as a threat multiplier for farmers (Chatty and Sternberg 2015, Ilık Bilen 2019).

Regarded as one of the most vulnerable countries in the world regarding climate change due to its environmental stress rate, sensitivity rate and poor adaptation capacity, Cambodia is already experiencing water shortages for both agricultural production and personal use. However, this problem is expected to get worse as a result of increasing drought caused by climate change. For example, the droughts that occurred one after the other in 2001, 2002, and 2003 affected especially some regions of the country very negatively, as the damage caused by the drought between 1987-2007 was 138 million dollars (Oudry et al., 2016). Unlike floods, storms, or cyclones, the slow onset nature of drought and its evolution and transformation over time make it difficult to understand in-depth coping strategies, including migration, as well; in Cambodia, robust data on drought-induced migration are critically incomplete (Oudry et al., 2016, Ilık Bilen 2019).

The field studies conducted in Mexico, on the other hand, provide us with a different picture of the way climate change-induced migration occurs. Contrary to the cases in Africa, results from the multilevel discrete-time event history models in Mexico in 1986-99 challenge the assumption that climate-related migration will be predominantly short-distance and local; instead, it shows that climate change is more strongly affecting international movements from rural Mexico (Nawrotzki et al., 2016a. With the existence of strong migration networks and wage differences arising from climate change, in the years following international migration due to climate change, it is possible to encounter climate change-induced migration cases in different regions of Mexico. As a result of the analysis of the situation of peasants working in temporary agricultural production in San Luis Potosi and Zacatecas between 2000-2010, it was seen that migration was a result of adverse economic-climatic conditions (Aragonés Castañer 2017, 384). In the same period, it is seen that the rate of migration from rural to urban increases by 3.6% in each additional drought period (Nawrotzki et al., 2017). It is understood that poor groups who live directly dependent on natural resources see international migration as the only way to overcome their vulnerability (Aragonés Castañer 2017, Ilık Bilen 2019).

The results of a study conducted in Northwest Nicaragua, on the other hand, reveal data to question the understanding of "migration as a type of adaptation". Findings obtained from household questionnaires, qualitative interviews and focus group interviews show that household labor migration neither facilitates adaptation to climate change nor is the result of adaptation. It points to the weak position of the squeezed small farmers, mostly due to the tightened power relations and land scarcity. The research reveals that labor migration barely makes semi-subsistence agricultural production possible and increases existing inequalities (Ilık Bilen 2019).

4. CONCLUSION

Anthropogenic climate change further increases existing environmental, economic and social vulnerabilities. Consequently, climate change adaptation should be broader than tackling the marginally increasing impact of anthropogenic climate change. Focusing on the ineffective effects of climate change in the local context leads to some strange policy distortions. In the Philippines, for example, policy makers have begun to acknowledge the projected flood threats of annual sea level from 1 to 3 millimeters of climate change per year. But they are also unaware of or ignore the excessive groundwater pull that lowers the land surface by a few centimeters a year, which is one of the main reasons for increasing flood risk.

In current climate change scenarios, migration due to enhanced climate change is a key point. However, the amount of this depends on how well international societies adhere to the mitigation and adaptation plans. The international community should not be faced with the prospect of massive displacement from climate change. The problem needs international recognition, a better understanding of its dimensions, and a willingness to deal with it. This can happen in several ways.

1. The international community must formally acknowledge the impasse of forced climate migrants. While it is not clear that an expanded definition of refugee that includes environmental degradation as a “valid” driver of displacement will provide clear benefits for all (traditional and environmental) refugees, some form of international awareness needs to keep the position on the international agenda.

2. The development and adaptation policies of forced climate migrants in potential source countries should focus on reducing people's vulnerability to climate change, moving people out of marginal areas and supporting more resilient livelihoods. Especially, more efficient use of existing resources will offset some of the predicted effects of climate change. For example, irrigated agriculture in Pakistan uses 85 percent of the country's fresh water supply, but leakage and evaporation mean 50 to 65 percent of it is efficient.

3. More research is needed to understand the causes and consequences of climate migration and to track numbers. Meanwhile, practitioners should develop better communication and working relationships between different human rights, population, environment, and migration organizations that share authority to respond to population displacement.

4. Finally, the international community needs to help developing countries generate incentives to retain skilled labor, as well as allow developing countries to take advantage of the benefits that streamlined labor markets can bring. The international regulation of labor migration is inherently intertwined with climate change adaptation and capacity building in vulnerable countries. Migration will be used by some households in vulnerable countries as a means of adapting to climate change. Obviously, there must be a policy balance that supports incentives for workers to stay in their home country while not closing the door to international labor mobility (Brown (2008).

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