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MODULE 3

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

AC	Adaptation Capacity
ACCI	Adaptation Capacity to Cope with Impacts
ACRI +	Advancing Climate Risk Insurance
ADIS	Animal Diseases Information System
AFAD	Disaster and Emergency Management Authority
BaltCICA	Climate Change in the Baltic Sea Region: Impacts, Costs and Adaptation
BECCS	Bioenergy with carbon capture and storage
BEPA	Biomass Energy Potential Atlas
BFY	Biophysical Approach
BGB	Underground Biomass
BMZ	German Federal Ministry of Economic Cooperation and Development
BOTAŞ	Petroleum Transport by Pipelines Joint Stock Company
CARICOM	Caribbean Community and Common Market
CASA	Global Ecosystem Modeling for Greenhouse Gases from Satellite Data
CCAP	Climate Change Action Plan
CCRA	Climate Change Risk Assessment
CDD	Cooling Day Degrees
CEQ	The Council on Environmental Quality
CH_4	Methane
CIF	Climate Investment Funds
CIRCE	European Regions toward Circular Economy
CMIP5	Coupled Model Comparative Project in Climatology 5
CO_2	Carbon dioxide
COP	Conference of the Parties
COVID 19	Corona Virus Disease
CSP	Concentrated Solar Energy
CVET	Veterinary Emergency Team
DICE	Dynamic Integrated Climate-Economy model
E	Effect
E	Exposure
EC	European Commission
ECDPC	European Center for Disease Control and Prevention
EEA	European Environment Agency

EFSA	European Food Safety Authority
EMODnet	European Marine Monitoring and Data Network
EPDK	Turkish Energy Market Regulatory Authority
EPİAŞ	Energy Markets Operation Joint Stock Company
ET	Vulnerability
ETKB	Republic of Turkey Ministry of Energy and Natural Resources
EU	European union
EÜAŞ	Electricity Generation Joint Stock Company
EUEI PDF	European Union Energy Initiative Partnership Dialogue Facility
EUROSEM	European Soil Erosion Model
EV	Economic Value
FAO	United Nations Food and Agriculture Organization
FEMA	Federal Emergency Management Agency
fPAR	Photosynthetic Active Radiation
FUND	Climate Framework for Uncertainty, Negotiation and Distribution
GCM	Global Climate Models
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GIZ	German International Cooperation Agency
GMES	European World Tracking Program
GPG	Good Practice Guide
GPP	Gross Primary Production
GPS	Global Positioning System
H_2O	Water vapor
HELCOM	Helsinki Commission
HEPP	Hydroelectric Power Plant
IAA	Integrated Assessment Approach
IAM	Integrated Assessment Models
ICRM	Integrated Climate Risk Management
ICT	Information and Communication Technologies
IDB	Inter-American Development Bank
INDC	Nationally Determined Contribution Intentions
INTARESE	Integrated Assessment of Health Risks from Environmental Stress Sources in Europe
IPCC	Intergovernmental Panel on Climate Change
K	Fragility

LCLU	Land Cover/Land Use
LDCF	Least Developed Countries Fund of Global Environment Facility
LULUCF	Land use, land use change and forestry
MERGE	Model for Estimating Regional and Global Effects
MEU	Mibnistry of Environment and Urbanization
MICRODIS	Integrated Health Social and Economic Impacts of Extreme Events: Evidences, Methods and Instruments
MODIS	Medium Resolution Imaging Spectroradiometer
MRI	Meteorology Research Institute
MTA	General Directorate of Mining Exploration and Research
Mtep	Ton equivalent oil
N_2O	Dinitrogen monoxide
NACE	NACE code, the field of activity of the workplace and the workplace hazard class information in connection with it.
NAP	National Adaptation Plan
NASA	US National Aeronautics and Space Administration
NDVI	Normalized Vegetation Difference Index
NGO	Non-Governmental Organizations
NIDIS	National Integrated Drought Information System
NO	Nitrogen Oxide
NOAA	US National Oceanic and Atmospheric Administration
NPP	Net Primary Production
NPP	Nuclear Power Plants
O_3	Ozone
ODA	Official Development Assistance
OSPAR	Convention for the Protection of the North-East Atlantic Marine Environment
PAGE	Action Partnership in Green Economy
PDSI	Palmer Drought Severity Index
PEA	Political Economy Approach
PESERA	Pan-European Soil Erosion Risk Assessment
Pg	Picogram
PM 2.5	Particulate matter 2.5 m in diameter or less
PNI	Percentage Normal Index
PURGE	Public health impacts of greenhouse gas emission reduction strategies in urban settings
R	Risk

RA	Product for Inhalation
RASFF	Rapid Alert System for Food and Feed
RCM	Regional Climate Models
RCP	Representative Concentration Routes
RERA	Renewable Energy Resource Areas
RHA	Risk-Hazard Approach
RICE	Regional Integrated Climate-Economy
S	Sensitivity
SCC	Social Cost Of Carbon
SDG	Sustainable Development Goals
SEPA	Solar Energy Potential Atlas
SIC	Soil Inorganic Carbon
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SPI	Standard Precipitation Index
SREP	Program for Scaling Renewable Energy in Low Income Countries
SRES	Emissions Reports Special Report in Evaluation Reports
SSP	Socio-economic Scenarios
SU25	Climate Index
T	Heath
TDRP	Turkey Disaster Response Plan
TEDAŞ	Turkish Electricity Distribution Corporation
TEİAŞ	Turkish Electricity Transmission Joint Stock Company
TEN-T	Trans-European Transport Networks
TKİ	Turkish Coal Enterprises
TTK	Turkish Hard Coal Authority
TÜİK	Turkish Statistical Institute
UN	United Nations
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
URGENCHE	Urban Reduction of Greenhouse Gas Emissions in China and Europe
USA	United States of America
USACE	United States Army Corps of Engineers
USAID	United States Agency for International Development
USD	United States Dollar
USGCRP	US Global Change Research Program
USLE/RUSLE	Revised Universal Earth Loss Equation

VIROCLIME	Impact of Climate Change on The Transport, Consequence And Risk Management of Viral Pathogens in Water
VNR	Voluntary National Review
W	Precipitation
WAHIS	World Animal Health Information System
WEI	Water Use Index
WEPP	Water Erosion Estimation Project
WHO	World Health Organization
WISE-Marine	Water Information System for Europe
WMO	World Meteorological Organization
WOAH	World Organization for Animal Health

EXECUTIVE SUMMARY

1. Information Sources For Climate Change Adaptation

Prof. Dr. Ayşegül TANIK

Adapting to the effects of climate change is described as ensuring that the people's livelihoods, economies and natural systems are affected less by the changes due to climate and in some cases benefit from adaptation. Climate change adaptation is the actions and measures taken to help societies and ecosystems cope with the changing climate conditions. In other words, adaptation to climate change is the process of strengthening, developing and implementing strategies to combat the effects of climate events (risks), gain benefits from them and manage their effects. The main purpose of all documents prepared by the European Commission is to ensure that the regions of Europe that will be affected by climate change are prepared for it and to determine the priorities for the first and basic actions at the society level. In this context, various documents have been published and adaptation has been planned.

2. Technologies For Adaptation To Climate Change: The Role Of GIS And Remote Sensing In Modeling The Impacts Of Climate Change

Prof. Dr. Süha Berberoğlu

In line with climate change, it is important to understand the change in ecosystem that may occur as a result of climate change and the functioning mechanisms between ecosystem functions using spatial information technologies (GIS, spatial models, GPS and remote sensing) together with ground data and to model the spatial distribution of some environmental risks (Erosion, Net Primary Production and fire) that may occur as a result of this and evaluate it on a national scale.

When the Total Net Primary Production values in the Basins are examined in the conducted study, it is seen that Seyhan Basin is the riskiest basin with a very low increase, followed by the Asi basin, Ceyhan basin and the Eastern Mediterranean basins. In terms of total Net Primary Production increase values in the basins, it is seen that the highest increase will be in the Sakarya basin with 14,70%, followed by the Marmara and Büyük Menderes Basin. In terms of erosion, it is predicted that the total amount of erosion in the future will be the highest in the Tigris Basin, Euphrates Basin and Sakarya Basin. It is predicted that approximately 38 million tons of erosion will increase throughout the country.

In the current forest fire risk map, the riskiest basins are observed in the Middle Mediterranean, Western Mediterranean, Büyük Menderes, Seyhan basins and additionally in the region between the Sakarya basin and the Western Black Sea basin. The highest risk of forest fires in the future shows a risk trend from the Mediterranean coasts to the western coasts.

3. Climate Modeling, Climate Predictions, Application Technologies For Monitoring Climate Change

Prof. Dr. Süha Berberoğlu

These are models that try to show the relationship between climatic components (atmosphere, lithosphere, biosphere, hydrosphere and cryosphere) with quantitative (measurable and observable) methods. Despite all its complexity and practical difficulties, the most important tool in predicting the future climate is climate modeling. All climate models are basically constructed by taking into account the energy coming from the sun via short wave radiation and the energy from the earth with long wave radiation. Any change in this balance causes a change in temperatures. Climate models studies have two different working principles:

- Global Climate Models (GCMs) and
- Regional Climate Models (RCMs).

Global Climate Models (GCMs) are models in which fluid motion and energy transfer are both integrated over time.

In summary, models that provide more detailed and high-resolution information for smaller areas by using low-resolution gridded information obtained from global climate models are regional climate models.

4. Vulnerability and Vulnerability Evaluation and Vulnerability Indicators

Prof. Dr. Ayşegül TANIK

Vulnerability refers to the extent to which a system is affected and unable to cope with the adverse effects of climate change, including climate vulnerability and extreme climatic conditions. Vulnerability is a function of the nature, size and speed of climate change and variability a system is exposed to, its vulnerability and adaptation capacity. Adaptation measures are sectoral, national and local implementations to reduce vulnerability. Risk assessment and vulnerability assessment studies conducted in various countries are summarized in this study.

The most effective method in determining and prioritizing adaptation measures is to make a vulnerability assessment. Vulnerability is a guide in risk studies in evaluating the applicability of the actions required to reduce the risk in line with multiple parameters. Sectoral vulnerability analysis is an evaluation system used to determine how certain sectors may be affected by natural (flood, drought, storm, earthquake, etc.) or man-made (terrorist attacks) disasters. When the methods used in formulating the exposure, sensitivity and adaptation capacity components are examined in order to determine the vulnerability, it was seen that three main variables were used; namely index, indicator and parameters. Parameters that have a certain unit are variables that can be compared with world standards and come together to form indicators reflecting the general situation in the physical, social, economic, etc. framework. Indicators reflect which physical, social and economic factors the indices are based on. Indices show whether the sources of vulnerability increase or decrease due to social or climatic conditions or administrative deficiencies. The uses of these indicators in vulnerability analysis and evaluation have been explained specifically in various case studies.

5. Vulnerability By Sectors: Tourism

Prof. Dr. Mehmet Somuncu

Climate, coasts, oceans, mountains, forests, wildlife and the ecosystems associated with them provide attractiveness for many destinations. In this sense, climate is an important touristic attraction. Additionally, climate has a significant impact on tourism activities. Therefore, the climate can provide advantages and disadvantages for tourism regions.

The tourism sector is one of the economic sectors that are extremely sensitive to climate change, which can be negatively affected from it. The relationship between climate change and tourism has two different dimensions. On the one hand, the tourism sector is affected by the negative impacts of climate change and on the other hand, the impact of the carbon emissions caused by the sector on climate change is substantial. Considering the effects of climate on tourism in the tourism sector's struggle with climate change, adapting to climate changes is known to be the most urgent solution. However, when examining the effects of tourism on climate, the main discussions focus on mitigation studies. Therefore, mitigation and adaptation studies need to be handled and carried out together because the budget, time and other resources to solve the problems are limited. In addition to this, although environment and economy are generally considered to be opposite to each another, it is clear that that progress in one direction will only be possible with developments in the other direction.

Because tourism is mainly based on natural resources, Turkey is a country that will be affected most by the direct impact of climate change and will be at risk. Types of tourism such as winter sports tourism, especially coastal tourism, are currently affected by climate change and this impact is expected to increase even further in the future. Therefore, identifying risks arising from climate change in Turkey's tourism and developing the necessary measures for these risks, namely adapting the sector to climate change, is a necessary and an urgent requirement.

6. Vulnerability by Sectors: Agriculture

Prof. Dr. Zeynep Zaimoğlu

Food demand is among the problems that have to be dealt with the increasing of the world population. Meeting the food demand in sustainable agriculture is important for food security in a sustainable life. Breakdowns occur in agricultural policies made to ensure food security. The countries that direct the agricultural policies should take into consideration the percentage of and the people who make a living from agriculture in other countries when making the choice of the way to move ahead.

In the breakdowns occurring in agriculture for food security, per capita food production and consumption is gradually decreasing. Mankind has caused damage to the environment with what they do to survive and made the consequences of this inevitable.

There are many countries that have difficulty meeting even their basic needs. In short, there is a disproportionate situation in the supply-demand relationship and it cannot meet the basic needs in food.

The use of natural resources, the reduction of arable land, the reduction of usable water resources and the unconscious consumption are the biggest factors in not meeting the basic needs.

However, considering that the relationship between climate and agriculture is a living system, the result is that it should be addressed regionally in order to prevent vulnerability in the agricultural sector. The environmental-climatic-economic vulnerabilities of the region should be evaluated and it is necessary to determine what needs to be done and to follow the policies accordingly.

7. Vulnerability by Sectors: Energy

Prof. Dr. Levent Aydın

The energy industry is divided into various sectors within itself such as oil, coal, natural gas and electricity, and the vulnerability indicators of these sectors are defined separately because each sector has its unique characteristics. Using these defined vulnerability indicators, it is discussed in detail what kind of measures can be taken for the adaptation of the energy sector to climate change on the basis of source, generation, distribution, transmission and demand. After listing adaptation types in the energy sector and adaptation solutions that protect energy markets, the sensitive aspects of Turkey's energy sector or their vulnerabilities against climate are discussed.

8. Vulnerability by Sectors: Health

Prof. Dr. E. Didem Evci Kiraz

Climate change has taken the lead in vulnerability due to its negative effects on health. Individual-social-global, national-international, household-neighborhood-region-city and across-the-border vulnerability levels are different from each other. The increasing population and especially the urban population density (the number of people per square kilometer) make it impossible to build and maintain healthy living environments. While people are trying to settle near the centers that will meet their demands; these centers have become risky areas in terms of environment, social structure and health. People and societies who think they have developed have started to ignore the social determinants of health, especially such as starting a healthy life and maintaining a quality life. It becomes difficult to try to explain the rapidly increasing effects of climate change and the processes of being prepared, adapting, gaining resilience, managing events properly, and rapidly restoring society after the effects have disappeared to people with confused agendas.

9. Vulnerability by Sectors: Transportation

Prof. Dr. Cem Soruşbay

A large portion of Turkey's population is concentrated in the coastal regions, where sea level rise, coastal erosion, floods and meteorological extremes occur more commonly due to climate change. Heavy rain and storms create high risks for critical infrastructures in the transportation sector, cause temporary and permanent disruptions in the operation of the system, and cause economic losses. While temperature increases cause problems such as deformation of the rails in railway transportation, it affects passenger comfort in road transportation. In order to prevent the negative effects and possible risks caused by climate change on the transportation sector, first of all, vulnerable sub-sectors and geographical regions with high vulnerability should be determined.

Increases in the severity and frequency of impacts such as floods and extreme weather actions caused by climate change pose a significant threat to the transportation infrastructure (highways, bridges, railways, airports, ports, waterways, etc.). Determining and evaluating this issue regionally will determine the level of vulnerability in the sector.

Although the exposure rate and the amount of risk are different in the sub-units of the sector, eliminating the negative effects is generally the first option. However, in some cases, according to the cost-benefit analysis, it would be an effective approach to remove highways, highways or railways from possible vulnerable areas.

10. Vulnerability by Sectors: Construction and Infrastructure

Prof. Dr. Erdem Görgün

The vulnerability has been explained as the state of a system being sensitive to and unable to cope with the adverse effects of climate change, including climate variability and extreme climatic events. The vulnerability assessment helps to identify the most sensitive points to climate change in the sectors. A complete vulnerability assessment is performed by evaluating the exposure and sensitivity of the system and adaptation capacity, as well as the climate stimuli in the system.

It is known that the construction and infrastructure sector is one of the most vulnerable sectors against climate change. Even if mitigation strategies against climate change are implemented, their effects will continue in the coming years. For this reason, adaptation has become a necessity for the construction and infrastructure sector in order to reduce vulnerability to the potential impacts and risks of the climate change.

11. Vulnerability by Sectors: Industry

Prof. Dr. Erdem Görgün

Vulnerability is defined as "the level of sensitivity to the damage that a system will encounter as a result of being exposed to environmental and social stress in the absence of adaptation capacity". In determining and prioritizing adaptation strategies, sensitivity / vulnerability analysis helps to determine whether a system is sensitive or not, and if so, to what extent. The level of vulnerability varies depending on the nature, size and speed of the climate change and variability a system is exposed to, its sensitivity and its adaptation capacity. The four parameters observed in the analysis of fragility are exposure, sensitivity, potential impact and adaptation capacity.

The degree of sensitivity of the industrial sector to climate conditions can be related to factors such as the development level of the industrial sector in the region under study, water consumption information, energy use information and waste water quantities and characteristics. The degree of adaptation capacity of the industrial sector to climate conditions depends on indicators such as the economic capacity, physical infrastructure, social capital, development level, institutional capacity and data accessibility of this region.

12. Vulnerability by Sectors: Ecosystem Services

Prof. Dr. Süha Berberoğlu

There are two main opposing perspectives for determining the economic value of the benefits gained from the ecosystem. The first of these is the view that the elements in the cycle of essential nutrients such as water, oxygen, and carbon, which are a part of the ecosystem, should not be traded by converting them into commodities. Another view contrary to this is the view that natural resources, which have been used unlimitedly, would have been used more limitedly and carefully in the past if they had economic value.

Revealing the economic difference between the loss in the ecosystem service and the use of natural resources aims to answer the question of which use is more advantageous in terms of environmental sustainability and economic gain. The carbon economy, which has been transformed into a commodity that can be bought and sold after the Kyoto protocol, still does not have a single structure or mechanism that exhibits certainty. More than one model has been developed by naturalists and economists within the scope of the Integrated Assessment Models (IAMs) approach in order to minimize these uncertainties regarding global climate change and determine the possible effects and costs. Among these models, MERGE, FUND, PAGE, DICE and RICE models stand out. The common point of these models is to determine the optimal level at which the Marginal Reduction Cost is equal to the Marginal Carbon Cost to prevent global climate change. The Social Cost of Carbon (SCC) has an important place in global warming and global economic policies. The Social Cost of Carbon is a concept that can be modeled globally as well as at national or regional scales.

13. Social Vulnerability, Vulnerability in Cities and its Indicators

Doç. Dr. A. Ufuk Şahin

A polar bear staring over a melting glacier without knowing where to go is an iconic photograph symbolizing climate change and its negative effects. While the world we live in is changing at a dizzying pace, humanity is dealing with a wide variety of multi-layered problems related to each other such as new technologies, environmental problems, and social injustice. Intense human activities such as the rapidly increasing population, globalization, global trade, industry, agriculture and tourism are changing and transforming today's world, probably in an irreversible way. Apart from the technical problems that climate change will cause, the humanitarian crises it will create and its reflection on various social classes can make our lifestyle, the environment we perceive and the cities even more vulnerable. In this context, it will be briefly summarized what the climate change is and the vulnerability and possible solution scenarios that it will create in cities will be examined throughout this study.

14. Uncertainty and Risk Management: Uncertainty

Prof. Dr. Erdem Görgün

Uncertainty refers to the state of cognitive deficit due to lack of information or disagreements about what is known and what can be known; it can be represented by quantitative measures or qualitative statements. Probability density functions and parameter ranges are among the most common tools for characterizing uncertainty. Identifying and quantifying uncertainty can play a valuable role in communicating the decision-making process.

One of the consequences of the climate change is variable temperatures. When the average temperature changes of global models are examined, it is seen that the temperature increases are quite uncertain depending on the anthropogenic emission level of greenhouse gases. While the different scenarios show a wide range of trends in CO_2 emissions in the atmosphere, all of them predict that there will be an increase in CO_2 concentration by the end of the century. The large amount of variation between the estimates of different scenarios is indicative of uncertainty. Identifying and evaluating uncertainties can be used as an aid to understanding the effects and consequences of the climate change and taking adaptation measures.

15. Uncertainty and Risk Management: Risk

Prof. Dr. Erdem Görgün

Risk is a state of uncertainty where some possible consequences create an undesirable effect or significant loss. Major risks in climate change lead to instability and insecurity in economic systems that threaten adequate social welfare due to the inability to adapt to changes in the environment. Climate change risk depends on the decisions of decision-makers who manage the dependencies between climatic and socio-economic-environmental systems as well as climatic factors. Inadequate decisions can cause the systemic risk to spread across all systems.

Risks are divided into three categories as acceptable, tolerable and intolerable risks. Risk analysis helps determine which of these categories a risk falls into. In addition, risk analysis contributes to the process of estimating the potential impacts of the climate change and evaluating local vulnerability and adaptation capacity.

INFORMATION SOURCES FOR CLIMATE CHANGE ADAPTATION

Prof. Dr. Ayşe Gül Tanık

1. INFORMATION SOURCES FOR ADAPTATION TO CLIMATE CHANGE

Adaptation to climate change includes the actions realized and measures are taken to help communities and ecosystems cope with changing climatic conditions. Adaptation to climate change is the process of strengthening, developing and implementing strategies to combat the effects of climate events (risks), gain benefits and manage their effects. Even if the factors that cause climate change (greenhouse gas emissions, deforestation, etc.) are now eliminated, it is a known fact that their effects will continue for the next 50 years. For this reason, the importance of adaptation to climate change is increasing day by day.

On the other hand, the economic cost to be met in order to adapt to the impacts of climate change will be much lower than the cost of the damage caused by climate change if sufficient and necessary measures are not taken, which is highlighted in the IPCC 5th Evaluation Report. For this reason, adaptation to climate change is not a necessity, it has become an obligation (IPCC, 2013). Climate change adaptation should be implemented for the following reasons:

- To understand the effects of climate change well,
- To minimize its negative effects,
- To turn some of its effects into opportunities,
- To be prepared for the effects,
- To reduce the risk and damage with the least cost,
- To solve current problems.

1.1. Green Paper Prepared by the European Commission

The main purpose of European Commission on climate change and adaptation is to ensure the preparedness of the regions that will be affected by climate change in the whole world and especially in Europe and to determine the priorities for the first and basic actions at the community level. For this reason, the Commission listed things to do under Green Certificate in 2007.

Green Paperis about examining adaptation and mitigation from the same perspective. The whole world faces two major problems due to climate change. The first is greenhouse gas emissions. Making the necessary legal regulations for low carbon emissions is the joint decision of Europe. The purpose of the EU council s to mitigate greenhouse gas emissions by 20% by 2020 and 50% by 2050, compared to 1990. The second problem is that although global efforts are made to reduce the effects of climate change, societies will have to be exposed to these effects in the coming years. It is imperative to reduce emissions for compliance.

The Green Paperhas been prepared to review the policies to be implemented by Europe against climate change and effective adaptation strategies to be taken by regional and local governments. In addition, the measures to be taken by Europe are aimed to benefit and implement by other countries that are not members but whose conditions are in line with any of the EU member states.

1.2. Focus on EU Actions

The issues that the EU focuses on during the adaptation process are briefly summarized below.

Early warning systems

Ensuring integration into adaptation while implementing and changing current and future legislation and policies

- Agricultural and rural development
- Industry and services

- Energy
- Transportation
- Health
- Water
- Sea and fishing
- Ecosystem and biodiversity
- Other natural resources

Integrating adaptation into existing public funding programs

- While publicly supported adaptation programs are being carried out, member countries are required to implement adaptation activities.
- These activities are partially related to infrastructure systems. While the service life of large-scale infrastructures such as bridges, airports and highways is between 80-100 years, the service life of buildings is between 20-50 years.
- The 'climate-proof principle should be implemented in medium and long-term investments.
- The European Social Fund also plays a active role in creating broad and comprehensive public awareness against climate change.
- Thanks to this fund, various opportunities such as new job opportunities for young people with a low carbon economy, preventive health measures for children and the elderly are prepared.

Integrating adaptation into EU external activities

Although there are economic, political, social and environmental differences, adaptation strategies to be applied in countries are similar. For this reason, it is necessary to work in coordination for adaptation. The EU Common Foreign and Security Policy play an important role in enhancing EU capacity and dealing with border disputes. In this context, countries are grouped according to their development levels.

- I. Developing countries
- ii. Neighboring countries
- iii. Industrialized countries

Reducing uncertainty by expanding the knowledge base through integrated climate research

The EU's 7th Framework Research Program puts a strong emphasis on climate change foresight capacity, modeling and adaptation strategies.

Preparation of coordinated and comprehensive adaptation strategies covering European society, business and public sector

The need for adaptation can cause massive restructuring in various economic sectors such as agriculture, forestry, renewable energy, water, fishing and tourism, or ports, industrial infrastructures and coastal areas, floodplains and regions with urban settlements in the mountains, which are especially exposed to climate change. An improved dialogue environment should be established with relevant parties and non-governmental organizations (NGOs) in order to identify systematic problems that may arise.

1.3. White Paper Prepared by the European Commission

The aim of the White Paperissued in 2009 by EU Commission after Green Paperis to create a basic framework to minimize the effects of climate change and to ensure that the EU countries act together within this framework. In general, the document explains the main ways to increase the resilience of important sectors of Europe such as agriculture, biological diversity (biodiversity) and coastal ecosystems, in a way that minimizes vulnerabilities to climate change. The EU framework has taken a gradual approach. Level-1 (2009-2012); It is aimed to conduct a ground study for the preparation of EU adaptation strategies to be implemented during Stage-2 (2013).

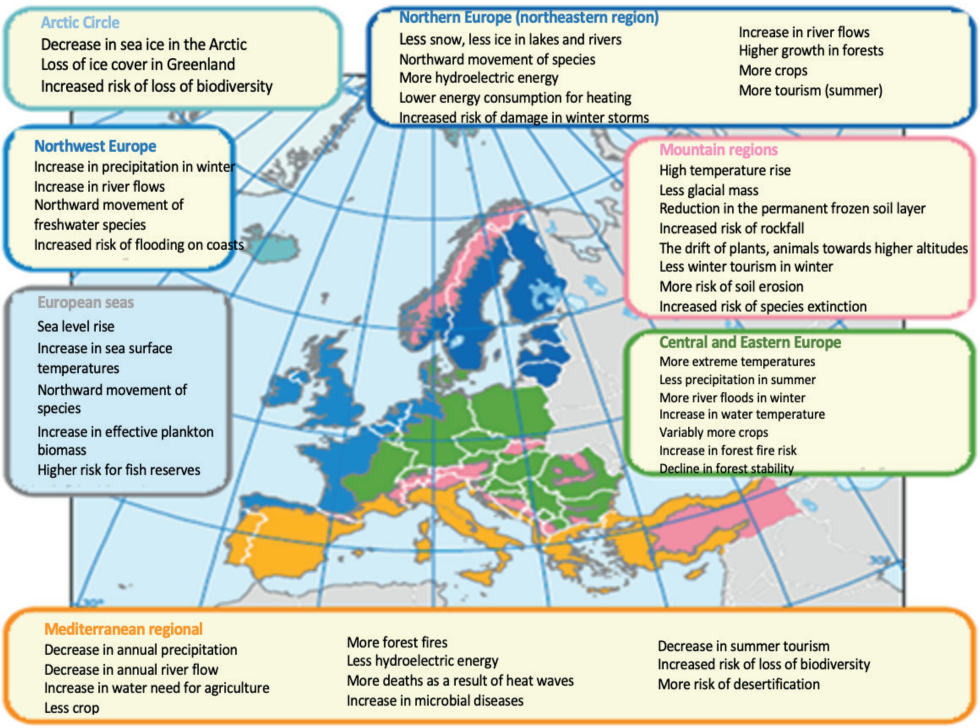
1.4. Integrating Adaptation into EU Policies

By integrating adaptation actions into EU policies

- Increasing resilience of health and social policies
- Increased resilience of agriculture and forests
- Increasing biodiversity, ecosystems and water resilience
- Increasing the resilience of coastal and marine environment
- Increasing the resilience of production systems and physical infrastructure systems

will be provided. In Figure 1 the predicted effects of climate change in the European Regions are shown on the map.

Figure 1: Projected impacts of climate change in European Regions



Resource: European Environment Agency, 2014

The things to highlight among the 2020 targets of the EU are given below.

- Making safe investments for environmental and climate policy and calculating environmental investments of social activities
- Better integration of environmental problems into other policy areas and ensuring consistency in creating new policies
- Making the cities of the Union more sustainable
- Helping the Union to tackle with the international environmental and climate challenges more effectively.

1.4.1. Human, Animal, Plant Adaptation Activities

It provides comprehensive information on the EU acquis on veterinary and phytosanitary, including human health (EU Commission, 2013d). The focus is on how the EU can take action against all diseases seen or likely to be seen in Europe. Although the data and models obtained provide some degree of elimination of uncertainties, the current situation shows that the most important impacts of future climate change are on health. Many disasters such as storms, heatwaves, especially water, food, and the spatial distribution of infectious diseases, and the frequency of cardio-respiratory diseases are diseases and injuries caused by extreme weather events. According to the impact assessments conducted by some European countries and funded by the EU, WHO's Regional Office for Europe and the European Center for Disease Control and Prevention acknowledge that climate change has a major impact on the distribution of many disasters and health conditions.

Increase of extreme weather events and their effect on human health: The increase in death and disease is a priority problem due to the increase in annual average temperatures in Europe. Annual average temperature deaths in Member States are estimated to increase between 1% and 4%. According to this, temperature deaths will be around 30000 in 2030, and between 50000 and 110000 in 2080.

Food and foodborne diseases: Heat-sensitive infectious diseases (foodborne infections such as Salmonella) are estimated to occur in an average of 20000 - 40000 more cases in 2030. The IPCC predicts that contagious and infectious diseases which are transported by mosquitos and ticks caused by climate change, are a result of distortions that occur in geographical order, population size and seasonal activities.

Food and food safety issues: Climate change has an enormous impact on mycotoxins (a substance produced by fungi) in food and nutrients. Climate change is the most important factor in fungal colonization and mycotoxin production on the agricultural ecosystem.

Water-related problems: Heavy rains cause the spread of waterborne diseases due to contaminated water overflowing from sewers or the transport of pathogens. In addition, low water flow during the summer months increases the potential risk of bacterial and chemical contamination. High water temperatures also cause an increase in harmful algae blooms.

Air quality: The greatest damage caused by climate change to air quality is seen in the ozone layer. Temperature, humidity and wind directions affect the current ozone level.

Allergies: Increasing temperatures are altering the global pollen load and this affects the allergic sensitization rate over a long period. Allergic diseases caused by airborne allergens have been increasing in the past 10 years. In the general population, especially children are in the class that poses a risk. People are already struggling with various chronic diseases such as asthma, and it is estimated that this will occur in 40% of the European population by 2040.

Infrared (UV) radiation: Another indirect effect of climate change is the changing infraredradiation. Due to the stabilization of the ozone level in the stratosphere layer, a decrease in the average UV radiation level is observed. It causes skin cancer, including malignant tumors and cataracts, due to overexposure of UV rays.

Increasing health inequalities: Poor groups also fall under the influence of stress due to the inequality in health services caused by climate change. This situation endangers many development efforts, including development goals.

Sensitive groups: Since health and well-being are closely linked to socio-economic factors such as income, housing, employment, education, gender and lifestyle, climate change impacts are changing health inequality between countries, distribution imbalances for low-income groups and some vulnerable groups.

Environmental migrations: There is a complex relationship between climate change and environmental degradation and international migration. This situation is summarized in another working document. Current data indicate that, despite future environmental changes, environmental migration will occur between developing countries and the EU.

EU capacity in responding to the effects of climate change on human health

Legal rule: Among the main measures to be taken at EU level are to encourage cooperation between member states in the field of health and to support European solidarity. This is particularly important in establishing a framework for sharing best practices and experiences.

International Health Regulations: EU Member States are implementing the International Health Regulations published in 2007. This statute is a multilateral agreement governing the collective defense mechanism used to detect diseases and respond to public health risks and emergencies.

Political context: At the Fifth Environment and Health Ministerial Conference held in Parma, Italy in 2010, all EU Member States of the World Health Organization (WHO) approved the 'commitment to act' declaration, which constitutes the

European Regional Framework for Action.

European Environment and Health Action Plan: This document specifically addresses climate change and health issues. It also aims to create a prediction in determining the problems that arise on the environment and human health.

EU Health Strategy: It is an important document in terms of protecting its citizens against the effects of climate change and health threats on human health. Member states have concluded that a collaborative approach is inevitable at the EU level in the face of major health threats and problems with a cross-border or international impact (such as worldwide epidemics or bioterrorism).

EU Health Program: It has 3 goals.

- Ensuring and improving the health safety of citizens,
- Promoting health and addressing health inequalities.
- Creation and dissemination of health information and data.

This program also finances projects to reduce the effects of climate change on health.

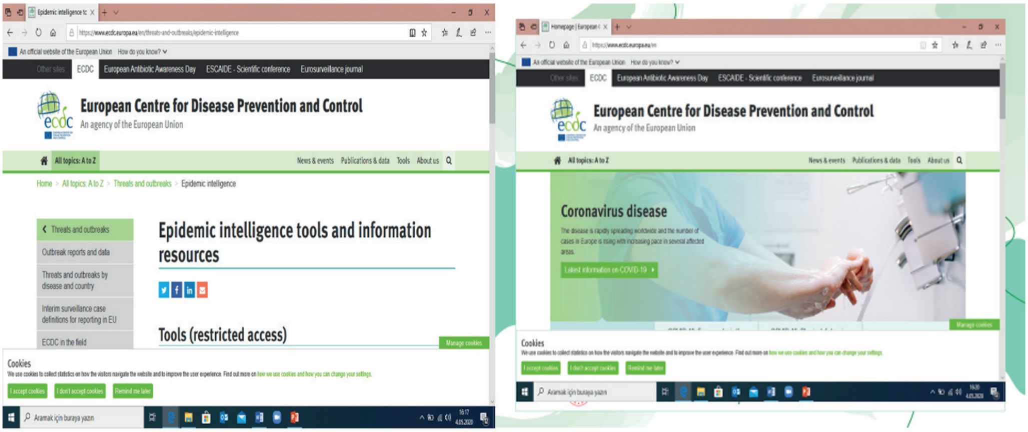
EU statistics program: European Health Survey adopted on health uses a health monitoring system that includes environmental variables as part of Eurostat data collections.

Networking for epidemiological surveillance and control of communicable diseases: With the decision number 2119/98/EC published by the European Commission "Establishing a network for epidemiological surveillance and control of communicable diseases in the community", EU activities have been initiated to establish Pan-European cooperation on 60 communicable diseases.

Health Safety Committee: The Committee aims to prevent bioterrorism in particular.

Figure 2 displays the web page images of the European Center for Disease Prevention and Control (ECDPC).

Figure 2: Images of health-related EU web pages



Resources: ECDPC, 2020

European Center for Disease Prevention Control (ECDPC): The main task of the center is to ensure the surveillance of diseases and epidemics that may pose a risk to human health and to prepare a risk assessment. The center directly investigates the dangers of climate change on human health.

Food safe response mechanisms: The European Commission has developed a tool called Rapid Alert System for Food and Nutrition (RASFF) in order to ensure information exchange between Member States' administrations. In this way, they quickly identify food and nutritional risks that threaten human health due to climate change.

European Food Safety Authority (EFSA) - foodborne risks: In addition to the occurrence of mycotoxins in foods, the Commission required EFSA's data collection and compilation.

EU framework programs for research on Human Health:

- Integrated environmental health impact assessment is developed by many projects. These projects are INTARESE, URGENCHE and PURGE. All of the projects carry out an integrated assessment of the effects of all climate change adaptation measures on human health.
- CIRCE;evaluates the effects of climate change in the Mediterranean Region. It examines the relationship between risks such as infectious diseases and temperature and air pollution, especially in 10 Mediterranean cities.
- MICRODIS is developed as an integrated protocol with a social, health and economic core section that provides descriptive analysis and mapping of the various health effects caused by floods.
- VIROCLIME is developed to explain the relationship between waterborne viruses and human health and the predicted effects of climate change.

EU capacity in response to the animal health impacts of climate change: EU legislation and Member States' emergency plans provide effective and immediate response mechanisms to prevent the spread of animal diseases. The Animal Disease Information System (ADIS) provides more understandable epidemiological data for risk management to change their plans according to the current epidemic situation. This system will be combined with the World Animal Health Information System (WAHIS), which is the information system of the World Animal Health Organization (OIE), and will be made more comprehensive. The EU Veterinary Emergency Team (CVET) can be invited to support Member States' governments or in dealing with animal disease outbreaks that occur for the first time in underdeveloped countries.

EU capacity in responses to plant health effects of climate change: The legal regulations created by the EU in order to abolish the effects created by climate change on plant health are based on the legal framework established for the marketing of plant health, plant reproductive material, plant protection products and their sustainable use, and the introduction of genetically modified organisms.

The Directives provide the opportunity to grow plants in line with the adaptation of plant varieties resistant to agro-climatic conditions, drought and disease.

In addition, the plant protection products created by the EU for the protection of plants whose risks have increased due to climate change in the control of pests and epidemics play a very important role today and in the future.

Union actions on the effects of climate change on human, animal and plant health

Human health:

- The Commission proposal from the Council and the European Parliament on serious cross-border threats to health was adopted in the first half of 2013.

Animal Health:

- Animal Health Law: The proposal made by the European Commission in 2013 was adopted in 2014.
- Animal Diseases Information System: It was started to be used in 2014.
- EU Rapid Response Network and Crisis Management on Certain Infectious Animal Diseases: Recommendations for the evaluation of this mechanism are included in the Animal Health Law with its implementation actions.

Phytosanitary:

- Phytosanitary Law: The proposal made by the European Commission in 2013 was adopted in 2014. While preparing the legal proposal, attention has been paid to the formation and spread of plant pests in the EU in determining the measures to be taken due to climate change.
- Vigilance at EU borders: Controls at the Union's borders are particularly applied to identify foreign and pest species new to Europe. Forests, plants and ornamental plants within the Union do not pose any threat. However, timely

detection of new pests coming during the shipment of plants imported from underdeveloped countries is of great importance.

1.4.2. Marine Adaptation Activities

Marine adaptation activities are detailed under various headings in the EU Commission (2012). At this stage, activities will be summarized under headings.

Current policy framework at EU level and related adaptation activities:

- Marine Framework and Flood Directives
- Marine Strategy Framework Directive
- Integrated coastal area management
- Natura 2000, habitats and bird directives
- Support tools and information: Tools have been developed to increase the spread by barter method of examples that are well applied in adaptation in coastal area management.

Climate-ADAPT: The European Climate Adaptation Platform was launched in March 2012. It has been developed to share the knowledge gained through case studies on adaptation in Europe and to provide users (such as lawmakers, researchers) to produce their climate change adaptation policies and to offer potential adaptation options.

OURCOAST: This database is a comprehensive compilation of hundreds of case studies of successful integrated coastal zone management practices implemented in the EU. The system focuses on adaptation to climate change, adaptation information and communication systems, planning and land management tools and coordination mechanisms.

EMODnet: (A European Marine Observation and Data Network): It was started in 2006 and ended in 2008. EMODnet is a common gateway for high-quality data that enables researchers and service providers to see the effects of human activities on the seas and oceans.

WISE-Marine (Water Information System for Europe): The system has been developed to provide information about marine components.

EU Fund: It has created many funds in order to ensure cooperation between member states and regions on climate change. Under the Multi-Annual Finance Framework, it will represent at least 20% of climate-related expenditures between 2014-2020.

Activities of the Member States and EU Marine Zones:

- Activities of Member States
- Coastal basins: Helsinki Commission (HELCOM) Action Plan (2007) emphasized the need to take action against climate change in the Baltic Sea Region. The EU Baltic Strategy also specifies the measures that can be taken for extreme weather events in the Baltic Sea. BaltCICA (Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region 2009-2012) Project is prepared to develop adaptation actions against climate change in regions and municipalities. In 2009, the commission aims to cooperate with OSPAR and 15 governments to protect the aquatic environment of the North-East Atlantic. North Sea Safecoast Project in sub-regions aims to evaluate coastal flood and erosion risk management issues and to improve climate change until 2050.
- Outermost regions: Although climate change vulnerability studies in the outer regions continue, priority is given to understanding risks rather than adaptation projects. Adaptation investments in these regions are generally made for flood and erosion. The estimated cost for these measures between 1998 and 2015 is on average 237 million €.
- Arctic regions: The Ottawa Declaration of 1996 created the Arctic Council.

This council is an international forum that promotes communication, coordination and interaction in Arctic countries. Six working groups emphasize that 'sustainable development' is one of the thematic areas required for adaptation to climate change.

Better informed decision-making systems: Marine Knowledge 2020 Strategy, prepared in 2010, indicates that the data in Europe are prepared by hundreds of different institutions. The strategy aims to improve the understandability of marine regions thanks to marine data provided from many different sources. European World Tracking Program (GMES) and the program's ocean services aims to create a service network for added value service providers, public and private users. In order to benefit from all this information, the future objective of the Commission is to combine the GMES program with the database it creates with the data it receives thanks to such programs as OURCOAST, EMODnet, WISE- Marine and Climate-ADAPT. Thanks to all the data sources mentioned the data are collected within the scope of the Water Framework Directive and the Flood Directive.

Blue Growth /Paper:

- Increasing the resilience of EU soils.
- Increasing the resilience of key sensitive sectors. Thanks to Blue Growth, the Commission plans that it will be able to achieve growth and jobs in the long term, in line with the targets of the 2020 European Strategy. For these goals to be successful, climate change must also be taken into account.

The Blue Paper(2012) prepared by the EU Commission generally aims to make maximum use of Europe's seas in a sustainable manner. The promotional brochures of the blue growth are given in Figure 13.

Figure 3: Blue growth promotional brochures

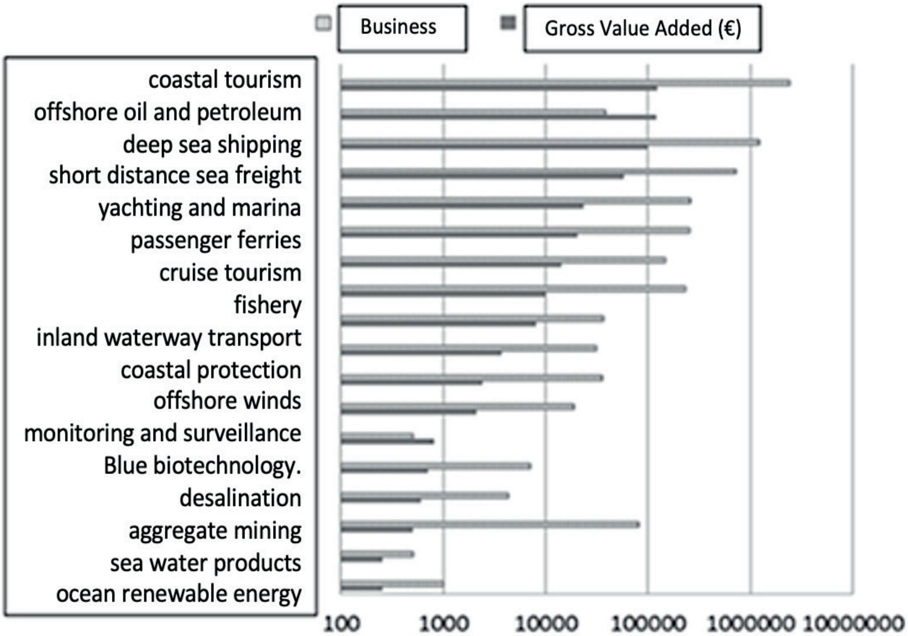
Resources: EU Commission, 2012

Blue Economy: It is necessary to be prepared for technological progress, demographic changes, the growing scarcity of natural resources and the growth of hitherto undeveloped countries' economies, including neighboring countries.

Blue Economy Activities: While emerging sectors will provide large proportions of employment, some of the traditional activities will continue to provide high rates of employment. The blue economy needs to continue to move forward on its sustainability route and taking into account the potential environmental concerns of the marine environment. During the studies, the primary goal is to reduce the negative environmental impacts of marine activities such as the emissions of pollutants.

Figure 4 shows the economic and employment dimensions of the sea and maritime economic activities.

Figure 4: Economic and employment dimensions of the sea and maritime economic activities (logarithmic scale) (EU Commission, 2012)



1.4.3. Forest Adaptation

Forests and forest land cover 40% of the European continent. Thanks to afforestation and natural succession, forests in Europe are increasing at an average annual rate of 10%. However, globally, forests are decreasing. Forests are multi-functional structures that serve economic, social and environmental purposes. In addition to creating living space for animals and plants, it plays an active role in reducing climate change. Approximately 25% of EU forests are under Natura 2000 protection. In addition, most of the remaining part is also protected under EU nature legislation. Forest biomass is the most important resource for renewable energy. It also accounts for about half of the EU's total renewable energy consumption.

Important developments in the field of Sustainable Forest Management are Resource Efficiency Roadmap and 2020 targets, including the Europe 2020 strategy for growth and employment, Rural Development Policy, Industrial Policy, Plant Health and

Reproductive Materials Strategy and Biodiversity and Bio-Economy Strategies, EU Climate and Energy Package and 2020 Goals. EU Forest Strategy created in 1998 constitutes an important framework for this issue (EU Commission, 2013a). Figure 5 contains a book cover and a brochure for forest management that reflects the EU's perspective on forest adaptation.

Figure 5: Book cover reflecting the EU's perspective on forest adaptation and the announcement brochure of the international conference on 'The Future of Our Forests' held in April 2019

EU strategy on climate change for forests and forest-based sectors

It addresses coherent and holistic forest management, multiple benefits from forests, the integration of internal and external forest policies, and the entire forest value chain.

Guidelines

- Considering the multi-functional role of sustainable forest management and forests in the provision of goods and services in a balanced way and ensuring the protection of forests.

- Ensuring resource efficiency, optimizing and developing forests and forest sector in rural development, and creating new business areas.

Forest targets for 2020: This attitude of the EU will increase the promotion of sustainable forest management and reduce deforestation on a global scale.
Eight linked priority areas:

Contributing to the main social goals with sustainable forest management

- Supporting urban and rural communities,
- Promoting competition and sustainability of EU's forest-based sectors, bio-energy and the wider green economy;
- Forests in a changing climate,
- Protection of forests and increasing ecosystem services.

Database development:

- EU programs such as LIFE + ensure that the needed resources are mobilized. The Commission and member states have developed a modular system with studies on forest information and biomass and ongoing work on biodiversity.
- New and innovative forestry and value-added products.

Increasing coordination and communication

- Working together and understanding our forests for a consistent management
- Forests from a global perspective

This strategy aims to increase the coherence in policies between the EU and Member State states, to set goals and commitments on international problems related to forests. In this way, support is provided to the EU and Member States by formulating clear and consistent targets.

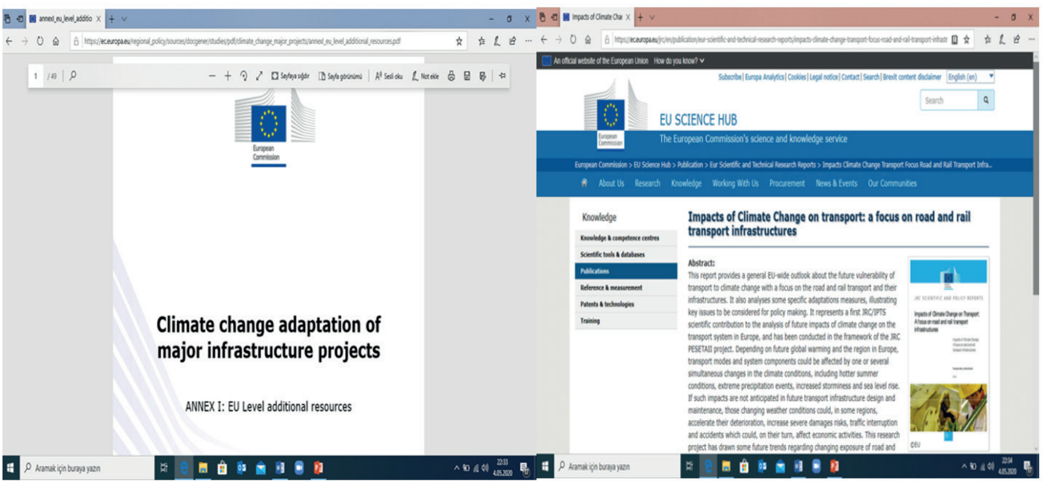
1.4.4. Infrastructure Adaptation

The word infrastructure generally refers to physical formations in a wide range of policy areas, including communication, emergency services, energy, finance, food, health, education, civil defense, transportation and water. From private property to schools or industrial establishments, buildings are the most common type of infrastructure.

Network infrastructure, especially energy (such as grid, power plants, pipelines), transportation (such as roads, railways, airports), ICT (such as data cables) and water (such as water supply pipelines, wastewater treatment plants) infrastructures are very important for today's economy and in terms of directing their societies. Designing infrastructures to be resistant to climate change is an important element for early adaptation (EU commission, 2013b).

Figure 6 shows the cover of the project report prepared by the EU on infrastructure and the image of the relevant front page of the study on the impact of climate change on transportation infrastructure.

Figure 6: The cover of the project report prepared by the EU on infrastructure and the view of the relevant head page of the study on the impact of climate change on transport infrastructure



The impact of climate change on infrastructures varies depending on the locations of the states in the EU, their exposure to risks, their current adaptation capacities and the regional economic development levels.

Currents and shapes: All extreme weather events caused by climate change affect the functioning and durability of infrastructures. The adaptation capacity of local governments, governments and societies, together with the region where infrastructure is located, generally determines the dimensions of climate sensitivity and vulnerability.

Terrestrial dimensions: Europe has a huge terrestrial diversity. For this reason, the resilience of infrastructures is generally related to regional and local terrestrial conditions.

- Cities and urban areas
- Coastal areas
- Mountain regions
- Outermost regions

Industry-specific effects

Transport infrastructure: Increasing frequency and intensity of extreme weather events (such as storms, floods and heat waves), such as rising temperatures and rising sea levels, also do great damage to the functioning of transport infrastructure in the EU. Climate change affects not only transport infrastructure, but also the distribution of transport and traffic flows (eg changes in tourism patterns as a result).

Energy infrastructure: Climate change affects energy transmission, distribution, production and demand. New seasonal and regional needs, such as the physical effects of extreme weather events, lead to new problems in transmission and distribution channels. At the same time, these problems are subject to balancing conditions arising from the integration of large amounts of electricity generation from renewable energy sources.

Buildings and structures: Buildings and infrastructures can be sensitive to climate change due to their design (low resistance to storms) and location (flood-prone areas, landslides).

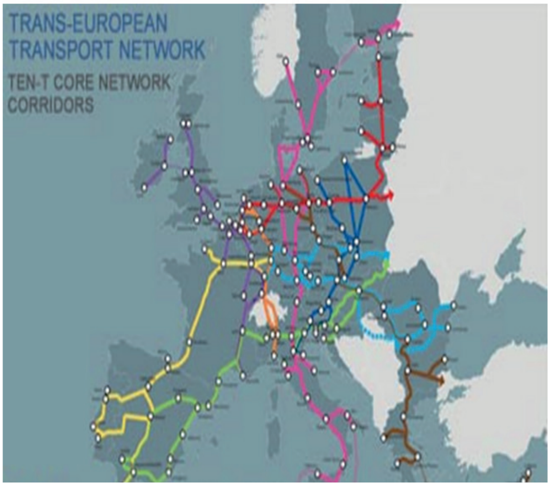
Problems

- Building new infrastructures by considering current and future climatic conditions in terms of region, design and operation.
- Increasing the resilience of existing infrastructures against the effects of climate change throughout their lifetime with strengthening and/or maintenance regimes.

Transportation: The transportation sector is of vital importance in fulfilling economic and social activities. In addition, this sector is highly dependent on environmental conditions. Investments made in transportation infrastructure are increasingly risky due to changing climatic conditions and extreme weather events. The newly created TEN-T / Trans European Transport Guideline focuses especially on the issue of risk assessment in infrastructure planning and the resilience of adaptation measures to climate change.

Figure 7 shows this generated TEN-T network.

Figure 7: TENT-T (Trans-European Transport Networks) network in Europe (EU Commission, 2012)



EU documents for improved climate resilience

- Technical standards
- Environmental impact assessment and strategic environmental assessment
- Flood risk assessment and management framework
- Climate tightness of the infrastructure

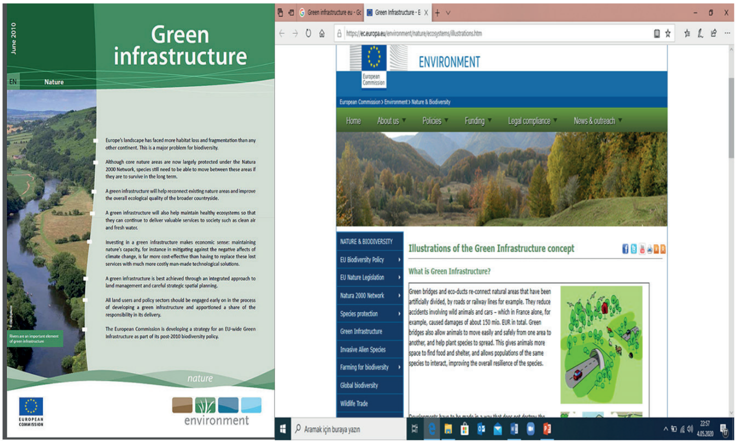
Financing climate change-resistant

- EU Funding
- Private sector investments and job opportunities
- The role of insurance

Green Infrastructure: Green Infrastructure Certificate published by the European Commission in 2013 is a system that provides multiple functions and benefits on the same spatial area. These functions are mostly environmentally, socially and economically important. The document creates the potential to deal with multiple problems simultaneously with green infrastructure projects, rather than gray infrastructure solutions that often perform single functions such as drainage or transportation.

Green infrastructure is a kind of spatial planning that increases the capacity of nature in terms of having people benefit from nature and environmental services such as clean air and water. Another effective feature of Green Infrastructure is to provide the fulfillment of more than one function in the same spatial area. Figure 8 shows the EU's web pages promoting Green Infrastructure.

Figure 8: Promotion brochures for web pages promoting the EU's Green Infrastructure (EU Commission, 2013c)



Benefits of green infrastructure

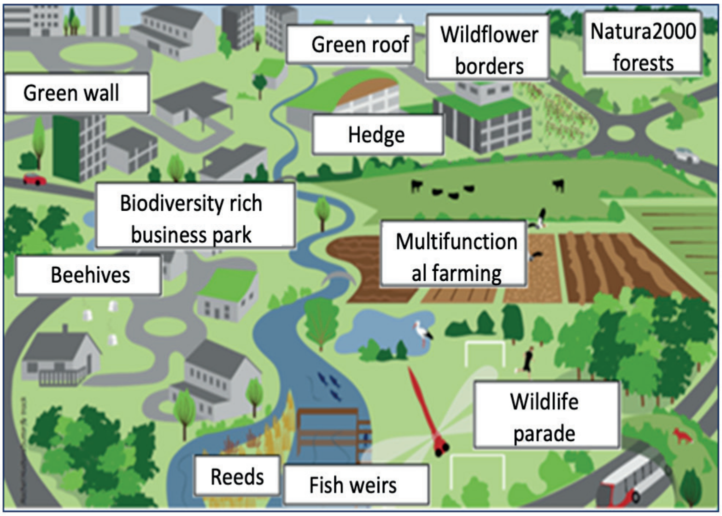
- Environmental benefits
- Social benefits
- Climate change adaptation and mitigation benefits
- Benefits to biological diversity

The relationship between Natura 2000 and Green Infrastructure: Natura2000 is located in the center of Green Infrastructure. Natura 2000 is not only an important resource for the preservation of biodiversity and healthy ecosystems in order to regenerate degraded environments, but also provides society with an annual gain of around € 200–300 million. Thanks to European Green Infrastructure generation centers, Natura 2000 sites form the strategic focal point for improving the natural environment and increasing the quality of life. Potential components of green infrastructure are presented in Figure 9.

Creating green infrastructure

- Benefits of spatial planning at a strategic level
- Possible components of green infrastructure (core areas, restored habitats, natural features acting as wildlife corridors, artificial features that improve ecosystem services, sustainably managed buffer zones, multifunctional zones)

Figure 9: Potential components of green infrastructure



Resources: (EU Commission, 2013c)

1.4.5. Web Portal: European Climate Adaptation Platform

It is the official website created to assist countries that want to disseminate and implement the harmonization activities implemented by the EU, through the web portal. In the content of the site, there are steps to be followed when determining adaptation options, sectoral analysis and adaptation options in general.

Necessary steps for adaptation

- Preparing the region for adaptation
- Determining the risks and vulnerabilities of climate change
- Determining adaptation options
- Evaluation of adaptation options
- Implementation
- Monitoring and development

EU-based sector policies

Common sector policies of Europe;

- Agriculture and forestry
- Biodiversity
- Coastal areas
- Disaster risk reduction
- Finance
- Health
- Infrastructure
- Marine environment and fishing
- Water Management

There are a total of 62 adaptation activities within the scope of adaptation activities against climate change on the official Climate-ADAPT portal of the EU. Under 9 main sector headings, priority sectoral-based adaptation actions, which should be focused on in the relevant sector, are grouped among the 62 measures in question (Climate-ADAPT, 2020).

2. USA ACTION PLANS

In addition to the EU, the adaptation process in the USA is also briefly mentioned in this section.

2.1. Adaptation Actions of the Federal Government

The Interagency Climate Change Adaptation Task Force met under the Obama administration in Spring 2009 co-chaired by the White House Environmental Quality Council and the White House Office for Science and Technology Policy, with representatives of the National Oceanic and Atmospheric Administration (NOAA) and more than twenty federal agencies. In October 2010, the Adaptation Task Force policy objectives and a set of recommendation reports were submitted to the President.

A second report was published by the Adaptation Task Force in October 2011. In this report, the duties of the federal government to promote and strengthen a better understanding of climate change are highlighted (USA, 2014).

2.2. President's Climate Action Plan

The country's first integrated Climate Action Plan was published under the Obama presidency in July 2013. The plan focused on the issues of the federal government to stop carbon pollution, to prepare the USA for the effects of climate change, and to work with international communities to reduce emissions.

2.3. National cross-cutting adaptation strategies

The 'National Action Plan: Changing Climate Management Priorities for Freshwater Resources' developed by federal agencies in October 2011 is aimed to plan water resources while protecting water quality, human health and aquatic ecosystems. National Ocean Policy Implementation Plan was published in April 2013 to ensure resilience and adaptation to climate change and ocean acidification.

2.4. Institution Adaptation Plan

It has been decided to publish annual sustainable planning procedures within the scope of the Institution Adaptation Plan. These plans aim to integrate adaptation planning and the operations, policies and programs of all federal agencies.

Managing initiatives related to selected examples between institutions and national adaptation specific to institutions

National Integrated Drought Information System created by the parliament in 2006 aims to adopt a more proactive approach to drought. Web-based USA Drought Portal provides public access to NIDIS to users.

Implementation of adaptation with disaster recovery during Hurricane Sandy

After understanding the need to better explain existing data to the public and develop new climate-related decision-making tools, federal governments decided to introduce future flood risk tool packages. FEMA, CEQ, USGCRP, NOAA and USACE data were gathered and an understandable tool for the local decision makers.

- Coordinating disaster management
- Management of fires that are hard to be extinguished
- Sea level rise

US Geographical Survey, National Park Services, US Fish and Wildlife Services and private and nonprofit organizations work towards vulnerability assessment of the National Coastal Zone to sea level rise and the increased risk of erosion of the North Atlantic Coast and to determine adaptation measures (the USA, 2014).

- Conservation of biological diversity
- Understanding the effects of climate change

- Protection of human health
- Natural resources management

The US Department of the Interior is developing an information system to support local and state efforts for US natural resources management and climate change preparedness. The Department's WATERSMART program assists states with issues such as rapid population growth, climate change, aging of infrastructure and land use change.

- Supporting the agricultural sector
- Building a more resilient transport sector
- Preparing for future energy needs
- Developing tools to support local decisions
- Promoting resilience at the community level
- Protection of government organizations
- Designing infrastructures for the future
- Regional, state, local and tribal adaptation initiatives.

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TECHNOLOGIES FOR ADAPTATION TO CLIMATE CHANGE: THE ROLE OF GIS AND REMOTE SENSING IN MODELING THE IMPACTS OF CLIMATE CHANGE

Prof. Dr. Süha Berberoğlu

1. INTRODUCTION

Global scale climate change impacts are expected to be more heterogeneous at regional scale, independent from the general. In this context, risks on ecosystems functions and services will increase. For this purpose, it is necessary to determine the current and potential effects of climate change and to develop advanced models and to determine the ecological risk limits of marine and terrestrial ecosystems at the regional scale.

Therefore, by using spati al information technologies (GIS, spatial models, GPS and remote sensing) together with spatial data in line with climate change, understanding the funct ioning mechanisms between ecosystem change and ecosystem functions that may occur as a result of climate change, and modeling the spatial distribution of some environmental risks (Erosion, Net Primary Production and fire, etc.) and evaluating at the country scale, are important.

In this context, erosion, Net Primary Production (NPP) and forest fires spatial and temporal distribution prediction of Turkey using Pan-European Soil Erosion Risk Assessment (PESERA) erosion model, NASA-CASA, which is a terrestrial ecosystem model for simulating the vegetation dynamics and forest development, and forest fire risk were modelled with multi-criteria analysis. The PESERA model inputs used in the study included 128 different data sets produced from baseline data such as soil, geology, topography and climate. In addition, land cover, NDVI and percent tree cover maps derived from remotely sensed data (MODIS and high spatial resolution data) are also used within the NPP modelling. The spatial resolution of the study was 250 m. The future climate change scenar io is based on the RCP (Representative Concentration Pathways) introduced in the fifth report of the IPCC.

The specified environmental variables are modeled for the current and future with the help of spatial information technolog ies. When the results across the country are compared, it is estimated that 0,048 Pg of carbon increase in NPP and erosion will increase from 285,5 million tons to 323,5 million tons. The results were evaluated in a detailed manner on the basis of basins in seasonal and spatialterms, and risky regions in our country were created.

2. NET PRIMARY PRODUCTION

One of the most important ecosystem components that can be used as an indicator of climate change is the Net Primary Productivity (NPP) of vegetation in our country, where species diversity is high. Plants use some of the photosynthesis products in respiration and the rest to produce new tissues in their bodies. Gross primary production (GPP) is the name of this reaction of plants; the difference between respiratory product (Rs) and gross primary production is called NPP (Berberoğlu et al., 2007). NPP is also equal to the net carbon stored within the plant biomass per unit area in time.

- NBÜ= BBÜ – RA

NPP is one of the important biophysical variables of vegetation activity and is of great importance for the global carbon budget. NPP is also one of the most important ecosystem components for the existence of life and the continuation of biodiversity in terrestrial ecosystems and an important determinant for ecosystem performance.

NPP prediction models used for the prediction of terrestrial ecosystems are divided into three types; statistical, parametric and process-based (Ruimy et al., 1999a). Statistical models work at a basic level, and NPP estimates are made by establishing a statistical relationship between climatic data and NPP. It is quite difficult to calculate the necessary parameters and variables in parametric models (Prince, 1991; Potter et al., 1993; Foley, 1994; Ruimy et al., 1999b; Sun and Zhu, 2001; Taşkınsu-Meydan et al.,. 2010. These models are more complex compared to statistical models. Process-based models predict NPP use the relationship and interaction between the fraction of Photosynthetically Active Radiation (fPAR) and vegetation index (Running et al., 1989; Bonan, 1995; Foley, 1995; Liu et al., 1997; Meydan, 2008). In these models, NPP is calculated based on the light use efficiency. Process-based physical models are widely used today, with the high accuracy they provide for predicting NPP. Process-based models use Light Use Efficiency (LUE), solar radiation and photosynthesis energy parameters in the estimation of seasonal and monthly spatial distribution and changes of NPP.

2.1. NASA-CASA Net Primary Production Modeling

The NASA-CASA model approach simulates nitrogen and carbon transformations in the ecosystem using existing land use/cover. It includes the interrelationships of gas flow controls such as nutrient availability in the substrate, soil moisture, temperature, texture and microbial activities. The model is designed to simulate carbon detection, nutrient distribution, litterfall, soil-nitrogen mineralization, CO_2 exchange, additionally N_2O and NO production, CH_4 consumption daily and seasonally (Potter et al., 2001). The CASA Model uses light use efficiency, PAR (photosynthetically active radiation (wavelength between 0,4-0,7 µm) - the amount in megajoules per square meter per month) and NDVI (Normalized Difference Vegetation Index) and estimates the NBU values according to the months by calculating fPAR.

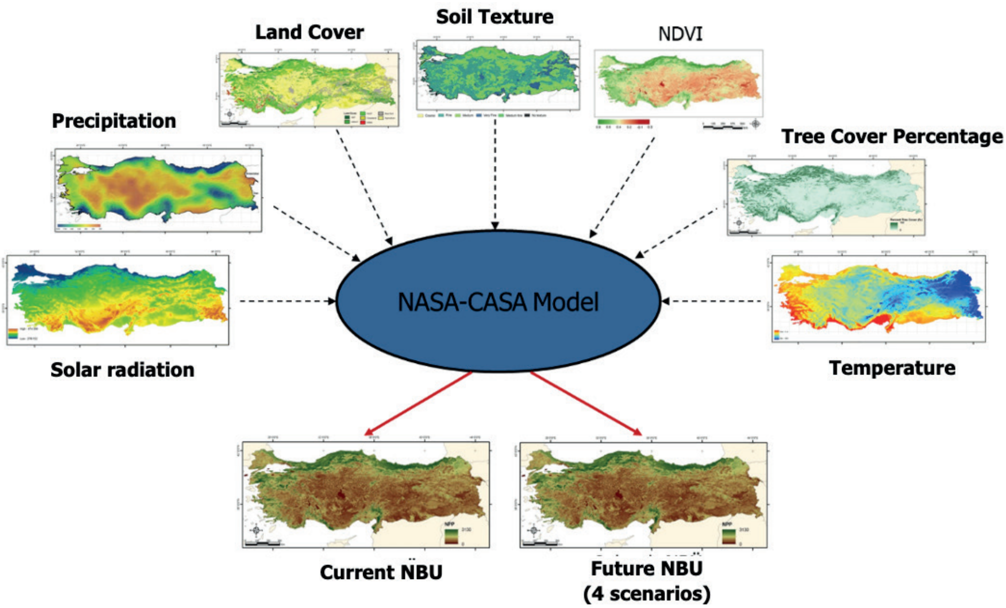
- NBÜ=f(NDVI) PAR ε T W

In the relation, ε = light use efficiency (for Turkey is within the interval of 0.35-0.40), T = temperature and W = precipitation (Berberoğlu et al., 2007). In the calibration and other stages of the model, the increase in ε * value, which can occur with the increase of atmospheric CO_2, is effective in the increase of the NPP value. T and W values were calculated with the temperature and precipitation data.

In the model, the monthly NPP cycle was calculated based on the light use efficiency to determine the net carbon absorbed by the vegetation. By using this model, changes in terrestrial net primary production at regional and global scale can be predicted in the future with different climate values. In order to create the model, light usage efficiency, temperature, precipitation, solar radiation, tree canopy percentage, land cover and soil texture maps of the region and NDVI values form the input data (Berberoğlu et al., 2007).

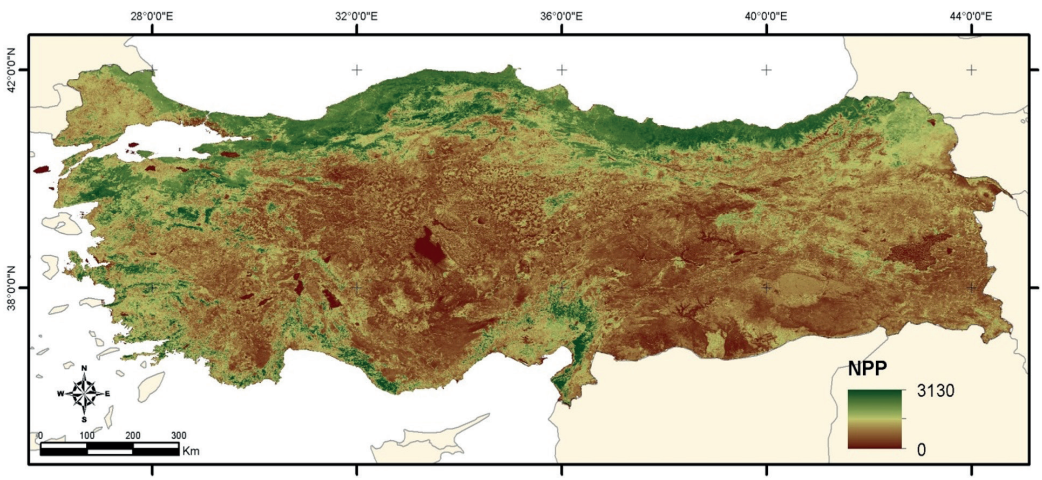
The model starts with generat ing "fPAR" and "ε" parameters for NPP in the "x" field at "t" time (Potter et al., 2001). In the model, the highest measurable LUE (ε) is an important metric. In the NPP estimation with CASA model, light use efficiency, temperature, precipitation, solar radiation, percent tree cover, land cover and soil texture maps of the reg ion and NDVI values were used (Figure 1). NPP map was derived using these inputs together with the model algorithm (Figure 2).

Figure 1: NASA-CASA model entries



Resource: Berberoğlu, 2014

Figure 2: Turkey's total annual NBU map

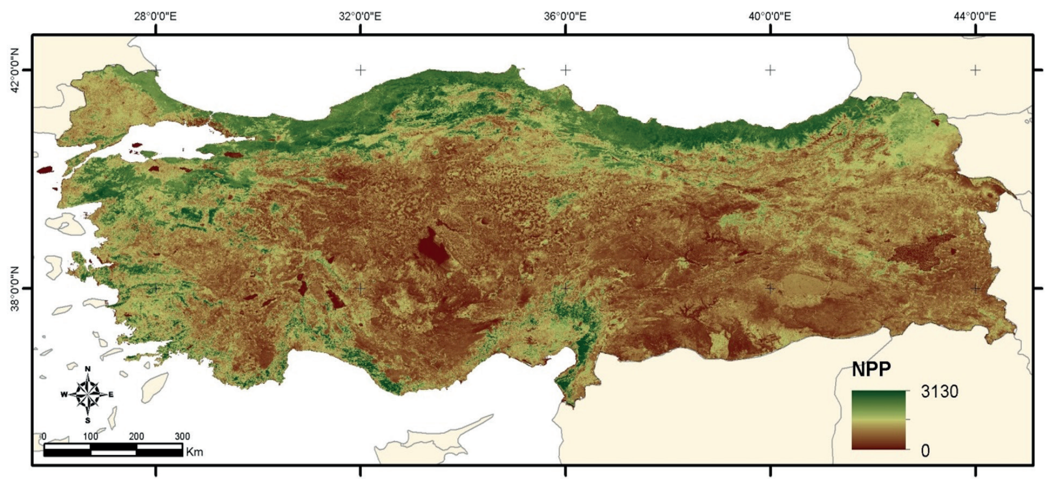


Resource: Berberoğlu, 2014

The total annual forest NPP (2000-2010) amount was estimated as 0.64 Pg y-1. NPP difference images between current and future were produced for 4 different RCP scenarios (RCP 2.6, RCP 4.5, RCP 6.0, RCP 8.5) at a spatial resolution of 250 m (Figure 3).

Significant differences are seen in the spatial distribution of NPP in Turkey. The amount of increase in future scenarios is estimated as +626 and +703 gCy-1. The increase was mostly found at the broadleaf forests in the northern part of Turkey.

Figure 3: NASA-CASA Model Net Primary Productivity for Future (2060-2080) - Current (2000-2010) Difference Map (RCP85)



Resource: Berberoğlu, 2014

All scenarios demonstrate that increase will occur in Turkey's northern part and there will be a high decrease in the southern part. When the difference images are examined, it clearly shows that the highest increase in NPP is in these regions due to the increase in precipitation and temperature, especially in the high regions. The carbon amount according to the land cover classes of the model results is given in Table 1.

Table 1: Current and future NBU values by Land Cover groups

Land use/ cover classes	2000-2010		2060-2080							
	Current NBU		RCP2.6		RCP4.5		RCP6.0		RCP8.5	
	Yıllık (gCy^{-1})	Toplam (Pt)	Yıllık (gCy^{-1})	Toplam (Pt)	Yıllık (gCy^{-1})	Toplam (Pt)	Yıllık (gCy^{-1})	Toplam (Pt)	Yıllık (gCy^{-1})	Toplam (Pt)
BDF	1839.71	1.442	1969.54	1.544	1965.70	1.541	1981.30	1.553	1970.94	1.545
MBNLF	1311.06	1.028	1400.43	1.098	1407.68	1.103	1413.80	1.108	1418.99	1.112
NLEF	1665.93	1.306	1810.18	1.419	1832.89	1.437	1838.41	1.441	1860.31	1.458
Pasture	875.59	0.686	943.90	0.740	950.00	0.745	949.74	0.744	954.74	0.748
BSBS	1260.99	0.988	1329.12	1.042	1364.75	1.070	1359.23	1.065	1393.80	1.093
Open area	665.35	0.522	708.10	0.555	709.27	0.556	709.43	0.556	710.19	0.557
Agriculture	1008.15	0.790	1084.36	0.850	1097.09	0.860	1098.74	0.861	1110.12	0.870
Total:	3130	2.454	3056	2.396	3093	2.425	3133	2.456	3186	2.497

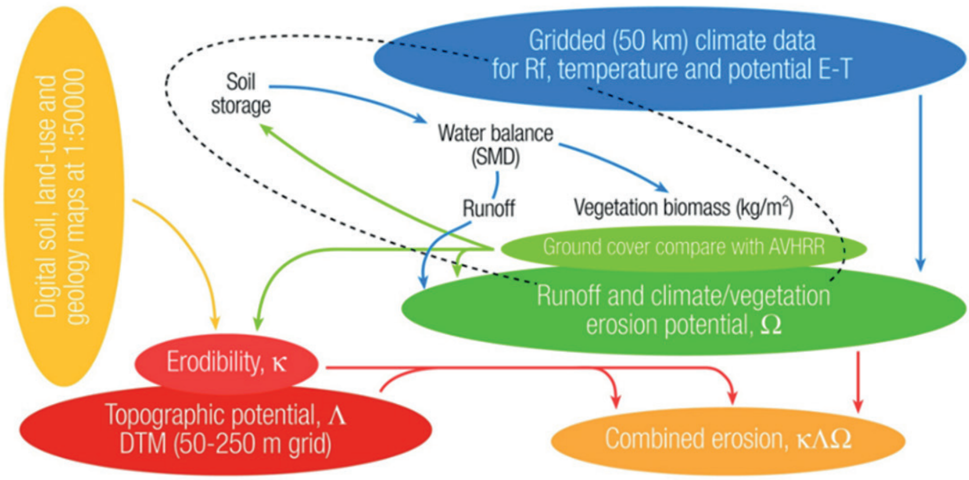
BDF; Broadleaf forest, MBNLF; Wide / Coniferous Mixed Stand, NLEF; Coniferous Forest, BSBS: Shrub / Ground cover.
Resource: Berberoğlu (2014)

3. EROSION

The PESERA (Pan-European Soil Erosion Risk Assessment) model (Kirkby, 1999; Kirkby et al., 2000) was developed as a regional tool to predict soil erosion under various land use, soil and landscape characteristics. Many soil erosion models were developed in the past with the development of USLE method (Wischmeir and Smith, 1978), USLE (RUSLE) (Renard et al., 1991), WEPP (USDA- Water Erosion Prediction Project) (Nearing and Nicks, 1998) and EUROSEM. (European Soil Erosion Model) (Quinton and Morgan, 1998) was developed. The USLE and RUSLE models were developed primarily for the assessment of average annual soil loss. Therefore, the USLE and RUSLE models are weak in estimating the deposition and sediment amount from complex shaped slope profiles or in determining the temporal and spatial distributions of erosion. EUROSEM is a physically based model that is generally used for periodic periods demanding data requirements in small areas (Kirkby, 1998). The WEPP model, on the other hand, is a physically based model that is widely used for simulation, but it requires a large database.

PESERA Model integrates climate, vegetation, topography and soil data into a single structure to calculate surface runoff and soil erosion (Figure 4). The data required for each of the factors within the model can be obtained from relevant sources and combined in a physically-based model, and realistic calculations can be made for soil erosion.

Figure 4: PESERA Model Approach



Resource: Irvine ve Kosmas, 2007

Erosion is mainly controlled by factors such as climate, vegetation, soil and topography (Kirkby, 2003). Soil erosion was calculated by integrating soil erosion (k), runoff and climate/vegetation potential and topography potential in PESERA Model.

E=K x L x W

In the equality;

- E: Soil erosion amount (ton / hectare / year)
- K: Erodibility (mm)
- L: Stands for the topographic potential based on a digital elevation model
- W: Stands for the runoff and climate/vegetation soil erosion potential based on gridded climate data, vegetation cover, water balance and a plant growth model.

$$W = \sum_{r>h} P\ (r - h)$$

In the equality;

- W: Surface flow (mm)
- P. Surface flow rate above threshold (mm)
- r: total precipitation (mm)
- h: threshold value (mm).

To apply the PESERA model; 128 grid format maps have been completed. Most of these data are based on soil and climate data. From these maps, many layers such as 96 monthly climate data and 25 land cover data were used. The others are 6 soil features and 1 topography-related layers (Figure 5).

As a result of erosion modeling, the amount of soil lost from the country's surface in one year was estimated to be approximately 285 million tons. The amount of fertile land lost only from agricultural areas is approximately 55 million tons/year. This clearly shows that 30% of erosion is in agricultural areas. The remaining 68% was found to be in scrub and degraded forest areas, and 2% in forests and residential areas. When we look at overall average erosion, 19 basins are below the overall average of Turkey, 6 basins were found to be above. It is seen that there are Tigris, Eastern Mediterranean, Asi, Antalya, Ceyhan and Seyhan Basins above the average (Table 2).

It has been observed that the amount of erosion is highest in bushy areas, degraded natural areas and olive groves. According to the monthly erosion results, it was observed that the amount of erosion increased from September when the rains started until November. When it comes to the winter months, the transformation of precipitation into the snow and the decrease of runoff reduce the amount of erosion. In April, an increase is observed in the melting snow waters, which turn into surface flow with the filling of water reserves with the melting of the snow.

Figure 5: Flow diagram of the main factors controlling erosion

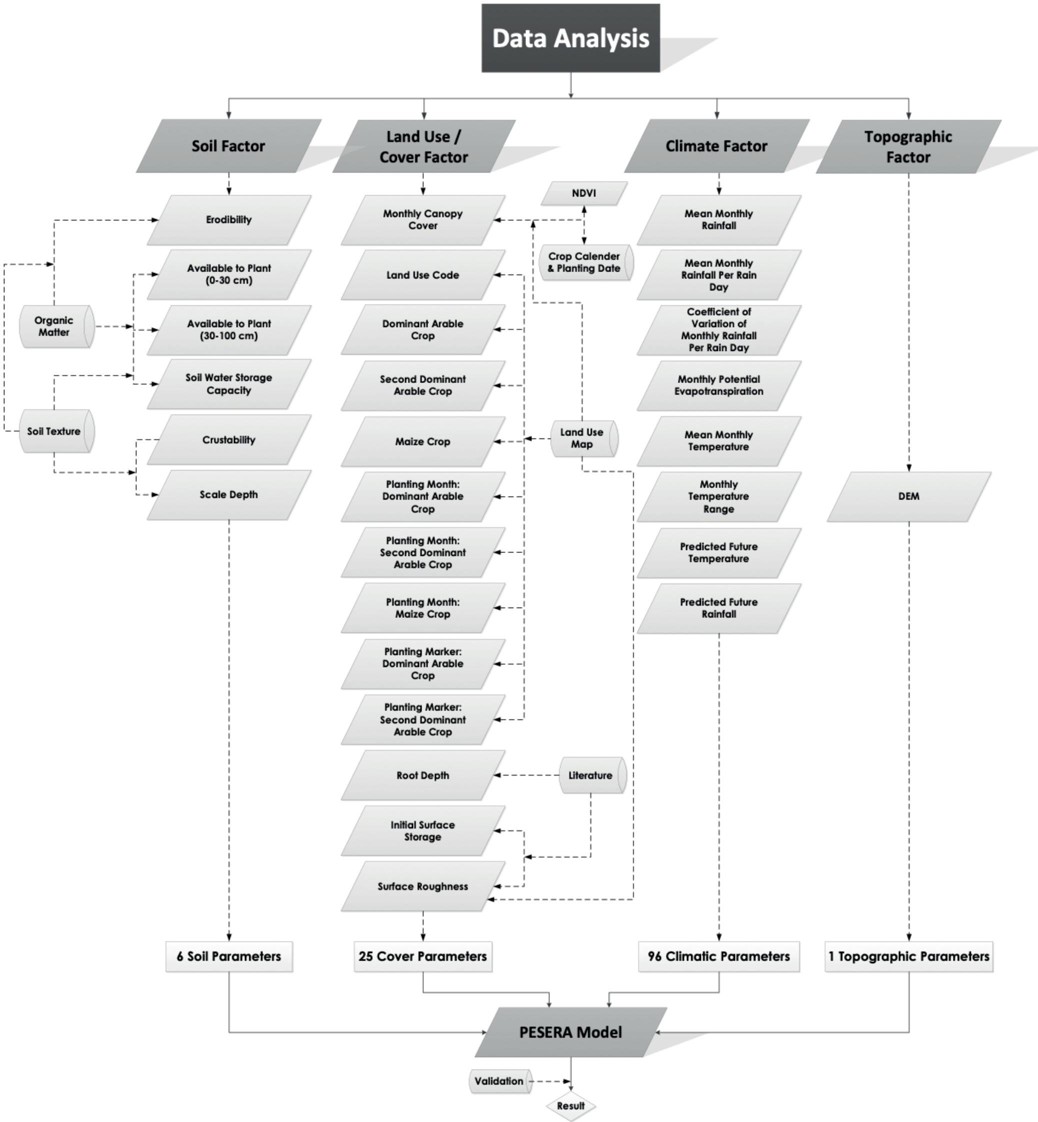


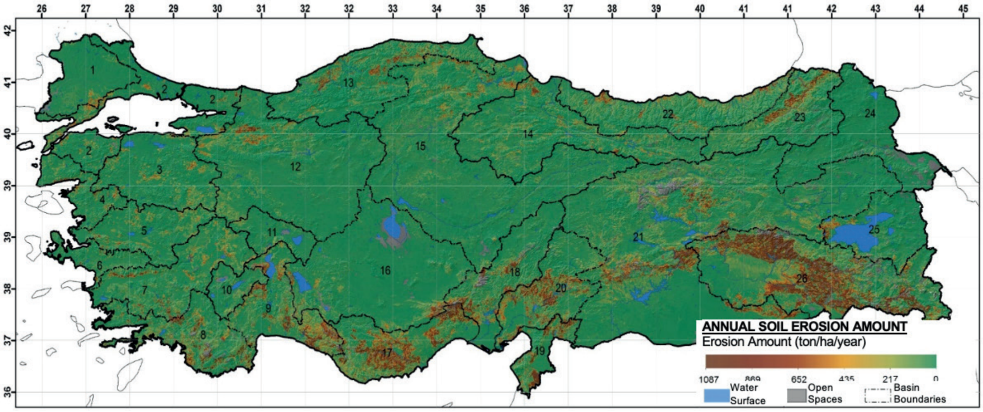
Table 2: Erosion amounts in Turkey as a result of model

Basin Name	Total Area (Ha)	Annual Erosion Amount				Standard deviation	Total Erosion Amount (%)
		(ton/ha/year)			(ton/year)		
		Min.	Max.	Avrg.	Total:		
(01) Meric Ergene Basin	1446560	0	65,76	1,24	1671587,5	2,82	0,59
(02) Marmara Basin	1686190	0	117,82	1,85	3976831,25	5,01	1,39
(03) Susurluk Basin	2429150	0	109,29	1,74	4150856,25	4,46	1,45
(04) North Aegean Basin	988287	0	133,13	2,38	2306900	6,44	0,81
(05) Gediz Basin	1715540	0	132,88	2,08	3512218,75	5,21	1,23
(06) Küçük Menderes Basin	697435	0	147,80	1,72	1164087,5	4,58	0,41
(07) Büyük Menderes Basin	2602000	0	265,80	3,04	7785237,5	8,05	2,73
(08) Western Mediterranean Basin	2100680	0	540,28	5,27	10371043,75	16,38	3,63
(09) Antalya Basin	1953360	0	702,92	7,94	14281818,75	23,70	5,00
(10) Burdur Lakes Basin	647022	0	86,04	1,85	1083312,5	3,23	0,38
(11) Akarcay Basin	799542	0	61,13	1,36	1022643,75	2,47	0,36
(12) Sakarya Basin	5892650	0	331,54	1,58	9223881,25	4,27	3,23
(13) Western Black Sea Basin	2887070	0	256,25	2,61	7422168,75	9,09	2,60
(14) Yesilirmak Basin	3861560	0	111,26	2,17	8184812,5	5,28	2,87
(15) Kizilirmak Basin	8223410	0	172,29	1,63	12996750	3,98	4,55
(16) Konya Closed Basin	5437010	0	232,32	1,31	6476343,75	3,74	2,27

Basin Name	Total Area (Ha)	Annual Erosion Amount				Standard deviation	Total Erosion Amount (%)
		(ton/ha/year)			(ton/year)		
		Min.	Max.	Avrg.	Total:		
(17) Eastern Mediterranean Basin	2235730	0	447,76	11,10	24071625	24,22	8,43
(18) Seyhan Basin	2168070	0	313,90	3,93	7963843,75	12,32	2,79
(19) Asi Basin	783898	0	316,20	8,84	6718737,5	22,93	2,35
(20) Ceyhan Basin	2147080	0	549,62	6,88	14331275	18,85	5,02
(21) Firat Basin	12182200	0	443,97	2,92	32867312,5	9,24	11,51
(22) Eastern Black Sea Basin	2382610	0	524,58	3,07	7148293,75	7,10	2,50
(23) Coruh Basin	2023900	0	402,28	3,72	7131250	11,79	2,50
(24) Aras Basin	2792860	0	63,82	0,57	1453393,75	0,86	0,51
(25) Lake Van Basin	1797260	0	492,69	2,03	2702225	7,45	0,95
(26) Dicle Basin	5423800	0	1086,57	17,60	85413562,5	43,30	29,92
Turkey General	77304874	0	1086,57	3,88	285432012,5	15,08	100

When we look at the average erosion amount, the Asi Basin and Antalya Basin come after the Tigris Basin. In the Aras basin, where the annual erosion amount is the least, the average erosion is calculated as 0,57 tons/ha/year and the total erosion is 1 453.394 tons/year (Figure 6).

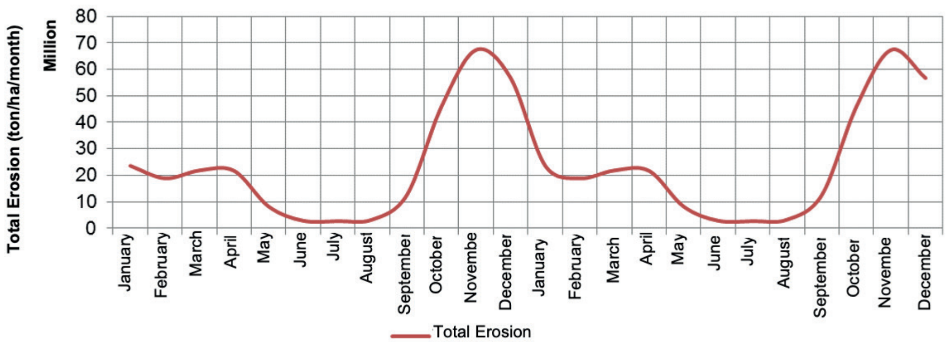
Figure 6: Annual Soil Erosion Amount



Resource: Berberoğlu, 2014

In the summer months, the amount of erosion that occurs due to the increase in temperature and decrease in precipitation decreases to the lowest levels (Figure 7).

Figure 7: Total monthly erosion cycle

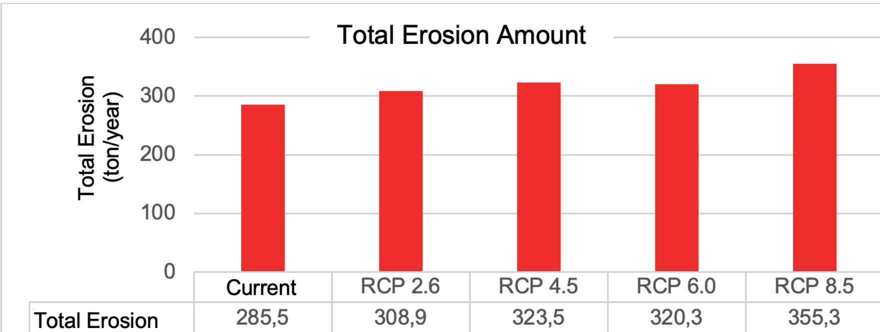


Resource: Berberoğlu (2014)

5. According to 4 different RCP scenarios (RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5) introduced at the IPCC Assessment report, the average temperature and precipitation data for the years 2060-2080 created by the Hadley center (HadGE-AO) were used. After the pre- processing of these data, the results were produced by applying the

PESERA model. According to the model it is clear that it will increase the amount of erosion in Turkey as a result of climate change. While the average erosion amount is 3.88 tons/ha/year today, it is predicted as 4.2, 4.41, 4.36 and 4.84 tons/ha/year in 2070 for the RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 scenarios respectively. It is seen that the total amount of erosion in our country will increase together with average overall country scale under climate change (Figure 8).

Figure 8: Changes in present and future total erosion amounts



Resource: Berberoğlu, 2014

4. FOREST FIRE RISK MODEL

The material needed within the scope of the forest fire risk analysis covering the Aegean, Mediterranean, West Marmara and northern Central Anatolia Regions is the input data shaped by the natural and human effects of the area. Areas at risk in terms of forest fires are rich in forest assets, but contain features that will trigger fires in terms of climatic factors. In this context, the Black Sea Region, which has the richest and most productive forests in terms of forest assets, is therefore not included in this analysis. Climatic factors such as drought, low humidity, dry days after rain, maximum temperature and solar radiation that will affect fire formation are the common factors affecting fire formation.

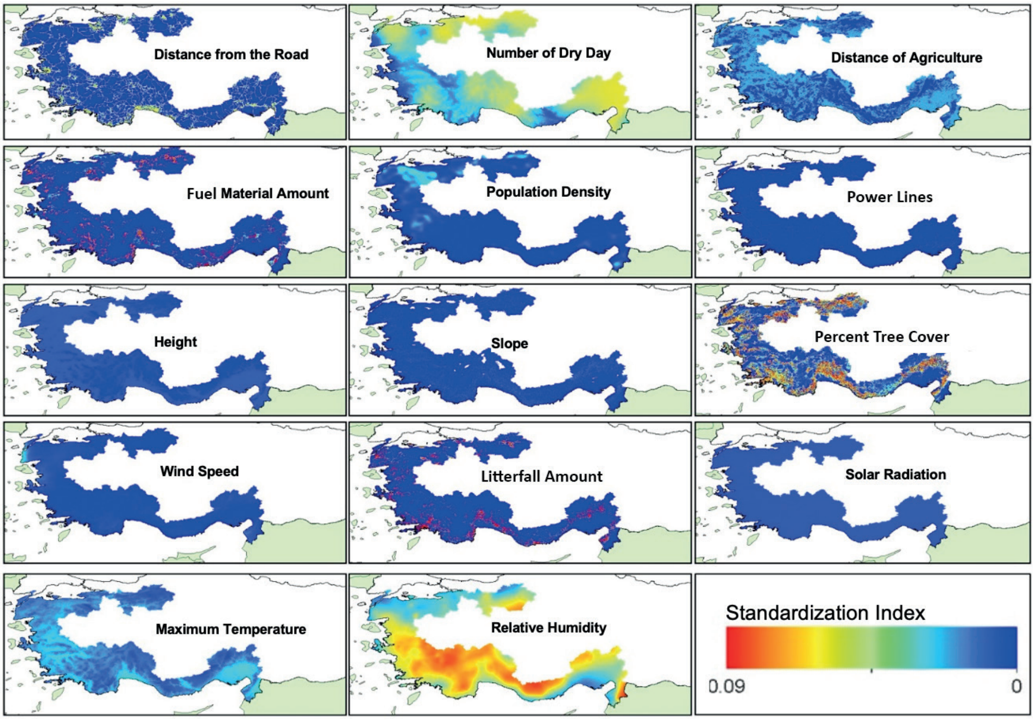
4.1. Forest Fire Risk Factors

Altitude, climate (Solar radiation, wind speed, relative humidity, maximum temperature and number of days after rain (12 months data for each climate variable)). In addition to these inputs, slope, CORINE land cover, stand, forest canopy, amount of litterfall, stand types, fuel, settlement density, road, power lines and distance maps to agricultural areas were produced and included in the model.

4.2. Standardization of Forest Fire Risk Factors

After the determination of the effective factors on fire risk, these factors, which are in different formats, values and intervals, need to be standardized in order to create the same scale. In this context, Fuzzy method, one of the widely used standardization methods for the multi-criteria analysis approach, was used. In this process, 14 different input data that constitute forest fire risk have been standardized (Figure 9).

Figure 9: Standardization of Forest Fire Risk Factors



4.3. Weighting of Forest Fire Risk Factors

The survey study was used in order to weight the standardization of forest fire risk factors. The weights of risk factors obtained by using the results of the survey based on expert opinion were evaluated using the simos method (Table 3).

Table 3: Risk Coefficient of Forest Fire Risk Factors

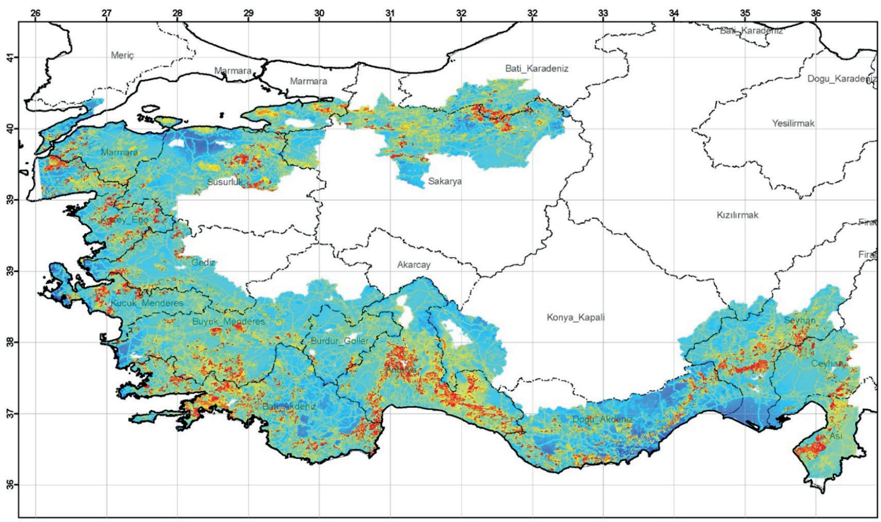
Forest Fire Risk Factors	Factor Risk Coefficients
Height	0,009
Power Lines	0,009
Slope	0,021
Distance to Agricultural Areas	0,021
Population density	0,034

Forest Fire Risk Factors	Factor Risk Coefficients
Distance to Road Networks	0,059
Number of Days After Rain	0,059
Solar Radiation	0,071
Relative Humidity	0,097
Percentage Tree Cover	0,109
Wind speed	0,122
Litterfall	0,134
Fuel Index of Stand Types	0,134
Maximum Temperature	0,122

4.4. Determination of Forest Fire Risk

Based on the weights given in Table 3, a multi-criteria analysis process was carried out with standardized images of the factors, and forest fire risk areas image was produced in the research area (Figure 10). While creating the forest fire risk map, it was designed to take 1 for the place where the risk is the highest and 0 for the lowest place.

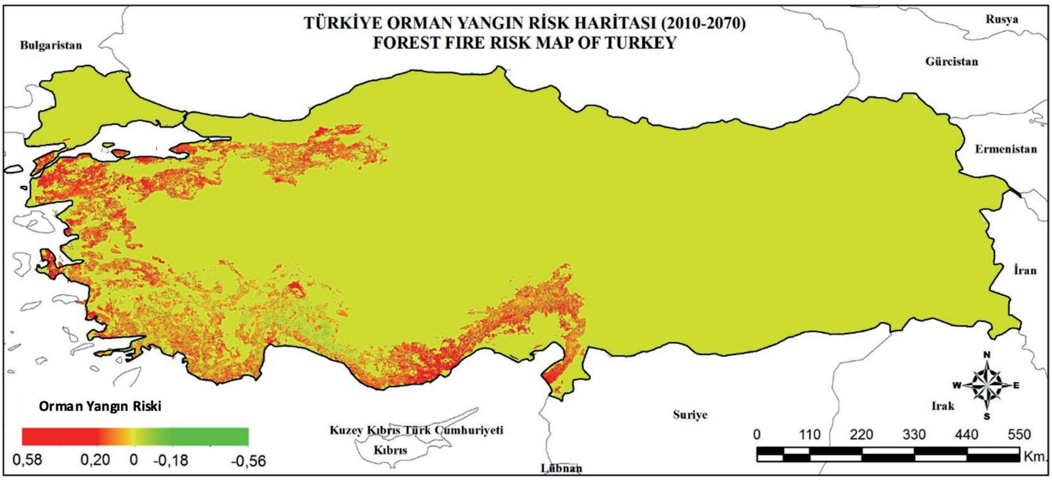
Figure 10: Turkey Forest Fire Risk Map



Resource: Berberoğlu, 2014

When the results obtained are evaluated, it is observed that the areas with the highest fire risk are Antalya, Menderes and Seyhan basins. In addition, in this study, it was revealed that the forest fire risk is not only in the Mediterranean and Aegean coasts, but also in the forests located at the intersection of Sakarya and Western Black Sea basins, including the northern part of the Central Anatolia Region. When the current risk is compared with the future risk map made with the climate data obtained from RCP scenarios, it is seen that there will be a significant risk increase in the Middle and Eastern Mediterranean (Figure 11).

Figure 11: Current and future forest fire risk change map



Resource: Berberoğlu, 2014

5. DROUGHT INDEX

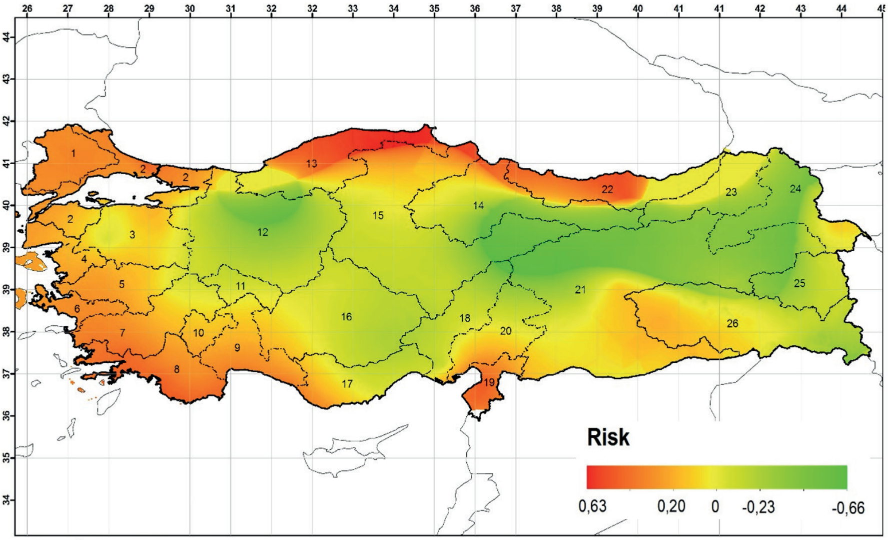
According to the current situation (the 1990s), future (2070s) climate change data are taken from the modeling results of a regional climate model (RCM). The Regional Climate Models developed in Japan are based on the MRI model. The potential impacts of climate change are estimated according to the A2 scenario of the special report on release scenarios (SRES). The drought index, which is the ratio of precipitation to potential evapotranspiration, was calculated using climate data measured for present conditions and data estimated by RCM for the future. Changes in drought have been evaluated by comparing current and future index values. Drought variables were interpolated to determine the local distribution with the help of geostatistical methods.

In Turkey's southern regions, especially in the coastal areas of the Mediterranean, the precipitation estimated for the year 2070 will be 29.6% less than the current figures. In contrast, an increase in precipitation up to 22% is predicted along the Black Sea coast. The model predicts a temperature increase of 2.8-5.5 ° C in different regions of the country. This increase in temperature could lead to a higher evaporation demand in the atmosphere (on average 18.4% in the Mediterranean coastal areas, 22.2% in the Black Sea coastline and 17.8% in the whole country). Thus, an increase in drought is predicted for all of Turkey except the North-East region (Figure 12). Comparing the future vegetation with the current situation, it is predicted that there will be a change from deciduous broad-leaf forests to evergreen coniferous forests in the northern coastal areas. Mixed forest cover may spread to the inner parts of Eastern Anatolia and the north-west part of our country in the future (Önder et al., 2009).

Turkey's drought index was standardized with fuzzy method and drought risk maps were obtained. The regions specified in the drought index were used as threshold values in standardization processes.

Hyper arid zone		P/ETo < 0,9
Arid zone	0,9 ≤	P/ETo < 6,0
Semi arid zone	6,0 ≤	P/ETo < 15,0
Low humid area	15,0 ≤	P/ETo < 22,5
Humid area	22,5 ≤	P/ETo

Figure 12: Current and future drought risk change map

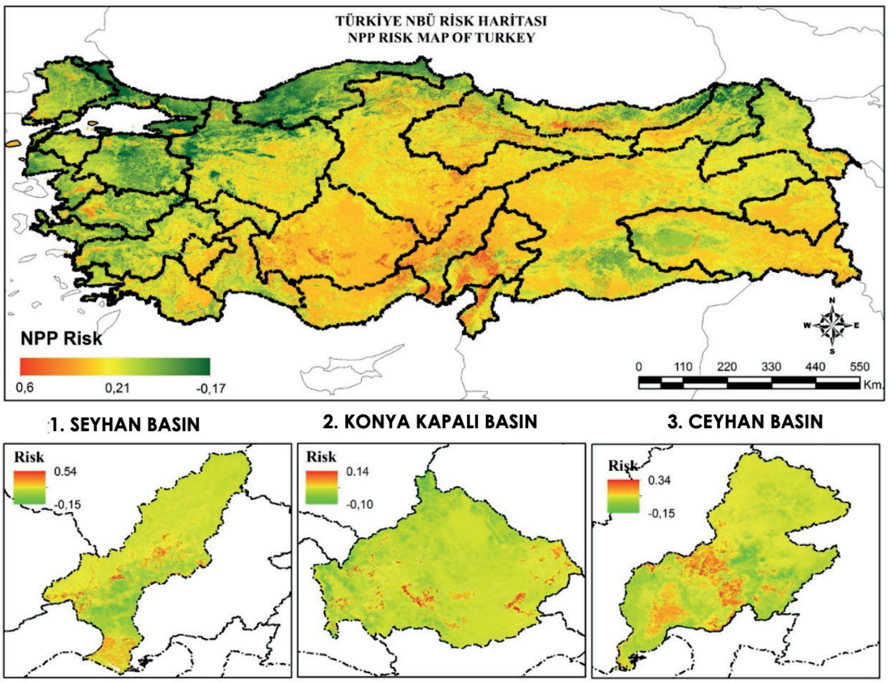


Resource: Önder et al., 2009

6. CONCLUSION

It has been determined that the risk will decrease in terms of Net Primary Production in the Western Black Sea and Eastern Black Sea Regions, while the risk will increase in the future in the Eastern Mediterranean region and around Konya. When the Total NPP values in the basins are examined, the most critical basin is the Seyhan Basin and followed by the Asi basin, the Ceyhan basin and the Eastern Mediterranean basins -(Figure 13). It is seen that the basins with the highest increase in NPP are Fırat, Sakarya and West Black Sea basins. It is seen that the highest increase will be in Sakarya basin with 14,70% in terms of total NPP% increase values in the basins, followed by the Marmara and Büyük Menderes Basin (Table 4).

Figure 13: Three risky basins for NPP



In terms of erosion, the total amount of erosion in the future is predicted to be mostly in the Tigris Basin, Euphrates Basin and Sakarya Basin (Figure 14). In the Eastern Black Sea and Çoruh basin, it is estimated that the amount of erosion will decrease according to the Climate change RCP 4.5 scenario. It is predicted that approximately 38 million tons of erosion will increase throughout the country according to the RCP 4.5 scenario. Current and future erosion amounts and increase-decrease values in each basin are given in Table 5.

Figure 14: Three risky basins for the amount of erosion

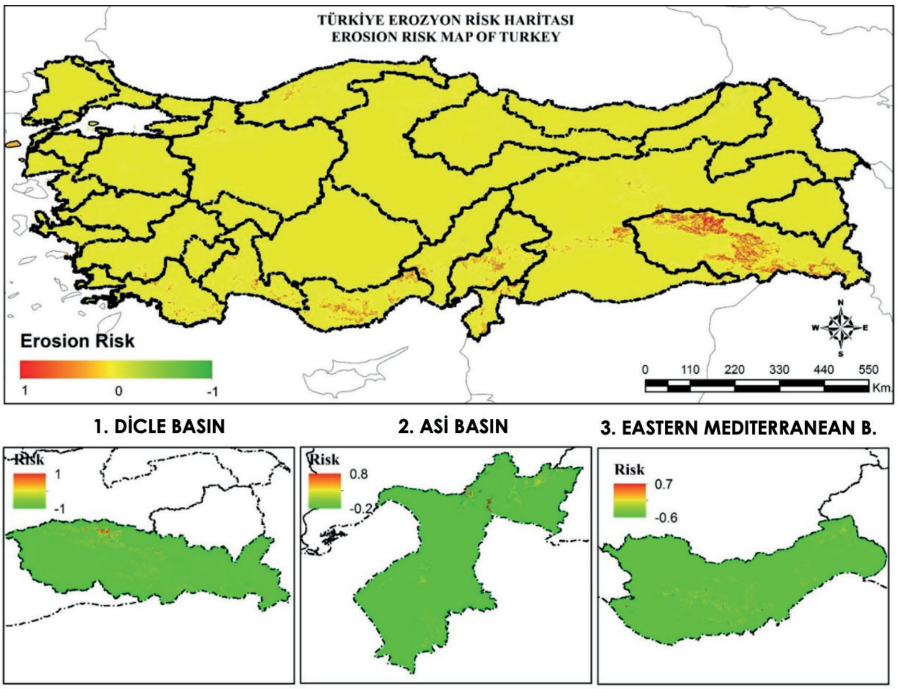


Table 4: Net Primary Production Changes in the Basins

Basins	Current Net Primary Production (g C m² yr⁻¹) Avrg.	Current Net Primary Production (Petagram) Total	Standard Deviation	Total Percent (%)	Future Net Primary Production (g C m² yr⁻¹) Avrg.	Future Net Primary Production (Petagram) Total	Standard Deviation	Total Percent (%)	Annual Net Primary Production Difference (g C m² yr⁻¹) Avrg.	Annual Net Primary Production Difference (Petagram) Total	Standard Deviation	Percent NBU Difference Change (%)
(01) Meriç Ergene Basin	1191,73	**0,023**	341,03	2,17	1327,56	**0,025**	379,05	2,24	379,05	**0,003**	78,18	11,58
(02) Marmara Basin	1648,16	**0,050**	582,47	4,75	1818,59	**0,055**	646,64	4,85	646,64	**0,005**	87,37	10,88
(03) Susurluk Basin	1532,49	**0,048**	553,03	4,58	1699,94	**0,053**	604,57	4,70	604,57	**0,005**	86,48	11,01
(04) Norh Aegean Basin	1422,91	**0,018**	554,10	1,72	1554,73	**0,020**	577,97	1,74	577,97	**0,002**	72,75	9,56
(05) Gediz Basin	1088,02	**0,024**	480,97	2,26	1230,23	**0,027**	502,18	2,37	502,18	**0,003**	83,42	13,08
(06) Küçük Menderes Basin	1499,47	**0,013**	598,53	1,25	1629,55	**0,014**	625,23	1,26	625,23	**0,001**	61,80	9,18
(07) Büyük Menderes Basin	1069,08	**0,035**	503,12	3,34	1185,03	**0,039**	520,44	3,43	520,44	**0,004**	69,55	10,87
(08) Western Mediterranean Basin	1176,29	**0,031**	619,43	2,92	1237,08	**0,032**	633,15	2,84	633,15	**0,002**	61,17	5,93
(09) Antalya Basin	1146,63	**0,028**	645,37	2,67	1207,77	**0,030**	654,99	2,60	654,99	**0,002**	70,02	5,43
(10) Burdur Göller Basin	718,13	**0,006**	340,34	0,56	777,61	**0,006**	355,12	0,56	355,12	**0,000**	63,60	8,28
(11) Akarçay Basin	855,61	**0,009**	435,89	0,83	944,21	**0,010**	449,05	0,85	449,05	**0,001**	52,98	10,35
(12) Sakarya Basin	960,33	**0,073**	588,99	6,98	1101,37	**0,084**	644,51	7,41	644,51	**0,011**	83,16	14,70
(13) Western Black Sea Basin	2003,81	**0,077**	406,57	7,29	2224,59	**0,085**	489,37	7,49	489,37	**0,009**	102,00	11,17
(14) Yeşilırmak Basin	1307,39	**0,066**	512,25	6,28	1358,21	**0,069**	517,86	6,03	517,86	**0,003**	67,93	3,91
(15) Kızılırmak Basin	942,41	**0,101**	541,69	9,58	1005,27	**0,107**	564,62	9,45	564,62	**0,007**	67,83	6,70
(16) Konya Kapalı Basin	626,81	**0,043**	367,00	4,10	650,35	**0,045**	359,98	3,94	359,98	**0,002**	52,79	3,76
(17) Eastern Mediterranean Basin	908,05	**0,025**	562,17	2,40	931,56	**0,026**	564,91	2,28	564,91	**0,001**	56,62	2,72
(18) Seyhan Basin	920,74	**0,025**	481,28	2,39	924,76	**0,025**	474,70	2,23	474,70	**0,000**	72,32	0,47
(19) Asi Basin	1243,57	**0,012**	748,11	1,15	1281,04	**0,012**	705,38	1,09	705,38	**0,000**	90,51	3,43
(20) Ceyhan Basin	1089,20	**0,029**	645,87	2,80	1110,72	**0,030**	618,62	2,64	618,62	**0,001**	84,12	2,00
(21) Fırat Basin	727,22	**0,113**	334,93	10,74	802,04	**0,124**	345,17	10,96	345,17	**0,012**	58,14	10,31
(22) Eastern Black Sea Basin	1983,33	**0,062**	500,48	5,91	2072,46	**0,065**	569,57	5,72	569,57	**0,003**	100,98	4,91
(23) Çoruh Basin	1270,20	**0,034**	518,52	3,21	1377,29	**0,037**	601,50	3,22	601,50	**0,003**	103,01	8,48
(24) Aras Basin	1114,46	**0,041**	392,67	3,86	1199,42	**0,044**	425,95	3,85	425,95	**0,003**	44,97	7,82
(25) Van Lake Basin	653,96	**0,015**	335,49	1,43	700,14	**0,016**	354,80	1,41	354,80	**0,001**	38,68	7,18
(26) Dicle Basin	739,13	**0,051**	270,49	4,81	805,70	**0,055**	281,32	4,86	281,32	**0,005**	62,64	9,13
Turkey General	**1049**	**1,051**	**603,57**	**100**	**1134**	**1,136**	**643,49**	**100**	**1049**	**0,086**	**603,57**	**8,23**

Resource: Berberoğlu, 2014

Table 5: Erosion Changes in the Basins

Basins	Total Area (ha)	Current Annual Erosion (ton/ha/year) Avrg.	Current Annual Erosion (ton/year) Total	Standard Deviation	Total Percent (%)	Future Annual Erosion (RCP 4.5) (ton/ha/year) Avrg.	Future Annual Erosion (RCP 4.5) (ton/year) Total	Standard Deviation	Total Percent (%)	Annual Erosion Difference (Future-Current) (ton/ha/year) Avrg.	Annual Erosion Difference (Future-Current) (ton/year) Total	Standard Deviation	Percent Difference Change (%)
(01) Meriç Ergene Basin	1446560	1,25	**1680393**	2,83	0,59	1,62	**2174390**	4,05	0,67	0,37	**493997**	1,30	29,40
(02) Marmara Basin	1686190	1,84	**3977269**	5,01	1,39	2,26	**4842766**	6,37	1,50	0,42	**865497**	1,74	21,76
(03) Susurluk Basir	2429150	1,75	**4149691**	4,46	1,45	2,17	**5150123**	5,63	1,59	0,42	**1000432**	1,72	24,11
(04) North Aegean Basin	988287	2,39	**2307754**	6,45	0,81	2,68	**2579235**	7,35	0,80	0,31	**271481**	1,23	11,76
(05) Gediz Basir	1715540	2,08	**3510656**	5,21	1,23	2,50	**4223397**	6,50	1,31	0,42	**712741**	1,78	20,30
(06) Küçük Menderes Basin	697435	1,72	**1162554**	4,58	0,41	1,93	**1299844**	5,35	0,40	0,22	**137290**	0,98	11,81
(07) Büyük Menderes Basin	2602000	3,04	**7781877**	8,05	2,73	3,39	**8670585**	9,05	2,68	0,35	**888709**	2,41	11,42
(08) Western Mediterranean Basin	2100680	5,28	**10371128**	16,38	3,63	5,98	**11658013**	18,61	3,60	0,70	**1286885**	4,39	12,41
(09) Antalya Basin	1953360	7,94	**14281298**	23,70	5,00	7,97	**14301704**	22,93	4,42	0,03	**20406**	5,07	0,14
(10) Burdur Göller Basin	647022	1,86	**1084645**	3,24	0,38	2,25	**1317224**	4,19	0,41	0,40	**232579**	1,31	21,44
(11) Akarçay Basin	799542	1,36	**1022955**	2,47	0,36	1,63	**1224376**	3,07	0,38	0,27	**201421**	0,91	19,69
(12) Sakarya Basir	5892650	1,58	**9229103**	4,27	3,23	1,96	**11391187**	5,31	3,52	0,37	**2162084**	1,33	23,43
(13) Western Black Sea Basin	2887070	2,61	**7429461**	9,09	2,60	2,75	**7832629**	9,96	2,42	0,14	**403168**	4,04	5,43
(14) Yeşilırmak Basin	3861560	2,17	**8185246**	5,29	2,87	2,35	**8852063**	4,81	2,74	0,18	**666817**	2,44	8,15
(15) Kızılırmak Basir	8223410	1,63	**12999138**	3,98	4,55	1,86	**14832626**	4,28	4,59	0,23	**1833488**	1,53	14,10
(16) Konya Kapalı Basin	5437010	1,31	**6481597**	3,74	2,27	1,46	**7252429**	3,70	2,24	0,16	**770832**	1,77	11,89
(17) Eastern Mediterranean Basin	2235730	11,10	**24081919**	24,21	8,44	11,81	**25539717**	26,13	7,90	0,69	**1457798**	7,31	6,05
(18) Seyhan Basin	2168070	3,93	**7975201**	12,34	2,79	4,11	**8335723**	12,45	2,58	0,18	**360523**	6,48	4,52
(19) Asi Basir	783898	8,84	**6716191**	22,93	2,35	9,61	**7238074**	27,40	2,24	0,74	**521884**	7,19	7,77
(20) Ceyhan Basin	2147080	6,88	**14330509**	18,86	5,02	8,07	**16800904**	24,88	5,19	1,19	**2470395**	10,47	17,24
(21) Fırat Basir	12182200	2,92	**32868784**	9,23	11,51	3,54	**39793938**	10,84	12,30	0,62	**6925154**	3,79	21,07
(22) Eastern Black Sea Basin	2382610	3,08	**7149896**	7,10	2,50	1,75	**4051295**	4,17	1,25	-1,33	**-3098601**	5,92	- 43,34
(23) Çoruh Basir	2023900	3,72	**7133061**	11,79	2,50	2,86	**5484484**	6,93	1,70	-0,86	**-1648576**	9,22	- 23,11
(24) Aras Basir	2792860	0,57	**1454000**	0,86	0,51	0,63	**1588620**	0,93	0,49	0,05	**134619**	0,48	9,26
(25) Van Lake Basin	1797260	2,03	**2697829**	7,43	0,95	2,07	**2745264**	6,79	0,85	0,04	**47436**	4,64	1,76
(26) Dicle Basir	5423800	17,60	**85402421**	42,30	29,92	21,53	**104283897**	50,34	32,24	3,92	**18881476**	19,90	22,11
Turkey General	77304874	**3,88**	**285.464.573**	15,07	100	**4,41**	**323.464.508**	17,41	100	0,52	**37999935,7**	6,53	13,31

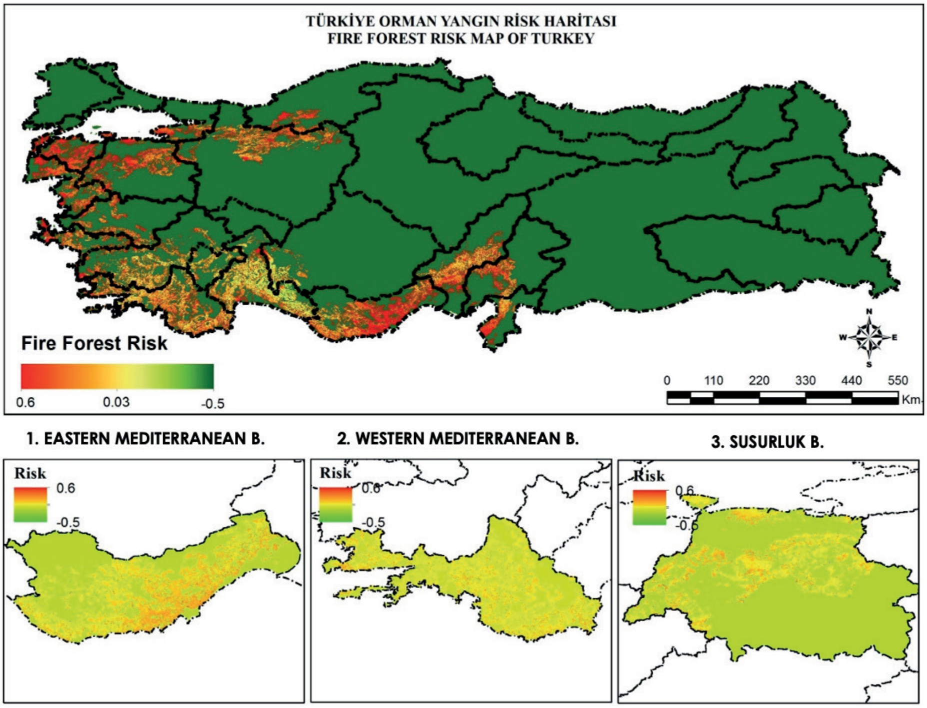
Resource: Berberoğlu, 2014

In addition to the current forest fire risk, the RCP 4.5 scenario was used in order to obtain the future forest fire risk. In the current forest fire risk map, the basins with the highest risk are observed in the Middle Mediterranean, Western Mediterranean, Büyük Menderes, Seyhan basins and additionally in the region between the Sakarya basin and the Western Black Sea basin. It is observed that the level of solar radiation is high in areas with high fire risk. Solar radiation is highest in Seyhan, Ceyhan, the Eastern Mediterranean, additionally, there is a part of the Western Black Sea basin including Bolu and Sakarya. In addition to solar radiation in the area, it is remarkable that the maximum temperature rate is high in areas where forest fires are high. In addition, the rate of the number of days passing after precipitation in these regions has been achieved higher than the Aegean and Mediterranean coasts. As this period increases, the possibility of a fire increases.

While 10 indicators were kept constant during the determination of future forest fire risk, the relative humidity, precipitation, maximum temperature and solar radiation data were updated according to the RCP 4.5 scenario. The highest risk of forest fires in the future shows a risk trend from the Mediterranean coasts to the western coastal areas. While the average value of solar radiation within the working area boundary is 452.743 J/kg today, it has been calculated that this average will decrease to 438.380 J / kg in the future. In terms of relative humidity, the Seyhan and Ceyhan basins show a negative trend.

When the current and RCP 4.5 relative humidity data in the study area are compared, it is estimated that an increase of 7,66% will occur in general. The increase in humidity in the Marmara and Western Black Sea basins is remarkable. However, it is estimated that the Seyhan, Ceyhan and Hatay basins, where relative humidity is expected to decrease, will have a higher risk of forest fire in the future compared to the present (Figure 15).

Figure 15: Three risky basins in terms of forest fire risk



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CLIMATE MODELING, CLIMATE PREDICTIONS, APPLICATION TECHNOLOGIES FOR MONITORING CLIMATE CHANGE

Prof. Dr. Süha Berberoğlu

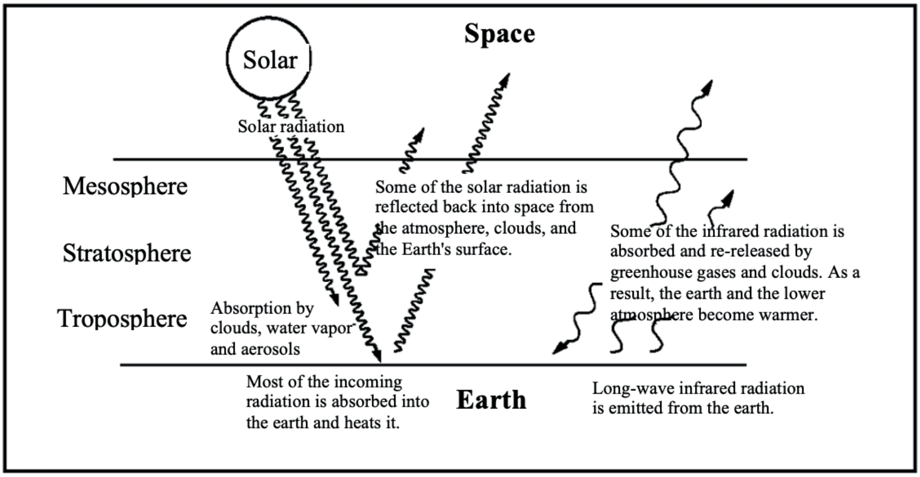
1. INTRODUCTION

The climate system is a complex and interactive system encompassing the atmosphere, land surfaces, snow and ice, oceans and other bodies of water and living things. This system changes gradually over time under the influence of its internal dynamics or due to changes in external factors. External forces include natural events such as volcanic eruptions and solar variations and human-induced changes in the composition of the atmosphere. Solar radiation is the power source of the climate system. Three basic processes affect the radiation balance of the Earth and thus change the climate:

- Changes in incoming solar radiation (due to changes in the Sun itself or the Earth's orbit)
- Changes in the reflected portion of solar radiation (this portion is called the albedo and may change due to cloud cover, small particles called aerosols or changes in land cover)
- Changes in long-wave radiation sent back from the earth to space (due to the accumulation of greenhouse gas emissions in the atmosphere). In addition to these, winds and ocean currents have important effects on the climate due to their role in heat distribution on the Earth's surface (Anonymous, 2019).

It is a fact accepted by many scientific environments that global average surface temperatures increase and climate changes due to the rapid increase in greenhouse gas emissions caused by human activities. 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 long-wave ground radiation emitted from the Earth's hot surface is absorbed by the many radially active trace gases (greenhouse gases) in the upper levels of the atmosphere before escaping into space and then released again. The most important natural greenhouse gases are water vapor (H_2O), which provides the biggest contribution, carbon dioxide (CO_2), methane (CH_4), diazotmonoxide (N_2O) and ozone (O_3) gases in the troposphere and stratosphere. In average conditions, the Earth/atmosphere combined system will be warmer than it would be in an environment without greenhouse gases, as the long-wave ground radiation escaping into space is in equilibrium with incoming solar radiation. 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 (Figure 1) (Türkeş, M. 2001).

Figure 1: Greenhouse effects



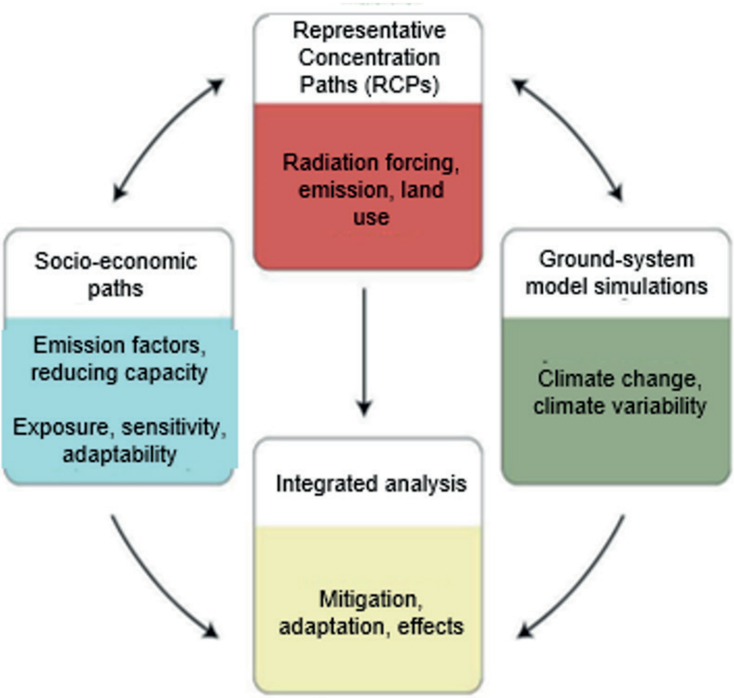
Resource: According to WHO, 1996 Türkeş, 2000

2. CLIMATE CHANGE

Climate change is defined as changes in the average state of the climate over decades or much longer. Climate changes in geological periods not only changed the world's geography but also caused permanent changes in ecological systems, especially through glacial movements and changes in sea level. Climate changes directly affect the life of human beings and all living things. The most important study in predicting the likely future climate is climate modeling (MGM, 2013; Demir, Ö., et al., 2013; Demircan, M., et al., 2014a; Demircan, M., et al., 2014b). The Intergovernmental Panel on Climate Change (IPCC) was established by the World Meteorological Organization (WMO) and the United Nations Environment Program in 1988 in order to prevent and reduce the changes in climate caused by human activities globally with the industrial revolution, and to coordinate climate change and global studies. IPCC is one of the most important organizations coordinating the work on climate change today. One of the most important study subjects of the IPCC is the studies to reveal possible alternative situations for the future. Scenarios are stories that depict some future events (Gregory & Duran, 2001). A scenario is not a forecast of the future, but a description of possible alternative situations (IPCC, 2000).

Emission scenarios were created in order to reveal the potential future amounts of greenhouse gas concentrations during the scenario development process within the climate change studies. In this context, emission scenarios are forecasting the future atmospheric concentrations of substances such as greenhouse gases and aerosols that disrupt the radiation balance of the earth (Moss et al., 2010). Besides, emission scenarios constitute one of the most important components of climate change studies. In these scenarios, while calculating greenhouse gas emissions for the future, different demographic development, socio-economic development and technological change projections are used. These are scenarios with a new approach based on the balance change in solar radiation caused by greenhouse gases to represent the number of greenhouse gases in the atmosphere (Figure 2).

Figure 2: Working principle of the scenarios

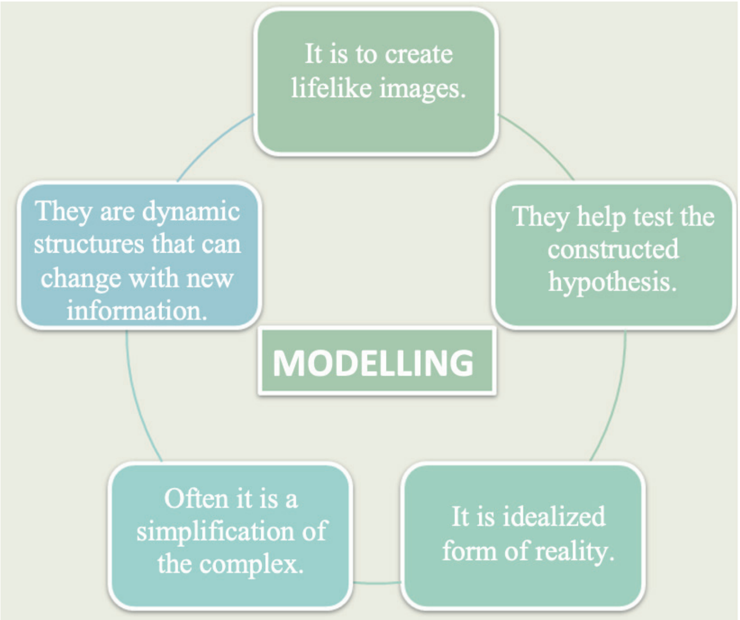


Resource: Adapted from O'Neill and Schweizer 2011 by Gündoğan A.C.

3. MODELING CONCEPT

In line with the desire of mankind to cope with the problems encountered since the first ages when the scientific method was not defined yet, to understand the universe and to dominate nature, to live more comfortably and safely, human beıngs felt the need to experiment either on the system itself or on an abstract / concrete model. For this reason, the concept of modeling has developed over time. Modeling is making images that look like reality. Models help us test the hypotheses we construct. Therefore, it is inevitable to use models in science. On the other hand, the model is the idealized form of reality. Often it is a simplification of the complex (Figure 3). Models are dynamic structures that can change with new information. In the 20th century, with the developments in the field of computer technology, the concept of modeling has been used for climate (Akçakaya, et al., 2015).

Figure 3: Modeling logic



Resource: Akçakaya A., et al., 2015. Turkey climate projections and climate change with the new scenario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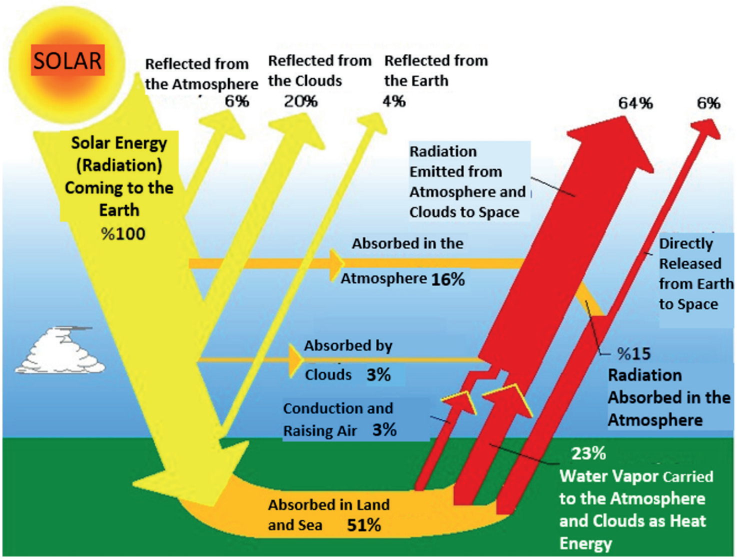
4. CLIMATE MODELING

These are models that try to show the relationship between climatic components (atmosphere, lithosphere, biosphere, hydrosphere and cryosphere) with quantitative (measurable and observable) methods. Despite all its complexity and practical difficulties, the most important tool in predicting future climate is climate modeling. In this way, the general framework of the climatic conditions after a certain period of time is tried to be drawn by taking the current situations into consideration and making various calculations. One of the main challenges of climate models is that the atmosphere must work much faster than real-time changes in its chemical and physical structure (Akçakaya, et al.,. 2015.

All climate models are constructed taking into account the energy coming from the sun via short wave radiation and the energy coming from the earth with long wave radiation. Any change in this balance causes a change in temperatures. The "climate modeling" method, which has been applied for about 20 years, requires three different measurements; Measurement of greenhouse gas emissions, ocean surface temperature measurement and soil surface temperature measurement (Figure 4) (Çelik, 2011).

Figure 4: Components of climate modeling



Resource: Global Climate Modeling, MGM 2015

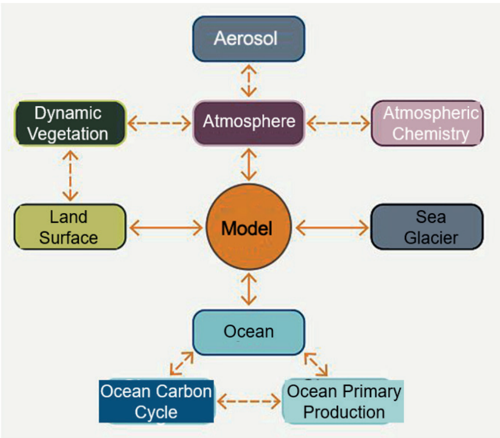
Climate models studies:

- Global climate models (Global Climate Models-GCMs) and
- Regional climate models (RCMs).

4.1. Global climate models (Global Climate Models-GCMs)

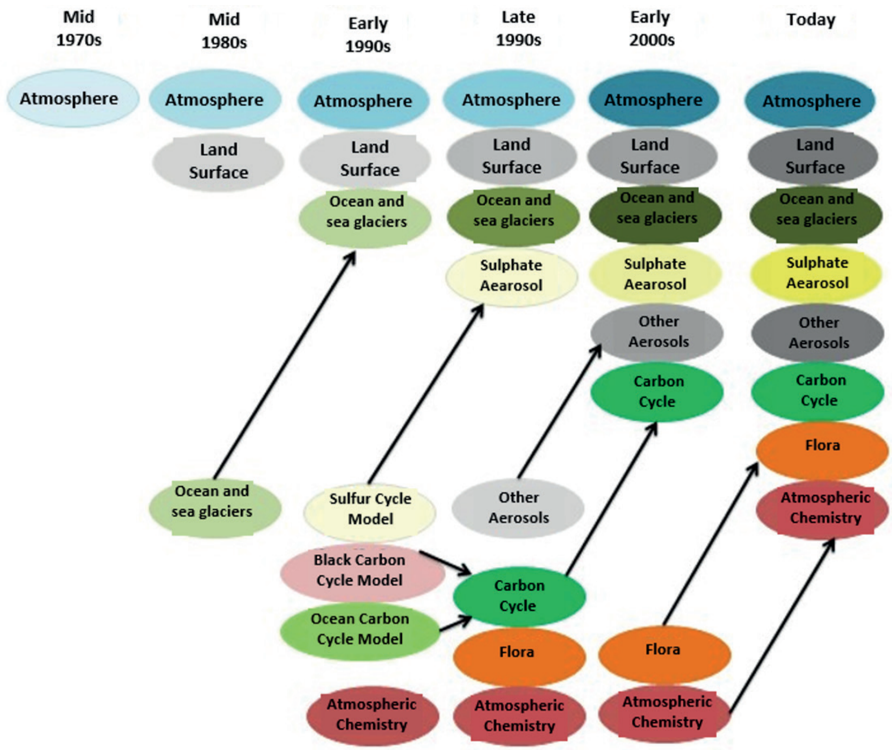
Global Climate Models (GCMs) are models in which fluid motion and energy transfer are both integrated over time. Unlike simple models, in these models the atmosphere and ocean are divided into grid computing units horizontally and vertically. Atmospheric models model the atmosphere and impose sea surface temperatures as boundary conditions within the model. Combined atmosphere-ocean models (coupled models), on the other hand, combine atmosphere and ocean models (Figure 5). For example: HadCM3, EdGCM, GFDL, C.X etc. The first Global Climate Model was developed by NOAA in the 1960s. GCMs are the most complex of climate models and as many processes as possible are embedded in these models. But they are still being developed, and there is still uncertainty (Figure 6.) (MGM, 2015).

Figure 5: Components of global climate models



Resource: Translated from Climate Change in Australia, 2015 technical report

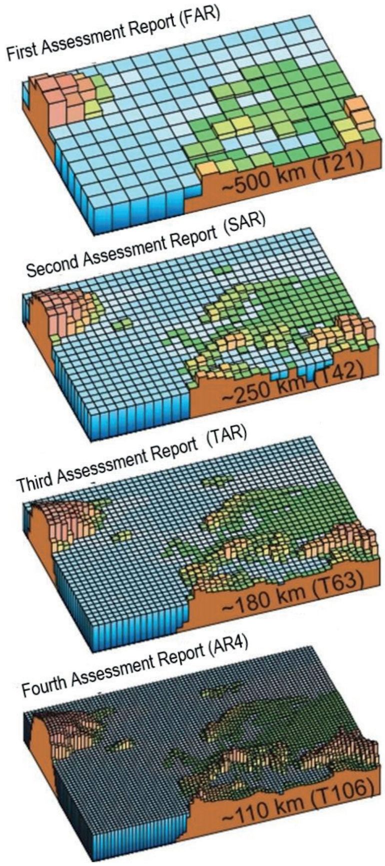
Figure 6: Historical Development of Global Climate Models (GCMs) in Component Structure



Resource: New Scenarios for Climate Change Projections with Turkey, TR2013-CC

With the increasing computing capacity with the developing supercomputers in the last decade, these models have been continuously improved. This computational increase has also led to an increase in the length and resolution of the simulations with models running, adding more and more components and processes. In this way, models used to evaluate future climate changes have developed over time (Figure 7) (Le Treut, H., et al., 2007).

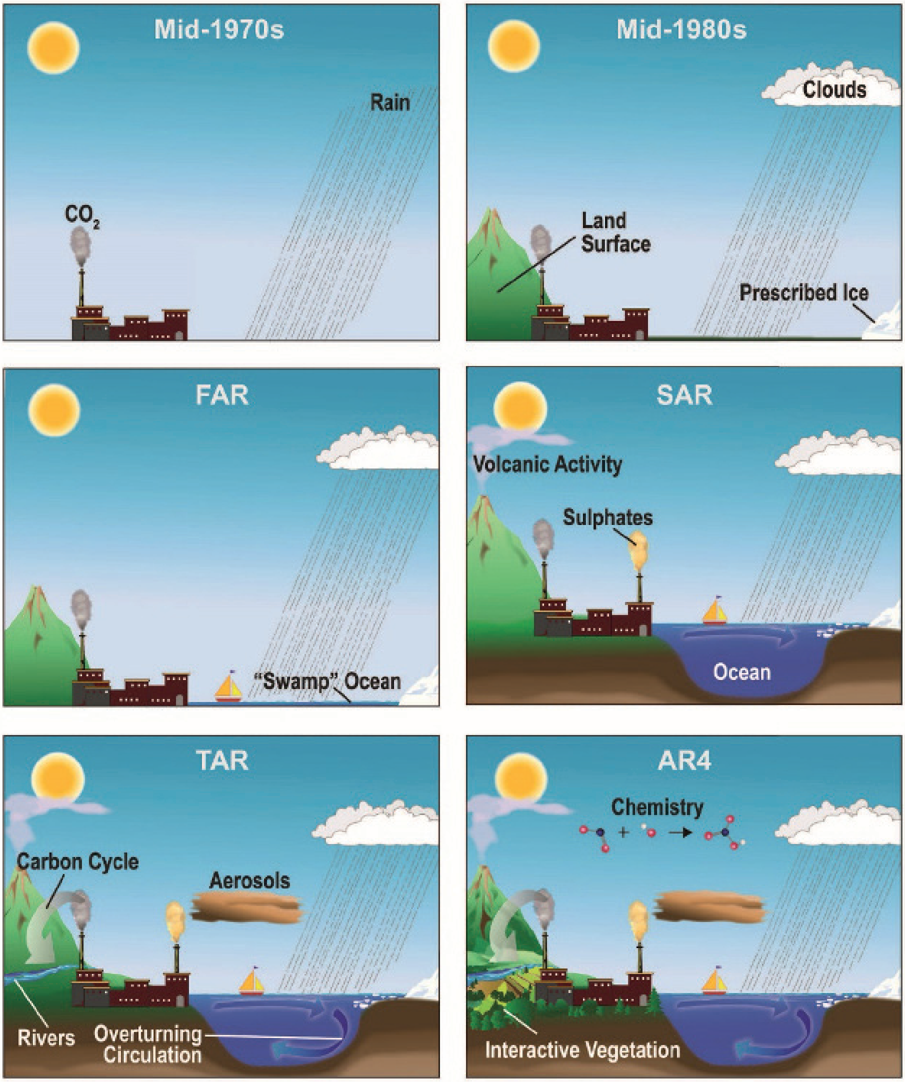
Figure 7: Geographical resolution of climate models used in IPCC Assessment Reports



Resource: Historical Overview of Climate Change Science, 2007

More comprehensive and more capacious models have emerged with additional physics processes included in models that become more complex with added components and processes, as shown in Figure 8. Current climate forecasts use much more complex combined ocean-atmosphere models, including chemical or biochemical components, and can evaluate the time-dependent change of the climate process in different scenarios (Le Treut, H., et al., 2007).

Figure 8: Historical Process of Global Modeling Studies



Resource: Historical Overview of Climate Change Science, 2007

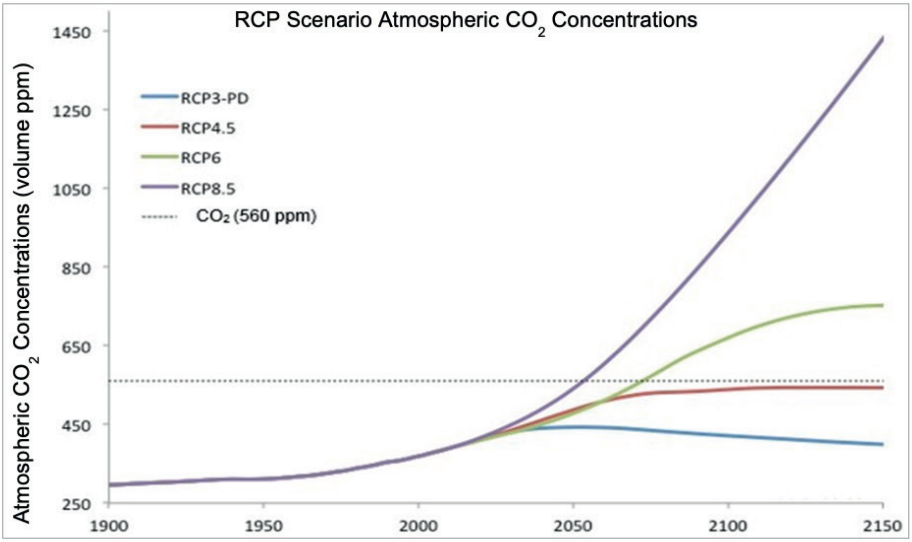
Considering all these processes, the achievements achieved in Global Climate Models structures with the developing technology are summarized below;

- The greatest impact on the success of climate model studies has been with the development of computing technologies (computer technology).

- Grid-cell sizes decreased, time steps shortened and temporal resolution increased.
- The number of cells (grid) and model components increased in horizontal and vertical directions.
- Increased computing capacity has allowed new components to be added to models continuously (better representation of the initial conditions).
- Another positive effect of the improvement of the computing capacity has led to the continuous increase of the horizontal resolution of the models, that is, to obtain more detailed products. (The first model had a resolution of 700 km and was very simple for today (150-200 km))

Climate model simulation corresponding to global scenarios IPCC 5. It is based on global climate models developed by modeling groups around the world through CMIP5 supporting the Assessment Report. These projections are prepared for the different greenhouse gas and emission scenarios used in the last IPCC assessment report, and Representative Concentration Pathways / RCPs representing land-use changes. Representative concentration routes (RCP) are the four concentration trajectories of greenhouse gases adapted by the IPCC for the 5th Assessment Report (AR5). In other words, representative concentration routes are scenarios created for concentration amounts of emissions that disrupt the earth's radiation balance. RCPs are defined according to their radiative stress levels and routes. These four scenarios predict the future climate, taking into account how much greenhouse gases will be emitted in 2100. These four RCP scenarios are consist of RCP 2.6, RCP 4.5, RCP 6 and RCP 8.5. with +2,6, +4,5, +6,0 and +8,5 W / references which take into account the possible values of radiative forcing in 2100 compared to pre-industrial. These scenarios represent the radiative forcing to be achieved in 2100. For example, the RCP 2.6 scenario corresponds to a radiative forcing of 3 W / before 2100 and 2.6 W / in 2100 (IMM, 2019). The change in radiative forcing from the industrial revolution years to 2150 is shown in Figure 9.

Figure 9: The Change of Radiative Forcing from 1900 to 2150



Resource: Intergovernmental Panel on Climate Change 2014:

The RCP 8.5 scenario is the highest risk group scenario where the radiative power approaches 8.5 W/. Taking into account the high population, which increased in 2100, and that the per capita income is gradually decreasing, it makes assumptions based on the long-term energy demand, greenhouse gas emissions and the effect of land use, the development of technology and the increase in energy needs. It predicts that CO_2 equivalent concentrations will reach 1370 ppm by approximately 2100. The RCP 4,5 scenario expresses the scenario that accepts that long-term greenhouse gas emission trends and changes in land use cause radiative power to be around 4.5 W/ in 2100 and that there will be a decrease in radiative energy and emissions from 2050. It predicts CO_2 equivalent concentrations to reach approximately 650 ppm by 2100 (Table 1).

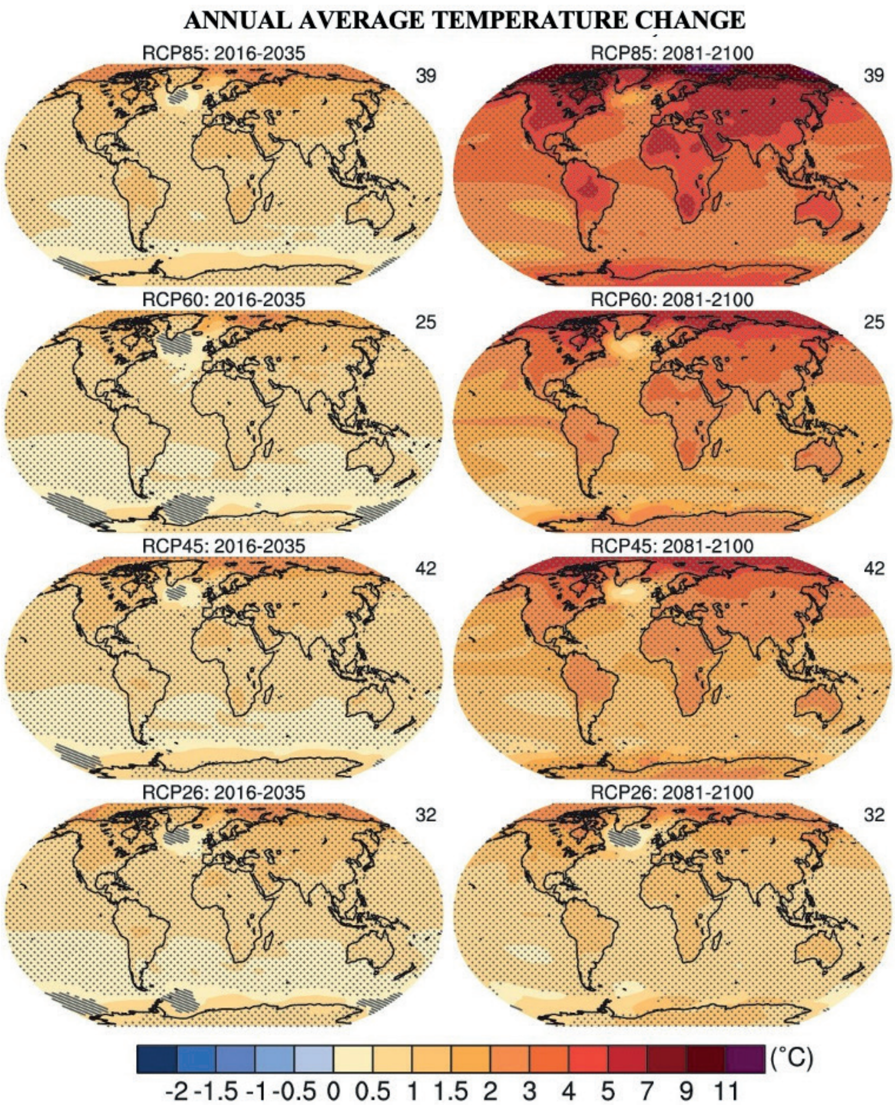
Table 1: Representative Concentration Route Scenarios (RCPs) types

Name (RCP's)	Radiation Forcing	Time	Radiation Forcing Change	Concentrations (CO_2 equivalent)	Emissions (Kyoto Protocol Greenhouse Gases)
RCP 8.5	> 8,5 W/	2100'de	Increase	> ~1370 (2100'de)	The increase continues until 2100
RCP 6.0	~6,0 W/	2100 sonrası	Stabilization without passing the target	~ 850 ppm (2100'de)	Decline in the last quarter of the century
RCP 4.5	~4,5 W/	2100 öncesi	Stabilization without passing the target	~ 650 ppm (2100'de)	Decline since mid-century
RCP 2.6	~3,0 W/	2100 öncesi	Peak and decline without reaching 3.0 W /	Zirve ~ 490 ppm ve düşüş (2100'de)	Decline in the last quarter of the century

Resource: IPCC Expert Meeting Report, IPCC 2007.

Global Climate Models are created based on the scenarios determined within the scope of the IPCC in order to carry out joint studies in the international arena and to make comparisons in a healthy and easy way. The numbers in the upper right part of the maps indicate the number of Global Climate Models run for each scenario (Figure 10., Figure 11). The scenarios RCP4.5 (42 Global Climate Model) and RCP8.5 (39 Global Climate Model) were the most preferred scenarios within the scope of IPCC 5th Assessment Report.

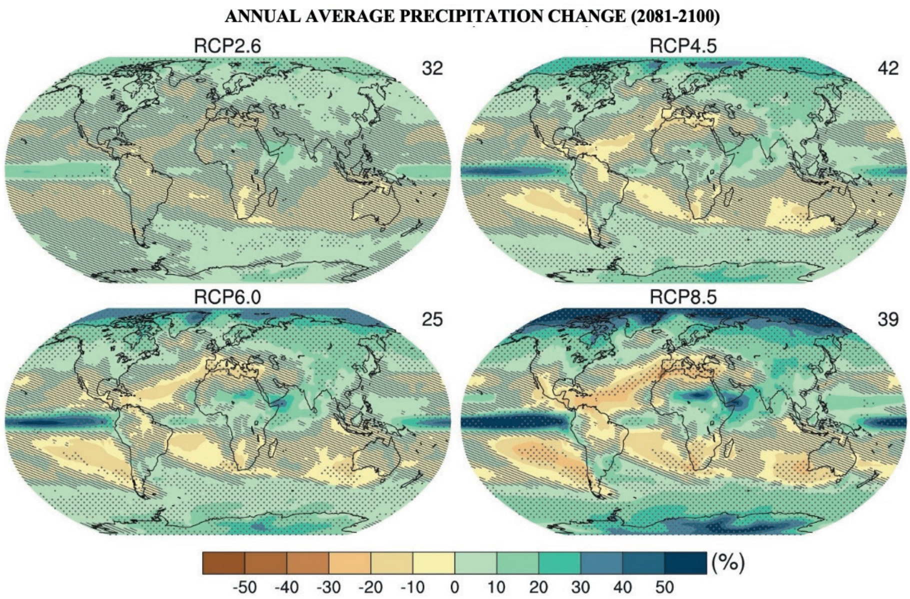
Figure 10: Annual Average Temperature Anomalies Projections



Resource: IPCC 5th Assessment Report

In all scenarios and for the whole period according to the annual average temperature projections, increases are foreseen overall Turkey. According to total annual precipitation projections, decrease is projected in precipitations overall Turkey in the final part of the century (2081-2100).

Figure 11: Annual Total Temperature Anomalies Projections



Resource: IPCC 5th Assessment Report

Unified model comparison project (Coupled Model Intercomparison Project-CMIP) has been put into force by the Working Group on Coupled Modeling (WGCM) bringing together 20 different climate modeling groups in order to develop a standard experimental protocol for the outputs studied from the atmosphere-ocean general circulation model pairs, in order to coordinate the new generation climate model studies (Figure 12) (Table 2).

Figure 12: Coupled Model Intercomparison Project-CMIP cycle

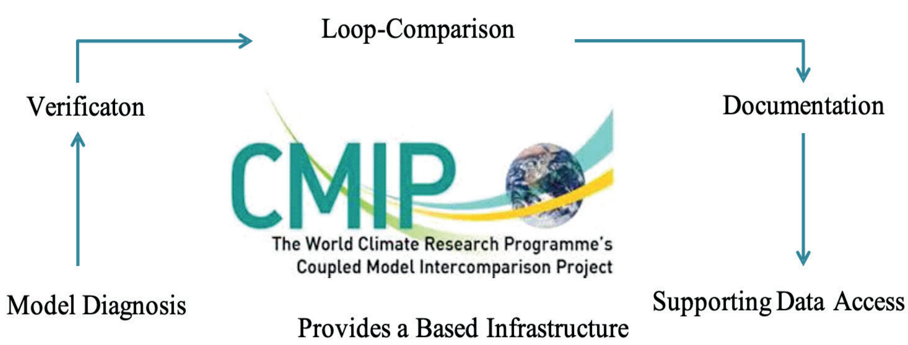


Table 2: Major Global Climate Models from global model data sets produced under CMIP5

Model Name	Relevant Country and Institute	Integrated RCP scenarios
ACCESS-1.0	CSIRO-BOM, Australia	4.5,8.5
BCC-CSM1.1	BCC, CMA, China	4.5,6.0,8.5
CanES	CCCMA, Canada	2.6,4.5,8.5
CCSM4	NCAR, USA	4.5
CESM1-BGC	NSF-DOE-NCAR, USA	4.5, 8.5
CESM1-CAM5	NSF-DOE-NCAR, USA	4.5,6.0,8.5
CMCC-CM	CMCC, Italy	4.5, 8.5
CNRM-CM5	CNRM-CERFACS, France	2.6,4.5,8.5
CSIRO-MK3 6.0	CSIRO-QCCCE, Australia	2.6,4.5,6.0,8.5
GFDL-CM3	NOAA, GFDL, USA	2.6,4.5,6.0,8.5
GFDL-ESG	NOAA, GFDL, USA	2.6,4.5,6.0,8.5
GFDL-ESM	NOAA, GFDL, USA	2.6,4.5,6.0,8.5
HadCM3	MOHC, UK	4.5
HadGE-AO	NIMR-KMA, Korea	2.6,4.5,6.0,8.5
HadGE-ES	MOHC, UK	2.6,4.5,6.0

Resources: Republic of Turkey Ministry of Forestry and Water Affairs, Impact of Climate Change on Water Resources Project Final Report, 2016

The most commonly used model among these models is the HadGE-ES Global Model (Global Environment Model Version 2). HadGE-ES model is a 2nd generation global model developed by the Hadley Center, a research organization affiliated with the UK Meteorology Service. There are many versions of this model with similar physical properties but with different builds. The HadGE series includes a combined atmosphere-ocean configuration and a place-system configuration that includes dynamic vegetation, ocean biology, and atmospheric chemistry. HadGE 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. There are many versions of this model with similar physical properties but with different builds.

Table 3: Current HadGE Global Model Versions

HadGE Formations	Model Process
HadGE-A	Troposphere, Earth Surface and Hydrology, Aerosol
HadGE-O	Ocean and glaciers
HadGE-AO	Troposphere, Earth Surface and Hydrology, Aerosol, Ocean and glaciers
HadGE-CC	Troposphere, Earth Surface and Hydrology, Aerosol, Ocean and glaciers, Carbon cycle, Ocean biogeochemistry
HadGE-CCS	Troposphere, Earth Surface and Hydrology, Aerosol, Ocean and glaciers, Carbon cycle, Ocean biogeochemistry, Stratosphere
HadGE-ES	Troposphere, Earth Surface and Hydrology, Aerosol, Ocean and glaciers, Carbon cycle, Ocean biogeochemistry, Chemistry

Resources: Republic of Turkey Ministry of Forestry and Water Affairs, Impact of Climate Change on Water Resources Project Final Report, 2016

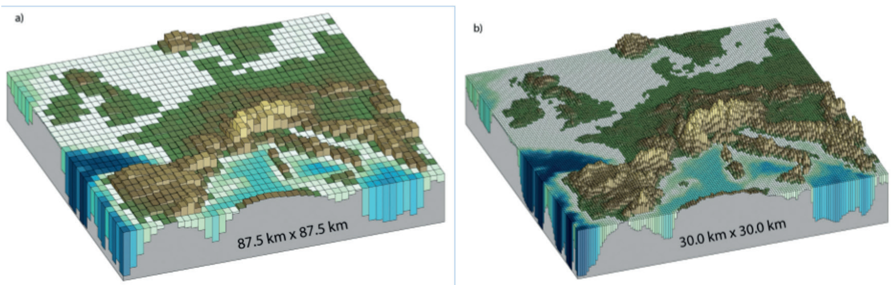
Although the global climate projections give information about the general view, they are insufficient in local and sector-based impact, analysis and research studies due to their low resolution (110-300 km). For this reason, more detailed projections are needed by using the outputs of Global Climate Models (GCMs) as inputs in Regional Climate Models (RCM).

4.2. Regional Climate Models (RCMs)

Due to computational difficulties, Global Climate Models (GCMs) usually have a horizontal resolution of 100-300 km. With this resolution, regional climate changes 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.

Regional climate models, which are complementary to global climate models, are used for many regions of the world. These models reveal detailed climate processes by adding more information to global climate analyzes or simulations. The relationship between global and regional climate models is very similar to the relationship between global and regional weather forecast models. In the last 20 years, significant progress has been achieved in research on regional climate models, and the increase in resolution has made it possible for models to simulate longer periods (Rajib and Rahman 2012). A regional model usually represents a specific area of the earth in higher resolution. Thus, country-scale projections can be produced with a high-resolution limited area regional climate model (Ministry of Forestry, 2016). In summary, the models that provide more detailed and high-resolution information for smaller areas by using low-resolution gridded information obtained from global climate models are regional climate models (Figure 13). Small-scale weather events and atmospheric processes such as facade systems or precipitation systems can be expressed in more detail with regional climate models.

Figure 13: Gridded approach used in Regional Climate Models



Resource: Intergovernmental Panel on Climate Change (IPCC), 2013

Basically, the Regional Climate Model (RCM) also exhibits a dynamic structure like the Global Climate Model (GCM), but consists of 3 main processes. These are:

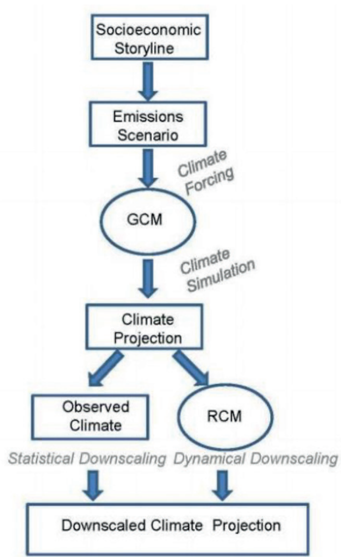
- Taking limit values from GCM,
- Obtaining own local data for the defined area,
- Solving of RCM's own dynamic equations with the help of these two data and generating values for the redefined area.

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. 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). The first version, RegCM1, was presented to the scientific community in 1989 and later versions were developed (RegC-1993, RegC.5-1999, RegCM3-2006, RegCM4 2010).

4.3. Downscaling

The purpose of downscaling is to obtain regional details from low resolution numerical simulations and scattered observations. There are two basic approaches, dynamic and statistical, to shrink climate information (Figure 14.).

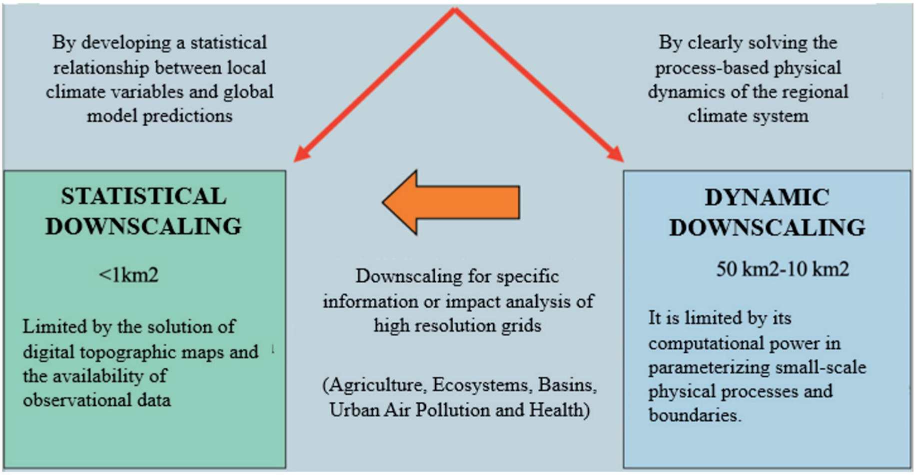
Fgure 14: Components in Downscaling



Resource: Translated from Daniels et al., 2012

Statistical downscaling uses observed relationships between local synoptic states and large-scale climate to construct the statistical model. This often leads to a very close representation of the climate observed in the statistical downscaling model, regardless of the host global climate model selection. Dynamic downscaling is a common approach used to achieve regional conditions that are not well reflected in low-resolution global models. In this method, a certain area is defined in RCM and certain dynamic climate factors obtained from GCM are applied to the specified area (Figure 15).

Figure 15: Relationship between downscaling methods



Source: Translated from the IPCC Third Assessment Report, 2009.

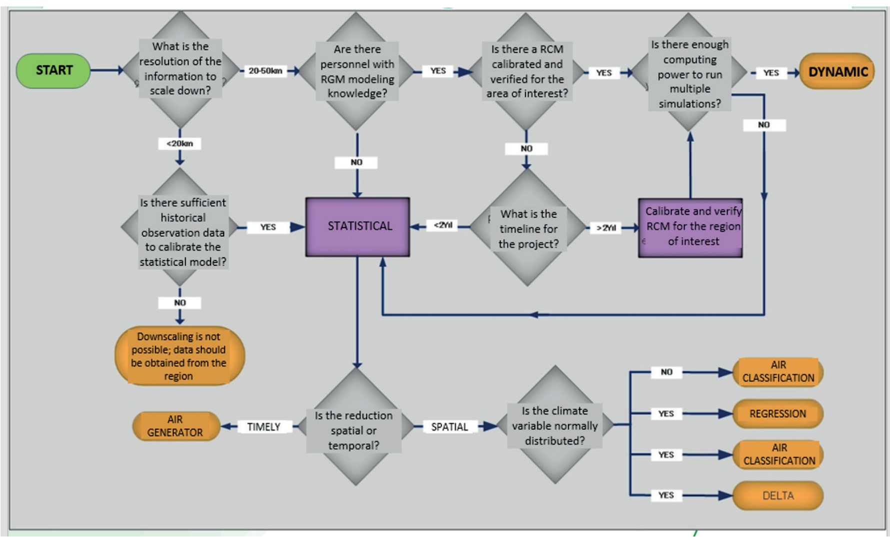
Strengths of Statistical Downscaling;

- Requires less computer power to compute
- Allowing a large number of affinities
- Requires limited GCM input data with coarse temporal resolution
- GCM can reduce simulated variables to parameters related to direct effects.
- Weaknesses of Statistical Downscaling;
- Assuming that model parameters have not changed
- Conversion factors not always based on well understood physical mechanisms
- Failure to catch systematic changes in regional coercion
- Scaled variables being limited in number and inconsistent
- Dependence on the availability and quality of regional observations
- Strengths of Dynamic Downscaling;

- The conversion factor is largely based on understandable numerical methods
- Maintains the mathematical description of the system
- Uses a full set (multi-level and high time-frequency) of internally consistent minimized variables
- Not directly dependent on the availability of observations, but applicable everywhere.
- It can include potential changes in the territorial strain as well as unstable relationships between large and small scales.
- Weaknesses of Dynamic Downscaling;
- Requires intensive computing power in computing
- Requires a large number of (multi-level, high time-frequency) GCM input data High error rate of surface variables on a regional basis
- Inability to directly generate parameters suitable for impact.

The strengths and weaknesses of both techniques should be taken into account in determining the appropriate scale-down technique in the projects to be implemented. In this context, the scheme given in Figure 16 will be a guide in deciding the correct downscaling technique.

Figure 16: The stages to be used in the selection of downscaling technique



Resources: African And Latin American Resilience To Climate Change (ARCC), 2014

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VULNERABILITY AND VULNERABILITY EVALUATION AND VULNERABILITY INDICATORS

Prof. Dr. Ayşe Gül Tanık

1. INTRODUCTION

As mentioned in the 4th Assessment Report of the IPCC, it is necessary to first determine the vulnerability for adaptation to climate change. Vulnerability states to what extent a system is affected by the adverse effects of climate change, including climate vulnerability and extreme climatic conditions, and to what extent it is unable to cope with it. Vulnerability is a function of the nature, size and speed of climate change and variability a system is exposed to, its sensitivity and adaptability (IPCC, 2007).

Intergovernmental Panel on Climate Change (IPCC) defines the vulnerability to climate change as a function of 3 main factors. These are:

- Types and dimensions of exposure to the effects of climate change (Exposure),
- Sensitivity of systems to a certain level of exposure (Sensitivity),
- It is the capacity of the system to cope with or adapt to (Adaptive Capacity).

Exposure (E): It refers to factors outside the system under studies, such as changes in climate variability, including extreme weather events, or rates of change in average climate conditions. Exposure to drought will increase due to changes in the duration and frequency of drought events due to global warming. Exposure alone is not a sufficient index for determining vulnerability. The exposure index changes depending on the strength of sensitivity and adaptability. In the case of high exposure, if the sensitivity is low, i. e. the potential impact is low and the adaptation capacity is high, the vulnerability is low.

Sensitivity (S): The degree to which a system is negatively or positively affected by climate variability or change. This impact may be direct (for example, a change in crop yield as a result of a change in average temperature, temperature range or variability) or indirect (e.g. damage caused by increased frequency of coastal floods due to sea level rise). Sensitivity is shaped according to the natural and/or physical characteristics of the system such as topography, resistance to erosion of different soil types, vegetation cover. Sensitivity also refers to human activities affecting the physical structure of a system such as land management, water management, resource consumption and population pressure.

Adaptation Capacity (AC): It means the ability of a system to adapt to climate change, variability and possible extreme and moderate harms, to take advantage of opportunities and cope with its consequences. Adaptive capacity determines the capacity of a system to create and implement adaptation measures. Some of these factors can be listed as follows;

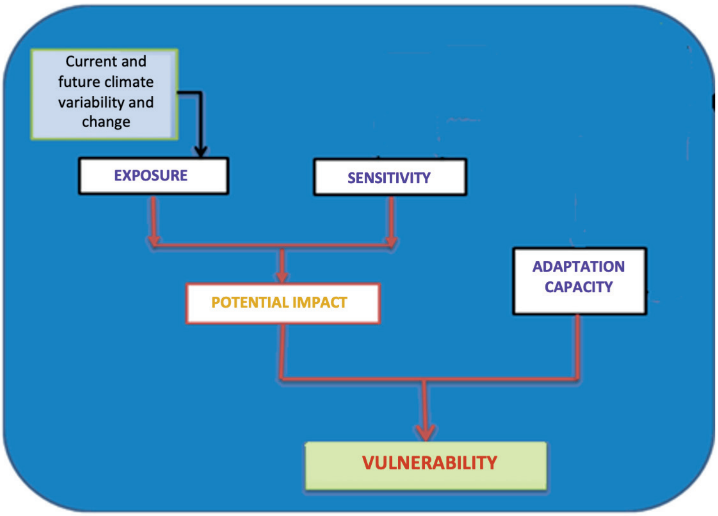
- Information
- Technological structure
- Institutional structuring
- Economy

In this section, the fragility (vulnerability) indicators used in the sectoral analysis, as well as the vulnerability assessment will be explained using the project outputs recently carried out in our country as an example.

2. REDUCING VULNERABILITY BY ADAPTATION MEASURES

Adaptation measures are the applications implemented at sectoral, national and local levels to reduce vulnerability (for example, drought and water scarcity can be coped with using effective irrigation systems). In Figure 1, the components of the vulnerability are shown as a flow chart.

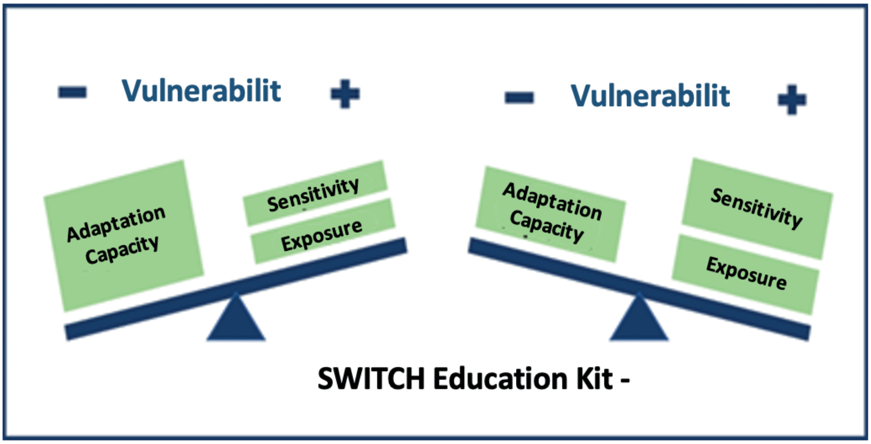
Figure 1: Components of vulnerability



Resource: GIZ, 2012

Potential Impact: When exposure and sensitivity are taken together, it determines the potential effect that occurs. For example, drought (exposure) caused by a decrease in precipitation and increase in temperatures, combined with limited water resources (sensitivity), causes a decrease (potential effect) in agricultural production. The effects of climate change and drought can create a chain for direct effects from the biophysical area to the social area and the indirect effects they cause (e.g. decrease in yield, decrease in income). The direct dependence on natural resources in many developing countries means that there is a very strong link between the biophysical impacts of climate change – human activities – prosperity. The functions of the vulnerability analysis components are shown in Figure 2, and the chain effect of climate change on natural resources and livelihoods is shown in Figure 3.

Figure 2: Functions of Vulnerabilility Analysis Components



The direct dependence on natural resources in many developing countries means that there is a very strong link between the biphysical impacts of climate change– human activities – well-being (Figure 3).

2.1. Leading Conceptual Frameworks in Climate Impact Assessment

Pioneering studies on vulnerability assessment are impact assessment approaches. Figure 4 shows the first conceptual framework for assessing climate impact. The vulnerability assessment approaches used today are generally based on the main principles based on Füssel and Klein's first studies in 2006.

Flow charts covering first and second-generation evaluations are given in Figure 5 and Figure 6, respectively. It is noteworthy that adaptation capacity is not included in the first-generation evaluation. However, in the 2nd generation study, it is understood that non-climatic factors also come into play in addition to adaptation capacity.

It is seen that these pioneering studies were developed and used in all countries with some modifications in the following years. In Figure 7, the adaptation policy evaluation scheme is given.

Figure 3: Chain effect of climate change on natural resources and livelihoods (GIZ, 2014)

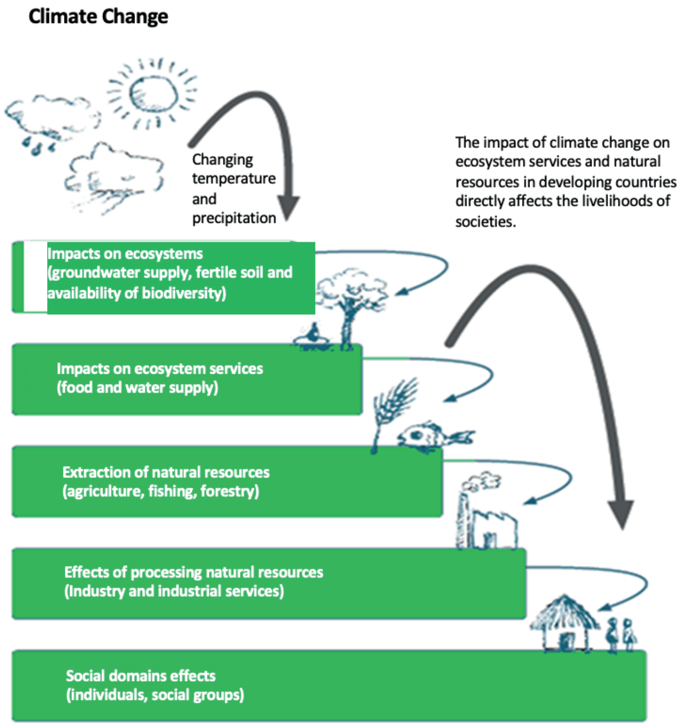


Figure 4: The first conceptual framework in the assessment of climate impact (Füssel & Klein, 2006)

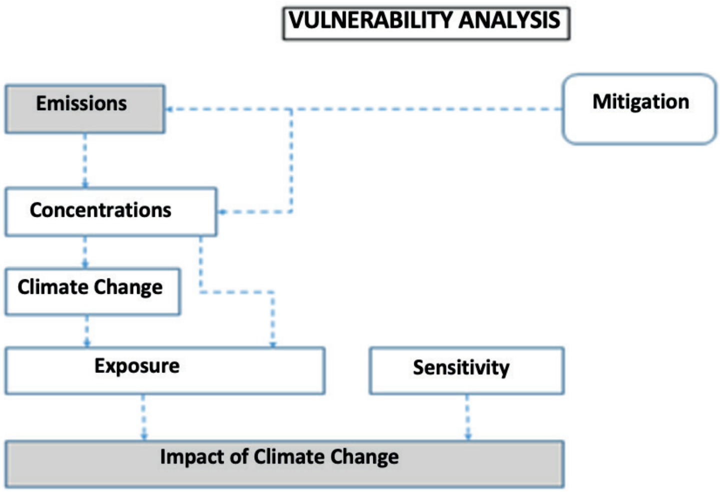


Figure 5: First-generation vulnerability assessment (Füssel & Klein, 2006)

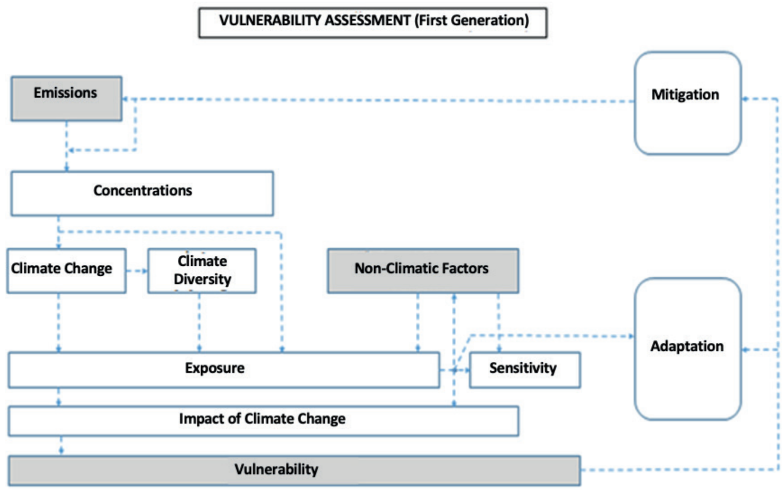


Figure 6: Second generation vulnerability assessment (Füssel & Klein, 2006)

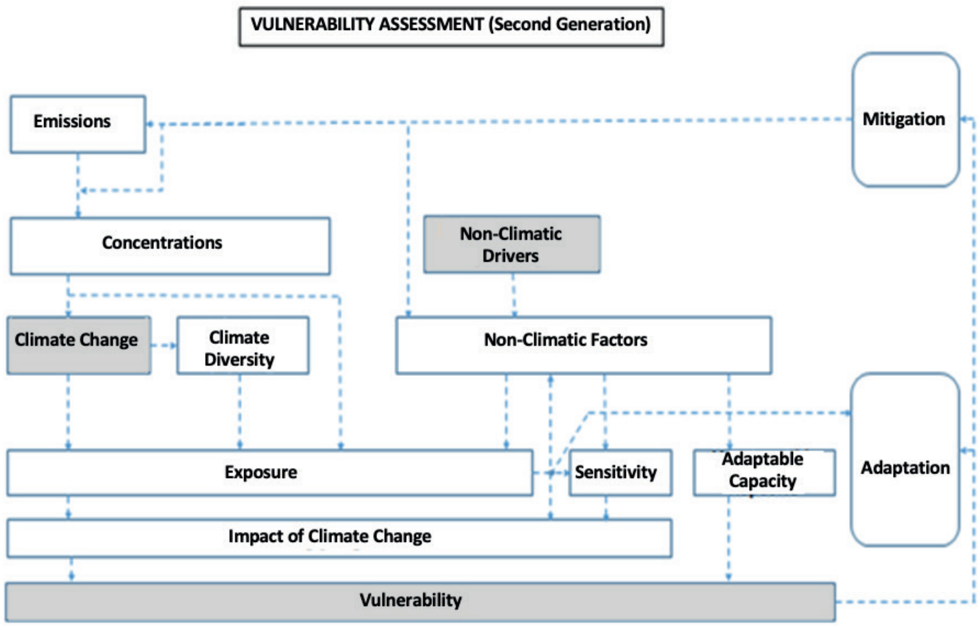
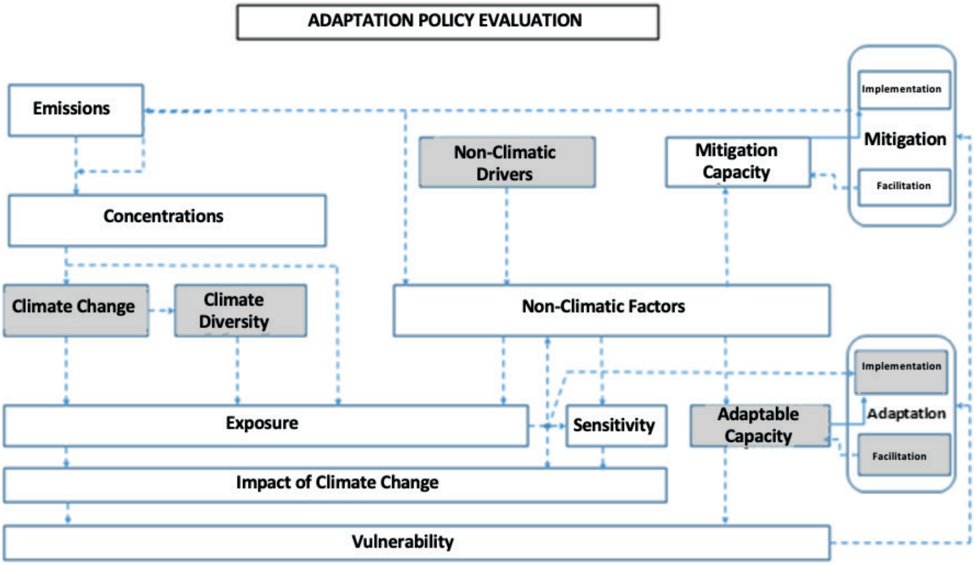


Figure 7: Adaptation policy evaluation (Füssel & Klein, 2006)



2.2. Risk Assessment and Vulnerability Assessment Studies Conducted in Various Countries

The first studies on the subject and the first 5-year process in England started in 2012 under the name of 'Climate Change Risk Assessment (CCRA)'. The CCRA has generally evaluated the major potential risks and opportunities in the face of climate change in the UK. With this independent analysis, risks in various sectors have been reviewed and evaluated. In this way, it will be easier to make comparisons between various sectors and to identify risks across and within sectors. A summary of possible climate change risks in the London Metropolitan is provided in publication UK (2012).

Natura 2000 network in another pioneering study in Europe developed a vulnerability methodology to evaluate the changes in European habitats in the face of climate change. A total of 231 habitat types are listed in the 71 priority habitats of the European Union (EU) Habitats Directive (those that occur in natural life at EU borders and are under threat of extinction). In the context of conservation of natural life (including the protection of habitats and species against climate change), it requires identifying and prioritizing the most vulnerable species and considering them first in adaptation actions. Vulnerability analysis is responsible for informing and alerting decision-making mechanisms on these prioritized species (ETC/ACC, 2010).

An indicator-based report on climate change, its impacts and vulnerability concepts for European countries was also prepared in 2012 (EEA, 2012).

The Inter-American Development Bank (IDB) Environmental Protection Measures Unit also prepared a report on the Caribbean (IDB, 2014). This technical documents which is prepared for the Caribbean mention the most suitable risk and vulnerability analysis methods.

The State of California in the USA has played a leading role among all states with its support to research activities in the development and planning of climate change policies and on climate change and its effects. The California Report is a report that brings together and presents a large number of scientific data that can be used as 'indicators' in sectoral impact analysis (California Report, 2013). These indicators were produced by federal agencies, universities and other research organizations as well as monitoring and research activities conducted in the state. For those selected for sectoral analysis up-to-date and representative indicators that generally describe how the amount, regime and frequency of meteorological data such as climate change and temperature and rain change, and the role of heat traps in the emission of greenhouse gases. These are important in terms of showing how all environmental conditions of humans, animals and plants, especially freshwater and marine ecosystems, are affected by climate change. This 2013 report is the updated version of the first version published in 2009.

At the workshop in Namibia where international experts were convened, a circular prepared by the FAO in 2012-2013 was presented. In this circular, various vulnerability methodologies on climate change have been introduced. The bibliographies are given in the footnotes of all the aforementioned methodologies, and the methods on the vulnerabilities of predominant climate change in the fish and seafood sector are introduced (FAO, 2013).

GmbH (The Deutsche Gesellschaftfür Internationale Zusammenarbeit), or GIZ, as it is known, is an organization specialized in international development. Today, it carries out many increasing climate change adaptation projects all over the world. Projects completed in the context of GIZ's vulnerability analysis and assessment are on a local scale in India, Cambodia, Bolivia, Kenya, Tunisia, Peru and Jordan. (GIZ, 2012).

One of the most recent studies is on the development of indicators for risk assessment, which is planned to be implemented in West African countries. Instead of classical approaches known to date, the multi-scale participation process was used in the study (Asare-Kyei, Kloos, & Renaud, 2015). As of the point reached, suitable indicators for multi-risk assessment and their weights have just been determined.

The development of the science of climate change and the fact that the countries of the world gain experience in this regard, determine adaptation actions and implement them depending on the fact that studies aimed at reducing possible effects can be carried out in parallel. Therefore, it is important to implement many concurrent projects in order to examine the various potential impacts on climate change. In this context, the United Nations (UN) has a great responsibility. Since climate change and its effects recognize no boundaries and are a problem of international importance and concern of every country, the search for solutions on a global scale is instrumental in the simultaneous execution of many projects. In fact, these studies are a must. The UN published a book in 2011 and informed all interested parties about these analysis methods by including the vulnerability analysis studies carried out in various countries of the world until then (UN, 2011). The World Health Organization, another international organization, prepared a report on risk assessment against climate change in order to increase the awareness of the world in 2014 and also presented future projections and scenarios (WHO, 2014).

3. VULNERABILITY ASSESSMENT

The concept of vulnerability is primarily important for adaptation. This concept helps to understand the truth behind the negative effects of climate change and identify the most sensitive points to climate change. The most effective method in determining and prioritizing adaptation measures is to conduct "vulnerability assessment". Vulnerability is a guide in evaluating the applicability of the actions required to reduce risk in risk studies in line with multiple parameters.

Sectoral vulnerability analysis is an evaluation system used to determine how certain sectors may be affected by natural (flood, drought, storm, earthquake, etc.) or man-made (terrorist attacks) disasters.

Vulnerability analysis works cover four approaches. These are:

- Risk-Hazard Approach (RHA),
- Political Economy Approach (PEA),
- Integrated Assessment Approach (IAA)
- Biophysical Approach (BA)

Table 1 summarizes the vulnerability approaches.

Table 1: Vulnerability approaches

Approach	Quality	Focus
RTY	The state of the disaster is analyzed with a descriptive approach rather than definitive. In other words, the vulnerability is considered with a hardware perspective.	It focuses on the effects of disasters on engineering and technical fields.
SEY	The concept of vulnerability is defined as "internal social vulnerability" or "cross-scale social vulnerability". "Responding capacity", "coping capacity" and "flexibility" are key features of vulnerability.	It focuses on people and takes into account the "why" and "to whom" questions.
EDY	Mixed method approaches, internal and external dimensions of vulnerability are evaluated together.	Both the socioeconomic and biophysical dimensions of vulnerability are in focus.
BFY	Evaluates the level of damage caused by environmental stress in both social and biological systems.	Social and biological dimensions of vulnerability are at the forefront.

Resources: Zarafshani et al., 2012

3.1. The Use of Sectoral Vulnerability Analysis in Planning Adaptation Strategies

Although there are some indices for sectoral vulnerability analysis generalized by the IPCC and a method mentioned above about how to evaluate the vulnerability in general terms, there is no widely accepted method for the analysis of sectoral vulnerability. Generally, underdeveloped and developing countries apply the method recommended by the IPCC. On the other hand, some European countries such as Spain, Italy, Greece, the Netherlands and Portugal have adopted the IPCC's definition of vulnerability.

Vulnerability and risk assessment studies in the USA are handled with a different approach. Most of the states create their management plans and vulnerability analysis studies are included in these plans. Colorado, Arizona, Kansas, Texas and Nebraska are the states most exposed to drought. For example, in the State of Colorado Drought Management Plan, exposure and sensitivity indexes are not examined separately, but the "impact" index is used instead, and this index reflects all environmental pressures such as temperature increase, lack of precipitation, excessive water consumption, and urbanization (Colorado Water Conservation Board, 2013). In studies adopting the IPCC method, as mentioned before, the effect is examined under two separate components as exposure and sensitivity.

When the sectoral vulnerability studies conducted overall in Turkey are examined, two studies come to the fore. Within the scope of the "Impact of Climate Change on Water Resources Project (Climate Water)", which was conducted to determine the effects of climate change on the surface waters and groundwater at basin scale and to determine adaptation activities, in three pilot basins (Büyük Menderes, Ceyhan and Meriç-Ergene) sectoral vulnerability analysis of climate change was conducted on the basis of basins. In this analysis, in addition to basic sectors such as domestic water use, agriculture, industry and ecosystem, sectors that stand out in each basin and are important for that basin are also examined. For example, the tourism sector as examined in Büyük Menderes, the energy sector in Ceyhan Basin and the industrial sector in Meriç-Ergene Basin (Iklim, 2016). The results of this study, which is carried out for all basins, will be a useful source for the development of climate change adaptation studies, which is one of the important global problems of our age. Drought Management Plans made on the basis of sub-basins in Konya, Akarçay, Eastern Mediterranean, North Aegean, Küçük Menderes, Antalya, Burdur and Van basins are important studies that have been conducted with sectoral vulnerability analysis works at drought scale in Turkey (Drought, 2019).

In these studies, in which qualitative and quantitative approaches are used together for determining vulnerability, the levels of exposure to drought in the main sectors of agriculture, domestic water use, industry and ecosystem were determined based on sub-basins. Adaptation strategies include actions that make species, natural systems and human communities less affected by the adverse effects of changing conditions. These strategies can be applied in many different ways. In most studies in the literature, these strategies are classified under three separate headings as resistance, flexibility and facilitated transformation. Resistance strategies for adaptation aim to prevent the direct effects of climate change. Resilience strategies aim to increase the capacity to cope with the effects of climate change by bringing the critical ecological process to a high level of function or integrity (Drought, 2019).

Facilitated transformation strategies predict the nature of climate change-related to transitions and include actions that facilitate transitions compatible with future climatic conditions while minimizing ecological degradation by working with these expected trends. Some views characterize resistance and resilience strategies as conservation and restoration of natural conditions. On the other hand, facilitated transformation is considered as a series of 'anticipated' strategies as it is based on future conditions.

Füssel and Klein (2006) focused on the issues of including the factors determining the vulnerability outside the climate, including adaptation capacity, into adaptation studies and targeting the reduction of these pending issues rather than estimating the expected losses. In order to determine future management actions, planners should carefully evaluate the past and current conditions. This assessment is used in decision-making processes to determine the behavior and magnitude of the change likely to occur. In this context, sectoral vulnerability analysis is a widely used tool to develop climate change adaptation strategies.

Sectoral vulnerability analysis is used in studies conducted to adapt to climate change in many countries around the world. Since responsiveness and adaptability indexes reflect the current state of the system, it will be determined at what points the sensitivity of the system to climate conditions increases and what kind of policies could make the sector less vulnerable to climate change with the development of technology.

3.2. Sectoral Vulnerability Analysis Methods

At the first stage of sectoral analysis and vulnerability assessment, a detailed literature study has been carried out on the studies conducted on the subject overall the world and in Turkey. In the literature study conducted;

- Scientific articles in the literature (Ravindranath et al., 2011; Zarafshani et al., 2012; Xiaoqian et al., 2013; Brown et al., 2016; Ruminata & Handoko, 2016)
- Study reports prepared by countries such as the USA, Bangladesh, Greece, Germany, Ethiopia, South Africa, Australia in different climate zones (Rajsekhar & Singh, 2015; Sehgal et al., 2013; Deressa, Hassan & Ringler, 2008; Zebisch et al., 2005),
- Reports prepared by different institutions such as IPCC (2014), UNEP (2009); EC (2014) etc. were examined and a comparison was made on the methods applied in countries with various economic, social and climatic characteristics from different parts of the world.

As a result of the literature study, the following were determined

- Sectors used in vulnerability analysis studies,
- The methods used to formulate the exposure, sensitivity, economic value and adaptability components of the vulnerability,
- Indices (parameters) widely used for each sector,
- Normalization methods used in vulnerability analysis studies,
- Weighting methods used to calculate indexes.

3.2.1. Calculation of exposure, sensitivity and adaptability indexes

When methods used for formulating the exposure, sensitivity and adaptation capacity components in order to determine vulnerability; it was seen that three main variables were used, namely index, indicator and parameter.

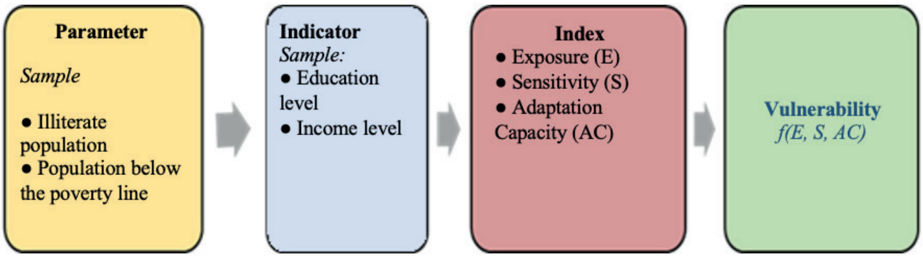
Parameters that have a certain unit are variables that can be compared with world standards, and they come together to form indicators that reflect general conditions within physical, social, economic, etc. frameworks.

Indicators reflect on which physical, social and economic factors the indices are based on.
Indexes show that the sources of vulnerability increase or decrease due to social or climatic conditions or administrative deficiencies.

In this context, by looking at these variables specified, the status change in natural resources will be seen and the effect of this change on the vulnerability of the system will be evaluated.

Figure 8 shows the index, indicator and parameters that make up the vulnerability.

Fgure 8: Index, indicators and parameters that make up the vulnerability



Resources: Drought, 2019

Depending on the realization of the impact of climate change on socio-economic life, the development of adaptation strategies has started to be considered important by governments.

Vulnerability calculations have been accepted in many countries that carry out vulnerability studies as an issue that should be handled as a function of exposure, sensitivity and adaptation capacity of vulnerability, as it was specified before. As a result of the literature research conducted in this direction, it was seen that 5 main methods stand out towards calculation of exposure, sensitivity and adaptation capacity indexes.

These main methods are;

- E= (M + D) - (UK) (1)
- E = (M x D) / (UK) (2)
- E = (M– UK) x (D) (3)
- E = (M+ D) / (UK) (4)
- E = (M+ D+ UK) / 3 (5)

3.2.2. The vulnerability calculation used in our country

Economic value expresses the profit/loss situations observed after the climate event and is generally considered as a separate index in studies in our country.

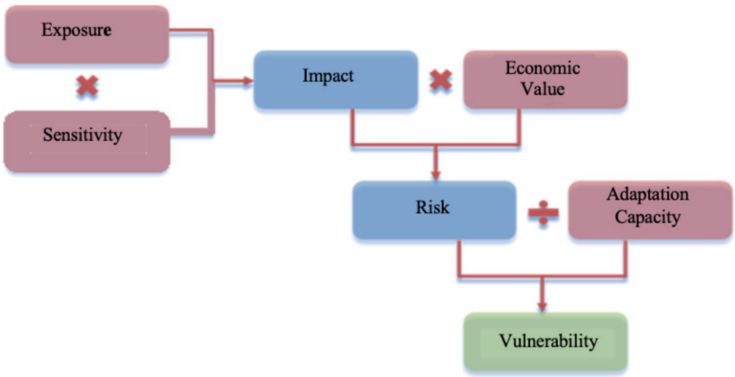
In addition to the three main elements proposed by the IPCC, economic value stands out as another index in the literature.

Sectors prominent in vulnerability calculations;

- Domestic water,
- Agriculture,
- Industry,
- Ecosystem.

These are the 4 main sectors. Apart from these basic sectors, energy, tourism and health and other sectors can also be examined. In Figure 9, the vulnerability calculation used in our country is given schematically. Among the vulnerability methods, it is similar to Equation (2).

Figure 9: The vulnerability calculation used in our country



Resources: Climate, 2016; Drought, 2019

Looking at the work done, the agricultural sector-related studies come to the fore. Studies conducted in underdeveloped countries such as Bangladesh, India and Pakistan are generally related to the agricultural sector. Management plans including non-agricultural sectors are created in developed European countries such as Greece, Spain, Italy, the Netherlands, Germany, Portugal, states such as Colorado, Nebraska, Texas, Kansas and Australia, which are most affected by the drought, and these plans include the actions. Apart from the agricultural sector, the studies also include studies on the industry, tourism, domestic (drinking and utility) water and ecosystem sectors. Energy and mining sectors are mostly examined under the industrial sector (Drought, 2019).

3.2.3. Sektörlerin etkilenebilirlik indekslerinde kullanılan parametreler

For obtaining the indices of exposure, sensitivity and adaptability as a numerical value, it is necessary to primarily determine the indicators, and in order to determine the indicators, the parameters that represent a particular indicator should be considered.

Exposure means the same for each sector. For example, drought does not vary in specific sectors as it expresses a decrease in the amount of water available due to low rainfall and/or high temperature.

Responsiveness and adaptability indexes differ for each sector as they determine the socio-economic status of the sectors and reflect their dependence on water use.

<u>Combining Parameters:</u> Since parameters determined under the scope of vulnerability analysis for each sector have different units from each other, the normalization process should be applied in order to make the results of the calculations comparable. The procedure of the normalization work carried out at this stage is of great importance. In the sectoral vulnerability analysis conducted worldwide, the maximum-minimum normalization method, which is widely used by the United Nations Development Program (UNDP) in calculations of the Human Development Index, has been adopted to perform the normalization process.

Equation (1) and Equation (2) show the normalization methods used for parameters with positive and negative correlation with the vulnerability value, respectively.

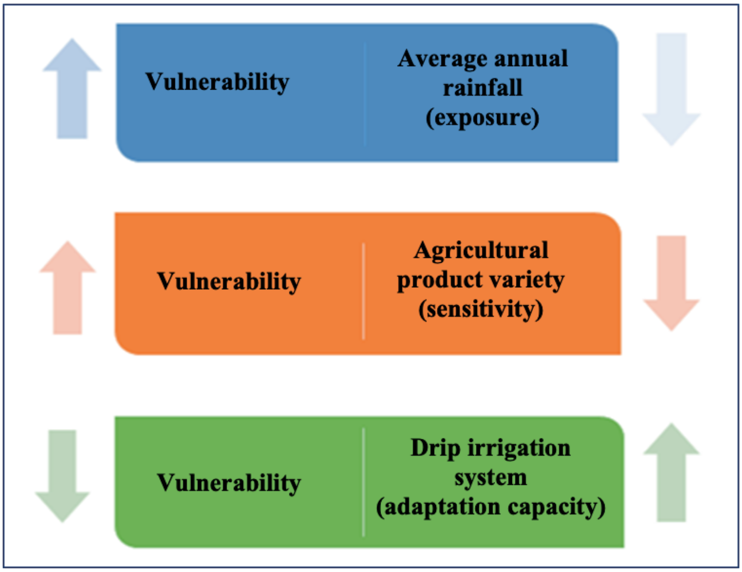
Normalized value =
(Actual Value-Minimum Value) / (Maximum Value-Minimum Value) × 100 (1)
Normalized value =
1- (Actual Value-Minimum Value) / (Maximum Value-Minimum Value) × 100 (2)
It is seen that the correlation of parameters with vulnerability is important, as expressed in the equations.

<u>Correlation of Vulnerability with Parameters</u>

Figure 10 shows how the relationship between vulnerability and parameters is established in the agricultural sector as an example. In the example given in the figure, the decrease in annual precipitation indicates that the agricultural sector is more severely exposed to drought. Decreasing the amount of annual precipitation will increase the value of the exposure index, and this will in turn cause an increase in the degree of vulnerability. In this case, the annual rainfall and vulnerability have a positive correlation and Equation (1) should be used in the normalization of this parameter.

Similarly, as a result of the decrease in agricultural product diversity, the sensitivity of the agricultural sector to drought will increase. This situation will cause the sensitivity index to increase. Considering the calculation equation used, the increase in the sensitivity index will cause the increase in the vulnerability value. Therefore, agricultural product diversity and vulnerability value also have a positive correlation. Existence of the drip irrigation system or excessive usage rate will increase the value of adaptation capacity index, thus decreasing the vulnerability value. In this case, the presence or use of the drip irrigation system has a negative correlation with the vulnerability and normalization should be performed with Equation (2).

Figure 10: Correlation of vulnerability with parameters



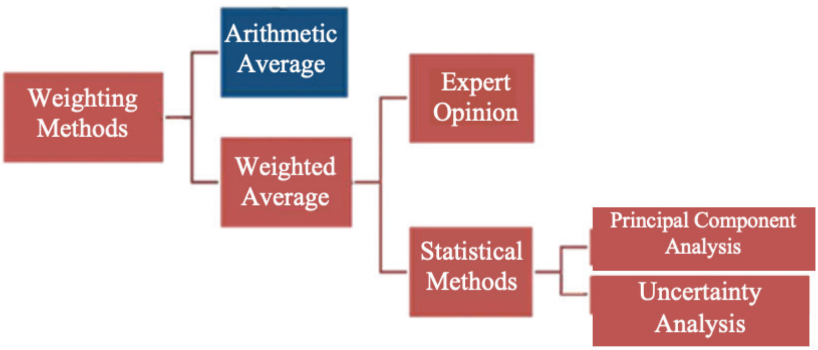
Scoring and Grading of Indexes: According to the normalization process, since the parameters and indexes take values between 0 – 1, all indexes could be scored between 1–4 in the calculation of vulnerability (Table 2).

Table 2: Scoring and grading of indexes

Normalized Value Range	Degree	Degree of Vulnerability	Degree of Exposure	Degree of Sensitivity	Degree of Economic Value	Degree of Adaptation Capacity
0 - 0,25	1	Slight	Slight	Slight	Slight	Slight
0.25 - 0.50	2	Medium	Medium	Medium	Medium	Medium
0,50 - 0,75	3	High	High	High	High	High
0,75 - 1,00	4	Very High	Very High	Very High	Very High	Very High

The weighting of Parameters: After normalization of the parameters, in the second step, the weighting has to be performed in order to combine the parameters. Two basic methods stand out in the literature being, weighted average and arithmetic average Figure 11 shows these methods schematically.

Figure 11: Weighting of Parameters



Weighted average: In order to calculate the weighted average, some statistical methods or expert opinions are used to determine the coefficients that show the effect rates of the parameters. The coefficients that weigh the parameters are determined by evaluating the existing data sets with statistical methods. Principal component analysis and uncertainty analysis are examples of these methods. However, such statistical methods require large data sets to evaluate the general behavior of the system. Therefore, in case of serious data gaps, it causes the system to be interpreted differently and may give misleading results.

Arithmetic average: While in the arithmetic average method, all parameters are assumed to be equally weighted for the vulnerability of the sectors, in the weighted average method, each parameter is considered to have a different effect on the vulnerability of the sectors. In cases such as insufficient data, the arithmetic average method is considered as the most usable method since expert opinion cannot be used due to the difficulty of using statistical methods and the difficulty of finding competent experts in each sector. Therefore, it is preferred. As a result of all calculations made, for example, a vulnerability degree is determined for each sub-basin and the sub-basins of the basin (s) in question are compared among themselves. As a result of the comparison, the sub-basin with the highest exposure (to the event) and the most socio-economically sensitive to this (event) are determined.

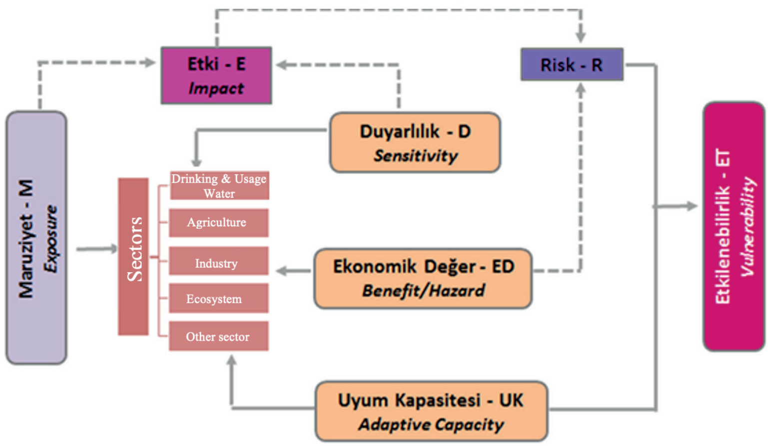
The vulnerability (fragility) indicators will be explained over 2 sample project studies (Sectoral Vulnerability Analysis Results).

These are:

- Climate Change Impact on Water Resources Project (2016) and
- Seyhan, Ceyhan and Asi Basins Drought Management Plans Preparation Project (2019).

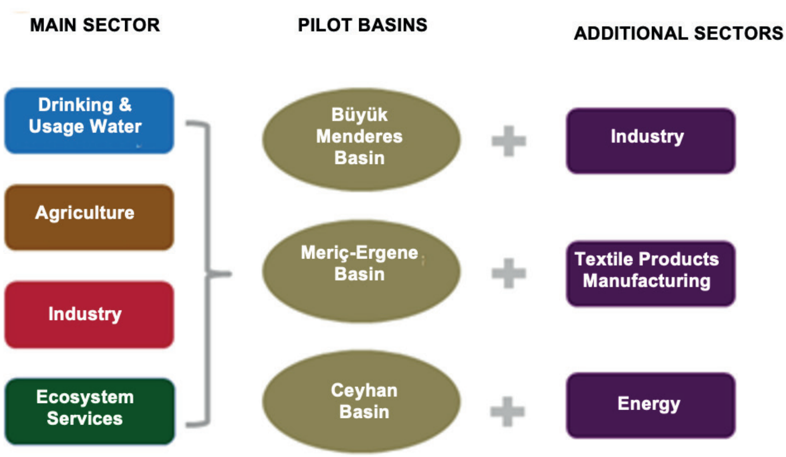
Figure 12 shows schematically the method used in the sectoral vulnerability analysis in the climate project. In Figure 13, sectors and basins used in the analyzes in the same project are indicated.

Figure 12: Sectors and basins used in sectoral vulnerability analyzes within the scope of the climate project



Resources: Climate, 2016

Figure 13: Sectors and sample basins used in sectoral vulnerability analyzes within the scope of the climate project



Resources: Climate, 2016

In this project, 3 different climate models were used and RCP4.5 and RCP8.5 scenarios were used in each model. Different exposure values were not calculated for each model. The water potential value (median) of the model that remained in the middle according to 50% probability was the data used for exposure indexing. Since climate projections are made every 10 years, values of different models are used in every 10 years for exposure indexing. Table 3 shows what exposure equality is. Figure 14, which follows the table, shows how the exposure value was calculated for the period 2061-2070 in the Büyük Menderes Basin as an example.

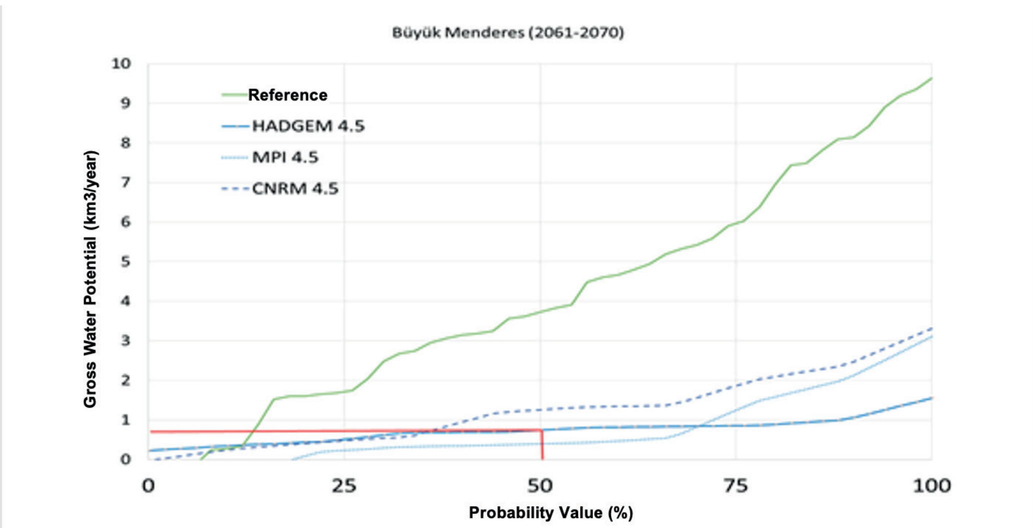
Table 3: Exposure equality

x	Water Potential (Technically and economically usable and unusable amount of water)
c	Domestic (Drinking and Utility) Water Requirements
d	Industrial Water Requirement
e	Agricultural Water Requirement
f	Ecological Water Requirement (10% of the water potential value)

Resources: Climate, 2016

Exposure Value = C + D + E + F / X

Figure 14: An example of finding the Büyük Menderes Basin exposure value for the period 2061-2070



Resources: Climate, 2016

4. SECTORS AND VULNERABILITY INDICATORS

4.1. Climate Project Examples

Within the scope of the sectoral vulnerability analysis of the project, the indices used in determining the sensitivity, economic value and adaptation capacity of each relevant sector and the weights determined within the framework of expert opinion are presented as diagrams. Among the sectors, only the Domestic Water sector was taken as an example and the methods and how the indices were calculated were explained in detail. Figure 15 gives the indices of agriculture, Figure 16 industry, Figure 17 ecosystem services, Figure 18 tourism, Figure 19 energy, and Figure 20 domestic water.

Figure 15: Agricultural sector vulnerability indicators

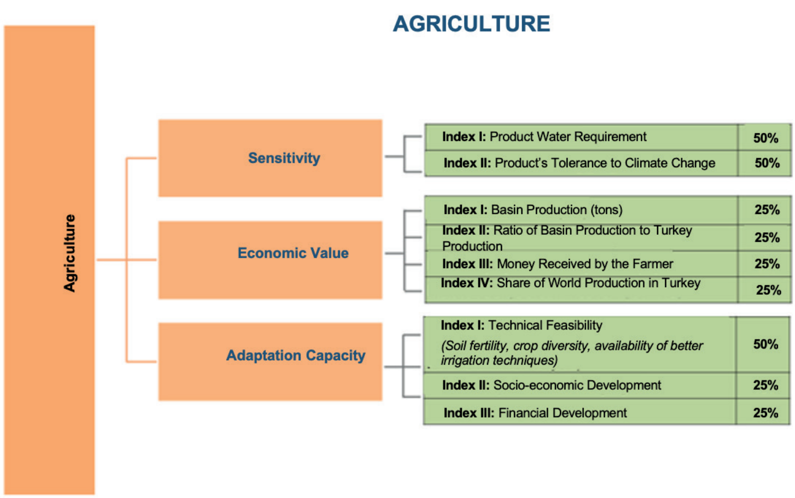


Figure 16: Industry sector vulnerability indicators

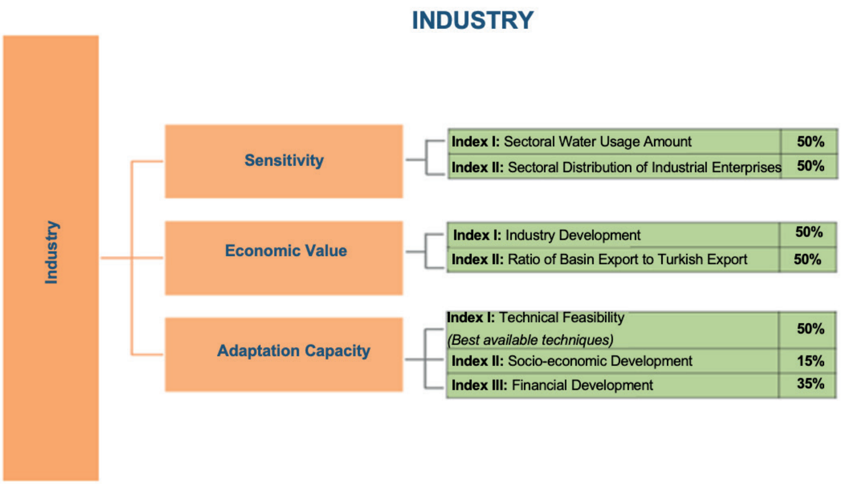


Figure 17: Ecosystem services sector vulnerability indicators

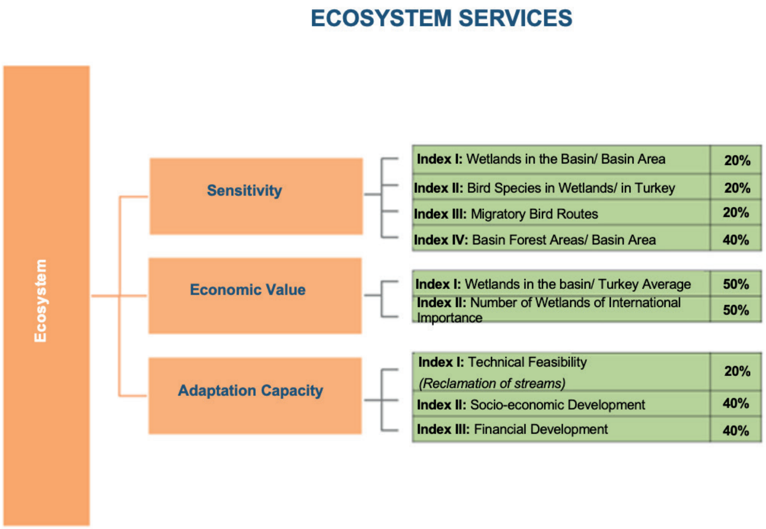


Figure 18: Tourism sector vulnerability indicators

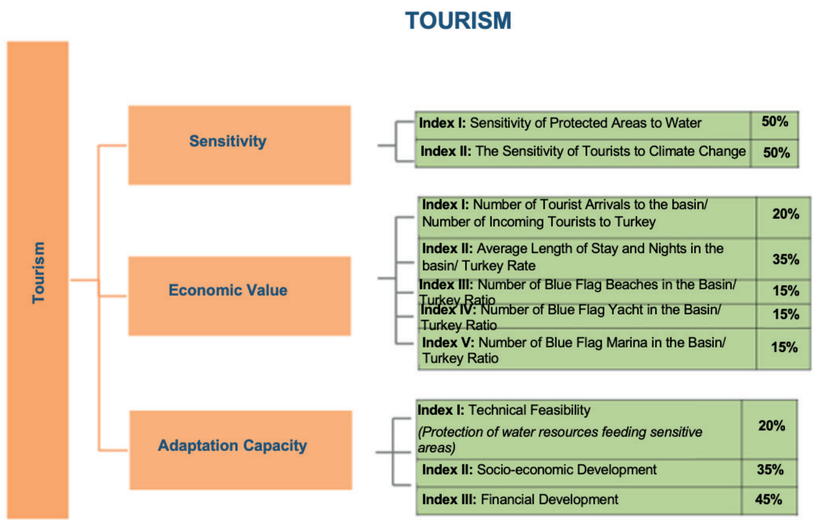


Figure 19: Energy sector vulnerability indicators

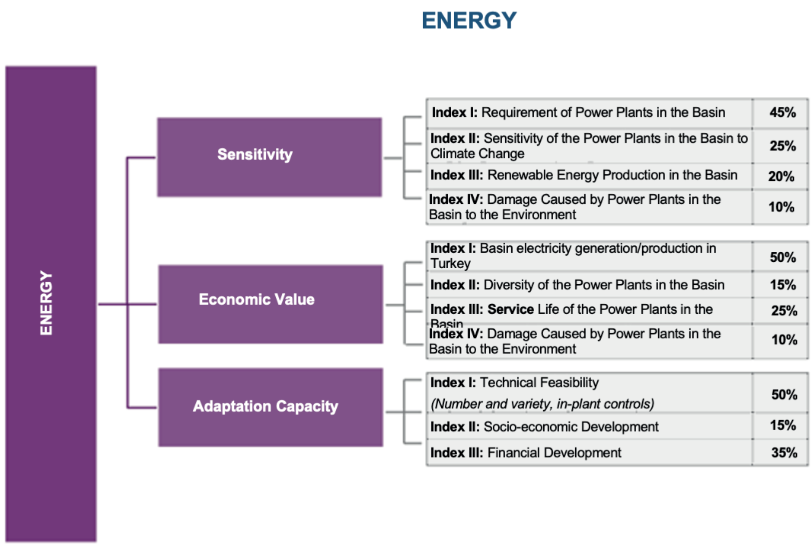
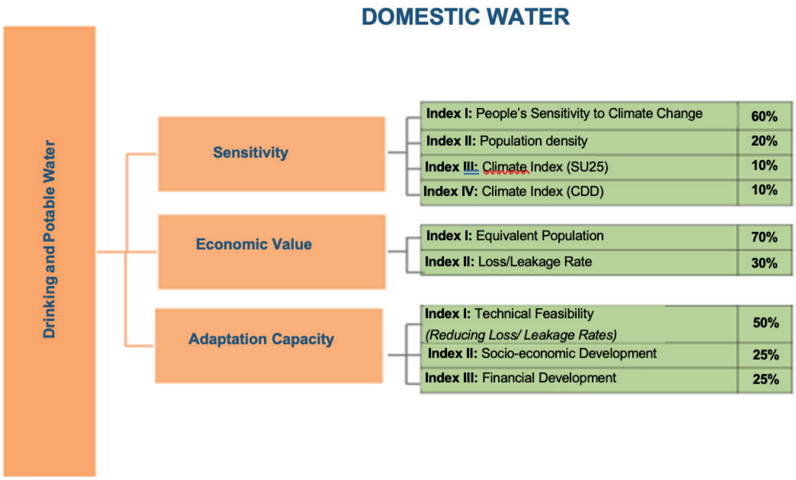


Figure 20: Domestic water sector vulnerability indicators



Indicators of the Domestic Water sector will be explained in detail at this stage.

Sensitivity: 4 different indices have been determined for the sensitivity parameter of the Domestic Water sector, and these indices and their impact rates are given in Table 4.

Table 4: Domestic water sensitivity indices

Index	Index Definitions	Impact Rate
Index I	People's Sensitivity to Climate Change	60%
Index II	Population density	20%
Index III	Climate Index (SU25)	10%
Index IV	Climate Index (CDD)	10%

Index I - People's Sensitivity to Climate Change

It is predicted that the amount of drinking and potable water will differ depending on climate change, and the sensitivity of humans and other living things in this direction is very high and will not change. Therefore, it was accepted that people would show the same sensitivity without any classification and this index was determined as 4, which is the highest effect value. However, with more detailed studies, the sources from which the drinking and utility water of each basin are supplied (surface and groundwater potential, dams in the basin and water holding capacities, etc.) can also be evaluated.

Index II - Population Density

Population density values of each river basin in Turkey were calculated and scoring was performed according to population densities for 25 basins. The index ranges determined for the population density are given in Table 5.

Population density values of the 25 river basins in Turkey were calculated in order to determine the value range of indices and range values were prepared taking into account all basins.

Table 5: Index ranges for population density

Population Density (person / ha)	Index II
<0,5	1
0,5≤ - <1	2
1≤ - <5	3
≥5	4

The population density in Büyük Menderes Basin is calculated as 0.83 people/ha. When looking at the population density range values of the Büyük Menderes Basin, it was determined that it was at the medium effect level by taking the value of 2 indices.

Index III - Climate Index (SU25)

The climate index value expressing the number of days above 25 °C in summer days were determined for each basin by taking the average of the reference period observation data. For this index, data produced under the scope of Climate Change Impact on Water Resources Project were used. The interval values were determined for the climate index expressing the number of days above 25 °C in summer days (Table 6).

Table 6: Index ranges for the climate index (SU25)

Climate Index (SU25)	Index III
≤100	1
101 - 120	2
121 - 139	3
≥140	4

For the Büyük Menderes Basin, it is calculated as 137 days above 25 °C in summer days, and it has been evaluated in the high impact level category by taking the value of 3 indices of this value.

Index IV - Climate Index (CDD)

The climate index value expressing the number of consecutive dry days was determined for each basin by taking the average of the observation data for the reference period, and scoring was made for 25 basins. For this index data produced under the scope of Climate Change Impact on Water Resources Project were used. The interval values determined for the climate index expressing the number of consecutive dry days are given in Table 7.

Table 7: Index ranges for the climate index (CDD)

Climate Index (CDD)	Index IV
≤50	1
51 - 70	2
71 - 84	3
≥85	4

The number of consecutive dry days for Büyük Menderes Basin was calculated as 79, and it was determined that it was at a very high impact level by taking the 3 index value.

Index intervals and weighted index values for the sensitivity parameter of the Domestic Water sector are given in Table 8.

Table 8: Domestic water sensitivity-weighted index value

Index	Index Definitions	Value	Impact Rate	Weighted Index Value
Index I	People's Sensitivity to Climate Change	4	60%	2,40
Index II	Population density	2	20%	0,40
Index III	Climate Index (SU25)	3	10%	0,30
Index IV	Climate Index (CDD)	3	10%	0,30
Sensitivity				3,40

Economic Value: Two different indices were determined for the economic value parameter of the domestic water sector, and these indices and their impact rates are given in Table 9.

Table 9: Domestic water economic value indices

Index	Index Definitions	Impact Rate
Index I	Equivalent Population	70%
Index II	Loss / Leakage Rate	30%

Index I - Equivalent Population

In order to include the amount of water consumed by ovine and bovine animals in Büyük Menderes Basin, the equivalent population value of the basin has been calculated. In the calculation, the values of the settled population in the basin and the numbers of bovine and ovine animals in 2014 and the water consumption values found were used.

The equivalent population value of Buyuk Menderes Basin, constitutes 3% of Turkey's equivalent population value (Table 10).

Table 10: Büyük Menderes Basin equivalent population

Type	Population (capita / animal)	Turkey * Population (capita)	Water Consumption	Eşdeğer Nüfus (kişi-havza)	Eşdeğer Nüfus (kişi-Türkiye)
Human	2.186.525	77.695.904	200	2.186.525	77.695.904
Cattle	723.862	14.244.673	50	180.966	3.561.168
Ovine	1.506.717	41.462.349	15	113.004	3.109.676
Total				2.480.494	84.366.748
The ratio of the Basin to the Country Equivalent Population				%3	

* Population data are 2014 data from TURKSTAT.

The index range values determined for the equivalent population index are given in Table 11.

Table 11: Index ranges for equivalent population

Equivalent Population	Index I
≤%2	1
%2,01 - %4	2
%4,01 - %10	3
≥%10,01	4

The equivalent population value of Büyük Menderes Basin has been calculated as 3%, this value is in the medium impact class and corresponds to 2 index value.

Index II - Loss / Leakage Rate in Water Transmission Lines

Loss and leakage rate index indicates an average loss/leakage value calculated in line with the loss/leakage rates in the water transmission lines of the provinces within the basin and the areal ratios of the provinces within the basin. Loss/leakage rates of the provinces in the basin have been found. For provinces for which this data is absent, the loss/leakage rate representing the current status of Turkey, which is 45%, was used. Loss/leakage rates of the provinces have been brought to the basin scale by considering the areal ratios of the provinces in the basin.

Index range values determined for loss/leakage rates representing an index of the economic value parameter are given in Table 12.

Table 12: Loss/leakage rate index ranges

Loss / Leakage Rate	Index II
≤ 20%	1
21% - 35%	2
36% - 49%	3
≥ 50%	4

The loss/leakage rates determined for the Büyük Menderes Basin in this context are given in Table 13.

Table 13: Loss/leakage rates on provincial basis for Büyük Menderes Basin

Provinces	Loss / Leakage Rate	The Part of the Provincial Area that Enters the Basin (%)	Loss / Leakage Rate in the Basin
Denizli	50%	37%	18,5%
Aydın	45%	%27	12,2%
Afyon	43%	13%	5,6%

Provinces	Loss / Leakage Rate	The Part of the Provincial Area that Enters the Basin (%)	Loss / Leakage Rate in the Basin
Uşak	45%	%12	5,4%
Muğla	33%	%11	3,6%
Büyük Menderes Basin			45,3%

For the Büyük Menderes Basin, the loss/leakage rate in water transmission lines is at a high impact level with a value of 45%. The weighted index value for the economic value parameter of the Domestic (drinking and utility) Water sector is given in Table 14.

Table 14: Weighted index value for drinking and potable water economic value parameter

Index	Index Definitions	Value	Impact Rate	Weighted Index Value
Index I	Equivalent Population	2	70%	1,40
Index II	Loss/Leakage Rate	3	30%	0,90
Economic Value				2,30

Adaptation Capacity

Three different indices were determined for the adaptation capacity of the Domestic Water sector, and these indices and their impact rates are given in Table 15. Applicable methods are available to reduce loss/leakage rates. For the technical feasibility index value, the socio-economic and financial development levels of the basins are taken into account. In addition, for this index, variables such as infrastructure difficulties, land slopes, etc. can be evaluated in detail by considering the variables.

Table 15: Domestic water adaptation capacity indices

Index	Index Definitions	Impact Rate
Index I	Technical Feasibility	50%
Index II	Socio-Economic Development	25%
Index III	Financial Development	25%

Index I - Technical Feasibility

In addition, with the Regulation on the Control of Water Losses in Drinking Water Supply and Distribution Systems, it has become a necessity to reduce the loss/leakage rates. The technical feasibility index of the said index was accepted as 3.

Index II - Socio-Economic Development

The socio-economic development indexes of the provinces in the Büyük Menderes Basin were found and the population ratios of the relevant provinces in the basin and the socio-economic development index of the basin were determined (SEGE, 2011). The index ranges determined for the Socio-Economic Development index are shown in Table 16, and the socio-economic development data of the basin are shown in Table 17.

Table 16: Index ranges for socio-economic development index value

Socio-Economic Development Index	Index II
<-1	1
(- 1) - 1	2
1 - 3	3
>3	4

Table 17: Büyük Menderes Basin socio-economic development index (SEGE, 2011)

Provinces	Development Index of Provinces	Rate of Population Entering the Basin (%)	Development Index in the Basin
Denizli	0,91	30%	0,27
Aydın	0,56	30%	0,17
Afyon	-0,1	5%	-0,004
Uşak	0,37	33%	0,12
Muğla	1,00	%2	0,02
Büyük Menderes Basin Socio-Economic Development Index			0,58

The socio-economic development index of the Büyük Menderes Basin is at the medium effect (2) level, taking the value 0.58.

Index III - Financial Development

The financial development indexes of the provinces in the Büyük Menderes Basin were found and the population ratios of the relevant provinces in the basin and the financial development index of the basin were determined (Economic Research Department, 2014). The index ranges determined for the Financial Development index are given in Table 18.

Table 18: Index ranges for financial development index value

Financial Development Index	Index II
<-2	1
(-1) - (-2)	2
(-1) - 1	3
>1	4

Financial development data of the basin are shown in Table 19.

Table 19: Büyük Menderes Basin financial development index (Economic Research Department, 2014)

Provinces	Development Index of Provinces	Rate of Population Entering the Basin (%)	Development Index in the Basin
Denizli	1,28	30%	0,38
Aydın	0,37	30%	0,11
Afyon	-0,9	5%	-0,05
Uşak	-0,98	33%	-0,32
Muğla	2,64	%2	0,05
Büyük Menderes Basin Socio-Economic Development Index			0,18

The Büyük Menderes Basin financial development index is at a very high effect (3), taking 0.18.

The weighted index value for the economic value parameter of the domestic water sector is given in Table 20.

Table 20: Weighted index value for domestic water adaptation capacity

Index	Index Explanation	Value	Impact Rate	Adaptation Capacity Weighted Index Value
Index I	Technical Feasibility	3	50%	2,75
Index II	Socio-Economic Development	2	25%	
Index III	Financial Development	3	25%	

The socio-economic and financial development indices calculated for the Büyük Menderes Basin are used in the relevant indices of all sectors.

Sectoral Vulnerability Analysis Results

Weighted index values for Sensitivity (S), Economic Value (EV) and Adaptation Capacity (AC) parameters of 5 main sectors, namely Domestic Water, Agriculture, Industry, Ecology and Tourismwere determined for the Büyük Menderes Basin. It is accepted that the index values determined for these parameters will not change during the projection period, and they are the values that represent the basin. It is important to update these values every 5 years. In Table 21, index values characterizing the basin are given based on sectors.

Table 21: Weighted index values of sectors for Büyük Menderes Basin

Sector / Parameter	Sensitivity (S)	Economic Value (EV)	Adaptation Capacity (AC)
Domestic Water	3,40	2,30	2,75
Agriculture	1,82	2,13	3,25
Industry	2,75	2,50	2,85
Ecosystem	2,20	1,50	2,40
Tourism	3,23	1,50	2,45

According to the methodology developed within the scope of the Sectoral Vulnerability Analysis study, the Impact (I) value is obtained by multiplying the Sensitivity (S) parameters determined specific to sector and basin and Exposure (E). Impact (I) parameter is calculated with the Economic Value (EV) parameter determined specific to the basin to create the Risk (R) value. Risk (R) parameter is divided into the Adaptation Capacity (AC) value determined specific to the basin to derive the Vulnerability (V) value of the sector.

The vulnerability values determined according to the RCP4.5 scenario for the Büyük Menderes Basin 2015-2020 period are given in Table 22 as an example for calculations. According to the vulnerability range and level are given in Table 23, the vulnerability values for both scenarios during the projection periods are presented in Table 24.

The vulnerability levels that are the result of the study in Table 25 are given according to the RCP4.5 scenario.

In addition, the visual version of the map presented in the table is given in Figure 21. Thus, the sectoral vulnerability assessment was completed.

Table 22: RCP4.5 scenario 2015-2020 period sectoral vulnerability analysis

Sector	Exposure (E)	Sensitivity (S)	Effect (E)	Economic Value (EV)	Risk (R)	Adaptation Capacity (AC)	Vulnerability (V)
Drinking and Utility Water	1	3,40	3,40	2,30	7,82	2,75	2,8
Agriculture	1	1,82	1,82	2,13	3,89	3,25	1,2
Industry	1	2,75	2,75	2,5	6,88	2,85	2,4
Ecosystem	1	2,20	2,20	1,5	3,30	2,4	1,4
Tourism	1	3,23	3,23	1,5	4,85	2,45	2,0

Table 23: Vulnerability range and level

Vulnerability Range	Influence Level	Severity of Influence
1 - 3	1	Slight Impact
4 - 6	2	Medium Impact
7 - 9	3	High Impact
9<	4	Very High Impact

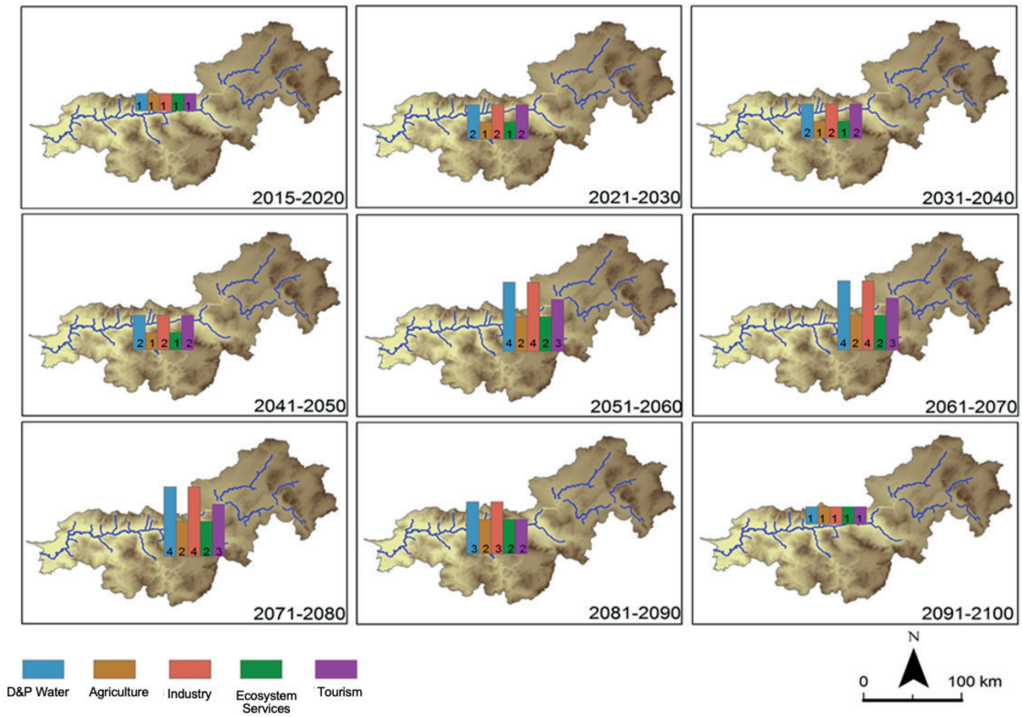
Table 24: Sectoral vulnerability values of Büyük Menderes Basin

Sectors / Years	Domestic Water		Agriculture		Industry		Ecosystem		Tourism	
	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5	RCP 4.5	RCP 8.5
2015-2020	2,8	5,7	1,2	2,4	2,4	4,8	1,4	2,8	2	4
2021-2030	5,7	2,8	2,4	1,2	4,8	2,4	2,8	1,4	4	2
2031-2040	5,7	2,8	2,4	1,2	4,8	2,4	2,8	1,4	4	2
2041-2050	5,7	11,4	2,4	4,8	4,8	9,6	2,8	5,5	4	7,9
2051-2060	11,4	8,5	4,8	3,6	9,6	7,2	5,5	4,1	7,9	5,9
2061-2070	11,4	11,4	4,8	4,8	9,6	9,6	5,5	5,5	7,9	7,9
2071-2080	11,4	11,4	4,8	4,8	9,6	9,6	5,5	5,5	7,9	7,9
2081-2090	8,5	11,4	3,6	4,8	7,2	9,6	4,1	5,5	5,9	7,9
2091-2100	2,8	11,4	1,2	4,8	2,4	9,6	1,4	5,5	2,9	7,9

Table 25: Vulnerability levels of sectors according to Büyük Menderes Basin RCP4.5 scenario

Years / Sectors	Domestic Water	Agriculture	Industry	Ecosystem	Tourism
2015-2020	1	1	1	1	1
2021-2030	2	1	2	1	2
2031-2040	2	1	2	1	2
2041-2050	2	1	2	1	2
2051-2060	4	2	4	2	3
2061-2070	4	2	4	2	3
2071-2080	4	2	4	2	3
2081-2090	3	2	3	2	2
2091-2100	1	1	1	1	1

Figure 21: Comparison of the vulnerability levels of the sectors according to the Büyük Menderes Basin RCP4.5 scenario



4.1. Drought Management Project Examples

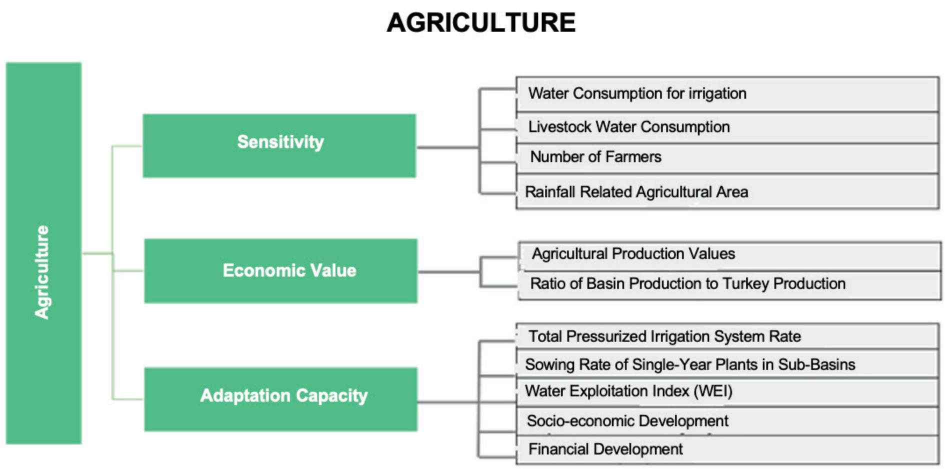
Agricultural sector vulnerability analysis calculations for Seyhan Basin

In the basin/sub-basins; sensitivity analysis was carried out by taking into account the water consumption for irrigation, livestock water consumption, the number of farmers and the ratios of agricultural land due to rainfall. Economic value analysis was carried out by looking at the ratio of agricultural production and basin agricultural production to country production. The adaptation capacity of the pressurized (closed) irrigation system has also been determined by taking into account the rate of annual crops, water use index, socio-economic and financial development values. The agricultural sector vulnerability analysis has been made with the calculations.

Figure 22 shows the vulnerability indicators of the agricultural sector.

The sensitivity index used in expressing the vulnerability defines the tendency of a system to be affected positively or negatively from climate events. The sensitivity of the system to climatic conditions is related to socio-economic factors such as population, infrastructure and income distribution as well as geographical conditions. While determining the sensitivity index value, the most up-to-date situations are taken into consideration for the parameters created by the mentioned factors.

Figure 22: Agricultural sector vulnerability indicators



In this section, where the sensitivity of the agricultural sector to drought climate events is determined, the sensitivity index is calculated using the parameters of water consumption for irrigation, the amount of livestock water consumption, the number of farmers and the ratio of agricultural land based on rainfall (dry agriculture).

Parameters and indicators expressing the economic value are generally used within the sensitivity index in studies conducted around the world.

In this study, economic value was used as a separate index in order to observe the relationship between drought and economic value more clearly. The economic value of the agricultural sector is expressed by comparing the agricultural production values in the sub-basin with the agricultural production values in Turkey and through the production shares in the country of agricultural products that have high production share/economic value in Turkey and/or in the world.

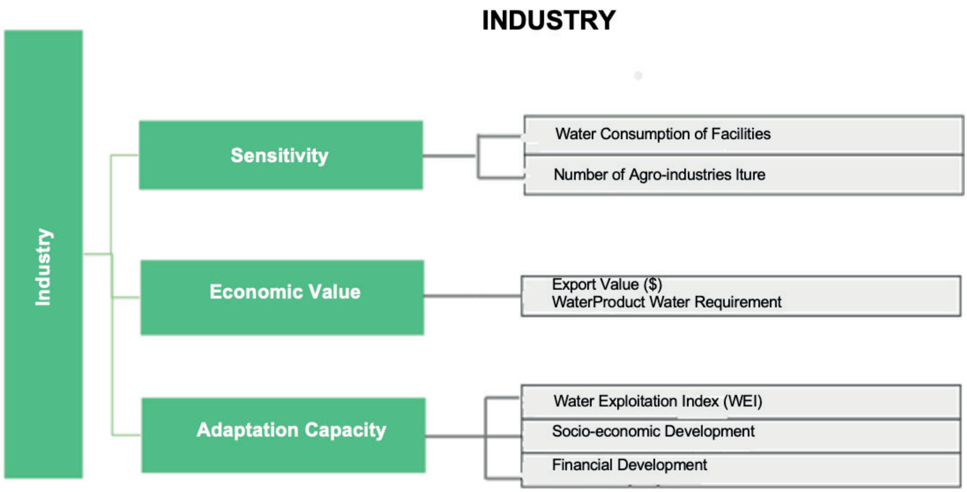
In the economic value index calculations, the products with major economic value in the basin were taken into account. In this study, the total agricultural production rate in the basin was calculated with the parameters of soy, citrus (tangerine, lemon, grapefruit, orange), apple, zucchini, peanut, watermelon and wheat production rate. Using the economic contributions of agricultural products, which have high production share in Turkey and are important for the basin, as a parameter together with the "Total Agricultural Production Rate" parameter, enabled including in the vulnerability analysis of some products which do not have homogenous distribution in the basis but which have high production share in the country.

Adaptation capacity index expresses the ability of the system to tolerate damages caused by climate event. In order to express the adaptation capacity index correctly, some indicators formed by various factors such as the sensitivity index are needed. The main indicators expressing adaptation capacity can be given as examples of a region's economic capacity, physical infrastructure, social capital, institutional capacity and data accessibility. While determining the adaptation capacity index value, the most up-to-date situations are taken into consideration for the parameters formed by the mentioned factors. In this section, where the adaptation capacity of the agricultural sector against drought climate events is determined, adaptation capacity indexes are calculated with utilization rates of water-saving pressurized irrigation systems, the planting rate of single annual crops determined in order to adapt the crop pattern to drought, water exploitation index (WEI), socio-economic development and financial development.

Industry sector vulnerability analysis calculations for Seyhan Basin

The degree of sensitivity of the industrial sector to climatic conditions is associated with factors such as the development of the industrial sector in the region under study and the amount of water consumption. The vulnerability indicators prepared for this sector are shown in Figure 23.

Figure 23: Industry sector vulnerability indicators



While determining the sensitivity index value, the most up-to-date situations are taken into consideration for the parameters created by the mentioned factors. In this section, where the sensitivity of the Industrial Sector to drought is determined, the sensitivity index consists of Water Consumption Values in sub-basins. Industrial water consumption values are a parameter that expresses how sensitive the industrial sectors in the sub-basins are in situations of drought and water scarcity. In the literature, water consumption amounts in different sectors has been used as a parameter that changes the vulnerability value (Swenson et al., 2013). In the calculation of industrial water use on the basis of sub-basin, water use values for each activity area and the sizes of the facilities were evaluated together. Industries, production areas and sizes in the basin industries have been obtained from the

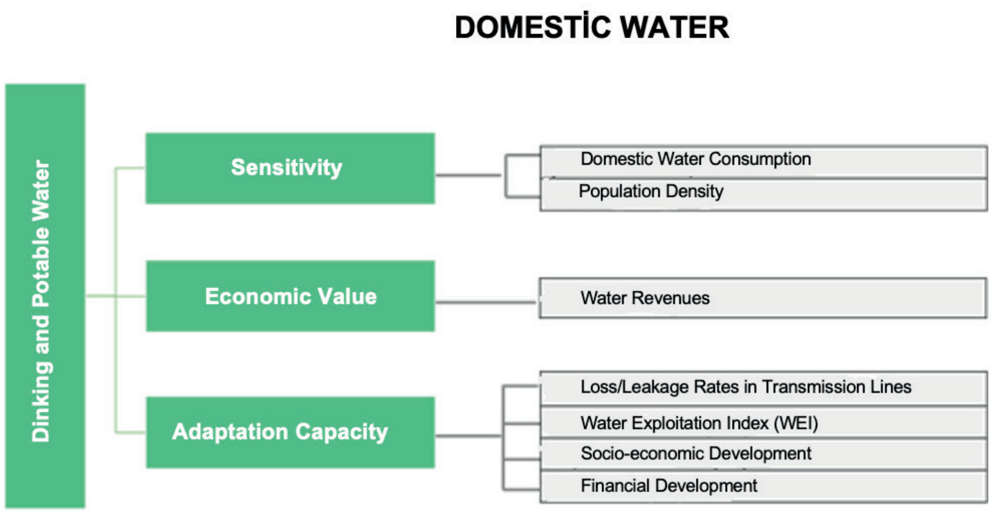
Ministry of Industry and Technology. Water uses for each field of activity were obtained from interviews with the facilities. Water usage information obtained from the literature for each NACE code was used for the values that could not be obtained from the facilities. Water consumption values were compared between sectors and the water consumption level was obtained for each sector. The determined water consumption values were summed up on the basis of facilities in sub-basins and expressed as the total water consumption value in sub-basins. The economic value index includes the number of workers employed and export values as a measure of the economic contribution of the industrial sector to sub-basins in this study.

The adaptation capacity index expresses the ability of the system to tolerate damages caused by the climate event. In order to express the adaptive capacity index correctly, some indicators formed by various factors such as sensitivity index are needed. The main indicators expressing adaptation capacity can be given as examples of a region's economic capacity, physical infrastructure, social capital, institutional capacity and data accessibility. While determining the adaptation capacity index value, the most up-to-date situations are taken into consideration for the parameters formed by the mentioned factors. Water exploitation index (WEI), socio-economic and financial development parameters are used in this section where the adaptation capacity of the industrial sector against drought climate events is determined.

Domestic water sector vulnerability analysis calculations for Seyhan Basin

Figure 24 presents the vulnerability indicators of this sector.

Fgure 24: Domestic water sector vulnerability indicators



The sensitivity of the domestic water sector to climatic conditions can be determined by the consumption of drinking and utility water in the region under study. In regions that need more domestic water, this sector is more sensitive to climate events. While determining the sensitivity index value, the most up-to-date situations are taken into consideration for the parameters created by the mentioned factors. In this section, where the sensitivity of the domestic water sector against the drought climate event is determined, the domestic water consumption and population density parameters are used to determine the sensitivity levels in the sub-basins.

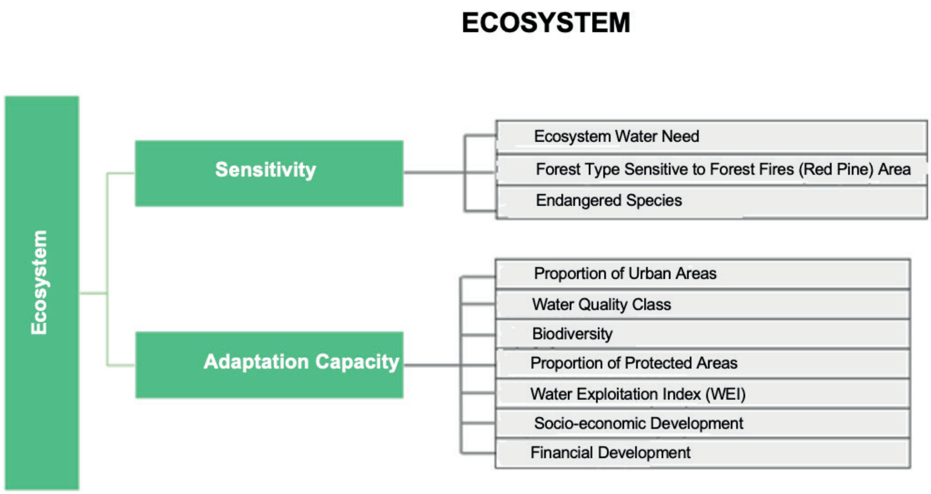
The water income parameter of municipalities, which expresses the economic status of sub-basins, was used to examine the relationship between the drought and the economic value of the domestic water sector. The adaptation capacity index indicates the ability of the domestic water sector to tolerate the harms caused by climate event.

While determining the adaptation capacity index value, the most up-to-date situations are taken into consideration for the parameters formed by the mentioned factors. In this section, where the adaptation capacity of the drinking and utility water sector against drought is determined, the water exploitation index (WEI) in the sub-basins, the reduction of the loss-leakage rate in the transmission lines, the socio-economic development and financial development parameters of the basin are used to determine the adaptation capacity.

Ecosystem sector vulnerability analysis calculations for Seyhan Basin

Figure 25 presents the vulnerability indicators of this sector.

Figure 25: Ecosystem sector vulnerability indicators



Drought, which causes reductions in the amount of usable water and changes ecosystem dynamics, causes the natural balance in the ecosystem to deteriorate and the quality of the ecosystem to decrease. The sensitivity of the ecosystem to climatic conditions can be determined by using the parameters of the amount of water that the ecosystem needs to sustain its existence, any pressure factor of the species in the ecosystem, the health status of the populations, and the susceptibility of forest areas that are developed in terms of ecosystem richness.

While determining the sensitivity index value, the most up-to-date situations are taken into consideration for the parameters created by the mentioned factors. In this section, where the sensitivity of the ecosystem to drought climate events is determined, the sensitivity index is calculated by the ecosystem water requirement in the sub-basins, the number of forest species sensitive to forest fire and the number of endangered species.

Adaptation capacity index refers to the ability of the ecosystem to tolerate damages caused by climate event. In order to express the adaptation capacity index correctly, some indicators formed by various factors such as the sensitivity index are needed. The capacity of the ecosystem to adapt to climate events, the environmental quality of the regions where different ecosystems live, the activities carried out by people in order to increase the ecosystem quality can represent the opportunity to create new habitats when the ecosystem is suppressed by the climatic conditions of the habitat in which the ecosystem lives. While determining the adaptation capacity index value, the most up-to-date situations are taken into consideration for the parameters formed by the mentioned factors. In this section where the adaptation capacity of the ecosystem against drought climate events is determined, the water quality degrees of the water bodies in the basin, the ratio of urban areas to the total sub-basin areas, biodiversity, water exploitation index (WEI), the ratio of protected areas, socio-economic and financial development parameters are used.

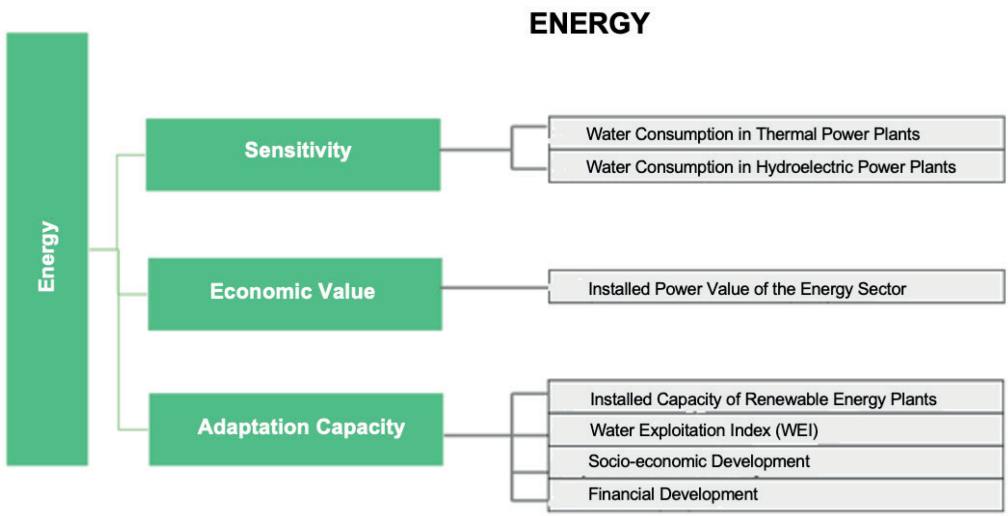
Energy sector vulnerability analysis calculations for Seyhan Basin

Figure 26 presents the vulnerability indicators of this sector. In this section, where the sensitivity of the energy sector against drought climate events is determined, the water consumption parameter of thermal power plants and hydroelectric power plants in sub-basins is used to express the sensitivity situation.

The economic value index was calculated with the installed power value parameter of the energy sector in this study.

In this section, where the adaptation capacity of the energy sector against drought climate events is determined, the installed power values and water exploitation index (WEI) parameter of solar and wind power plants in sub-basins are used to express adaptation capacity. While thermal power plants are energy systems that consume the most water due to the need for cooling water, wind and solar power plants consume less water. In addition, water consumption in biomass power plants is almost negligible.

Figure 26: Energy sector vulnerability indicators

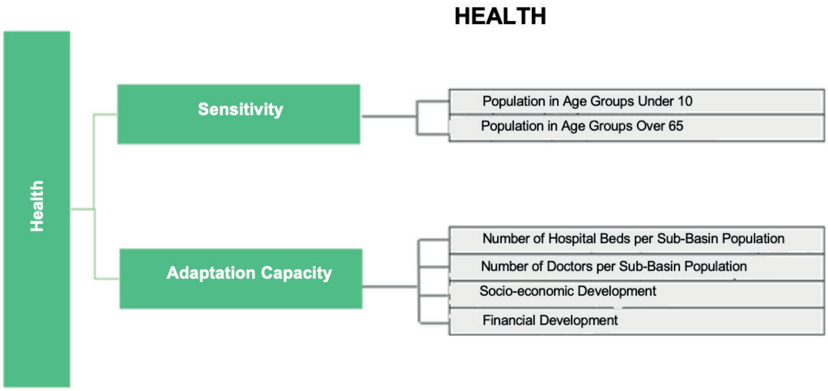


The widespread availability of energy systems that consume less water increases a region's capacity to adapt to water scarcity and drought.

Health sector vulnerability analysis calculations for Seyhan Basin

Figure 27 presents the vulnerability indicators of this sector.

Figure 27: Health sector vulnerability indicators



The sensitivity of public health to drought is expressed as the ratio of the population more vulnerable to climate events and events such as water scarcity, to the total population.

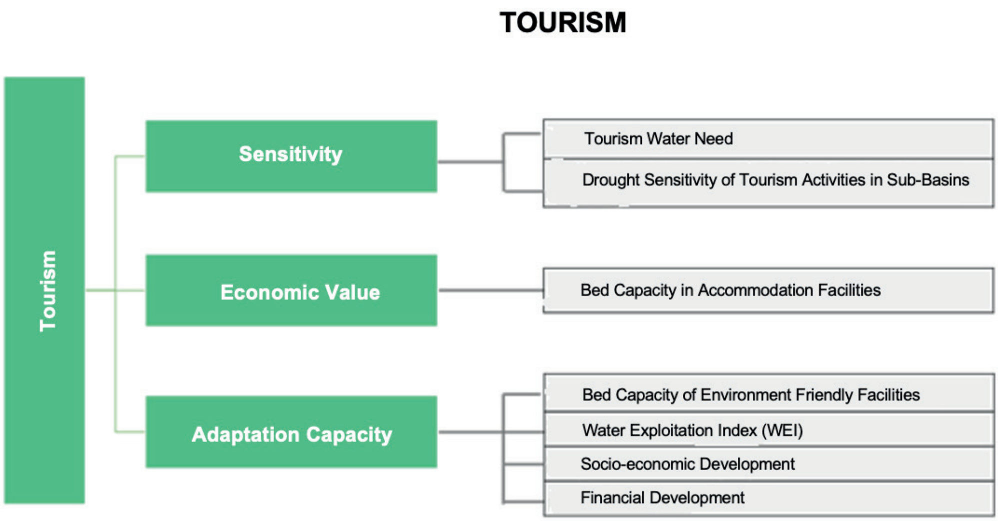
While determining the sensitivity index value, the most up-to-date situations are taken into consideration for the parameters created by the mentioned factors. In this section, where the sensitivity of public health to drought climate events is determined, the population over 65 years and the population under 10 years old are used to determine the sensitivity levels in sub-basins.

Adaptation capacity index expresses the ability of public health to tolerate the harms caused by climate event. The number and development of health institutions and organizations of a region can be given as an example to the main indicators that express the adaptation capacity of public health. While determining the adaptation capacity index value, the most up-to-date situations are taken into consideration for the parameters formed by the mentioned factors. In this section, in which the adaptation capacity of public health to the drought climate event is determined, the ratio of the number of doctors and beds in hospitals in sub-basins to the population and the parameters of the rural population with access to the health center, are used to determine adaptation capacity.

Tourism sector vulnerability analysis calculations for Seyhan Basin

Figure 28 presents the vulnerability indicators of this sector.

Figure 28: Tourism sector vulnerability indicators



In this section, where the sensitivity of the tourism sector against drought climate events is determined, tourism activities in sub-basins are used to express the sensitivity. The economic value index was calculated in this study with the bed capacity parameter of the accommodation facilities, which expresses the economic status of the sub-basins of the tourism sector. In this section, where the adaptation capacity of the tourism sector against drought climate events is determined, the Water Exploitation Index (WEI) parameter in the sub-basins is used to express the adaptation capacity.

While preparing the Seyhan Basin drought management plan, the effects of all vulnerability indicators were taken equally.

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VULNERABILITY BY SECTORS: TOURISM

Prof. Dr. Mehmet Somuncu

1. INTRODUCTION

Climate, coasts, oceans, mountains, forests, wildlife and associated ecosystems provide attractiveness for many destinations (Holden, 2008). In this sense, the climate is an important tourist attraction. Climate also has a significant impact on tourism activities. Therefore, the climate can provide advantages and disadvantages for tourism regions. In certain seasons of the year in tourism areas and regions, tourism becomes more intense than other times. The length of the most popular season, known as the high season, varies according to the climatic conditions of the tourism areas. The climatic conditions that can be considered ideal depending on the touristic activities are of vital importance in terms of the competition of the tourism regions. Both tourism businesses and tourists do not prefer disadvantaged climates as much as advantageous climates. Therefore, the climate has a determining feature in tourists choosing certain destinations. Because the efficient realization of the tourists' holidays or touristic activities depends primarily on the weather and climatic conditions in the touristic area (Güçlü, 2015). In this respect, the climate perception of tourism destinations may be an important component of the destination image (Day et al., 2013).

Climate is a resource for a variety of tourism activities depending on weather and climatic conditions, especially those such as sea or coastal tourism, winter tourism, health tourism and water sports. The sun is important for the masses who go on vacation. For that reason, the phenomenon called "Heliotropism", which is the behavior of the masses of tourists who like the sun and who are after sunny places, is considered as a fundamental argument for tourists (WTO, 2001 as cited in Martin, 2005). That is the reason for the development of tourism on the Mediterranean coast in Turkey and Europe. Because in this type of tourism, movement is from cold and humid climates to hot and temperate climates (Doğaner, 2001). This situation can be observed even within a country. Turkey is the best example. In Turkey with a coast length of 8,333 km where most part of the coasts are under the influence of Mediterranean climate, coastal tourism is not developed to the same extent in all the coasts. Although coastal geomorphology, accessibility and other infrastructural possibilities also affect this, the main determinant is the climate. Indeed, the climate determines the time for conducting coastal tourism under appropriate conditions on the coast of Turkey. Accordingly, swimming in a place, the possibility of various recreational activities on the coast and the sea depends on the existence of suitable conditions in terms of air and sea water temperatures and sunbathing time. For this reason, the periods when the climate is suitable for coastal tourism are 3 months on the Black Sea and Marmara coasts, 5 months on the northern shores of the Aegean Sea, 6 months on the south coast, 7 months on the southwestern Anatolian shores and 8 months on the Mediterranean coasts. Although the temperatures in the Mediterranean coasts reach overwhelming levels in July and August, coastal tourism starts earlier and ends later (Doğaner, 2001). This situation caused coastal tourism to develop internationally in the Mediterranean and Aegean coasts, and not sufficient to develop in the Marmara and Black Sea coasts.

Similarly, winter sports are directly dependent on climate resources and this dependency means that a stable and sufficient amount of snow is required in winter tourism centers in order to practice skiing. Without snow and low temperatures, it would not be possible to develop winter tourism or ski sports centers (Martin, 2005). As a matter of fact, the situation of the skiing sector in the Alps, Scotland and Canada where the winter sports industry has developed, is seen as an indicator of global warming and associated climate change. In this sense, coastal tourism and winter tourism, which are carried out massively in the world, are dependent on climatic elements such as temperature, sunbathing time and snowfall.

Another issue that needs to be addressed in the context of the relationship between air, climate and tourism is climate comfort. The climate comfort of the tourism area is important. Climate comfort is defined as the level of satisfaction of people participating in touristic activities regarding the climatic conditions in their environment. The climate comfort situation in tourism areas is important in terms of the tourists of all ages to be able to do all kinds of outdoor touristic activities healthily and comfortably and to provide all the benefits that tourists expect. In addition, it is an important issue that tourism planners and marketers should consider in order to protect tourists from possible risks and to make realistic plans according to climate conditions (Güçlü, 2015).

As a result, climate and its elements, sunshine duration, temperature, precipitation, wind, etc. are often a prime resource for a range of activities designed to meet tourist demand. However, climate may not be the main source for tourism everywhere. In some places, climate is complementary to other basic resources. In such cases, the climate does not directly create tourism, but it facilitates the development of tourism by performing recreational activities such as hiking, rafting, golf, hunting, fishing, mountaineering, or outdoor activities to the extent that weather and climatic conditions allow (Martin, 2005).

Fossil fuels, which started to be used with industrialization processess and use of which gradually increased, caused the accumulation of greenhouse gases in the atmosphere with increasing intensity. Intensive greenhouse gas accumulation has led to global climate change, which is the most serious, complex and largest-scale threat that humankind has faced throughout its known history (Republic of Turkey Ministry of Environment and Urbanization, 2016). It is clear that tourism, which is so important economically and socially, is closely linked to weather and climate and is extremely sensitive to these factors. Therefore, especially in countries, including Turkey, where the tourism sector is in the forefront, the effects to be caused by climate change become important. These effects are expected to positively or negatively affect the attractiveness of different regions in terms of tourism (Somuncu, 2016; 2018).

2. THE EFFECT OF CLIMATE CHANGE ON TOURISM AND THE VULNERABILITY OF THE SECTOR

The world's climate is changing and there is enough scientific evidence to demonstrate this change. There is a global consensus that the most important reason for this change is the increase in greenhouse gases in the atmosphere as a direct result of human activities (Alagedik et al., 2016; Gautier, 2014; IPCC, 2014; NASA, 2020; Republic of Turkey Ministry of Environment and Urbanization.2016; Türkeş, 2008a; Türkeş 2008b). The uncontrolled population growth and the resulting land-use changes and economic development cause human beings to pose numerous threats on the world climate (Eraydın et al., 2011; IPCC, 2014).

Since the beginning of industrialization in the 18th century, the extraordinary rise in the concentration of greenhouse gases in the atmosphere, especially carbon dioxide, has caused two important thresholds in terms of climate balances in the world. The first is that 350 ppm, which is the safe limit for climate balances in terms of the concentration of carbon dioxide in the atmosphere, was exceeded in 1988. Second, the average for April 2014 exceeded 400 ppm for the first time. It is known that the world experienced the 400 ppm level 4,5 million years ago. It is revealed that in the Pliocene period 5-3,6 million years ago, the global temperature was 3 °C or 4 °C higher than today, the poles were 10 °C warmer, and the sea level was 5-40 meters higher than today's level (Alagedik et al., 2016).

These findings, revealed by the 5th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) (AR5/2014) (IPCC, 2014), explain the deterioration in global climate balances and provide important clues about the future consequences. If the temperature increase approaches 2 °C compared to pre-industrialization, the risks will increase further and extreme weather events will become commonplace.

Scientific models reveal that as the amount of carbon dioxide in the atmosphere approaches 450 ppm, the temperature increase cannot be stopped and the risk of loss of climate balances exists (Alagedik et al., 2016). Currently, this figure has reached 413 ppm as of March 2020 (NASA, 2020).

The fact that the average temperature increased by 0,85 °C between 1880-2012 (today, this value was 0,98 °C), the hottest three years were experienced in the last ten years, and that 2016 was recorded as the hottest year measured, are stated as current indicators of long-term scientific estimates. (Alagedik et al., 2016; IPCC, 2014; NASA, 2020).

Established flows in tourism are often dependent on certain assumptions. For example, the assumptions that there will be a hot and dry summer in the Mediterranean, a dry season in the Caribbean at a predictable time each year, and regular snowfall in winter in the ski resorts of Europe and North America are have a role in destination selection of tourists and in tourism. However, these assumptions are under the threat of climate changes that develop as a result of global warming. Of concern is the uncertainty about how climate change will affect tourism demand for those whose livelihoods depend on tourism (Holden, 2008).

Tourism is a sector with a very high climate sensitivity. Climatic conditions play a role in determining many factors such as the suitability of the locations for touristic activities, the tourism season and activities. An increase in temperature, rise in sea level and extreme weather events will directly affect mass tourism. Drought and desertification, forest fires, water scarcity, biodiversity losses, coastal erosion, diseases due to extreme weather events and vector-borne infectious diseases are also indirectly affected by the effects of climate change on tourism (Simpson et al., 2008). In the report of Climate Change and Tourism Policy in OECD Countries published in 2008 by the World Tourism Organization and the United Nations Environment Program, the events that can be observed due to the effects of climate change in the Mediterranean Basin include warmer summers, water stress, biodiversity losses in terrestrial and aquatic ecosystems, and epidemic diseases (UNWTO and UNEP, 2008). In the final declaration of the Climate Change and Tourism Conference organized by the World Tourism Organization in Tunisia in 2003, there are very remarkable predictions for the Mediterranean basin. According to this declaration, it is stated that the temperatures will increase between 0,3 °C and 0,7 °C every ten years, the heat index (Temperature-Relative Humidity Index) will rise and the number of days above 40 °C will increase (Ministry of Environment and Urbanization, 2016; UNWTO, 2003).

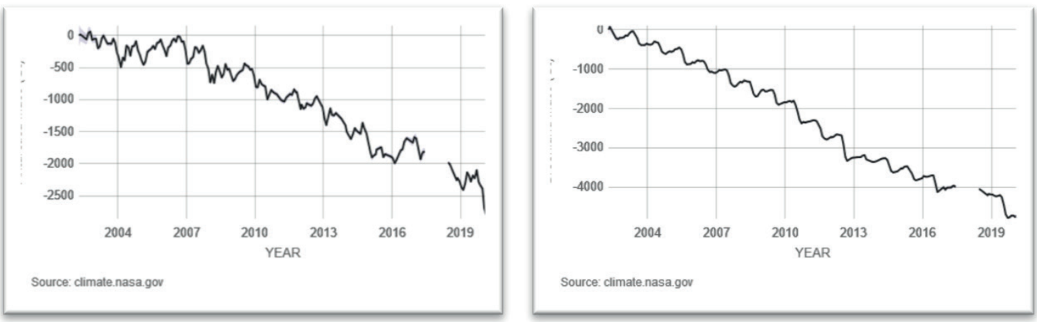
2.1. Vulnerability in Coastal Tourism

More than 60% of Europeans prefer coastal areas for vacation. More than 80% of tourism income in the USA is derived from coastal tourism. The tourism economy of developing countries, especially small island countries, is based on coastal tourism. Therefore, coastal tourism constitutes the most important market segment of the global tourism industry (Nicholls, 2014; UNWTO and UNEP, 2008). However, the world's seas and oceans are at risk due to the effects of climate change. Rising sea levels will have multiple and powerful effects on coastal tourism. The rise in sea level will flood some tourism structures such as beaches and cause them to lose their attractiveness. For example, almost a third of Caribbean resorts are less than a meter above high water level. A one-meter sea level rise will damage 49-60% of the region's tourist center properties, damage 21 airports or cause them to be damaged, and about 35 port lands will be inundated. By 2050, the cost of rebuilding tourism centers in the region is expected to be between 10 billion and 23.3 billion USD. Higher water levels and larger storms will also accelerate the erosion of beaches, dunes and cliffs. This deterioration or destruction on the coasts will reduce the attractiveness of tourism venues. Coastal erosion also has the potential to lower the prices that operators can demand for accommodation in the future (Nicholls, 2014). This means that tourism, which is an important source of income and economic development tool for underdeveloped or developing countries, will take a big hit.

Sea level rise is due to two factors related to global warming. These are the increase in the amount of sea water with the melting of land glaciers and the expansion of sea water as it gets warmer. Their heat content has also increased as the oceans absorb more than 90% of the additional energy resulting from the current imbalance in the planet's radiative budget. This excess heat has penetrated hundreds of meters deep into the world's oceans over the past 40 years. Due to this overheating, the upper ocean water level expanded, causing a significant rise in the global sea level average. According to the measurements made in recent years, it has been observed that half to two-thirds of the sea level rise is due to the thermal expansion of sea water and the remainder to the ocean discharge from the melting of glaciers and ice sheets (as cited in IOCC 2007b, Gautier, 2014).

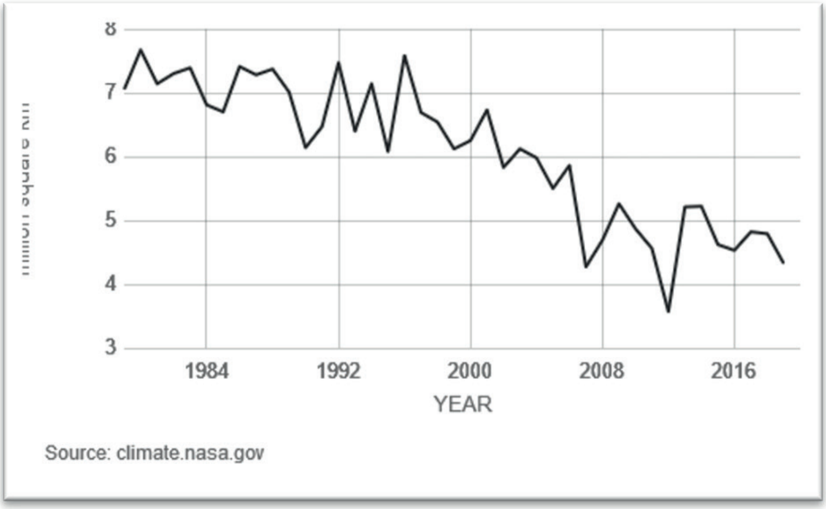
The global average sea level increased by about 0,2 meters in total in the 20th century. Today, it is increasing at a rate of 2,3 to 3 mm per year (Gautier, 2014). Figure 1 where the graph is created with the data obtained from the coastal mareograph data, clearly shows the trend in sea level changes between 1870 and 2013 (NASA, 2020).

Figure 1: Antarktika and Greenland Mass Variation Since 2002



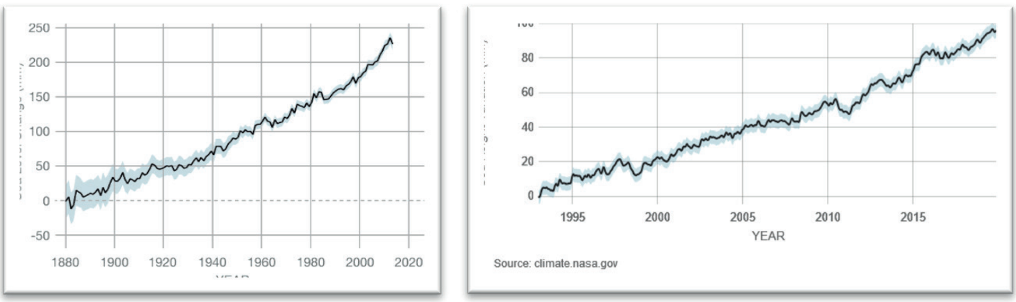
Resource: NASA, 2020

Figure 2: The Change in Arctic Sea Ice Since 1979



Resource: NASA (2020)

Figure 3: Change in Sea Level (1870-2019)



Resource: NASA, 2020

According to the modeling, it has been revealed that the sea level rise in 2100 may be between 31-65 cm (UNWTO and UNEP, 2008: 75). Considering this situation, it is clear how great the risks and dangers await countries with a coast, as well as small island countries. As a matter of fact, according to NASA (American National Aeronautics and Space Administration) data based on satellite images, the rate of change in sea level in the period 1993-2016 is 3.41 mm per year. Sea level rise since 1993, based on the last measurements taken in June 2018, was reported by NASA to be 86 (± 4) mm (NASA, 2020; UNWTO and UNEP, 2008).

Kiribati, an island state of Micronesia, is a very striking example of the sea level rise reflecting its present and future state. Kiribati, or officially the Republic of Kiribati, is an archipelago country in the central part of the Pacific Ocean. The inhabitants of Kiribati, which has a population of over 100,000, are spread over 33 islands made up of coral reef atolls that make up the country's territory. The annual income per capita in the country is 950 USD and the main means of income are agriculture, fishing and extraction and export of phosphate mines. The altitude of most of Kiribati is no more than 5 meters above sea level, and the ocean waters around the islands have been rising around 5 mm per year since 1991 (Moseley et al., 2014). If natural conditions persist in this way, it is estimated that most of Kiribati's islands will be inundated within the next 50 years. Kiribati President Anote Tong stated that the rural communities of the islands were affected by sea level rise, and that a village disappeared and seawater reaching drinking water pools in many communities now affects food products (Moseley et al., 2014).

It is not only small island countries that are at risk as a result of melting glaciers and rising sea level due to global warming. In the article titled "Greenland is melting and it's time to watch out" published on the NASA website about climate change, it is stated that the melting of the Greenland glacier has accelerated and it is emphasized that the melting of the second largest ice sheet on the planet will not slow down in the near future. It is stated that in the last decade alone, 2 trillion tons of fresh water gushing from ice like a fire hose has been discharged into the North Atlantic as measured by NASA's twin GRACE satellites. The most striking part of the article is that 5 million people live in 2.6 million homes 4 feet (approximately 121,9 cm) above sea level in the USA, which is one of the countries that contributed the most to this accelerating sea level rise (NASA, 2018a; 2020). Indeed, according to the data obtained from satellite images, the melting of the glaciers in Antarctica and Greenland has accelerated since 2002. Since this period, the loss in Antarctica glaciers was 127 Gigatons per year, while the loss in Greenland was 286 Gigatons per year (NASA, 2018a).

Rising temperatures and ocean acidification affect marine habitats and organisms. Especially coral reefs are under threat. Reefs and the marine life they host is a tourist attraction and contributes to global tourism revenues by 1,5 billion USD annually. More than 100 countries benefit from the recreational value of their coral reefs. The acidification of the oceans reduces the availability of calcium carbonate required for the corals that make up the reefs and leads to the deterioration of the coral reefs. Reefs are also susceptible to high temperatures, which will result in the death of corals from high incidence of 'bleaching'. Diving tourists, especially more experienced divers, may be susceptible to these coral bleaches. Although the level of awareness for bleaching is complicated among diving tourists, the economic implications of this issue are uncertain. Survey of tourists interested in diving in 1998 demonstrated that a little less than half of those conducted were concerned about the spread of coral bleaches that occurred that year, while other studies have noted decreased tourist satisfaction due to dead corals. In a scenario assuming a global warming of at least 2 °C by 2050-2100, reef structures decline with serious consequences for tourism in Australia, the Caribbean and other small island states. sees. It is very likely that, until the middle of the century, reef systems dominated by corals (more than 30% will disappear in some regions (Nicholls, 2014).

2.2. Vulnerability in Winter Sports Tourism

One of the places where the effects of climate change in terms of tourism are already beginning to be seen seriously are the winter tourism centers where winter sports are held and therefore the mountainous areas. In mountain tourism, which is important locally, regionally and nationally in economic terms, there has been a strong growth in the last thirty years, especially with regard to skiing. Today, there are 2,113 ski centers in 67 countries, 26,334 mechanical facilities and 6,000 ski areas in these centers. The total commercial bed capacity in winter tourism centers around the world is 6 million. Approximately 400 million skiers visit the ski resorts annually. However, these visits are stuck in a very narrow pattern in a limited number of countries and even in the ski center, and the growth in the global market has stagnated in recent years (Vanat, 2018).

The biggest weakness of this economic sector, which has such a size, is its strong dependence on the annual variability of climate and snow conditions and long-term trends. Climate change continues to pose a threat to the sustainability of snow sports tourism. Until a few years ago, some experts expressed the negativities in winter tourism centers due to the increase in temperature and the decrease in snowfall, but these negativities have become visible today. The ski season is shortened due to increased warming and insufficient snowfall. In places where the snow is insufficient, this deficiency is tried to be overcome by producing artificial snow with machines. However, if the temperature increase continues, it will not be possible to produce artificial snow in low altitude areas and on the slopes facing south. Variable snowfall, retreating glaciers and warmer winters have reduced the number of visitors to winter sports areas in Europe and North America. Warming will shorten the skiing season in addition to decreasing the number of facilities at low altitudes which are 'snow reliant'.

If the global temperature increases further, the snow reliability line in other mountain areas, especially in the Alps is expected to shift to higher areas (Snow reliability line is defined as the fact that a ski center jas at least 30 cm of snow cover for at least 100 days in at least 7 of 10 years) According to studies, the snow reliability line in the Alps will rise by 300 meters in 2030. This level is around 1500 m for the Alps (Ehmer and Neyman, 2008). Higher ski resorts may not bring about a collapse in winter tourism, but it is possible to say that a serious decline may occur.

It is known that global temperatures, which have increased by approximately 0,9 °C since the beginning of the 20th century, exceeded 2 °C in the high mountains and naturally have a negative effect on snow cover. Higher-than-normal temperatures in the winter seasons of 2001-2002 and 2006-2007 have already lead a negative impact on ski tourism, with loss of visitors between 7% and 84% in major destinations such as the Alps and the USA. In the near future, if these negativities persist, visitors will visit the same ski resort more often and for a short time, or try rival centers, and in the long term, they will change their visiting habits, including the option to stop skiing and review their destination loyalty. This situation poses a serious threat to the low altitude ski resorts of Austria, which is one of the important winter tourism centers in Europe. Recent studies by Robert Steiger from Innsbruck University have shown that today only 37% of ski resorts in Austria have snow reliability, and this ratio has increased to 96% thanks to artificial snow systems. Especially after the very hot 2006-2007 season, profit investments in the country increased and spread to 70% of the centers today. However, with the expected 2 °C temperature increase for the next 20-30 years, the rate of the center with snow reliability may decrease to 68% despite the artificial snow support, and may decrease to 29% with the expected 4 °C increase at the end of the century (Demiroğlu, 2015). These negativities are not limited to the Alps. It is a known condition that similar negativities are also seen in the USA, Canada and Turkey. The effects of global warming and associated climate change on tourism are not limited to these but may have various effects on the sector. These are briefly summarized below.

2.3. Other Direct and Indirect Effects of Climate Change on Tourism

Rising temperatures cause species to shift towards the poles and higher altitudes wherever possible. This could have serious implications for the eco-tourism industry, such as safari businesses, as natural reserves are increasingly geographically isolated. Under the assumption that up to 40% of the species in national parks in sub-Saharan Africa are unable to migrate, these generations will likely face extinction by 2080. Most wine producing regions may be less suitable for viticulture and this will have consequences for wine tourism (Geographical, 2016; NASA, 2018b; Nicholls, 2014).

High temperatures can cause more and more intense forest fires in some parts of the world. For example, in southern Europe, the fire season could be extended and there could be an increase in the number of days with high fire hazard. However, increased moisture in northern Europe is predicted to make forest fires rare. Severe droughts in North America have contributed to the top-to-root drying of forest trees, and rural fires have increased in frequency and duration. In addition, pest outbreaks have caused forests to dry up on a large scale from top to root.

There is a risk that climate change will turn some tourism centers, hotels and facilities into to the 'exhausted assets' and that investors and operators may experience financial losses, rendering them unusable.

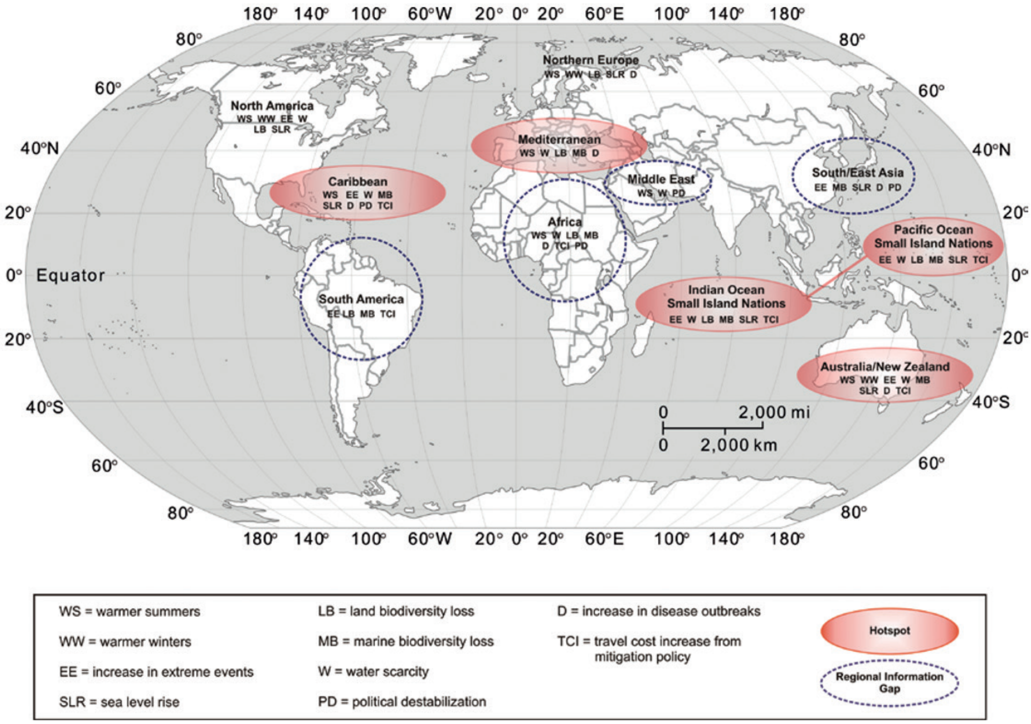
It is predicted that climate change will further reduce precipitation in some already arid parts of the world. Freshwater availability is already under pressure in many tourist destinations, with generally limited supplies, especially on small islands. Decreases in the availability or quality of water can have negative effects on tourism operators. Climate change can affect water availability in three ways: melting mountain glaciers; changing precipitation and evaporation patterns and sea level rise causing salinization of groundwater resources. Increasing water demand for agricultural irrigation or other industrial uses will increase the pressure on water availability. Therefore, it can be seen that tourism operators compete with residents in terms of water.

Like many industries, tourism is vulnerable to the effects of severe weather conditions associated with climate change. Coastal tourism is particularly at risk. Strong winds, waves, rains, and storm surges, along with the winds they bring, can cause disruptions in the areas of transportation, electricity and water supply that the industry relies on. More frequent and severe weather events may result in higher insurance premiums, as insurance companies respond to larger claims. When risk levels exceed certain thresholds, insurers will no longer offer coverage or raise premiums so high that those at risk cannot afford them. This could have serious implications for tourism operators, particularly those in coastal areas. Poorer countries tend to be less resistant to the effects of severe weather and less adaptable to more severe weather conditions. Accordingly, to the extent that they rely on local infrastructures, the tourism industries in these countries will be more vulnerable to damage than those in rich countries (Nicholls, 2014).

Extreme weather events can affect visitors' perceptions of the attractiveness of a particular tourist destination, as studies of persistent rainfall in Martinique or hurricanes in Anguilla have shown. The effect of climate change on human health and safety will most be felt by the population who are more prone to suffer from climate related health effects, who suffer malnutrition or food-water borne diseases. In some parts of the world, food and water resources are threatened by climate change and this trend is expected to increase. Climate effects have the potential to stifle the responsiveness of societies in more sensitive or less developed countries. Tourism businesses, particularly those in poorer parts of the world, will be more vulnerable to reduced security and social unrest caused by the effects of climate on food and water security and public health (Nicholls, 2014).

At the “Climate Change and Tourism Conference” held in Davos in October 2007, five of the world's ten largest tourism regions were defined as "hot spots" (UNWTO and UNEP, 2008); (Figure 2). These regions are Australia, Pacific Ocean, Indian Ocean, Mediterranean and Caribbean. Mentioned regions, are regions under threat from climate change. Each region is separately graded according to the direct and indirect effects of climate change (Hoegh-Guldberg, 2008); (Table 1). The Caribbean, as well as Australia and New Zealand, of the listed regions, are threatened by eight out of ten criteria. Turkey is also located in the Mediterranean Basin which is under threat from five to ten criteria.

Figure 4: Geographical Distribution of Key Climate Change Impacts Affecting Tourism Focuses



Resource: UNWTO ve UNEP (2008)

Europe is the most important region of the world in terms of international tourism. According to the data of the World Tourism Organization, international tourist arrivals worldwide in 2017 were 1.326 million, of which the share of European countries was approximately 51% (672 million). The 39'7 % of international visitors who visit Europe (267 million) have visited the Mediterranean countries of which Turkey is a part (UNWTO, 2018). Therefore, a region that is so important for world tourism is faced with risks arising from climate change (Ehmer & Heymann, 2008).

Table 1: Most-at-risk tourism destinations for mid to late 21st century

Regions	Hot spot	Hot summers	Warm winters	Increase in extreme weather events	Sea level rise	Decrease in terrestrial biodiversity	Decrease in marine biodiversity	Water scarcity	Political instability	Increase in infectious diseases	Increase in travel costs
Australia / New Zealand		●	●	●	●		●	●		●	●
Pasific Ocean*				●	●	●	●	●			●
Indian Ocean*				●	●	●	●	●			●
Southeast Asia				●	●		●		●	●	
Middle East		●						●	●		
Africa		●				●	●	●	●	●	●
Mediterranean		●				●	●	●		●	
North Europe		●	●		●	●	●			●	
South America				●		●	●				●
Caribbean		●		●	●		●	●	●	●	●
North America		●	●	●	●	●		●			

* Small island countries.

Resource: Hoegh-Guldberg (2008)

The risks identified for the Mediterranean Region can be listed as warmer summer months, biodiversity loss in terrestrial regions and seas, water shortages, and increased infectious diseases. All these risks arising from climate change have the potential to adversely affect tourism activities in the region.

3. CONCLUSION

As can be seen from the statements made so far, the tourism industry and destinations are clearly sensitive to climate variability and change. Climate determines the length and quality of the seasons in the trillion-dollar tourism industry and plays an important role in destination selection and tourist spending. In many places, tourism is closely linked to the natural environment. Climate affects a variety of environmental resources critical to tourism such as snow conditions, wildlife productivity and biodiversity, water levels and quality. It also affects various aspects of tourism operations (eg profit generation, irrigation needs, heating-cooling costs). The main impacts of climate change, which are foreseen by the Intergovernmental Panel on Climate Change (IPCC) and have the greatest potential significance for tourism sector, are summarized in table 2.

Table 2: Major Effects of Climate Change in Tourism Destinations and Possible Effects on Tourism

Effect	Possible effects on tourism
Higher temperatures	Changing seasonality, heat stress for tourists, cooling costs, changes in plant-wildlife-insect populations and distribution, spread of infectious diseases.
Reduced snow cover and shrinking glaciers	Insufficient snow in winter sports destinations, increase in snow making costs, shorter winter sports season, lessening the aesthetics of the landscape.
Increase in intensity and frequency of extreme storms	Risk for tourism facilities, increase in insurance costs/loss of insurability, downtime costs.
Increased evaporation and decreased precipitation in some areas	Water scarcity, competition for water among tourism and other sectors, desertification, increased fires affecting demand and threatening infrastructure.
Increase in the frequency of heavy rainfall in some areas	Flood damage to historical architectural and cultural assets, damage to tourism infrastructure, changing seasonality.
Sea level rise	Coastal erosion, beach area loss, high costs to protect and maintain port areas.
Increase in sea surface temperatures	Increased coral bleaching, deterioration in marine resources and aesthetics and snorkeling and diving destinations.
Changes in terrestrial and marine biodiversity	Loss of species and natural attractions in destinations, higher risk of disease in tropical-subtropical countries.

Effect	Possible effects on tourism
More frequent and large forest fires	Loss of natural attractions, increased risk of flooding, damage to tourism infrastructure.
Changes in soil (For example: moisture levels, erosion and acidity)	Impacts on destination attractors and loss of archaeological assets and other natural resources.

Resource: UNWTO and UNEP (2008)

The tourism sector is one of the economic sectors that are extremely sensitive to climate change and are negatively affected. In addition, it has an important role to fight against the negativities caused and to be caused by climate change. However, the relationship between climate change and tourism has two different dimensions. The tourism sector and all of its stakeholders should take actions and initiatives to reduce the impact of the sector on global climate change, resulting from carbon emissions, while combating the negative impact of climate change. In this struggle of the tourism sector with regard to climate change, when we look at the effects of climate on tourism, adapting to climatic changes is seen as the most urgent way known. However, when examining the effects of tourism on climate, the main discussions focus on mitigation studies. Therefore, since the budget, time and other resources are limited in order to solve the problems, mitigation and adaptation studies should be handled and carried out together. In addition, although it is generally thought that the environment and economy are diametrically opposed, it is clear that progress in one direction will only be possible with developments in the other (Patterson, 2005).

Because tourism is mainly based on natural resources, Turkey most affected by the direct impact of climate change and is a country that is at risk. Winter sports tourism, especially coastal tourism, etc. are is affected by climate change and this impact is expected to increase further in the future. Therefore, identification of risks arising from climate change in Turkey's tourism and development of measures for this, namely the sector to adapt to climate change, is a necessary and urgent situation. Indeed, depending on the problems caused by the cyclical situation in

2015 and in 2016 there have been significant declines in the number of visitors and tourism revenues from Turkey. According to the data of 2016 the number of tourists coming to Turkey decreased by 30.2 million and international tourism income by USD 10 billion, reaching to 18.7 billion USD (UNWTO, 2018). It is inevitable that the tourism sector, which is so affected by temporary negativities, will face more permanent negativities due to climate change. Therefore, the mitigation and adaptation efforts and works against climate change are highly important for the tourism sector in Turkey. Only in this way can the threats of climate change on the sector be turned into opportunities.

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VULNERABILITY BY SECTORS: AGRICULTURE

Prof. Dr. Zeynep Zaimoğlu

1. INTRODUCTION

The main problem of sustainable agriculture is to meet the food demand. Ensuring the food security of the current generation without sacrificing the needs of future generations is the foundation of sustainability. The agricultural sector is critical for social and economic progress, especially in the areas of eradicating hunger and poverty, creating employment and livelihood opportunities, and creating trade and conjunctural earnings. Agriculture also includes the threat of natural resource management, land degradation, water scarcity, deforestation, and biodiversity at the center of environmental concerns.

The effects of the reflection of climate change on the agricultural sector which can be seen most in our country and in the world can be expressed as follows, which are also called vulnerability:

- Yield reduction.
- Increase in irrigation water demand and cost.
- Shifts or changes in planting and harvest time
- Decrease in crop cultivation availability.
- More disease

In the face of these known vulnerabilities, the fact that the effects of climate change and the future damages of many areas, especially in the agricultural sector, are not fully predicted should not prevent policymakers from taking concrete and urgent measures. (FAO, 2009).

Agricultural sector vulnerability can be analyzed in three different groups as social, economic, and environmental fragilities.

2. SOCIAL VULNERABILITY

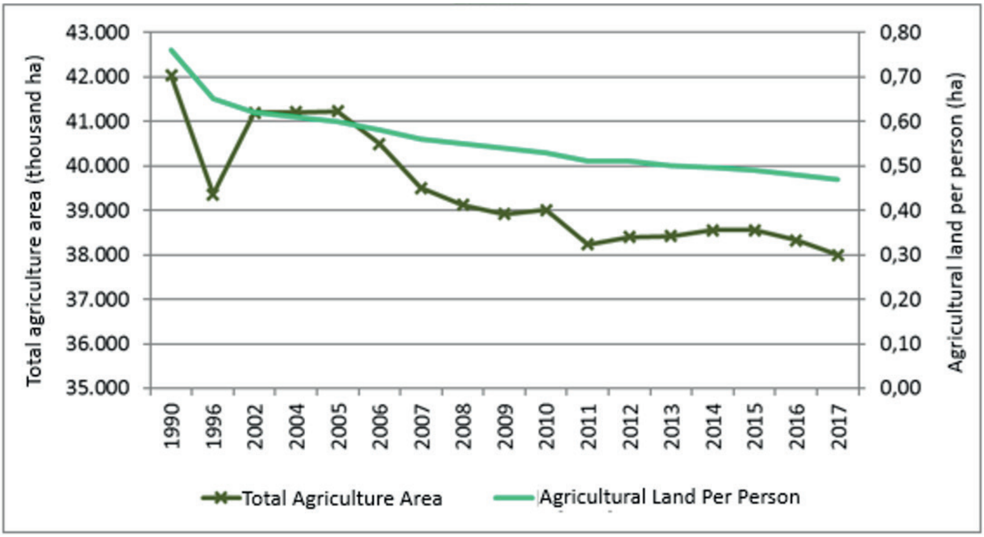
It is possible to mention many social vulnerabilities that contribute to the social security deficit on behalf of people living in rural areas and in the agricultural sector such as rapid population growth, poverty, and hunger, inability to access health services, low education levels, gender. The problems of hunger and poverty are interdependent and cannot be solved. Today, although the political lobbies that govern the strongest agricultural policies in the world are managed by metropolises such as Washington DC, Brussels, and Tokyo, only 3% of the population in these metropolises directly earn their living from agriculture. Less than 3% of the population in countries that have a say as policymakers in agriculture directly provide a livelihood from agriculture.

However, two-thirds of the population in underdeveloped and developing countries make their living directly from agriculture. Despite this, rural and agricultural societies are among the weakest political lobbies, and farming is considered among the least respected professions.

The world population is expected to increase in the next 50 years. It is a known fact that this increase in population has an even higher rate of increase, especially in Sub-Saharan Africa, South Asia, and the Middle East.

Considering the world agricultural lands and the amount of agricultural land per capita, it can be understood how it is necessary to simultaneously discuss the vulnerability in agriculture with social-economic vulnerability (Figure 1).

Figure 1: Ratio of the amount of World Agricultural Lands to Per Capita Area



Resource: TUIK, Ministry of Agriculture and Forestry

The serious concern is that in the last 20 years, per capita food production has decreased by 10% worldwide, and as a result of this decrease, the group consisting of 46 least developed countries is the most painful group and the number of undernourished human populations doubled, which makes up 10% of the world's population and only has 1% of the world's income. (FAO, 2019).

Similarly, the hunger percentage in Asia has similarly halved in Sub-Saharan Africa since the end of 1960 and continues to decline.

From nearly 30 years ago, the world was faced with a global food shortage that experts wrote in disaster scenarios, predicting it would lead to famine. This danger can be avoided by the development of an intensive international research effort and adoption of the farmer, and by the work of agriculture, lobbies depending on the results of the vulnerability analysis.

This "Green Revolution", driven by investment and knowledge, was most influential where environmental conditions existed.

3. ECONOMIC VULNERABILITY

The economic vulnerability of agriculture (Figure 2) is concerned with several interactive elements, including its importance in the national economy and trade. Foreign exchange earnings, aid and investments, international agricultural commodity and input prices, and production and consumption habits are among the most important factors affecting these vulnerabilities.

At the world level, agriculture's share of total gross domestic product (GDP) is about 13% in developing countries as opposed to 2% in developed countries. For central, east, and west Africa, this ratio is over 31% and South Asia is around 25%. In some 25 developing countries, this share is around 40-60%.

In the case of Africa, the decline in the standard of living has increased and the consumption expenditure of the average African was found to be one-fifth lower than it was a quarter-century ago (Boulanger, 2019). The richest 20% of the world's population consumes 85% of the world's income, while the poorest 20% live about 1% of global income.

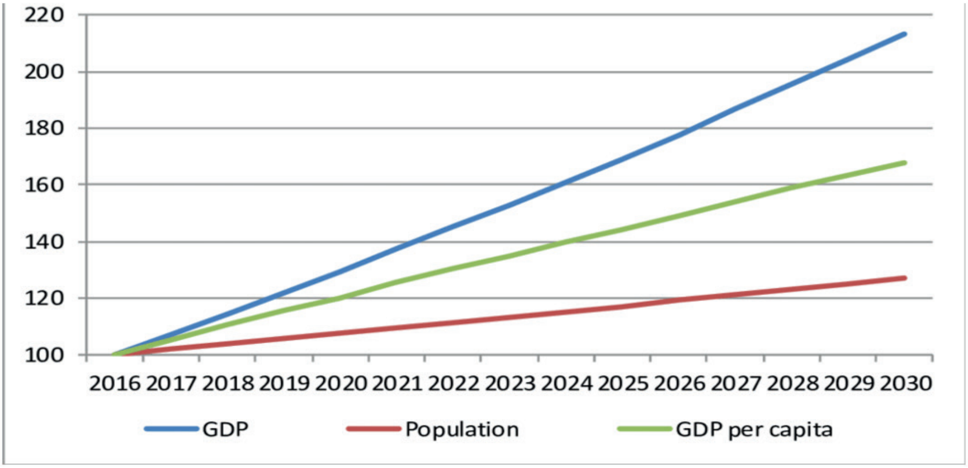
The economic challenge for developing countries is to identify specific agricultural and rural development needs and opportunities and to plan investments in a way that can contain food security and poverty.

Earth's soil and water resources are critical to human survival. In addition to food and other agricultural products, they also provide other basic life necessities.

The growing demand for food for a growing population is threatening natural resources as people try to make the most of the land currently in production, and damage is becoming more and more evident.

Arable soils lost due to erosion, salinity, desertification, and urban sprawl; water shortages; lost forests and their threats towards biodiversity loss is the intersection point of economic vulnerability and environmental vulnerability.

Figure 2: Prospective Model Results of Changes in the Gross National Product Depending on the Population



Resource: Boulanger et al., 2019

4. ENVIRONMENTAL VULNERABILITY

In the 21st century, we are faced with a more destructive environment and nature, with the damage to land and water ecosystems and the loss of production potential, pandemic, and the effects of climate change in every sector.

Combating climate change is vital to the pursuit of sustainable development; equally, the pursuit of sustainable development is an integral part of lasting climate change Sustainable agricultural land use must be based on sound agricultural principles, and adopt constraints and interactions.

Changing conditions, land management practices, land degradation, and efficiencies in this context will largely govern the sustainability of given land use, including the flexibility to diversify and develop a broad genetic base of other dimensions of agricultural production.

In addition, sustainability should be planned for the future to ensure sustainability with political, social, and economic pressures that may exacerbate corporate and environmental problems.

5. CLIMATE VULNERABILITY

Although the concept of vulnerability is generally considered as a social science concept, Turner et al.,. created this concept in 2003 to use it in global environmental practices within the framework of reduction and adaptation (Turner et al., 2003). Subsequently, the definition of vulnerability started to be used in many areas. The Intergovernmental Panel on Climate Change (IPCC) defined the phenomenon of vulnerability as "vulnerability to being adversely affected" in 2014 (IPCC, 2014).

- the magnitude and duration of the climate-related exposure (climatic exposure);
- sensitivity of the target system to climate risk;
- The ability of a system to withstand or escape exposure is defined as component of vulnerability (Kuş, 2019)

The definitions of climate influence, sensitivity, and adaptation capacity to which this definition is related are given as follows.

<u>Climatic effects:</u> Presence of human, economic, social, or cultural values in places that are likely to be adversely affected.

<u>Sensitivity:</u> It can be considered as the degree to which a phenomenon, object, or creature is affected positively or negatively by climate change. However, the important point here is that it is known that the effect can occur not only directly but also indirectly. (For example, land loss and quality change caused by rising sea level)

Adaptation capacity The ability of a phenomenon, object, or living thing to adapt to possibilities or harms.

Although it does not provide a clearly defined methodology, this definition of the IPCC has become the basis of many studies in the vulnerability literature (Kuş, 2019).

The relationship between these concepts can generally be considered as follows;

Vulnerability= Climatic Exposure + Sensitivity - Adaptability

The agricultural sector is one of the areas with the highest sensitivity in terms of vulnerability (Luo et al., 1999; Tao et al., 2011; Neset et al., 2019). In this regard, the analysis that needs to be done on each region should be done independently of each other and analyzed together. Since both climate and agriculture are very dynamic systems, there is not a fixed fragility methodology, but there are many different methods that can be used. Determining different methods according to the characteristics of the region is the most important issue in this matter.

The methodology can be summarized as follows;

Climatic influence, sensitivity, and adaptation capacities are each considered to be evaluated within themselves. While conducting climatic impact analysis, variables such as the change of maximum and minimum temperatures in selected specific years, precipitation regime changes, frost start and end dates, potential late frosts, and drought are examined together in line with the ideal climate projection for the region. With the methodology of the drought variable, it may also differ according to the region. Different methods such as SPI, PDSI or Emberger, or PNI can be used. A specific plant pattern can be used for sensitivity, as well as the sensitivity of the geography in general. Land use, erosion status, and soil structure are the most important parameters here. Especially the existence of dry farming should be evaluated well.

Irrigation requirement is the most important parameter in the adaptation capacity studies of agricultural fragility calculations. Values such as distance to water resources, soil structure and organic content, quantity, and quality of natural areas around, soil water holding capacity, groundwater density, and depth should be analyzed.

The values found in line with this methodology are usually normalized and the fragility can be calculated for each region by using at least 3-layer mapping. It is also of great importance to evaluate and verify the operations performed by applying them to the previous years with real data sets in order to understand the accuracy as it should be done in every scientific method.

While analyzing and reducing vulnerability plays a key role in sustainable agriculture, it is also one of the most important steps in terms of adaptation to global climate change. In a geography where vulnerability is increasing, the changes in the plant pattern that must be done continuously will strain the food supply chain together with climatic disasters. In addition, it is clear that the deterioration of water resources and the water regime of the basin will affect the existing ecosystem in the first degree, and all living things will be affected, and agricultural products may also be damaged by secondary reasons due to the dynamic structure of the ecosystem (pest invasions, etc.).

6. CONCLUSION

Agricultural risks also refer to the vulnerabilities in the agricultural sector. It is the loss or damage that may occur in agricultural production under normal conditions. These can be estimated by statistical methods. There are two types of risks. First, Incidental (Absolute) Risks; these are the damages that occur regardless of the natural structure and flow of the work and cannot be prevented by the business. Risks such as frost, hail, and fire are included in this group. Second, Commercial Risks; risks based on economic inputs from prices and costs

Certain tools are needed and used to manage risks and take precautions in agriculture. These tools can be listed as follows; direct financial aid, support purchases, product diversification in the production pattern of the enterprise, benefiting from harm-reducing technological developments, using irrigation systems that use water most economically, developing products resistant to diseases and pests and risks such as drought and frost, using producer savings, business organization, licensed warehousing, contract manufacturing, futures markets, and agricultural insurance.

It is possible to control the vulnerabilities due to climate change in agriculture throughout the world, with global political structures in which all social, economic, and environmental fragilities starting from food security can be controlled.

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VULNERABILITY BY SECTORS: ENERGY

Prof. Dr. Levent Aydın

1. VULNERABILITY INDICATORS IN THE ENERGY SECTOR

Measurement is important, given the need to adjust the state of a system, its evolution, and most importantly, decisions, policies and actions. Since climate variables can affect energy segments differently, mapping their vulnerabilities according to these variables and analyzing the effects on the entire energy system can provide a good measure of the resilience of the climate. Historical information can also provide a basis for inferring the impacts of future climate variability based on current variability.

It can also be difficult to measure the true impacts of climate change and to distinguish them from impacts caused by natural (existing) climate variability. Climate impact assessments are often based on scenarios for future climate development that are built on. Using such climate scenarios and comparing energy system performance with the current climate can create a number of indicators, but it is not clear to what extent these indicators represent the actual resilience of the energy system.

Therefore, several indicators can be used to evaluate the resilience of a system based on a comparison of current and future climate. Elasticity in resource donations is mostly associated with losses (or gains) in potential energy generation, while the flexibility of energy supply depends on the efficiency of energy production and conversion. In the first case, comparing the total available primary energy in the current climate with climate change scenarios provides an overall measure of loss or gain. Analyzing specific energy segments (eg hydroelectric, wind power or oil reserves) is also important, especially when energy systems have limited diversity.

The level of diversification of energy generation provides an important measure of flexibility as systems that rely heavily on a single energy source may be more exposed to climate effects. The diversity of a system does not allow a single indicator to be used as a good durability measure. Still, many indicators based on information about energy systems can be used to assess how vulnerable these systems are to climate change. In terms of energy diversity, fuel shares in total primary and final energy supply, and total electricity generation and installed capacity can be used as indicators. As renewable energy is more vulnerable to changes in climate, the participation of renewable sources in total energy supply and electricity generation / installed capacity is also important in assessing climate resilience.

For energy supply, variations in overall system efficiency (measured as the ratio of total final energy vs. primary energy consumption) caused by climate change may indicate how energy conversion and transport can be affected by climate change. Although this measure can have cumulative effects on energy supply, certain measures are required for specific energy sources to complete the understanding of the system supply vulnerability. The effects of climate change on the renewable electricity generation capacity factor (assuming average and critical production conditions) are a good measure for resources such as hydroelectric and wind power generation. Effects on thermal (fossil or nuclear) electricity generation are explained in terms of conversion efficiency or capacity changes. Climate impacts on liquid biofuel production can be assessed by changes in agricultural and adaptive productivity (eg energy per cultivated area).

At the end of the energy chain, assuming ceteris paribus conditions, differences in energy intensity of a consuming sector can simulate a picture of vulnerability by demand. The biggest challenge here is to do a rigorous analysis of ceteris paribus in long-term climate change assessments. Finally, the level of knowledge (both climate and energy) and knowledge about energy relationships should be considered as an indicator of resilience, as it allows for better understanding and earlier action to adapt to the impacts of climate change.

A recent study examines metrics for the Vulnerability and flexibility of energy systems and suggests a table like the one below. It summarizes climate-induced impacts on key energy systems and outlines possible adaptation measures that consider the following:

1.1. Vulnerability Indicators

Coal

- Number of coal mining facilities in an area less than 1 meter above sea level that could be flooded by a flood with a current recurrence period of 100 years.

Oil and gas

- Share (%) of offshore oil and gas facilities likely to be affected by more than 70 m / s storm in the next 20 years
- Share/number of refineries likely to be affected by more than 70 m / s storm in the next 20 years (%).

All Fossil Fuels

- Number of thermal (coal, oil and gas) power plants located in an area less than 1 meter above sea level and will be inundated by a flood with a current recurrence period of 100 years
- Additional information: the expected number of droughts causing thermal power plants to decrease by more than 10% in the next 30 years

Hydroelectric

- Expected precipitation change (%) in the next 20-50 years and/or probability of floods in each basin
- The number of multi-use dams in the country today: water volume for each dam (m^3)
- Explain what percentage of water is used for the following: agriculture; power; drinking; Additional info: additional flow expected from glacial melting (million m^3)

Transmission Systems

- Length of in-country, above-ground transmission and distribution lines (km)
- Distinguish the following: high- (transmission); medium and low voltage lines (Distribution)
- Identify transnational lines
- Number and length of power outages (malfunctions due to weather or equipment malfunction and outages caused by rationing)
- Average annual downtime hours
- Percentage of energy supply requiring regional transport over 50 km
- % Fossil fuel transportation
- % biomass transport; comment on the informal sector if possible

Biomass

- The ratio of biomass used for energy purposes in total biomass production (%)
- Distinguish between different sources and different applications if possible - agricultural biomass harvesting; electricity; temperature
- Forest (as defined by the UN Food and Agriculture Organization FAO) biomass harvest: electricity; temperature
- Expected precipitation change in the next 20-50 years (%)
- Additional info: Likelihood of a temperature rise beyond biological heat tolerance (%) of key biomass products within 20 years

Wind

- Number of wind turbines less than 1 meter above sea level
- Projected change in average wind speed over the next 20 years (%) depending on regional climate models

Sun

- Mind the difference between existing solar installation capacity () PV (MW) and thermal ()
- Ownership (private, government, public / private partnership, etc.)
- Expected temperature (° C) rise over the next 20 years related to PV capacity

It summarizes climate-induced impacts on key energy systems and outlines possible adaptation measures that consider the following:

- The ability of the energy system to resist damage and loss of function (technique);
- Institutional capacity, planning, training, leadership, experience and knowledge management to improve organizational performance (civic / organizational) related to the emergency;
- The manager's capacity to adapt in a timely manner for post-disaster recovery, improvisation, innovation and resource substitution (economic)
- ability of decision makers to predict the effect of local ecosystem services (environment) of the energy system
- characteristics of the affected population and community that make social groups more vulnerable or more adaptable to energy system-related disasters (social and cultural).

Table 1: Vulnerability to Climate Change in the Energy Sector

Item	Relevant Climate Effects			Effects on the energy sector
	General	Specific	Additional	
The effects of climate change on the resource support				
Hydroelectric	Flow	Amount (+/-) Seasonal flows high and low flows Extreme events	Erosion; Siltation	Reduced firm energy Increased variability Increasing uncertainty

Item	Relevant Climate Effects			Effects on the energy sector
	General	Specific	Additional	
Wind power	Wind field characteristics, changes in wind source	Changes in density, wind speed Increased wind variability Plant	Changes in vegetation (may change roughness and current wind)	Increased uncertainty
Biofuels	Plant response to climate change	Production of products Agro-ecological zones shift	Pests, Water demand Drought, freezes, storms	Increased uncertainty Increasing frequency of extreme events
solar energy	Atmospheric permeability	Cloud features		Positive or negative effects
Wave and tidal energy	Ocean climate	Wind field characteristics No effect on the tides	There is a strong nonlinear relationship between wind speed and wave strength.	Increased uncertainty Increasing frequency of extreme events
Effects of climate change on energy supply				
Hydroelectric	Water availability and seasonality	Water resources variability Increased uncertainty of expected energy output	Impact on the grid Excessive production waste Extreme events	Increased uncertainty System reliability revision Review of transmission needs
Wind power	Change in wind speed frequency distribution	Increased uncertainty in energy production	Short life reduces risk associated with climate change Extreme events	Increased uncertainty in energy production
Biofuels	Less conversion efficiency	High temperatures reduce thermal generation efficiency	Extreme events	Reduced energy Increased uncertainty
solar energy	Low solar cell efficiency	Solar cell efficiency decreases due to higher temperatures	Extreme events	Reduced Energy Production Increased uncertainty
Thermal power plants	Production cycle efficiency Presence of coolant water	Decreased efficiency Increased water needs, for example during heatwaves	Extreme events	Reduced Energy Production Increased uncertainty
Oil and gas	Vulnerable to extreme events	Cyclones, floods, erosion and siltation (coastal areas, on land)	Extreme events	Reduced Energy Production Increased uncertainty

Impacts on transmission, distribution and transfers				
Impacts on transmission, distribution and transfers	Increasing frequency of extreme events Sea level rise	Wind and ice Landslides and flooding Coastal erosion, sea level rise	Erosion and siltation Weather conditions that prevent transportation	Increased vulnerability of existing assets
Effects on design and operations				
Placement infrastructure	Increase of sea level	Increasing extreme events Coastal erosion rising above sea level Increasing frequency	Presence of water Permafrost defrost	More vulnerabilities to existing assets Increased demand for new good seating positions
Downtime and system bottlenecks	Extreme Weather Events	Impacts on isolated infrastructure Combined effects on multiple entities in the energy system	The energy system does not function properly when society needs it most	Increasing security gap Low reliability Increased social pres-sure for better perfor-mance
Energy trade	More security gap against existing assets	Cold periods and heat	Increased uncertainty against extreme events fluctuations in transmission	Increasing peak distribution and demand for energy transfer infrastructure
Effects on energy demand				
Energy use	Increasing demand for indoor cooling	Reduced demand for heating Increased energy use for indoor cooling	Efficiency reduction associated with increasing temperature	Increasing demand and peak demand pushing transmission and distribution systems
Other effects				
Intersectoral effects	Competition for water resources Competition for adequate seating	Conflicts in water distribution in stressful weather conditions Competition for good seating	Potential competition between energy and non-energy products For soil and water resources	Increased security gap and uncertainty Increasing costs

1.2. Vulnerability of Turkey Energy Sector

- In recent years, there has been a significant increase in the number of disasters such as a hurricane, flood, lightning, extreme heat and hail.
- economic losses caused by floods due to climate change in Turkey are in second place after the economic losses due to seismic disasters
- The hydroelectric potential is seen as fragile when considered under adaptation to climate change.
- Turkey is a country that has "water stress" in terms of water potential.
- In Turkey, the decrease in total rainfall is estimated to be more pronounced especially after the year 2041
- At home, families consume significant amounts of energy for activities such as heating, cooling, lighting, cleaning and personal care.
- Women play an important role in daily household activities, i.e. in energy consumption
- Women, as the target group, emerge as the most vulnerable group in energy consumption.
- Increase in temperature caused by climate change, imbalance in air movements, drought and sudden rainfall make it difficult to meet energy demand sustainably.
- Energy production and demand are particularly sensitive to the effects of climate change.
- The subtropical zone such as Turkey where both heating (winter) and cooling (summer) requirements are relatively high, could be bigger in Mediterranean and middle latitude climate countries.
- Primary energy sources required for electrical power generation will have to be used more
- The spatial distribution of strong blizzard, snow and ice storms, their period of impact, frequency and intensity affect energy infrastructure, energy transmission lines, natural gas and oil pipelines.
- Hydroelectric production, on the other hand, may be affected by changes in

water availability, especially in river basins where snowmelt is effective.

- Hydroelectric production based on large water structures is in danger
- Water consumption and use may increase in thermal power plants, production, cooling or washing processes.
- Energy-based production may stop due to changing rainfall regime and increasing droughts
- Concerns and complaints of new power plants about potential water use in basin or geographic areas will increase
- The connections between water and energy may be disrupted by the use of water in energy production and the use of energy in water transmission, distribution and waste water treatment.
- Special protection needs to be given to the poor who are most affected by climate change.
- Measures are needed to minimize the vulnerability created by climate change for all segments of society, especially disadvantaged groups.
- Energy poverty reduction should be targeted for low income groups
- Institutions related to disasters need to specialize in climate change, adaptation and energy infrastructure.

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VULNERABILITY BY SECTORS: HEALTH

Prof. Dr. Didem Evci Kiraz

1. INTRODUCTION

It is normal to feel concerned for the unknown, uncertain, unreachable. However, if this situation lasts long, it may create anxiety for the future. Climate change increases the level of anxiety in individuals and in society. In fact, the phenomenon of climate change has become a part of life like "chronic diseases (diabetes, obesity, high blood pressure, etc.)" group seen in individuals. The important points in chronic diseases are: early diagnosis, continuous monitoring, proper treatment, obeying the treatment protocols that last for the lifetime, rehabilitation (if required), increasing the quality of life (nutrition, physical activity, active life, social life, independent life) and looking at life with hope.

The individual is responsible for his health. ociety may only be healthy with healthy individuals and healthy living environments. When the vulnerability of an individual, a community or a region is in question, that means the vulnerability of the city and vulnerability of the country is in question. Adverse effects of climate change have taken the leading role in the said vulnerability.

2. VULNERABILITY IN HEALTH

In the field of health, vulnerability is used as a synonym for the word disadvantaged. In addition to the word disadvantaged, the words vulnerable, sensitive, defenseless are also used for vulnerability. In fact, the areas of use of these words are different, more their meanings.

Especially in elderly health, vulnerability is defined as the increased vulnerability caused by wear and weakness that comes about as a result of advancing age (Çiftçili, 2012). People with advanced age are included in this group. With the public health approach, the other group members can be listed as those who do not know health responsibility, who do not have health literacy, who do not benefit equally and fairly from the common service advantages such as the health service provided to the community, who have functional loss and disability and those who are classified according to their characteristics such as sex, place of living, social environment (Soner and Aydın Avcı, 2019; Ministry of Development, 2019).

3. VULNERABILITY APPROACH IN THE CONTEXT OF CLIMATE CHANGE

Intergovernmental Panel on Climate Change (IPCC) defined vulnerability as: “The degree of a system being affected by the adverse effects of the climate change including climate variation and extremities or degree of not being able to cope with them” (IPCC, 2001). As in the vulnerability description in health, the definition of vulnerability in climate change also varies with the priorities of the period. Disaster risk and vulnerability, vulnerability during and after the adaptation period, vulnerability that causes security flaws can be as examples of this (Downing, 2017).

Three components are needed to calculate vulnerability (V): exposure to climate change (E), sensitivity to the effects (S), and adaptive capacity for coping with the effects (AC). The equation is this: V= f (E, S, AC) (Carter and Mäkinen, 2011).

Vulnerability assessment is based on the monitoring, measuring, analysis and re-assessment of these three components. It is a method for searching for answers to the questions of who is affected by what and under which conditions, how defenseless is he against these effects, what are the personal and social characteristics that increase the effect, are there security flaws in internal and external macro and micro environments and for collecting evidence (Downing, 2017).

4. EFFECTS OF CLIMATE CHANGE ON HEALTH AND VULNERABILITY

From the climate change point of view, the list of the most vulnerable things in the world consists of five articles, although it has the potential of changing by time.

- Most vulnerable point: Cities
- Most vulnerable sector: Health sector. Every action causes a reaction. The magnitude of the reaction will increase depending on the magnitude of the action. Any event affecting the individual and community will bring about new and/or growing health problems that require immediate, urgent, high priority, unlimited and continuous service.
- Most vulnerable group: This varies depending on the effect climate change has on society. The basic determinants that play a role in the change are the physical, mental and social determinants of health. Age and gender, common living areas, intensive population movements, those who have limited access to energy/technology, poor people in cities, people living alone, and people under care must be remembered every time the effect appears.
- Most vulnerable country: The country that does not have preparation, resistance and adaptation policies
- Most vulnerable economy: The economy which is not prepared for the worst scenario.

In a study conducted in the USA, potential effects of climate change and variation on health were investigated. The group consisting of academicians, civil servants and private sector representatives reached the conclusion that improvements must be made in public health policies in order to be prepared against changing climate conditions and especially mitigate the impact on vulnerable groups (Patz et al., 2000). In the action plans in EU countries that have a hot weather warning system, priority has been given to the protection of the elderly, children and other vulnerable groups and to provide warning to them. Recommendations and precautions are presented such as avoiding high temperatures, limiting outdoor activities, wearing light-colored clothes, drinking water, cooling the occupied space, receiving medical assistance, following up on temperature forecasts and interior ambient temperature, applying sun screening creams, traveling at night and shifting the working hours to cooler times of the day (HHWS, 2016). It has been found that 28 out of 1 million deaths were caused by extreme cold between 1991-2015, especially in Eastern Europe. WHO published a warning on February 28, 2018, about cold airwaves. It was mentioned in the text of this warning that poor and vulnerable groups are under risk and the health problems that may be caused by the cold weather were indicated together with the precautions that must be taken by health and social services, individuals and society (WHO, 2018).

The more the adaptation of public health to climate change is delayed, the more the dimensions of the encountered problems will change and these incidents will increase. To increase the adaptation precautions for mitigating vulnerability and its adverse effects must be a goal for determining the public health adaptation strategy. They must not be turned into "documents that must be prepared", but they must be a part of life in the form of a series of activities that are "living, changeable, improving with implementation, encompassing everybody". Series of activities in the example of Nepal are listed under the following headings (Government of Nepal, 2015):

- ► Raising awareness of the public on climate change and its effects on health
- ► Producing evidences about the effects of climate change on national and international health
- ► Decreasing morbidity and mortality of contagious diseases (diseases caused by vector, water, air and food) and taking into consideration the malnutrition attributed to climate change
- ► Managing the risks of extreme climate events
- ► Health in all policies by way of multi-sectoral intervention to protect human health against climate change

Publichealthhastheexperienceofdealingwithclimate-sensitive-health consequences. In addition to risk management point of view, health impact assessment culture, using social indicators of health in analyses epidemiology is its most powerful tool. According to the definition made by Last in 1998 epidemiology "investigating the phenomena and situations related with health and their determinants in a certain society and using these activities in controlling the problems related with health" (Beaglehole R. et.al, 1998). Epidemiology may determine or foresee the health consequences and the burden they would cause in society by using investigation methods. Investigation methods can measure qualitative and quantitative data with definitive and analytical methods, present them for assessment and provide an alternative road map for policy-making and management.

John Snow is a doctor who describes all aspects of a disease before its cause is found. He identified the houses of all persons who died of cholera in London in years 1848-49 and 1853-54 and showed that there was a correlation between the source of drinking water and the deaths (Beaglehole R. et al., 1998). This study is considered as the most valuable study for the use of epidemiology, environmental health approach and use of geographical information systems (GIS) in health.

The use of GIS together with epidemiology for vulnerability assessment with public health approach ensures the provision of data close to reality. The five articles in the list of most vulnerable in the world can be easily determined by placing health data on geographic layers. This way, in every event where emergency health issues arise such as effects of the climate change more precise, rapid and safe target selection can be made for the purpose of prevention, protection, intervention and improvement. Systems compatible with developing digital platforms are being popular, which follow up on vulnerability indicators and provide instantaneous warnings. California Public Health Unit prepared "Climate Change and Health Profile" within the scope of CalBRACE Project. It shares this on interactive data visualization platform titled "Climate Change and Vulnerability Indicators (https://skylab.cdph.ca.gov/CCHVIz/). These indicators are arranged under three headings as follows:

- Environmental Exposures
- Population Sensitivity
- Adaptive Capacity.
- According to the California example, the criteria under each indicator are the following:
- Environmental Exposures
    - Extreme heat days
    - Air quality (P.5)
    - Air quality (Ozone)
    - Wildfires
    - Sea level rise
- Population Sensitivity
    - Children
    - Elderly
    - Poverty
    - Education
    - Outdoor workers
    - Vehicle ownership
    - Linguistic isolation
    - Physical disability
    - Mental disability
    - Health insurance
    - Violent crime rate
- Adaptive Capacity
    - Air conditioning
    - Tree canopy
    - Impervious surfaces

The classifications in this example may vary at the level of each country, region, city or neighborhood according to vulnerability assessments.

5. CONCLUSION

Individual-social-global, national-international, household-neighborhood- region-city and cross border vulnerability levels are different from each other. Plans and policies must be prepared accordingly. For the vulnerability assessment and management of climate change from the public health point of view time, manpower, cooperation culture and budget must be determined. The obtained experiences reminded humanity the importance of using the large data most efficiently, need for renovation and that digitalization is the future. Increasing population, especially population density (number of persons per square kilometer) makes it impossible to build and sustain healthy living environments. While the people are trying to settle in places close to the center, these centers became risky areas regarding environment, social structure and health. People who think they have improved began to overlook the social determinants of health such as beginning the life healthily and keep living a high quality life. Instead of stepping on earth with naked feet, they are more concerned to reach home with moving walkways and/or by beaming up. It is becoming difficult to describe the processes of rapidly increasing effects of climate change, being prepared, adaptation, acquiring resistance, managing the events properly and restoring the society to its former state after the effects disappear to people whose agendas and heads are so much confused.

To embody a seemingly abstract event, "evidence is needed". COVID-19 pandemic that broke out in December 2019 may be evidence. For other evidences, the reports published by WHO in COP 24 and COP 25 are of textbook quality.

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VULNERABILITY BY SECTORS: TRANSPORTATION

Prof. Dr. Cem Soruşbay

1. INTRODUCTION

Global activities carried out today for reducing climate change consist of mitigation policies and practices and adaptation strategies carried out simultaneously with these practices.

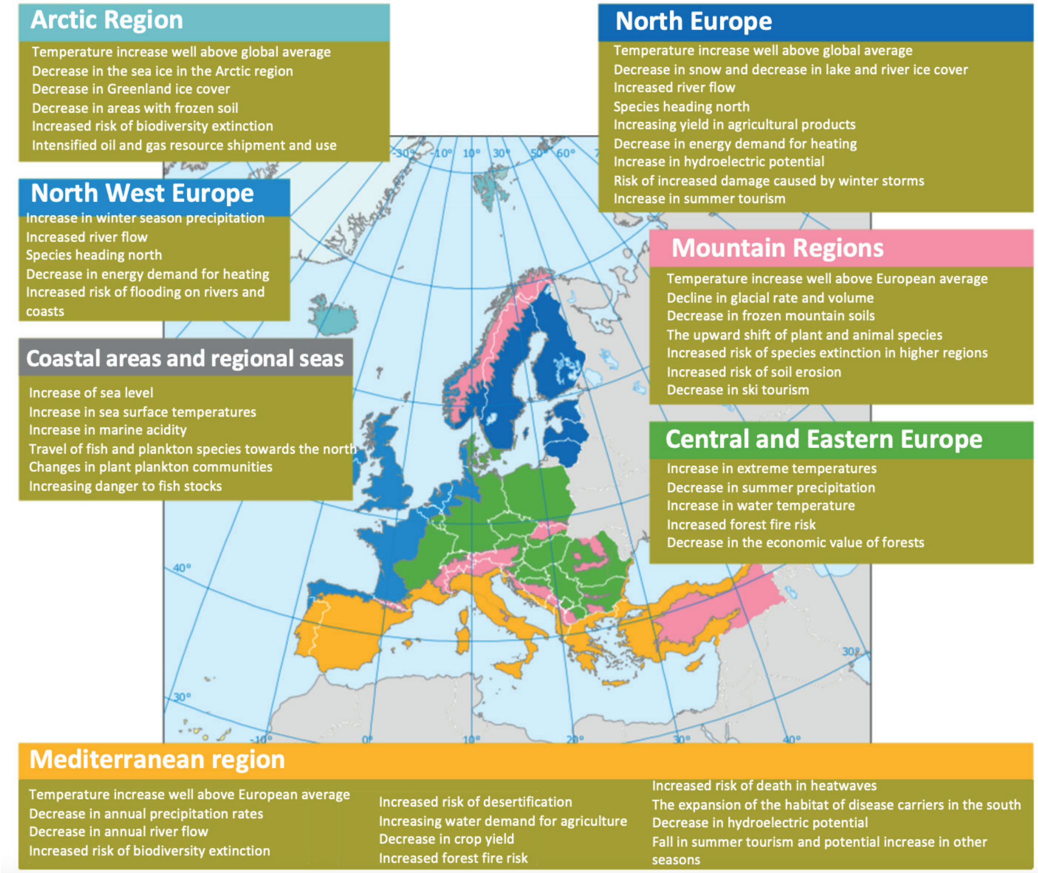
The layout of the majority of Turkey's population, transportation infrastructure and economic activities are concentrated in coastal regions. Increasing sea level due to the effects of climate change, coastal erosion, floods, meteorological extremes, observing extreme climatic conditions in inland regions, high air temperatures adversely affect the transportation sector along with many other sectors.

It is emphasized in the IPCC Assessment Report that in case the global temperature rise reaches 2 oC, this increase will reach 1-2 oC overall in the Mediterranean Basin where Turkey is located, with increase in regions where drought is felt, and increase of heat waves in inland areas as well as number of days with extreme heat (Silkin, 2014). Although the average temperature increases vary from one region to another, there will be temperature increases in coming years in Turkey that could reach to 5 oC. All these negative effects of climatic conditions show the sensitive position of the transportation sector (Figure 1).

In developing adaptation processes, sector-based risks, strategic options and costs should be determined first. The adaptation plan should be a sustainable approach that can make societies more resilient, with long-term results. In addition, targets and strategies should be determined by taking into account the combined effects in a way to ensure integration between sectors.

A major challenge in developing strategies for adaptation to climate change is the obstacles faced in realistically identifying negative impacts, vulnerabilities and uncertainties. The fact that the effects and uncertainties of climate change on the basis of the sector are not sufficiently known, cannot be measured, and cannot be analyzed and evaluated comprehensively with mathematical models, makes it difficult to develop a healthy strategy. For the right strategies, the risks and vulnerabilities in the sector should be evaluated clearly and accurately.

Figure 1: Predictions on the Effects of Climate Change (European Environment Agency).



Resource: European Environment Agency, 2014

For general strategies in the transportation sector, risks and vulnerabilities in the whole country can be defined, as well as regional risk and vulnerability definitions should be made taking into account the local conditions. Especially in our country, the economic infrastructure, geographical, demographic and climatic characteristics and transportation infrastructures of the regions change considerably.

2. DEFINITION OF VULNERABILITY

The concept Vulnerability express the tendency to be negatively affected by the effects of climate change. Fragility indicates the limitation of a system's adaptation capacity and the extent to which it cannot cope with adverse effects, and it is expressed as a function of the characteristics, size and speed of climate change and variability that the system is exposed to, its sensitivity and adaptation capacity.

According to the IPCC definition of fragility, it is a function of exposure (under the influence of changes in climatic conditions), sensitivity (susceptibility to adverse conditions) and the capacity to adapt (the ability to adapt to extreme damages and cope with its consequences) (IPCC, 2014).

Climate change can affect human health, food security, lifestyle, economic structure and migration dynamics. Increases in the severity and frequency of impacts such as floods and extreme air movement caused by climate change also pose a significant threat to the transportation infrastructure (highways, bridges, railways, airports, ports, waterways, etc.). Determining and evaluating this issue regionally will determine the level of fragility in the sector (İBB et al., 2018a).

The transportation sector, which has 25% of the final energy consumption in our country (2016), is an economically and strategically important sector in addition to determining the quality of life of individuals. For this reason, it is important to reduce the risks that may occur as a result of the vulnerability analysis from climate change.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3. VULNERABILITY ANALYSIS

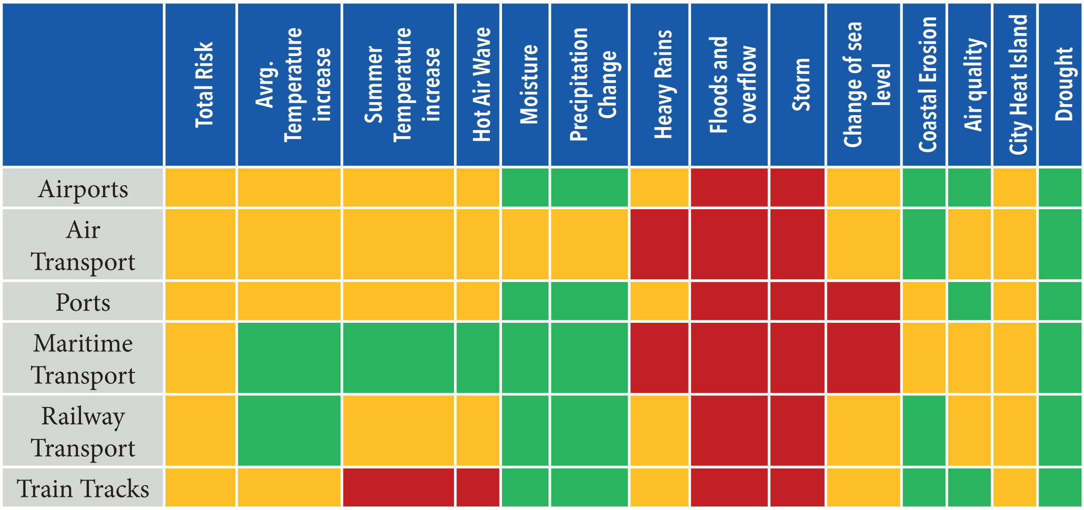
While planning the climate change adaptation strategy, current situation analysis should be done at the first stage. Afterwards, the strategy should be determined by evaluating the effects of climate change, identifying the risks and conducting regional fragility analysis.

When evaluated for the transportation sector, the changes that will be most affected by the sector, which pose a high risk, are heavy rains, storms, heat waves, floods and overflows, increases in sea level and summer temperature increases.

Heavy rain and storms create high risks for critical infrastructures in the transportation sector, cause temporary and permanent disruptions in the operation of the system, and cause economic damage. While temperature increases cause problems such as deformation of the rails in railway transportation, it affects passenger comfort in road transportation. Therefore, the evaluation of risks and impacts should be handled on the basis of sub-sectors and also regions. The stage reached in the study carried out for Istanbul is given in Table 1 (IBB, 2018b). The completed stages in the adaptation plan ("completed / about to finish", "implementation phase" and "not started") are indicated in the table from green to yellow and red.

Table 1: Transportation Sector Fragility Analysis.

	Total Risk	Avrg. Temperature increase	Summer Temperature increase	Hot Air Wave	Moisture	Precipitation Change	Heavy Rains	Floods and overflow	Storm	Change of sea level	Coastal Erosion	Air quality	City Heat Island	Drought
Road Bridge Tunnel	Yellow	Yellow	Red	Red	Yellow	Green	Yellow	Red	Red	Yellow	Green	Green	Yellow	Green
Road Transport	Yellow	Yellow	Yellow	Yellow	Green	Green	Red	Red	Red	Yellow	Green	Yellow	Yellow	Green
Sidewalks	Yellow	Yellow	Red	Red	Green	Green	Yellow	Red	Red	Yellow	Green	Green	Yellow	Green



Resource: İBB et al.,. 2018b

3.1. Road Transport

Heavy rains, hail, floods and overflows pose a high risk for road transport. Excessive precipitation in the highways connecting cities and urban transportation causes the system to lose its function and causes economic losses. Since asphalt and concrete roads do not pass rain water, sudden rains cause flooding if no measures are taken by adaptation actions. In addition, proper design of road slopes and construction of additional drainage lines in critical areas that pose a risk will reduce the risk.

High temperatures cause deterioration in asphalt roads and pose a risk in transportation. Seasonal decrease in average air temperatures will also increase the risk of freezing and icing on the roads.

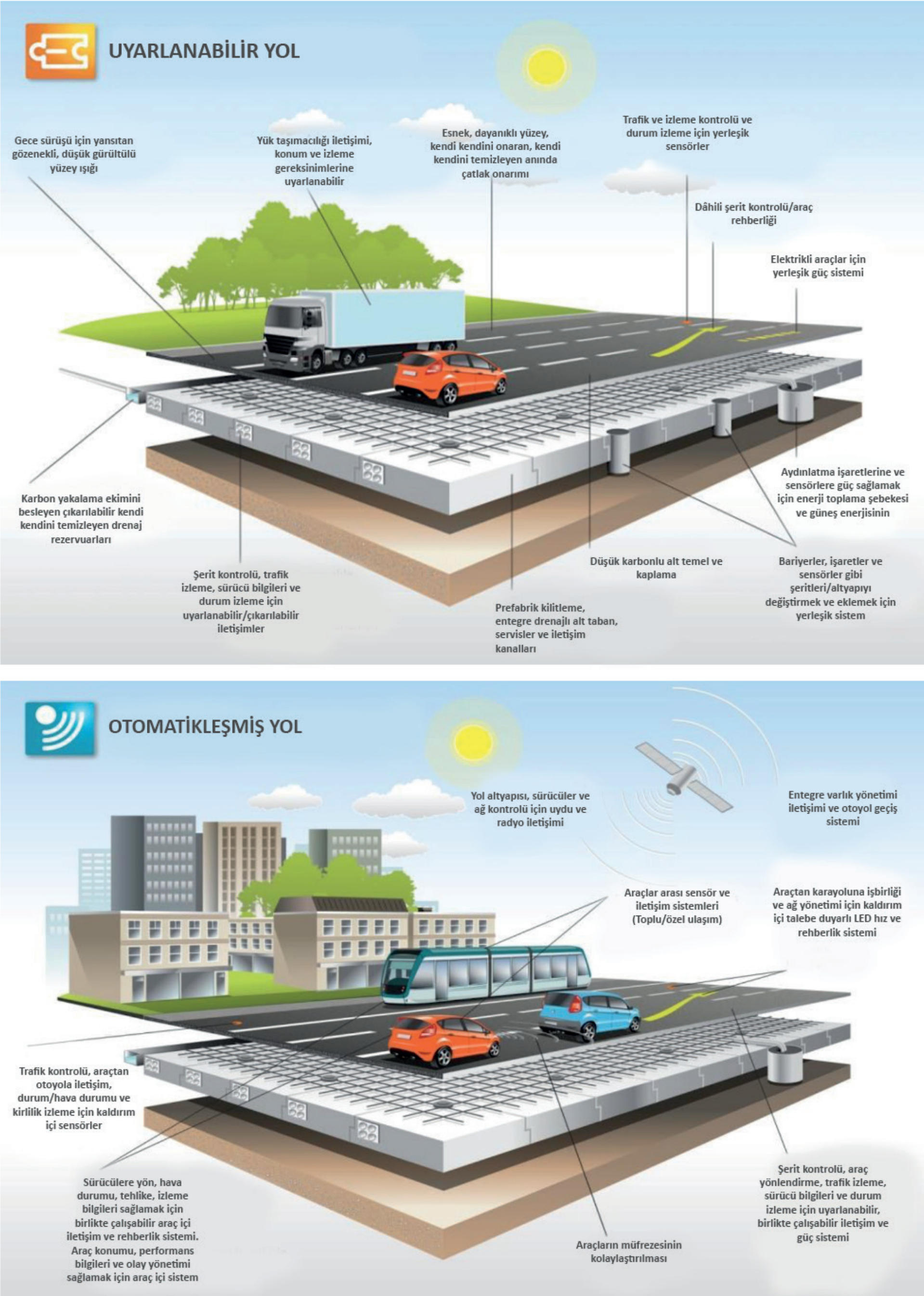
There are some developments in road technology to reduce these effects by adapting to the negative effects of climate change. Various European Union supported projects are being carried out in this regard, two of which are given in Figure 2 (FEHRL, 2018 a and b). Studies are continuing on the vehicle technique for the design of autonomous vehicles, which are expected to become widespread. Studies on road infrastructure required by the use of autonomous vehicles and actions on adaptation are combined. Technologies such as early warning systems and inter-vehicle communication on these roads also contribute to risk reduction.

Roads, bridges and tunnels have an important place in urban transportation. These infrastructures must be resistant to climate change in order for people to travel healthily. Summer temperature rise, heat wave, floods and overflows and storms pose a high risk. Especially in heavy rain, hail and stormy weather, road transportation can be made with difficulty, structural deficiencies reduce driving safety and cause accidents. This risk increases due to the higher speed of the vehicles on the ring roads in the city structure and may cause more serious accidents.

In order to prevent the risks in urban transportation, risk analyzes and measures should be taken regionally. For this, local strategies should be developed and action plans should be made.

Tunnels, which provide important transportation facilities in terms of traffic flow, create a risk of flooding and overflowing if necessary precautions are not taken. In order to prevent disruptions in transportation, the capacity of the rainwater drainage systems should be determined by taking into account the excessive rainfall and should be designed independently from the sewer.

Figure 2: Advances in Highway Technology and Adaptation to Climate Change



Resource : FEHRL, 2018 a and b

Structures such as highways, motorways and ports should be constructed in such a way that they do not prevent the drainage of flood waters to the sea quickly and with the shortest route.

In urban pedestrian transportation, the exposure of the sidewalks to adverse climatic conditions such as icing, excessive rainfall, etc. poses a danger in terms of pedestrian transportation and human health. The design, height and slope of the pavements are important in order to prevent water accumulation in case of excessive rainfall. Especially in the use by disabled people, it is necessary to prevent the risk and to use the buildings where the quality of the pavement is increased.

3.2. Airway Transport

One of the critical structures that will be affected by climate change is airports and air transport. Storms, floods and floods and high temperatures increase the risk of air transport.

Airport runways will be adversely affected by icing, strong wind, excessive rainfall, snow storm, etc. In addition, the disruptions that may occur in the transportation of passengers to the airports due to situations such as storms and excessive rain create additional difficulties in airline management.

3.3. Railway Transport

Railway transport is the least affected by climatic conditions compared to other sub-transport segments. However, the train track system should be designed in a way to prevent the risks caused by climate conditions such as temperature increase, flood, overflow, storm.

Train tracks expand and deform due to the increase in temperature, losing their function and may cause serious accidents. Therefore, the design of the lines should be done accordingly. In addition, bridges, tunnels and passages along the train line should be free from the negative effects of climate change (floods and overflows). In cases of excessive rainfall and floods, there should be drainage channels that ensure the removal of water from the system infrastructure. Damage to the rail system due to possible failures in the infrastructure causes accidents and increases the risk especially for high-speed train applications.

3.4. Maritime Transport

Turkey's northern, western and southern seas surrounding is an important component in the transport of passengers and freight. In addition, the seaway is widely used in daily life in big cities such as Istanbul, Izmir, etc.

Heavy rains caused by climate change, floods and overflows, storms, and changes in sea level pose risks for this sub-sector.

The increase in sea level will result in negativity in the functions of the ports. For this reason, commercial ports should be arranged accordingly and necessary precautions should be taken at the piers and marinas used for passenger transportation.

Disruptions in urban sea transportation cause people to turn to alternative transportation methods such as highways, create traffic congestion, and increase greenhouse gas emissions by causing an increase in energy consumption.

4. CONCLUSIONS

In order to prevent the negative effects and possible risks caused by climate change on the transportation sector, the fragile sub-sectors should be determined initially. Transportation is generally affected by adverse climatic conditions and extreme weather movements and precipitation.

Although the rate of exposure and the amount of risk are different in the sub-units of the sector, removing the negative effects is generally the first option. However, according to the cost-benefit analysis, in some cases, it will be an effective approach to remove highways, motorways or railways from possible fragile areas.

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VULNERABILITY BY SECTORS: CONSTRUCTION AND INFRASTRUCTURE

Prof. Dr. Erdem Görgün

1. CLIMATE CHANGE

With the increasing world population, increasing demand for food, water and energy, and a decreasing natural resource base, climate change will act as a 'threat multiplier', increasing resource scarcity and placing greater stress on socio-ecological systems (CNA, 2007).

In addition to the severe floods, storms, droughts and heat waves we have seen to date, the degradation of land and forests and the salinization of groundwater resources are often seen as a precursor of climate change, which interacts with other anthropogenic impacts on the environment (GIZ, 2014).

2. VULNERABILITY

Vulnerability in the IPCC's 4th Assessment Report "is the state of a system being vulnerable to and unable to cope with the adverse effects of climate change, including climate variability and extreme climatic events ". The vulnerability concept helps to understand the truth behind the negative effects of climate change and to identify the most sensitive points to climate change.

Climate risks arise as a result of the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems.

Adaptation and mitigation, including both the climate system and socio-economic processes, cause exposure and vulnerability.

Climate Change Effects and vulnerability assessments:

- Knowledge generation,
- Awareness raising,

- Identifying key aspects of climate impacts and vulnerability,
- Developing cooperation between stakeholders

It fulfills different explicit and implicit goals such as the foregoing (Buth et al., 2017).

The vulnerability assessment includes several sections:

- Climate and climate impact research,
- Climate impact assessment,
- Evaluation of adaptation capacity,
- Vulnerability assessment

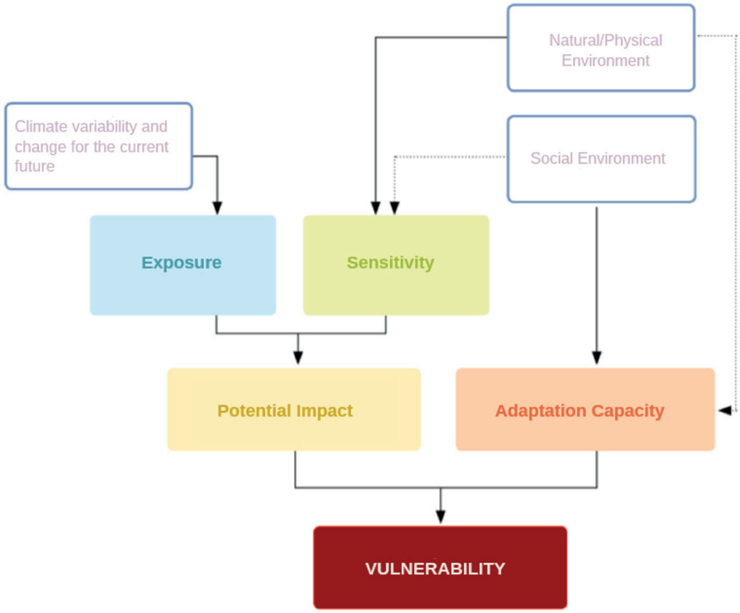
Vulnerability helps us understand what's behind adverse climate change impacts and identify the most vulnerable points to climate change.

A highly effective way to identify and prioritize adaptation measures is to conduct an assessment of vulnerability.

A complete vulnerability assessment requires assessment of the exposure and sensitivity of the system and adaptability as well as the climate stimuli in the system. Vulnerability is not a measurable feature of a system such as a temperature, precipitation or agricultural production. It is a concept expressing the complex interaction of different factors that determines the sensitivity of a system to the effects of climate change.

However, there is no fixed rule defining which factors to consider or the methods used to measure them. That's why we're talking about 'evaluating' vulnerability rather than 'measuring' it.

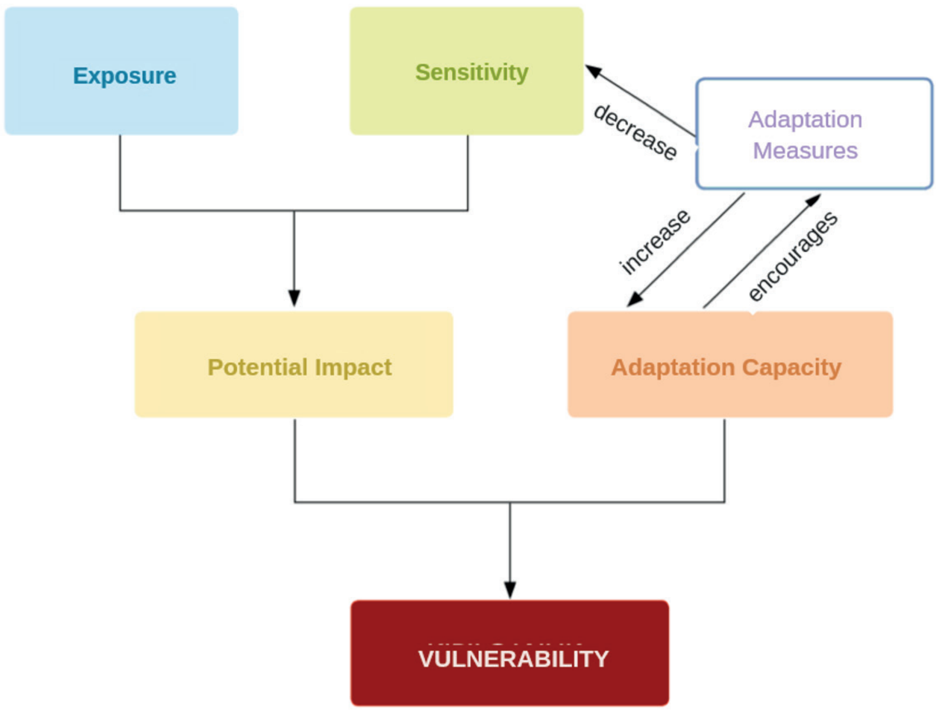
Figure 1: Vulnerability Components



A complete vulnerability assessment requires assessment of the exposure and sensitivity of the system and adaptability as well as the climate stimuli in the system.

How can adaptation measures reduce vulnerability?

Figure 2: The relationship between adaptation measures and vulnerability



Resources: GIZ, 2014

Since most of the construction activities take place outdoors, exposure and vulnerability to climate change is very high.

Damage to the physical infrastructure can lead to disruption of commercial activities and health and safety problems.

Vulnerability assessments in the industry define the risk of resources against climate change, vulnerable groups, identify potential risks and potential interventions.

Vulnerability assessments define critical infrastructure at risk from climate change and then develop prevention methods with the potential harmony.

The construction and infrastructure sector is one of the most vulnerable to climate change (World Bank, 2010).

Even if mitigation measures against climate change are implemented today, their effects will continue in the coming years.

Adaptation against climate change has become a necessity for countries around the world.

3. POTENTIAL IMPACT AND RISKS

Sub-sectors that can be affected in the construction and infrastructure sector:

- Water
- Energy
- Telecommunication
- Transportation
- Buildings

Water Sector

Main risks associated with climate change:

- Rainwater,
- Drainage,
- The potential for increased frequency of extreme daily rainfall events that affect capacity and maintenance of sewer infrastructure

If water systems cannot cope with extreme events or multiple incidents in a season, significant damage costs and environmental spills are likely to occur.

It can occur through acceleration of material degradation and the structural integrity of water supply, sewage and stormwater pipelines, increased ground movement, and changes in groundwater.

Water shortages may occur due to increased temperatures, decreasing available humidity, and greater demand for water associated with an increased population.

Decrease in annual rainfall in catchment basins will affect water supply.

Energy Sector

Increasing frequency and intensity of extreme storm events can cause significant damage to electricity transmission infrastructure and service.

Increased wind and lightning can damage transmission lines and structures; extreme rainfall events can flood power substations.

The increase in storm activity can lead to significant increases in power supply and infrastructure maintenance costs due to the frequency and length of power outages and disruption of services.

Long outages can also negatively affect other industries, especially those that produce, use cooling and heating systems.

Extreme heatwave events are likely to increase in frequency and create an increase in the peak of electricity demand for air conditioning.

The efficiency of the transmission will decrease due to the effect of high summer temperatures on transmission line conductivity.

Telecommunication Sector

The increasing frequency and intensity of excessive wind, lightning, and forest fire events can cause significant damage to the above-ground fixed-line transmission infrastructure and service.

Increasing excessive precipitation events are likely to affect underground telecommunications facilities.

The increase in storm activity can result in a significant increase in the cost of telecommunications supply and infrastructure maintenance due to the frequency and length of network outages and disruption of communication services.

Transport Sector

Increasing frequency and intensity of extreme rainfall events can cause significant flood damage in roads, railways, bridges, airports, ports and especially tunnel infrastructure.

Railways, bridges, airports and ports are susceptible to extreme wind events. Ports and coastal infrastructure are particularly at risk when storm surges are coupled with sea-level rise.

Increasing temperature and solar radiation can reduce asphalt life on road surfaces and airport asphalt.

Increasing temperature and expansion stress the steel in bridges and rails.

Increasing temperature causes expansion of concrete joints and protective coatings on bridges and airport infrastructure.

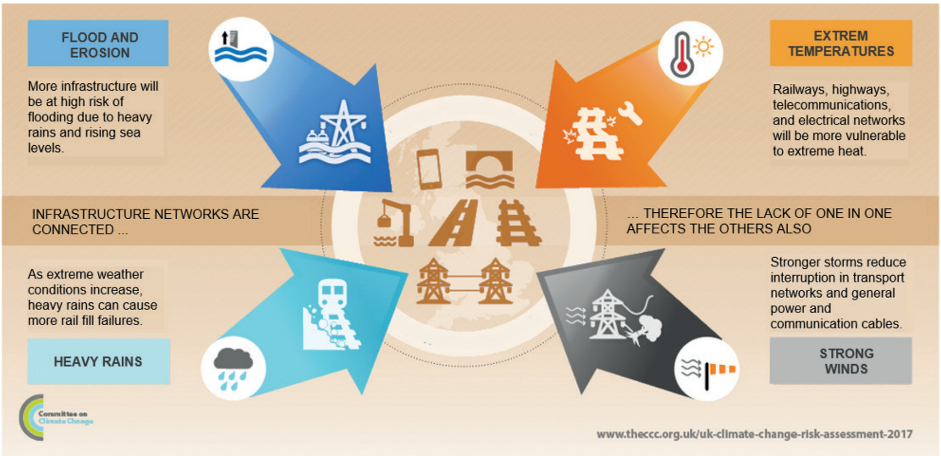
Building Sector

The increased frequency and intensity of excessive rainfall, wind, and lightning events can cause significant damage to buildings and facilities. Buildings and facilities close to the beach are at risk from sea-level rise.

Increasing temperature and solar radiation can cause expansion of concrete joints, steel, asphalt, protective coating, sealing materials, timber and wall materials, and may reduce the life of building and facility elements due to the fragmentation of materials.

It is predicted that climate change will cause significant risks for the construction and infrastructure sector.

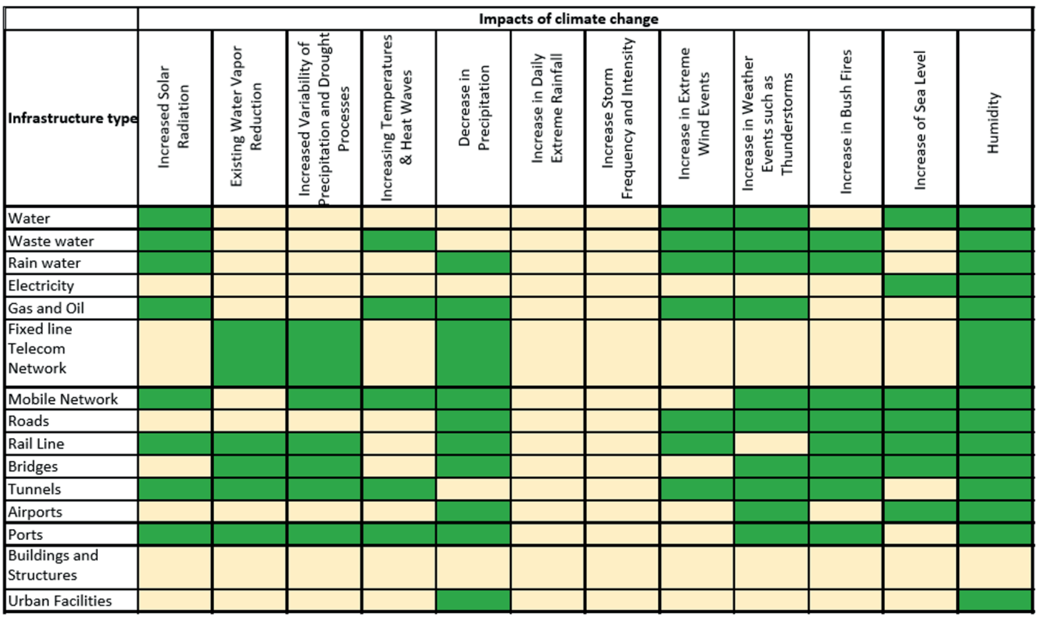
Figure 3: Potential impacts of climate change on the infrastructure sector



Resources: Richard Dawson, Newcastle University, 2017

Here, the green colors shown in Figure 4 indicate negligible risk and yellow represents the absolute risk.

Figure 4: Exposure to Climate Change and Sensitivity Matrix of Infrastructure sector



4. ADAPTATION MEASURES

Sustainable planning can reduce vulnerability to climate change by promoting adaptation and increasing viable capacity and resilience.

Climate-resistant adaptation measures for the sector:

- To ensure that structures are resistant to potential increases in extreme weather events such as storms, floods and heat waves, and extreme cold weather.
- To ensure that investment decisions take into account changing consumer demand patterns as a result of climate change.
- To increase flexibility so that structures can be changed in the future without creating excessive costs.
- To ensure that organizations and professionals have the right skills and capacity to implement compliance measures.
- To build a more flexible and robust infrastructure network that can cope with the projected climate impacts.

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VULNERABILITY BY SECTORS: INDUSTRY

Prof. Dr. Erdem Görgün

1. INTRODUCTION - WHAT IS VULNERABILITY?

Vulnerability was first introduced by Prof. Neil Adger, an academician from University of Exeter, Faculty of Nature and Environmental Sciences, as "the level of sensitivity to the damage a system will encounter as a result of being exposed to environmental and social stress in the absence of adaptation capacity".

Vulnerability is used as the word "vulnerability" in English. It is also referred to as " vulnerability".

Vulnerability is used as a concept to interpret the socio-economic effects of disasters caused by extreme weather events caused by climate change and it has been recognized worldwide by the IPCC.

The vulnerability concept helps to understand the truth behind the negative effects of climate change and to identify the most sensitive points to climate change.

The most effective method in determining and prioritizing adaptation measures is to make "vulnerability assessment". (Özdemir and Yazıcı, 2017).

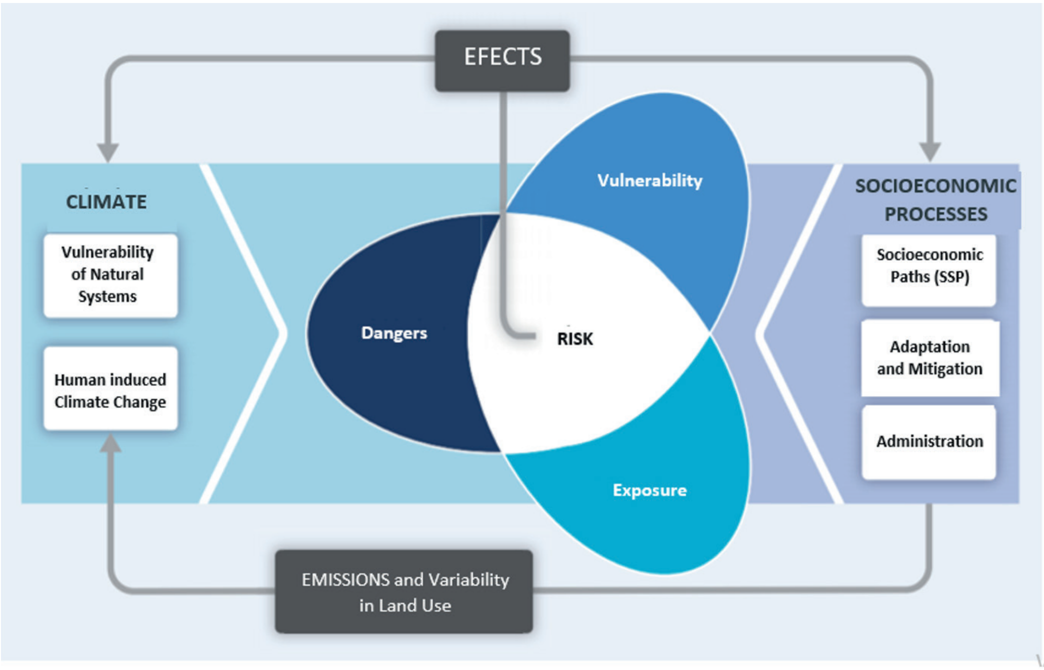
Fragility functions are given schematically in Figure 3.1. Vulnerability is a function the characteristic, size and speed of, its sensitivity and adaptability to climate change and variability to which a system is exposed (Kadioglu et al., 2017).

The IPCC defines the vulnerability to climate change as a function of three factors. These are:

- Types and extent of exposure to the impacts of climate change ,
- ii)Sensitivity of target systems to a certain level of exposure,
- iii) The target is the system 's capacity to cope or adapt.

Exposure refers to elements outside of the system under study, such as changes in climate variability, including extreme weather events, or rates of change in average climatic conditions. In some cases high levels of exposure are observed.

Figure 1: Diagram of the interaction between the physical climate system, exposure, and risks that produce vulnerability.



Resource: IPCC, 2014

Vulnerability in the IPCC's 4th Assessment Report "is the state of a system being vulnerable to and unable to cope with the adverse effects of climate change, including climate variability and extreme climatic events ".

2. VULNERABILITY PARAMETERS

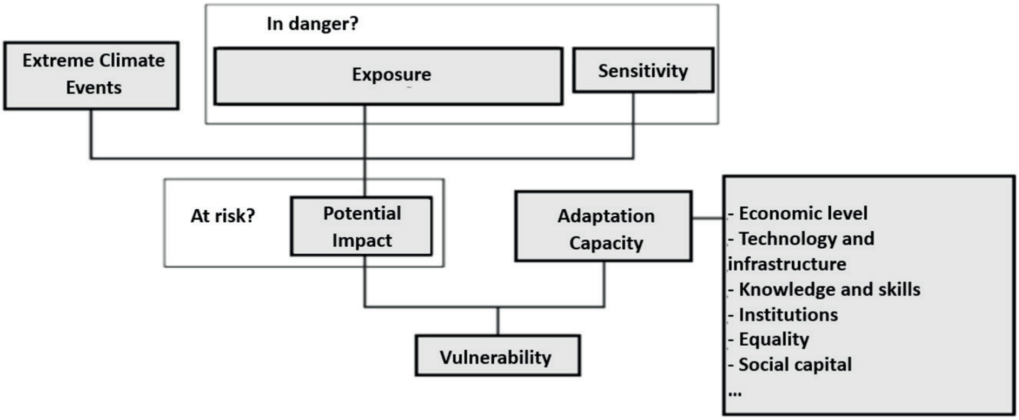
Four parameters in Vulnerability analysis;

- Exposure
- Sensitivity
- Potential Impact
- Adaptation capacity

These help us determine whether a system is sensitive and, if so, to what extent.

Combined, exposure and susceptibility to an event determine the potential effect. Vulnerability is the combination of potential impact and adaptability (Figure 2).

Figure 2: Factors contributing to potential impacts and fragility



- Exposure: It is directly related to climate parameters and these are the character, magnitude and speed of change and change in the climate.

Climate exposure indicators reflecting the exposure of the system to climatic events; include temperature rise, heavy rainfall, drought and sea level rise (IPCC, 2014).

High exposures can be eliminated with high adaptability and lower vulnerability values are achieved.

- Sensitivity: The degree to which a system is negatively or positively affected by climate variability or change.

Sensitivity is shaped according to the natural and/or physical properties of the system.

Sensitivity also refers to human activities that affect the physical structure of a system, such as land management, water management, resource consumption, and population pressure.

- Potential Impact It determines the potential effect that occurs when exposure and sensitivity are taken together.
- Adaptation capacity: It means the ability of a system to adapt to climate change, variability and possible extreme and moderate harms, take advantage of opportunities and cope with its consequences.

Similar to the sensitivity index, adaptation capacity also expresses the current situation.

Figure 3: Functions of Vulnerability Analysis Components

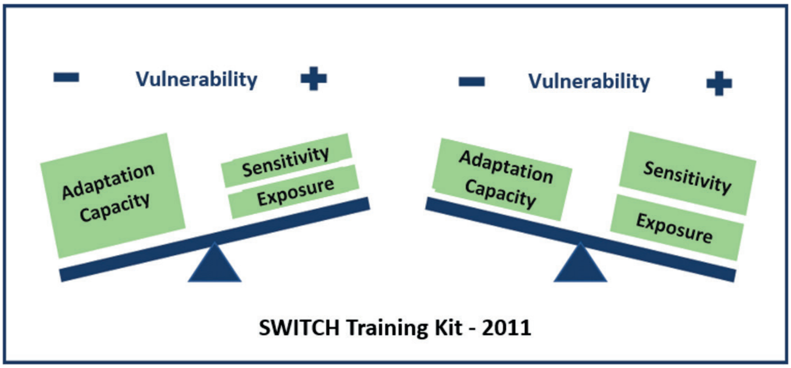
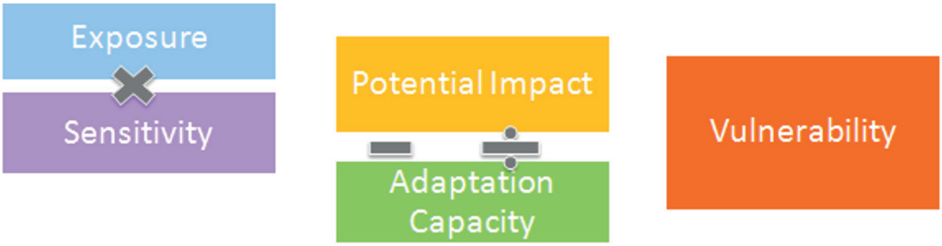


Figure 3 summarizes the results of the different scenarios between adaptability and sensitivity.

Systems with high adaptability and low sensitivity can tolerate the effects of climate change and have a low degree of vulnerability.

Systems with high sensitivity and low adaptation capacity are more sensitive to the effects of climate change and have a higher degree of vulnerability.

Figure 4: Vulnerability Equation



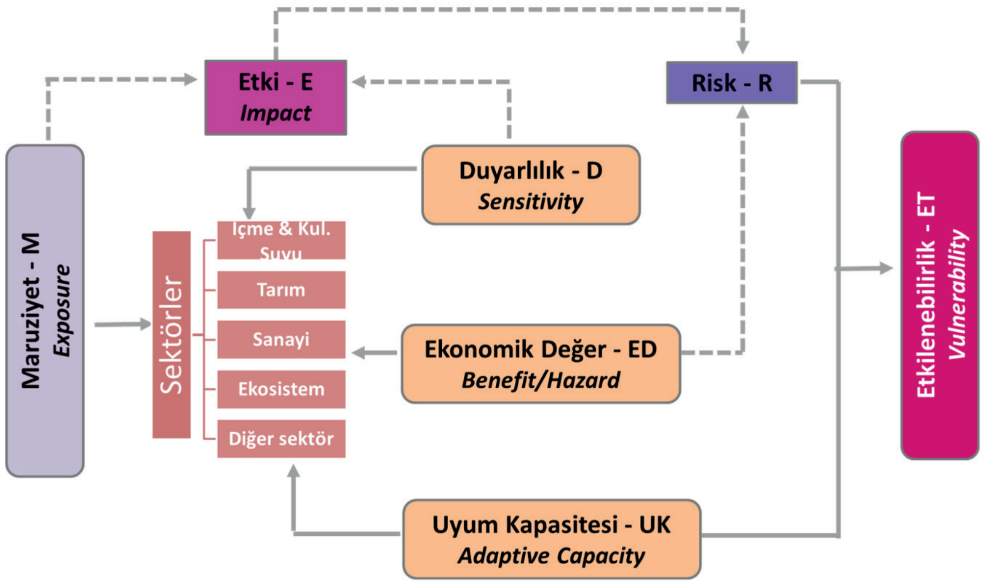
There are different vulnerability equations in the literature. While one calculates vulnerability by taking the difference in adaptation capacity from the potential effect; the other calculates vulnerability by finding the ratio of potential impact to adaptation capacity (Figure 4).

3. VULNERABILITY ANALYSIS

A methodology was developed in order to conduct vulnerability analysis for different sectors within the framework of the "Researching the Effects of Climate Change on Water Resources" project prepared for the former Ministry of Forestry and Water Affairs General Directorate of Water Management between 2013-2016.

Figure 3.5 summarizes the main components of this methodology. This developed method has been applied for some selected river basins and the results are presented in detail in the project report (Iklimsu, 2016).

Figure 5: Sectoral Vulnerability Analysis Basic Components



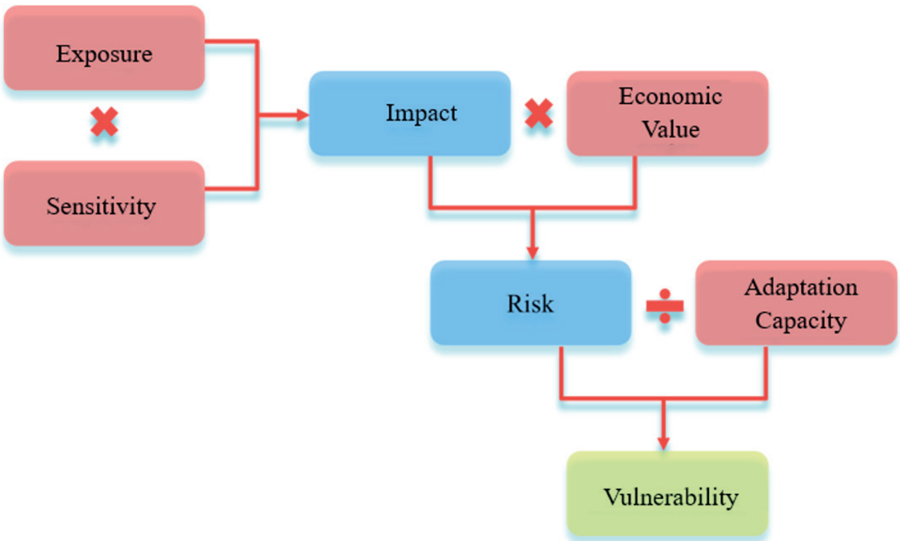
Intergovernmental Panel on Climate Change (IPCC) defines the vulnerability to climate change as a function of 3 main factors.

- Exposure: It refers to elements outside of the system under study, such as changes in climate variability, including extreme weather events, or rates of change in average climatic conditions.

- Sensitivity: The degree to which a system is negatively or positively affected by climate variability or change. This effect can be direct or indirect.
- Adaptive Capacity: It means the ability of a system to adapt to climate change, variability and possible extreme and moderate harms, take advantage of opportunities and cope with its consequences.

Figure 6 shows the vulnerability equation consisting of these elements.

Figure 6: Vulnerability Equation



Here,

- Exposure (E): It is the only variable in the system. It will be calculated according to the results of the RCP4.5 and RCP8.5 scenarios of the model reflecting the average with a probability of 50% in 10-year projection periods.
- Sensitivity (S) It has been calculated to reflect the current situation for each sector.
- Impact (I) Exposure (E) x Sensitivity (S)
- Economic Value (EV) It has been calculated to reflect the current situation

for each sector (drinking water, agriculture, industry, ecosystem and tourism).

- Risk - R: Impact (I) x Economic Value (EV)
- Adaptation Capacity (AC) It has been calculated to reflect the current situation for each sector (drinking water, agriculture, industry, ecosystem and tourism). 2014 data were used.
- Vulnerability (V) Risk (R)/Adaptation Capacity (AC)

Expressed as above.

4. VULNERABILITY IN THE INDUSTRY SECTOR

The degree of sensitivity to the climatic conditions of the industrial sector is associated with the development of the industrial sector in the region under study, water consumption information, energy use information, wastewater quantities and characteristics.

Information on medium and large-scale industrial facilities in the region, the number of employees, the activity areas of the facilities can be used as indicators for the calculation of sensitivity level.

Indicators such as the degree of adaptation capacity of the industrial sector to climate conditions, the economic capacity of the region under study, physical infrastructure, social capital, development level, institutional capacity and data accessibility are used. The most up-to-date status of these indicators should be considered in studies.

5. CLIMATE CHANGE AWARENESS IN THE INDUSTRIAL SECTOR

In a current survey study conducted by the Massachusetts Institute of Technology (MIT) and Boston Consulting Group (BCG) with the participation of nearly 2000 company executives in the USA; it has been revealed that climate change ranks very low on the "sustainability" agenda of companies. Although 67% of businesses believe that climate change is real, only 11% of those state that this is a very important issue. Although 27% of the companies surveyed think that climate change is a risk for them, only 9% think that they are prepared for these risks (Arat et al., 2003; Gandhi et al., 2006; Hilmioğlu et al., 2015; Davarcıoğlu, 2017).

If a similar survey is applied to a mass that represents general industrial profile in Turkey, what will the responses of the industrialists be?

It is of great importance that the mitigation and adaptation activities against the climate change problem are adopted by the industrialists.

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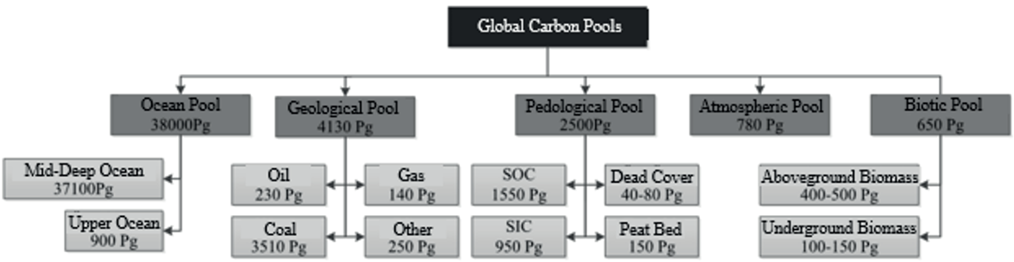
VULNERABILITY BY SECTORS: ECOSYSTEM SERVICES

Prof. Dr. Süha Berberoğlu

1. INTRODUCTION

Within the scope of combating global climate change, solutions have been sought at national and international level in order to prevent the increasing carbon emissions and prevent the environmental problems it creates. One of the leading causes of global climate change is the disruption of the flow balance between carbon pools. Damage to terrestrial carbon storages, increasingincreasing atmospheric carbon emissions, occurs due to the effects of industry and land-use change. One of the natural processes to prevent global climate change by reducing the greenhouse gas effect of atmospheric carbon emissions is to store carbon in terrestrial pools (Figure 1).

Figure 1: Global carbon pools



Resource: Ersoy, 2017

Carbon pools consist of five basic categories. Oceans play the biggest role among these sinks. However, pools where human influence is observed and causes the change of carbon pools to occur between biotic, pedological and atmospheric carbon pools. With the increase of awareness about global climate change, some projects have been developed to reduce atmospheric carbon. Within the scope of these projects, suggestions such as fluidizing and injecting atmospheric carbon into geological pools have been developed. However, such proposals are criticized for negativities such as carbon leakage, earthquake risk and high economic burden. For this reason, the importance of natural processes and biotic and pedological carbon pools of the ecosystem is gradually increasing (Lal, 2008).

Soils (pedological pool), which are considered to be the largest organic carbon reservoir in the world, constitute approximately 50-75% of the carbon pools of the terrestrial ecosystem and consist of Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC) pools (Mondal et al., 2016). SOC is composed of Soil Organic Matter (SOM). SOM generally consists of organic materials found in biomass, litter and humus components. Approximately 58% of the SOM level in the soil determines the SOC level (Lal, 2014a). In the event that living or dead plant-animal residues mix with the soil, the amount of organic matter in the soil and therefore the amount of organic carbon increases. The increase in soil pool provides carbon sequestration in the soil. This increase has been one of the suggested natural solutions for climate change mitigation or adaptation (Brandy and Weil, 2010). In addition, due to environmental factors, plant residues falling on the soil surface from vegetation are one of the factors that increase productivity with the organic matter they contain (IPCC, 2003). The dead cover layer is formed by shedding the shoots, branches, cones and fruits of the bushes and trees on the ground cover. The litter undergoes a chemical reaction by decomposing on the soil surface and decomposes into its components such as carbon, sulfur, nitrogen and phosphorus (Saatçi, 1975). Forest cover and plant type can be expressed in direct proportion to the amount of litter. An increase in the canopy in leafy forests brings along an increase in the amount of litter. For this reason, the increase in organic matter and carbon components mixed into the soil through litter brings with it a possible increase in carbon sinks.

2. MODELING OF CARBON COMPONENTS AS AN ECOSYSTEM SERVICE

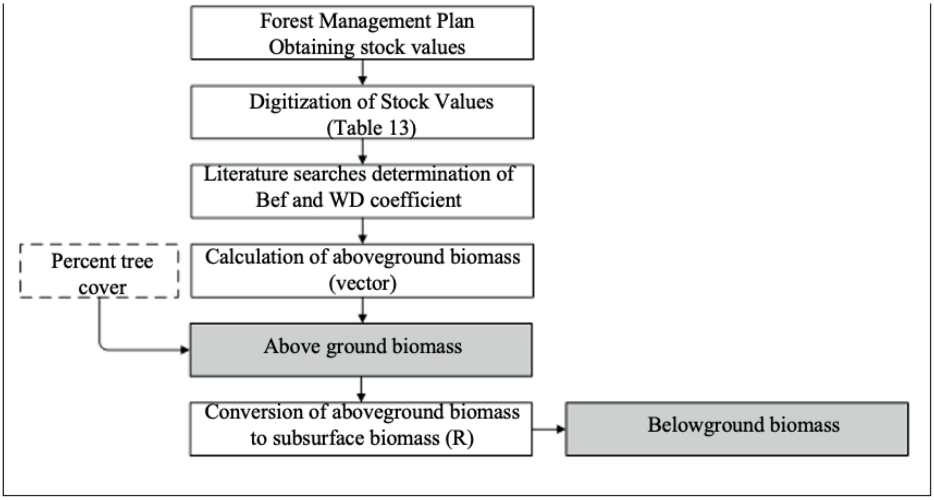
In terrestrial ecosystems, more than 80% of the carbon bound above ground and more than 70% of all soil organic carbon is bound by forest ecosystems (Jandl et al.,. 2007. This situation further increased the importance of forest ecosystems. Contrary to popular belief, carbon is not only stored in plants in forest ecosystems and other terrestrial ecosystems, but soils are also an important storage place. The amount of carbon stored in vegetation in terrestrial ecosystems is approximately 500 x 106 tons (Janzen, 2004).

The carbon in the soil changes depending on the aboveground biomass and has a large proportion (23-46%) of the total carbon retained in the forest ecosystem. The amount of carbon in forest soils in Turkey has been studied in research for various purposes (feeding and growth relationships, soil maps etc.). In a study that compiled the researches on organic carbon amounts in forest soils in Turkey, the average soil organic carbon was found to be 78 tons/ha for 1234 sample areas. However, there is no research directly on the carbon accumulation potential of forest soils (Tolunay and Çömez, 2008).

2.1. Above Ground Biomass Carbon

Living biomass is basically divided into two parts. These are above and belowground biomass. Aboveground biomass is the trunk, stumps, bark, seeds and branches above ground. Belowground biomass covers the belowground roots (IPCC, 2013). The Good Practice Guidance for Land Use, Land Use Change and Forestry (GPG-LULUCF)) is used as a guiding standard method in order to demonstrate the forest biomass in the forest ecosystem in countries which are parties to UNFCC and Kyoto Protocol and their changes. Throughout this approach, aboveground biomass is obtained primarily and underground biomass is estimated depending on the above-ground biomass (Figure 2).

Figure 2: Above and belowground biomass calculation method flow diagram



2.2. Under Ground Biomass Carbon

R coefficient (Root/Shoot Ratios) is used to convert aboveground biomass to belowground biomass.

BGB(Below Ground Biomass)=GS*WD*BEF*R

Thanks to the R coefficient, belowground biomass is obtained from above-ground biomass (Çömez, 2012; FRA, 2010; Levy et al.,. 2003. Since in each of the different studies, operations such as tree and root removal, measuring and proportioning the weights by performing field studies cannot be carried out, the results of previous research are used on this subject (Table 1).

Table 1: Conversion factor of above-ground biomass to belowground biomass

Type Class	Aboveground Biomass (Mg ha-1)	R
	<50	0.46
Coniferous Types	50-150	0.32
	>150	0.23
	<75	0.43
Leafy Species	75-150	0.26
	>150	0.24

Resource: IPCC (2003)

2.3. Soil Organic Carbon (SOC)

Soils consist of Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC) pools (Mondal et al., 2016). SOC is composed of Soil Organic Matter (SOM). SOM generally consists of organic materials found in biomass, litter and humus components. Approximately 58% of the TOM level in the soil determines the SOC level (Lal, 2014a). If living or dead plant-animal residues mix with the soil, the amount of organic matter in the soil and therefore the number of organic carbon increases. The increase in soil pool is one of the natural aids in climate change mitigation or adaptation by providing soil carbon sequestration (Brandy and Weil 2010). Soil samples are taken through field studies to determine the amount of carbon in the soil. Chemical analysis of these soil samples is made and organic matter is determined (Ersoy, 2017).

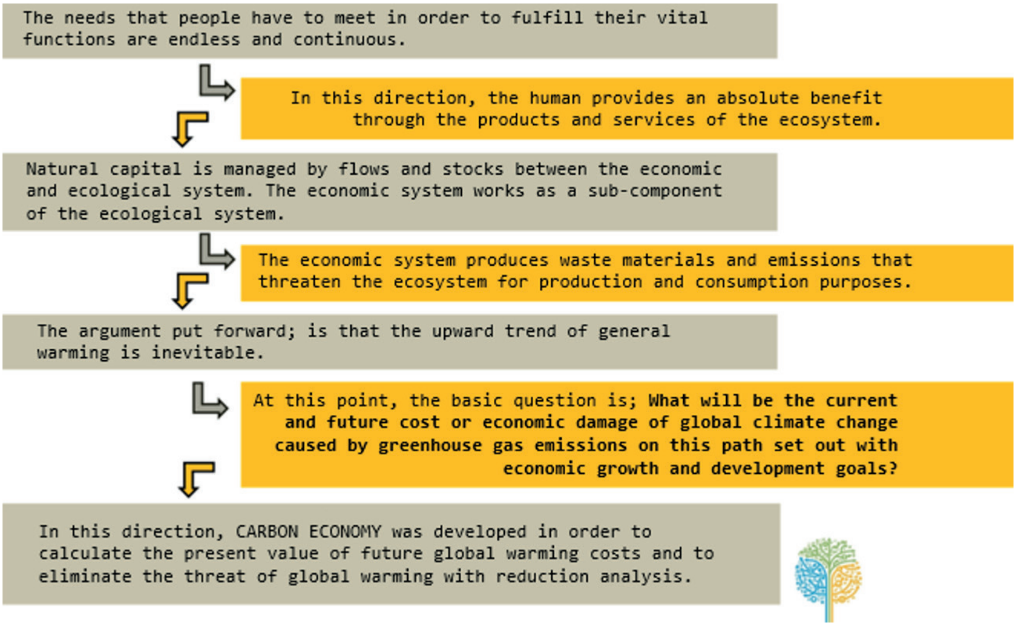
2.4. Litterfall

The amount of litterfall, which has an important place as an intermediate passage between the above-ground biomass pool and the soil carbon pool, is of great importance in the decomposition of organic matter on the soil and in the accumulation of soil carbon.

3. ECONOMIC VALUATION AND SOCIAL COST OF CARBON

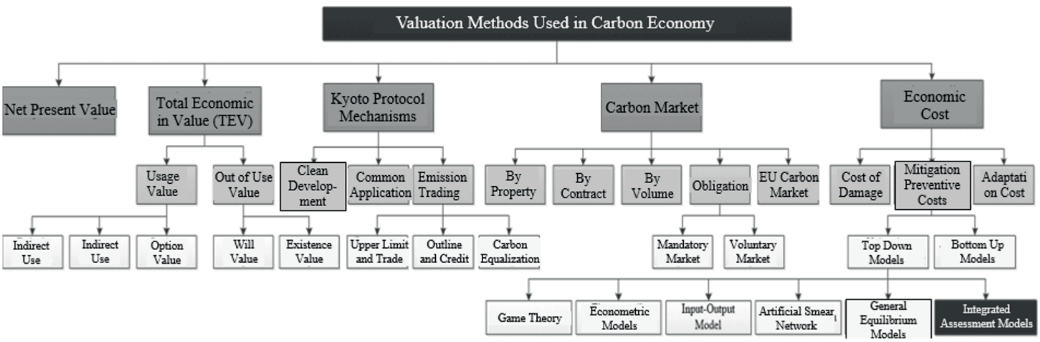
The basic point of view in the concept of ecosystem products and services is to determine the economic value of the benefits that people obtain directly or indirectly from the ecosystem. There are two main opposing perspectives for determining the economic value of the benefits from the ecosystem. The first of these is the opinion that the ecosystem has benefited humanity from the past to the present and in line with these benefits, elements in the cycle of basic nutrients such as water, oxygen and carbon, which are a part of the ecosystem, should not be traded by converting them into commodities. Another view contrary to this is the view that natural resources that have been used unlimitedly would be used more limitedly and carefully if they had economic value in the past. According to this view, every resource used for human benefit has an economic value and the user should have risked to pay this economic value in line with the benefit provided. As a matter of fact, the main economic goal of developing and developed countries is undoubtedly economic growth. However, while there are unlimited economic growth targets, the main point that is overlooked is that natural resources and the world are limited. In addition, the use of natural resources as free capital and the absence of any obstacles is a factor that shakes the justice balance for future generations. Increasing atmospheric carbon emissions and global warming threat are the most important indicators supporting this situation. Accordingly, studies on the determination of the economic values of ecosystem products and services are increasingly common in the international literature. Measuring the possible loss in ecosystem balance with economic value for economic purposes helps in the development of alternatives in the field of land use and landscape management. Revealing the economic difference between the loss in ecosystem services and the use of natural resources aims to answer the question of which use is more advantageous in terms of environmental sustainability and economic gain (Figure 3).

Figure 3: Global climate change and carbon economy framework



The carbon economy, which was converted into a commodity that can be bought and sold after the Kyoto protocol, still does not have a single structure or mechanism. Carbon economy methods, which are handled with more than one approach in our country and in the world, are summarized in Figure 4. Here, while categorizing the general framework of carbon economy methods, the methods used, analyzed or transferred in different studies were compiled (Mirici & Berberoğlu, 2017).

Figure 4: Valuation Methods Used in Carbon Economy



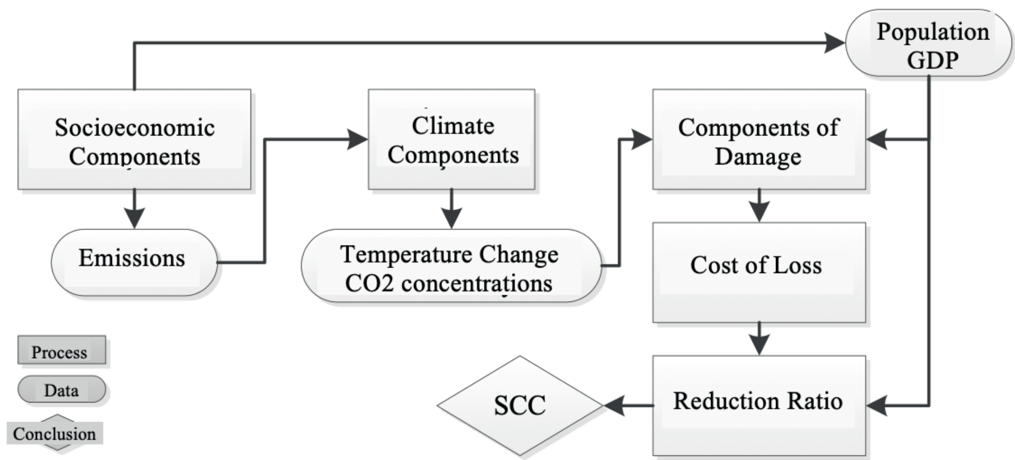
Resource: Mirici and Berberoğlu, 2017

3.1. Integrated Evaluation Models

Global climate change depends on many components such as economic power, population, technology and energy use of countries. For this reason, it is a phenomenon that preserves its uncertainty and stochastic structure. More than one model has been developed by nature scientists and economists within the scope of Integrated Assessment Models (IAMs) approach in order to minimize these uncertainties regarding global climate change and determine the possible effects and costs. Among these models, MERGE, FUND, PAGE, DICE and RICE models stand out (Kumar, 2013). The common point of these models is to determine the optimal level where the Marginal Reduction Cost is equal to the Marginal Carbon Cost with the aim of preventing global climate change (İşcan & Yılmaz, 2011).

The Social Cost of Carbon (SCC) has an important place in global warming and global economic policies. SCC can be modeled globally, as well as at national or regional scales (Figure 6).

Figure 5: General framework of the social cost of carbon



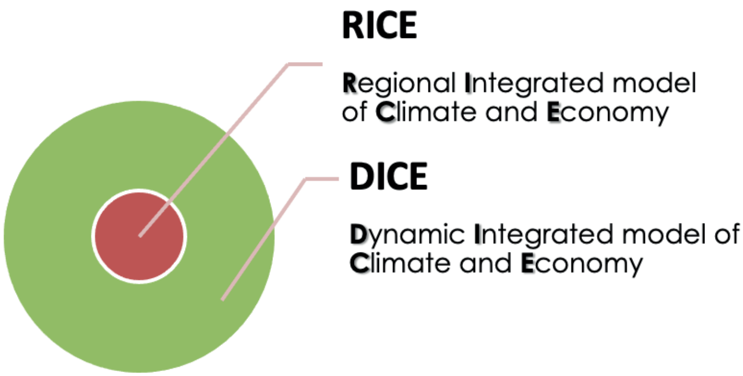
Resource: NASEM (2017; Nordhaus and Sztorc (2013); Stern (2006)

SCC can be defined as the cost associated with anthropogenic effects and economic damage caused by each ton of CO_2 emission added to the atmosphere. The cost of economic damage per unit increase in CO_2 emission represents the present value of the possible economic damage now and in the future. Estimates for SCC are generally produced by utilizing the target country's economy, the amount of emissions released into the atmosphere and global geophysical global warming parameters (Bijgaart et al.,. 2014; İşcan and Yılmaz 2011; Nordhaus 2011). Within this framework, there are three general differentiating model approaches: (i) models focused on optimal emission level and emission dynamics, (ii) models focused on uncertainties, and (iii) superficial detail weighted models. The common point of these models is to determine the optimal level where the Marginal Reduction Cost is equal to the Marginal Carbon Cost with the aim of preventing global climate change (İşcan & Yılmaz, 2011). FUND, PAGE, DICE and RICE models that use IAMS approach in carbon economy stand out (Kumar, 2013).

3.1.1. RICE Model Frame

One of the important studies in the field of global climate change and economy was carried out by Nordhaus (1991). In the period from 1980 until today, Nordhaus has developed the DICE - Dynamic Integrated model of Climate and Economy and RICE - Regional Integrated model of Climate and Economy models, and has kept the models up to date with the following studies he has conducted. The general purpose of these studies has been to control greenhouse gases and slow down climate change. The RICE model was last updated in 2010 and the DICE model in 2016. While the DICE 2016 model estimates the social cost of carbon at 30.69 USD (2015ppp) at the global level, the RICE model is modeled with different values at the regional level (Nordhaus 1991; 2010; 2011; 2013; 2017). The DICE model is the origin of the RICE model. In this context, the DICE model structurally includes the RICE model.

Figure 6: RICE and DICE model



The RICE model is basically a combination of three axes. These are (i) economic sector, (ii) global geo-physical indicators and (iii) policy optimizations. The most important point provided by the optimization mechanism is to model the optimal reduction factor, which will be calculated with different weights specific to countries with both optimal growth and economic and global indicators without completely sacrificing economic growth (Ersoy, 2017).

3.1.2. Neoclassical economic approach

The basic approach of neoclassical economics appears economic phenomena such as consumption, production and investment as well as the implementation of individual decisions and preferences. In this way, the price mechanism aims to balance between decisions and preferences. At this point, the mainstay of neoclassical thought is social and economic balance. In this context, the individual is both a producer and a consumer. It provides utility maximization when the individual is a consumer and rationality according to the profit maximization norms when the individual is a producer. Basically, neoclassical economic theory aims to find some universal rules based on individual behavior. The rationality in consumer behavior is to ensure a balance between limited natural resources and unlimited demands. Co-marginality can be defined as the equalization of the earnings obtained in the last unit of the expenditure made on each product (Akyüz, 2009).

3.1.3. Marginal Utility Theory

The neoclassical approach transforms the concept of value-in-use into a more quantitative one, and determination of price is achieved with the concept of marginal utility. Depending on the utility-value theory, the value of goods depends on the price, not the total utility it contains. Marginal utility is the inverse ratio of a good to its consumed quantity. Therefore, the scarcer a good is, the higher its marginal price and utility. In this case, the lack of resources is the main factor that determines the marginal benefits and values of goods.

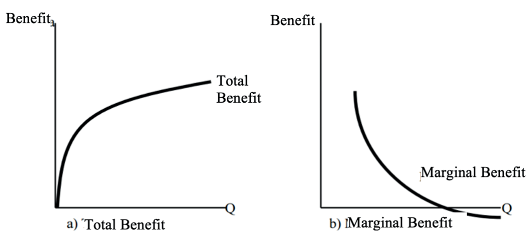
$$U = U(x) \qquad\qquad U' = U'(x) > 0$$

When the consumption-utility relationship is defined by the utility function, the total utility function provided by the good X from x units is expressed as U when required. As consumption increases, the total benefit increases. The derivative of this function gives marginal utility. In this case, marginal utility shows the change of one unit of increase in consumption on total utility. The increase provided by an increase of δx units in the consumed goods to the total benefit is provided by the following.

$$\delta U = \frac{dU}{dx}\delta x$$

Increasing goods consumed increases total utility while marginal utility decreases. On the other hand, the decrease in consumption increases the marginal benefit. This relationship can be observed as follows (Figure 7).

Figure 7: Total utility and marginal utility



Decreasing marginal utility as the amount of consumption increases is called diminishing marginal utility. Utility as an abstract concept has been much discussed within the framework of the neoclassical approach. At this point, the benefit is the price that the consumer gives up to spend on one additional unit of good. It decreases the benefit from continuously increasing consumer goods units (Akyüz, 2009).

3.1.4. Discount Rate and Time Preference

The individual's preference of two consumption values at the same level in the previous periods and the idea of consuming more in the future by saving his current consumption cause the future consumption to be evaluated by being subjected to a certain amount of reduction today.

Current consumption of X of good in period t: X_t
Future consumption of X of good in period t+n: Assumıng X_{t+n} the customer Xt a value more than X_{t+n} means MU(Xt)>MU(X_{t+n}). In this case, it is concluded that the present value of the benefit to be obtained from the consumption of this good in t + n period is lower than the benefit to be obtained from the consumption of the same good in t period. For this reason, the individual prefers the present, not the future. The time is reduced, providing less benefit as long as consumption is delayed. The reduced utility theory is used to model the preferences between time. For this, the reduction ratio is estimated by comparing the marginal benefit of today's and future consumption. The time preference rate of an individual is a function of the distribution of income over time. The ratio of the difference between the current marginal utility of current consumption and the current marginal utility of future consumption, to the present marginal utility of future consumption determines the time preference ratio (p) (Akyüz, 2009; Taşdemir, 2006).

$$p = \frac{MU(X_t) - MU(X_{t+n})}{MU(X_{t+n})}$$

p is the preference ratio of time, and R (t) is the most important factor directly affecting the reduction ratio. Although reduced utility is criticized by most researchers for some uncertainty and variability of personal preferences, it is preferred because of the convenience and simple framework it provides (Nordhaus, 2011). The discount rate, which goes from individual scale to national consumption, is determined according to the marginal utility of current and future consumption. In the estimates made for a country or region, if the future income is low and the marginal utility is high, the reduction factor decreases and thus the SCC value increases. Conversely, if the future income is high and the marginal utility is low, the reduction factor increases and hence the SCC value decreases. Therefore, as Diwany (2011) states, this approach, which is "separating the value of tomorrow from today", is the most important factor affecting climate change and thus the increase or decrease in carbon prices through the consumption attitudes of individuals between today and the future.

The economic perspective that is the basis of the RICE model is the neoclassical theory of economic growth. DICE/ RICE model which aims at resolving many environmental problem such as global climate change root cause of which is thought to be economic growth, increase in greenhouse gas concentrations, increase in industrial origin CO_2 and pollution of natural resources, is produced by Ramsey as an economic growth model (1928). In Ramsey's growth fiction, it was aimed to increase the welfare of the individual through consumption, and to achieve this, it was envisaged to save from the current consumption. Investments, which have an important place in neoclassical growth, are implemented through natural capital in this model. However, an important point in the model is that CO_2 and greenhouse gas emissions are used as negative natural capital. According to this theory, greenhouse gas emissions, which are natural capital, should be reduced. The RICE model has ensured the stocking of capital stocks as natural capital in neoclassical economics, and correlates it with emissions and constructed it in a negative way. One of the modern theories of optimal growth used in the model is represented by the welfare function (Koopmans, 1965; Nordhaus, 2017; Nordhaus & Sztorc, 2013).

$$W = \sum_{t=1}^{Tmax} U[\mathrm{c(t)}]\mathrm{L(t)R(t)}$$

In the equation given above, W, which is the social welfare function, refers to the reduction of per capita consumption in population-benefit weight totals. c (t) represents per capita consumption, L (t) is the population and R (t) represents the reduction factor. The reduction factor is one of the most important factors affecting intertemporal choices in the global climate change process. The reduction factor can be expressed as the ratio used in establishing the balance between the current consumption of the society and its future consumption. The reduction factor should determine the intertemporal choice so well that it should neither suffer from the current low consumption nor be held to the extent that future generations are not treated unfairly. As a matter of fact, the responsibility for future generations passes through the way of saving expected from the current generation (Ceylan, 2012; Uzunkaya, 2012).

$$R = (1 + p)^{-t}$$

R is the reduction factor, p is the reduction ratio or the purity ratio of the social time preference, t is the time. The utility of consumption is represented by the formula below. The indicator that determines the utility function U (c) is the elastic constant of the marginal utility of consumption. The elasticity parameter is the most important component of avoiding intergenerational inequality or injustice. If the elasticity coefficient is low, the consumption difference between generations is small, and if the flexibility is high, the difference between generations is high. In this case, flexibility is a measure of intergenerational sensitivity in utility theory (Nordhaus 2011, 2013).

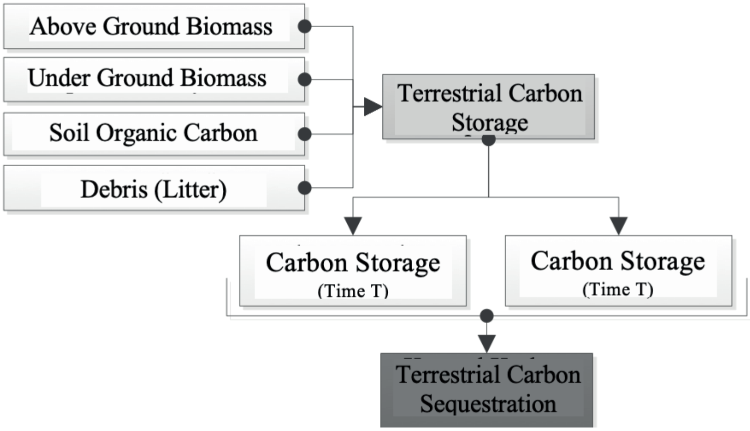
5. INVEST MODEL APPROACH

The Integration Valuation of Ecosystem Services and Tradeoff-InVEST model is a model developed by a group of ecologists and economists within the scope of The Natural Capital Project developed by Stanford University. The InVEST model models specific service evaluation processes, including procurement, support, regulatory and cultural services, at an ecological and economic level. Different ecosystem services are specifically resolved under different interfaces, and the algorithms developed in Python language provide significant advantages in terms of providing GIS integration and resolving them under different interfaces. Based on the existing carbon storage capacity stored in landscapes, the InVEST model aims to reveal the possible carbon sequestration between the current and the future and the economic value of this sequestration. The basic input data set produced with different methods in modeling consists of the following components:

- Current and future Land Use/Land Cover (LU /LC)
- Carbon pools (above ground, underground, soil, debris)
- Biophysical table (LU /LC and carbon components relationship)
- Social Cost of Carbon (SCC)

Considering the working principle of the model, it is based on modeling carbon storages with high precision and assigning LU /LC types using different landscape character types. Carbon sequestration is estimated by considering the change in the carbon capacity stored per unit area within a certain period of time. The frequently confused carbon storage and sequestration mechanism in this situation is briefly summarized below (Figure 8).

Figure 8: Relationship between terrestrial carbon storage and carbon sequestration



The InVEST Model maps the carbon storage capacity on LU/LC grid data. Therefore, Land use/cover maps are one of the most important inputs in the model. To map the cost of avoiding harm from carbon emissions, it is necessary to produce current and future IP/EC maps. Carbon sequestration estimates the economic value of carbon in each unit by calculating the difference in the carbon amount of the landscape that changes over time. The economic equivalent of carbon per unit area is also expressed as valuation. Besides the many advantages it provides, the InVEST model also contains some basic uncertainties. These uncertainties arise from limitations on certain issues within the model. The basic limitations of the model are that the carbon cycle is presented by a simplified mechanism, the carbon captured over time is based on the assumption of linear change, and potentially the reduction rate is based on future estimates or basic assumptions. In addition, sensitive indicators for carbon uptake such as the rate of photosynthesis and the presence of active soil organisms are ignored in the model.

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SOCIAL VULNERABILITY, VULNERABILITY IN CITIES AND ITS INDICATORS

Doç. Dr. A. Ufuk Şahin

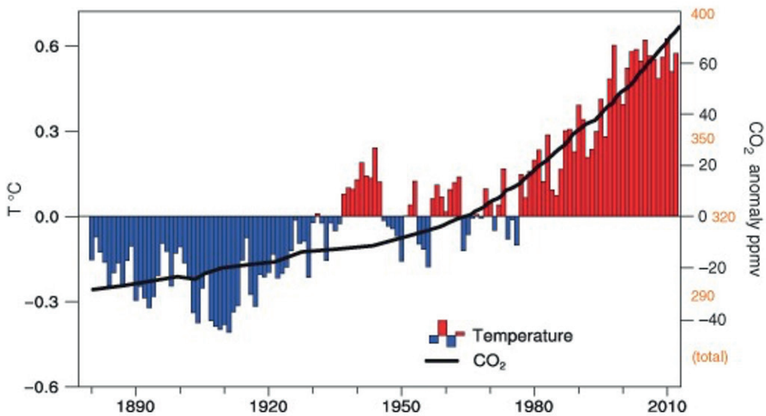
1. INTRODUCTION

An iconic photograph symbolizing climate change and its negative effects: a polar bear staring over a melting glacier without knowing where to go. While the world we live in is changing at a dizzying pace, humanity is grappling with various, multi-layered problems related to each other such as new technologies, environmental problems and social injustice. Intense humanitarian activities such as increasing population, globalization, global trade, industry, agriculture and tourism are transforming and irreversibly changing the world. Apart from the technical problems that climate change will bring, the humanitarian crises it will create and its reflection on various social classes can make our lifestyle, the environment and cities we perceive even more fragile. In this context, climate change will be summarized in this study in order to examine the vulnerability and possible solution scenarios that will occur in the cities.

2. WHAT IS CLIMATE CHANGE?

Climate change is defined as the change or variation in climate observed over a long period as proven by statistical tests. It is any change in climate with human activities or natural variability over time. According to the definition of the United Nations Framework Convention on Climate Change (UNFCCC), it is the variability that changes the composition of the global atmosphere directly or indirectly due to human activities and occurs within a certain period. The driving force of climate change is the increase in greenhouse gas emissions such as water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Especially after the industrial revolution, carbon emission and temperature change are clearly noticed. According to World Bank data, if the world continues like this, the increase in average temperatures is expected to be 4 °C in 2060. Figure 1 shows the changes in temperature and CO_2 over the years (Trenberth & Fasullo, 2013).

Figure 1: Average temperature and carbon change from 1880-2010

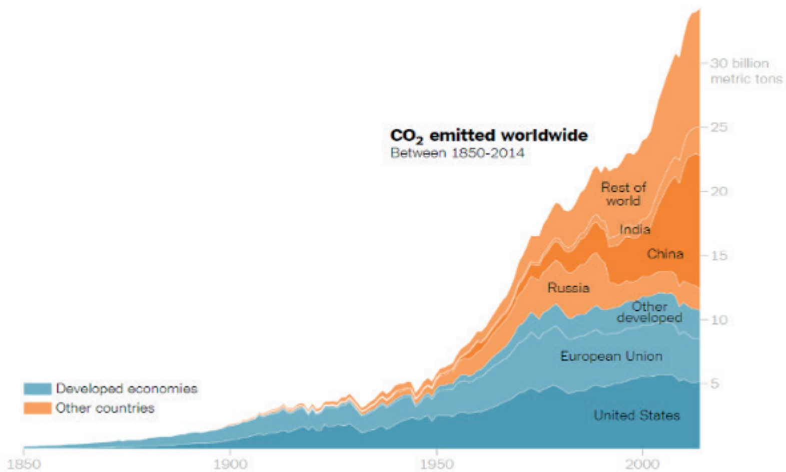


According to the Intergovernmental Panel on Climate Change, the main human resources in climate change are fossil fuels (56%) and deforestation (17%). 43% of fossil fuels originate from coal, followed by oil with 36% and natural gas with 20%.

Coal releases 1,7 times the CO_2 of natural gas per unit of energy produced into the atmosphere (IPCC, 2012).

Figure 2 depicts the countries that have contributed to carbon emissions since the 1800s (Gonchar, 2019). According to this, industrialized countries led by the USA are the countries primarily responsible for emission emissions. On the other hand, climate change, which was considered only a theory or an assumption by some segments until the 1990s, is a threat accepted by the whole world today. The United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992 to form the basis of the global response to the problem of climate change (UNFCCC 1992). Although this convention is considered the cornerstone, the 72 'Stockholm Conference and the 87'Brundtland Report have important implications for the creation of this convention. A conference of parties (COP) was held every year after the Framework Convention on Climate Change, and started to reap the fruits of these initiatives with the Kyoto Protocol (1997) and the Paris Climate Agreement (2015). The final documents of the COP meetings, which have developed depending on the international conjunctures and country performances (commitments), become clear symbols of the stage (effort) reached in the climate change negotiations. It has been included in the most recent Sustainable Development Goals.

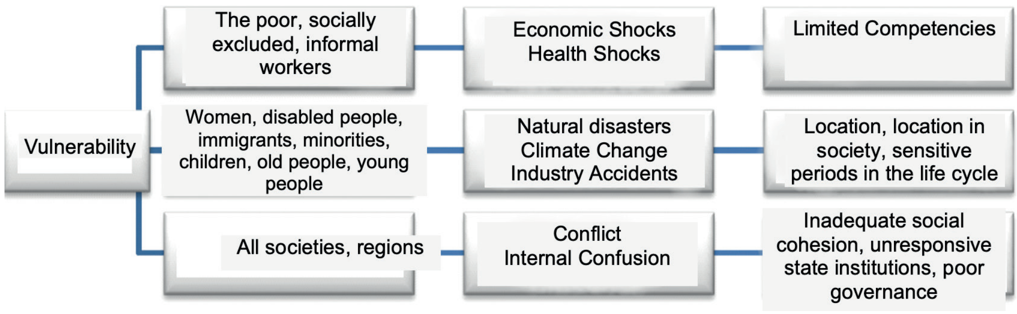
Figure 2: Carbon emissions of various countries by years



3. VULNERABILITY AND URBAN VULNERABILITY

Vulnerability is defined as the need for help in order to fulfill the basic functions, that is, a kind of addiction, a situation that prevents communication with others, and the inability to be protected from attacks, bad behavior and abuse. For today's world, this definition can be expanded as the attitude or behaviors of societies/ individuals towards risks. Vulnerable groups in the society, social classes such as the poor, informal workers, women, children, disabled people, immigrants can be shown. Vulnerability requires a more specific assessment especially in terms of developing countries, as stated in the Human Development Report (2014), as explained below (Figure 3), and especially groups such as women, the disabled, immigrants, minorities, children, the elderly and the young are more vulnerable to climate change and industrial accidents. Due to the geographical location of societies, their insufficiency in sustainable development and progress and their social vulnerability reduce their capacity to resist to disasters.

Figure 3: Vulnerability and social layers

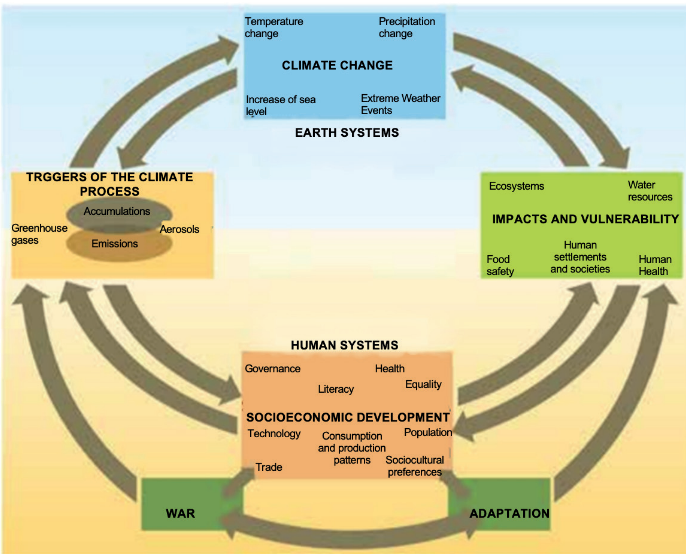


In order to reveal the relationship between climate change and vulnerability, first of all, the effects of climate change on cities should be revealed. The effects of climate change on cities can be classified as direct and indirect. The water cycle may be disrupted due to reasons such as the increase in evaporation as a result of the increase in temperature, less precipitation with the change of precipitation regime, increased surface flow due to urbanization, and insufficient feeding of groundwater. Using the water irresponsibly and the increase in industrial and agricultural activities will put more pressure on already limited water resources. Insufficient water supply is a very important problem that threatens every city and concerns every segment of society. However, untreated wastewater originating from industry, agriculture and domestic use pose a serious problem in terms of the environment. On the other hand, heat islands that increase due to air pollution (emission increases) that trigger climate change and dense urban building clustering are serious indicators of vulnerability for cities. Due to climate change, the economic infrastructures of cities may be affected and fertile agricultural lands may disappear. Due to pollution, economic sectors such as tourism, fishing, agriculture and service sectors may be adversely affected. For example, according to IPCC projections, the Mediterranean Basin is one of the most vulnerable regions of the earth to global climate change. It is expected that the temperature increase will increase to 4 °C in winter and 6 °C in summer despite having seasonal and regional differences (based on the 1960-1990 period). While a general decrease will be observed in winter precipitation in Turkey, there will be an increase in precipitation on the eastern half of Northern Anatolia. While in the National Action Plan released on Climate Change in 2011 it is foreseen that, in future years, the annual average temperature in Turkey will increase by 2,5° -4 °C and the increase in the Aegean and Eastern Anatolia regions will be 4 °C and in the inner region 5 °C, suggesting that Turkey's near future will have the warmer, more arid and uncertain structure in terms of rainfall (MoEU, 2011 TRCCAP 2011-2023). This shows that almost every city and every sector of our country will feel the effects of climate change.

Among the indirect effects of climate change on cities, as a result of the scenarios outlined above, are the increase in migration waves, increase in urban populations, increase in unplanned urbanization and consequently unemployment, deterioration of social balance, inadequate urban infrastructure, insufficient health and education system or collapse, and insufficient investments.

There should be a "flexibility-based planning" approach in the face of vulnerability. Similarly, vulnerability and adaptation capacity can be shown as the main components of adaptation policies in climate change. Climate change has certain impacts on settlements, in other words, urban (and the systems that make up urban areas) and rural areas, and these impacts are related to the vulnerability of the settlement. Vulnerability can be defined as the tendency of people, ecosystems and the built environment to be harmed by climate change threats; and adaptation capacity can be defined as the capacity to adapt to and shape climate change. Figure 4 summarizes this cycle.

Figure 4: Adaptation and Climate cycle



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

Coastal cities or settlements, in particular, are located in the most vulnerable geographic areas affected by climate change, as they are at risk of rising sea levels. These settlement are generally vulnerable and they have low level of resistance, which is due to decisions taken in relation to lands in order to overcome the problems related to the formation of floods and erosions, saltwater ingress, loss of infrastructure and arable land, reduction and pollution of potable water, destruction or loss of coastal ecosystems, economic damages in the tourism sector, etc.

3.1. Easter Island Example

Easter Island is a small island in the southwestern Pacific, covering an area of approximately 164 km^2, today connected to Chile. The island is about 3000 km from mainland Chile. Although the island's water resources are very limited, it is famous for its human-figured stone sculptures, the largest of which are 10 m in length and 82 tons in weight, called "Moai". It is estimated that 900 of these statues were erected between the years 1250-1500. Making, transporting and erecting these statues required intense manpower and using the forest resources, such as logs. Although it is not yet known for what purpose it was built, the idea of establishing power and dominance among tribes comes to the fore. Europeans made their first contact with the island in 1722. In the previous century, the population of around 15000 was between 2000-3000 in the 1700s, and between 1862-1888, 94% of the remaining population disappeared and the local population on the island decreased to 111 people. The reason for this is that the forests that existed were destroyed as a result of the sculpture-planting race due to cultural competition, and the society has become increasingly vulnerable as a result of intense humanitarian activities such as over-hunting, deforestation and over-planting and climate change. As a result of contact with Europeans, new diseases and enslavement destroyed Easter Island and its indigenous culture. According to many respected scientists, the example of Easter Island is a small-scale experiment for the impact of climate change on societies. See (Diamond,2005 and West,2008) for further details.

4. RESORT: SUSTAINABLE DEVELOPMENT

Certain measures should be taken to prevent climate change and the vulnerability of cities and society. Climate change is recognized as a global problem by the European Union (EU), and the EU adopts environmental management integrated with sustainable development and ensuring that global warming remains below two degrees compared to the pre-Industrial Revolution era for its climate change policy. In accordance with the notion of integrity, it is essential to prevent all kinds of environmental pollution that will impair the quality of life in the EU and to disseminate "protection and monitoring" techniques that include all sectors and are integrated with other policy areas. The EU plays a role that calls for the parties to take an active role and undertake obligations in the negotiations of the Convention and the Kyoto Protocol within the framework of its greenhouse gas emission reduction targets at international summits. The EU adopts a management approach that includes the issues of "adaptation and mitigation in climate change" and important criteria of its policy and aims to guide international practices in this regard. The success of these policies is possible with the sustainable development model. It is a development model that can meet the needs of today's generations without compromising the ability of future generations to meet their own needs. According to the paradigm of the 1970s, there is a slightly interacting relationship between the environment, society and economy. In the 1980-the 1990s, the environment, society and economy directly intersect and sustainable development is at its center. Today, the environment is inclusive. If there is no environment, there is no society, without society, there is no economy.

Sustainable development goals (SDGs) consist of 169 sub-goals under 17 targets that include many topics from poverty to climate change, from health to economic growth, from education to employment, from agriculture to industrialization, to international cooperation and many other issues (see Figure 5) to give a balanced weight to the economic, social and environmental dimensions of sustainable development. These goals are:

- Ending poverty in all its forms everywhere
- Ending hunger, achieving food security and good nutrition and supporting sustainable agriculture
- Ensuring a healthy and quality life at all ages
- Providing inclusive and equitable quality education and promoting lifelong learning opportunities for all
- Ensuring gender equality and empowering all women and girls
- Ensuring accessible water and wastewater services and sustainable water management for all
- Providing access to affordable, reliable, sustainable and modern energy for all
- Promoting stable, inclusive and sustainable economic growth, full and productive employment and decent work for all
- Establishing resilient infrastructures, supporting inclusive and sustainable industrialization and strengthening innovation
- Reducing inequalities within and between countries
- Making cities and human settlements inclusive, safe, resilient and sustainable
- Ensuring sustainable production and consumption patterns
- Take immediate action to combat climate change and its effects
- Protecting and sustainably using the oceans, seas and marine resources for sustainable development
- Protecting, improving and supporting the sustainable use of terrestrial ecosystems; ensuring sustainable forest management; combating desertification; halting and reversing land degradation; preventing the loss of biodiversity
- Building peaceful and inclusive societies for sustainable development, ensuring access to justice for all, and creating effective, accountable and inclusive institutions at all levels
- Strengthen implementation tools and stimulate global partnership for sustainable development

Figure 5: Sustainable Development Goals

Source: Republic of Turkey, Presidency Strategy and Budget Department, Sustainable Development Targets, http://www.surdurulebilirkalkinma.gov.tr/amaclari/

Although it has been examined under different headings, each goal in sustainable development is related to the other. Environment and climate change are at the heart of each. When the goal of combating climate change is analyzed, the sub-goals are as follows:

- Goal 13.1. Strengthening resilience and adaptation capacity to climate change hazards and natural disasters in all countries
- Goal 13.2. Incorporating climate change measures into national policies, strategies and planning processes
- Goal 13.3. Developing training, awareness, individual and institutional capacity on climate change prevention and mitigation, and adaptation to climate change and early warning.
- Goal 13.a. In order to meet the needs of developing countries in the context of meaningful mitigation actions and transparency in implementation; ensuring that the developed countries that are parties to the United Nations Framework Convention on Climate Change fulfill their commitments towards the purpose

of collectively mobilizing USD 100 billion annually from all resources as of 2020, and putting the Green Climate Fund into operation by completing the capital formation as soon as possible.

The indicators used for these goals are

- 13.1.1 Number of people directly affected by disasters are missing and killed per 100,000 people
- 13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework Document for Disaster Risk Mitigation, 2015-2030
- 13.1.3 Proportion of local governments implementing and adopting local disaster risk reduction strategies in line with national disaster risk reduction strategies
- 13.2.1 Improving low greenhouse gas emissions and climate resilience in a manner that does not threaten food production; the number of countries communicating the implementation of integrated policies/strategies/plans that increase the ability to adapt to the adverse effects of climate change (a national adaptation plan, determining national contribution, national communication, biennial update report, etc.)
- 13.3.1 Number of countries that have integrated mitigation, adaptation, reduction and early warning into their primary, secondary and tertiary education programs (on climate change)
- 13.3.2 Number of countries communicating the strengthening of institutional, systemic and individual capacity building to implement development practices, technology transfer (on climate change), mitigation and adaptation
- 13.a.1 Amount of USD mobilized per year between 2020 and 2025 in line with a $ 100 billion payable commitment
- 13.b.1 Number of least developed countries and small island developing states receiving some support and special support, including finance, technology and capacity building, for mechanisms to increase their effective management and planning capacities related to climate change, including a focus on women, youth, local and excluded communities. number

All the indicators seen can be defined as the parameters that indicate rural and social vulnerability. Turkey is one of the most effective governments since the beginning of the process. Being among 22 volunteer countries, the VNR report was prepared and presented in 2016. The road map was prepared in 2019 within this scope. It continues its other plans in a way that will be integrated with action plans in various fields. For example, the 11th Development Plan includes measures and targets to reduce vulnerability with sustainable development (11th Development Plan, 2019).

5. CONCLUSION

Climate change is keeping cities under pressure. The vulnerability of cities and societies is increasing. Expanding the scope of specialized aid for vulnerable groups, increasing the support for bringing the people in working conditions to the labor market, making social protection expenditures more effective, producing more data on relative poverty and developing differentiated policies according to these data, are important. Cities and life should be reconstructed in consideration of climate change. On the other hand, Sustainable Development Goals (SDGs) can minimize the effects of vulnerability.

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UNCERTAINTY AND RISK MANAGEMENT: UNCERTAINTY

Prof. Dr. Erdem Görgün

1. CLIMATE CHANGE

Since the 1850s, temperatures have been increasing steadily compared to the averages of the previous 30 years. According to recent studies by the Intergovernmental Panel on Climate Change (IPCC), the world's average surface temperature is expected to continue to rise for the rest of the 21st century.

According to the pre-industrial period, the global average surface temperature increase is predicted to be in the range of 1,5-4,8 °C until 2100. Greenhouse gas emissions released into the atmosphere until today will continue to contribute to global warming until 2050.

Even if greenhouse gas emissions are completely stopped today, warming will continue.

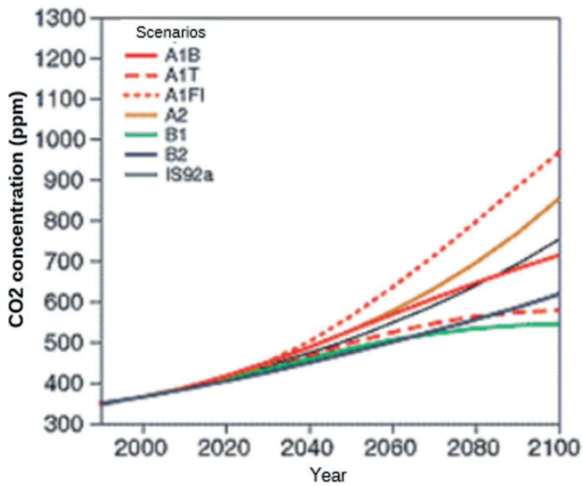
2. UNCERTAINTY IN THE EFFECTS OF CLIMATE CHANGE

When the average temperature changes of global models are examined, the extent of temperature increase is rather uncertain depending on the anthropogenic emission level of greenhouse gases. With this uncertainty, all scenarios predict an increase in temperature.

The debates on the effects of climate change are full of uncertainty. First of all, there is great uncertainty over the projected temperature increases and this entry has a tipping effect on the predicted effects. The latest IPCC reports reflect this uncertainty and are based on model temperature ranges linked to several different emission scenarios.

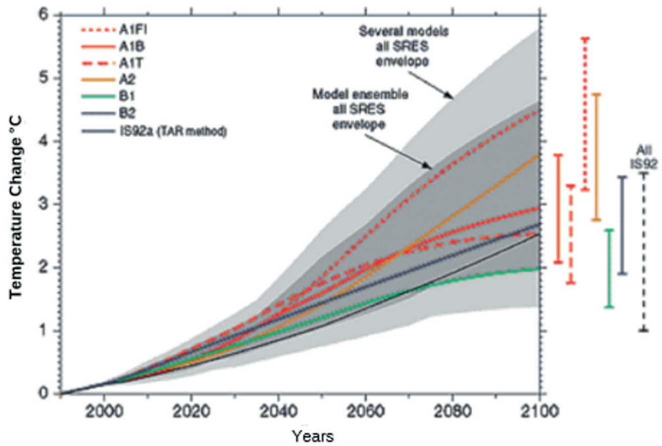
While the different scenarios show a wide variety of trends in CO_2 emissions in the atmosphere, all predict an increase in CO_2 concentration by the end of the century. As can be seen in Figure 1, it is predicted that the increase in CO_2 concentration will accelerate after a certain year in some scenarios, whereas in some scenarios, it is predicted that the increase in CO_2 concentration will slow down from a certain year.

Figure 1: CO_2 Projected increase graph in concentrations in different scenarios by years, IPCC, 2001



As can be seen in Figure 2, despite the increasing CO_2 concentrations of all scenarios, while climate models point out increases in temperature changes, the interval of these changes range between 1,5 to 6 C .

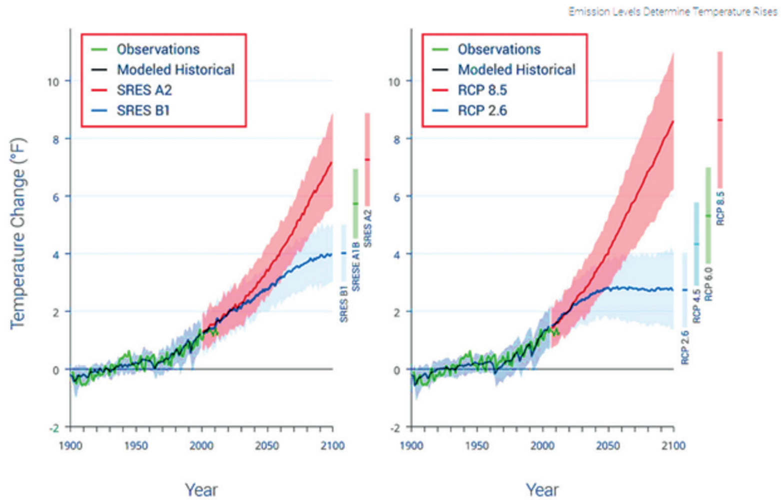
Figure 2: Projected temperature increases by years as a result of the application of different scenarios



Resources: IPCC, 2001

This large amount of variation between the predictions of different scenarios underscores the complexity in making climate predictions and the large amount of uncertainty found in climate change models. In Figure 3, the range of variation and uncertainties in temperature changes in another study were tried to be shown.

Figure 3: Global temperature changes and uncertainties



Resources: NCA, 2014

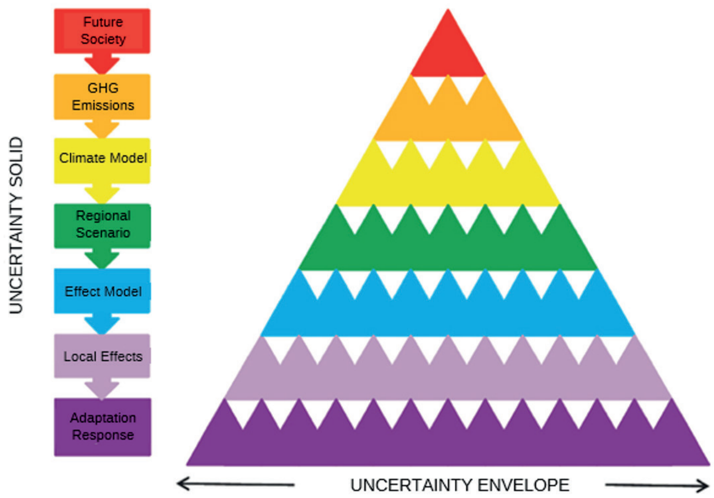
3. WHAT IS UNCERTAINTY?

Uncertainty has many sources ranging from measurable errors in data, to vaguely defined concepts or terminology, to ambiguous projections of human behavior (IPCC, 2014).

Uncertainty can be represented by quantitative measures (eg a probability density function) or qualitative statements (eg, reflecting the decision of an expert team).

Probability density functions and parameter ranges are among the most common tools for characterizing uncertainty.

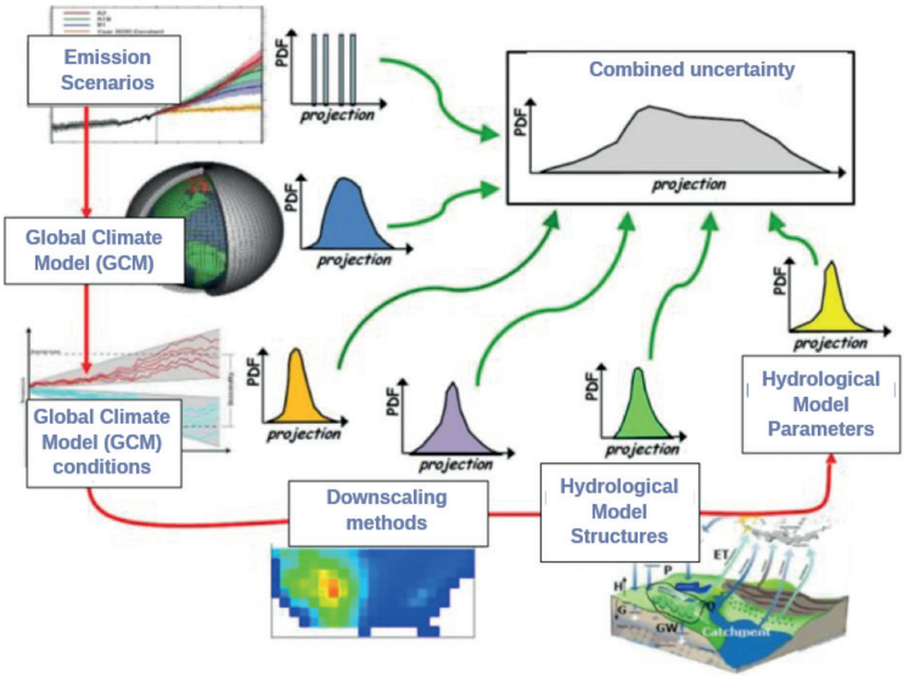
Figure 4: Representation of the "call for uncertainty" paradigm



Resources: Wilby & Dessai, 2010

The diagram in Figure 4 shows how the key methodological choices and uncertainties for assessing change effects combine to form a final predicted envelope (Wilby & Dessai, 2010).

Figure 5: The parameters that make up the combined uncertainty



Identifying and quantifying uncertainty can play a valuable role in communicating the decision-making process.

- Quantification cannot remove uncertainty, but it can help understand the levels of uncertainty we're dealing with.
- Probabilistic information can be a useful way to explain the probability of possible futures.
- Probabilistic information can provide valuable information about definitions of future changes, what to expect, and how to make decisions.
- Statistical methods and models play an important role in the interpretation and synthesis of observed climate data and projections from numerical climate models.

4. HOW IS UNCERTAINTY MEASURED AND DEFINED?

The IPCC has developed a common approach and calibrated language to evaluate and communicate the degree of certainty in its findings.

This approach has been put forward "IPCC Guidance Note on Consistent Treatment of Uncertainties (IPCC, 2010)"; implemented in IPCC 5. Evaluation Report (IPCC AR5, 2013-2014) and «Special Report on Global Warming of 1,5 °C (IPCC SR1.5, 2018)».

This approach realies on the degree of certainty in key findings, based on the IPCC team of authors' evaluations of underlying scientific understanding

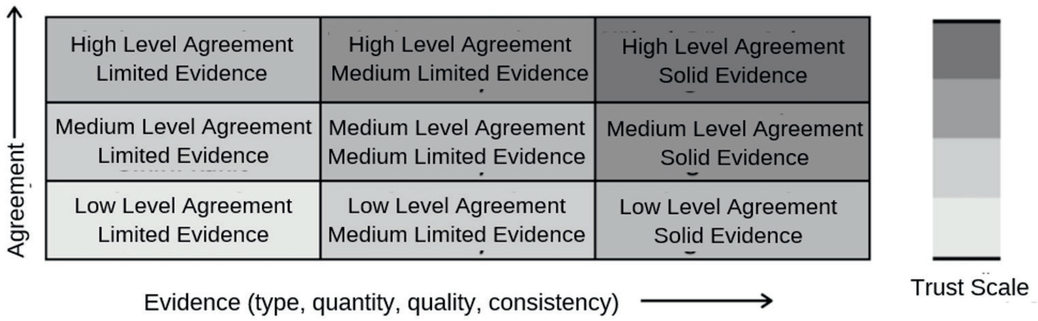
- Confidence and
- Likelihood

metrics.

<u>Confidence</u>

- It is expressed qualitatively.
- It tells you how confident we are about the validity of scientific findings.
- The five qualifiers are used to express the levels of confidence in key findings ranging from very low, low, medium, high, and very high.
- Trust level is determined by the type, quantity, quality and consistency of evidence.
- The basis for the level of confidence is given as a combination of evidence (limited, moderate, solid) and agreement (low, moderate, and high).

Figure 6: Measuring Confidence Level



In Figure 7, the basis for the level of confidence is given as a combination of evidence (limited, moderate, solid) and agreement (low, moderate, and high). Confidence increases towards the upper right corner.

In general, the evidence is most robust when there are multiple, consistent independent lines of high quality (Mastrandrea et al., 2010).

- " Very high confidence " means that there is at least a 9 in 10 chance of the finding being correct.

Figure 7: Chances of a finding to be correct based on their confidence level

Trust Terminology	Degree of Confidence on Being Correct
Very High Trust	At least 9 in 10 possibilities
High Trust	Around 8 in 10 possibilities
Medium Level Trust	Around 5 in 10 possibilities
Low Trust	Around 2 in 10 possibilities
Very Low Trust	Less than 1 in 10 possibilities

Possibility

- It provides a calibrated language for describing quantitative uncertainty.
- The precision of scientific findings is defined using probabilities.
- It can be used to predict the probability of occurrence of a single event or an outcome (for example, a climate parameter, an observed trend, or a predicted change over a certain range).
- Probability can be based on statistical or modeling analysis, the emergence of expert opinion, or other quantitative analysis.

Figure 8: Likelihood Scale

Probability Scale	
almost certain	99-100% Probability
Very Possible	90-100% Probability
Possible	66-100% Probability
Almost Unlikely	33-66% Probability
Unlikely	0-33% Probability
Very Unlikely	0-10% Probability
Almost impossible	0-1% Probability

The categories defined in this table can be considered to have "fuzzy" boundaries. The statement that an outcome is "probable" means that the probability of that outcome can range from ≥ 66% (implied fuzzy limits) to 100% probability.

In the absence of probable evidence to support climate change;

- Impact and vulnerability evaluations,
- Scenarios and
- Other qualitative explanations of future changes

are often used.

Scenarios:

Scenarios are plausible descriptions of how the future might evolve, prepared based on a rational and consistent set of assumptions about the fundamental driving forces (eg, rate of technological change, prices) and relationships.

Scenarios are neither predictions nor projections.

They give an idea of the consequences of developments and actions.

Pathways:

Pathways describe the temporal evolution of natural and / or human systems towards a future state.

The concepts of the path range from quantitative and qualitative scenarios (or narratives) of potential futures to solution-oriented decision-making processes aiming at desired societal goals.

Pathway approaches typically focus on biophysical, techno-economic and/or socio-behavioral trajectories.

Pathway approaches involve various dynamics, goals and actors at different scales.

Emission Scenarios:

The future development of greenhouse gas and aerosol emissions is based on a logical and consistent set of assumptions such as drivers (demographic and socioeconomic development, technological change) and their fundamental relationships.

Concentration scenarios derived from emission scenarios are used as inputs to climate models to calculate climate projections at multiple scales.

Representative Concentration Pathways- RCPs are a series of scenarios developed independent of IPCC AR5 (2014).

The word representative indicates that each RCP provides only one of many possible scenarios that could result in special radiation forcing properties. These are referred to as ways to emphasize that there are inherently consistent (time-dependent) forcing projections that can potentially be realized with multiple underlying socioeconomic scenarios, not precise scenarios.

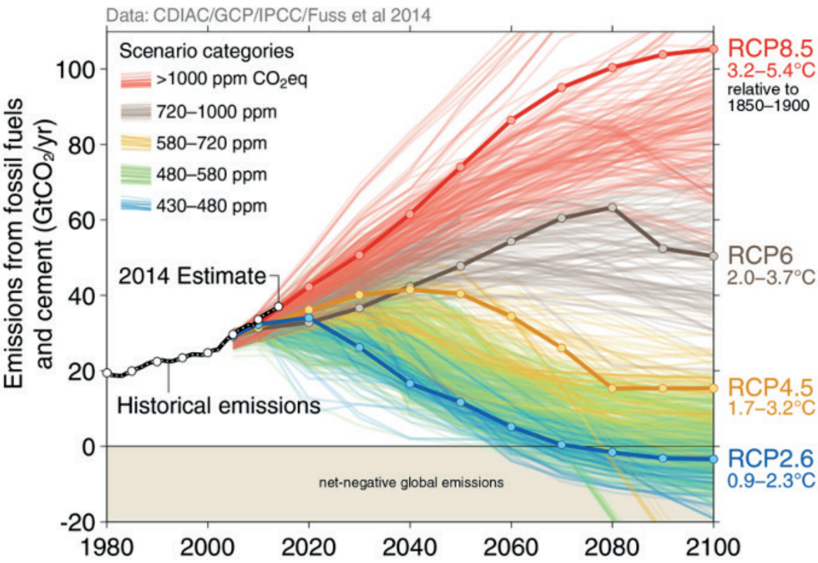
The number after the RCP abbreviation defines the approximate value of the radiation forcing (in terms of W m - 2) expected to be reached in 2100 (IPCC AR5, 2013).

Four RCPs have been selected and used for climate predictions and projections in IPCC AR5: RCP2.6 (tight mitigation); RCP4.5 and RCP6.0 (intermediate stabilization scenarios); and RCP8.5 (very high greenhouse gas emissions).

RCPs have been developed using Integrated Assessment Models (IAM) as input to a wide variety of climate model simulations to reflect their results for the climate system.

Climate projections are used for impact and adaptation assessments (IPCC AR5, 2014).

Figure 9: Change in fossil fuel emissions by years and different RCPs



As seen in Figure 9, scenarios created with different RCPs revealed different emission projections for the future. From here, it can be concluded that the current situation is in the way of "RCP 8.5" shown in red, and in this case, the worst scenario envisaged in the current situation is being experienced.

Socio-economic scenarios (SSP)

It defines a possible future for understanding the effects of climate change from national to local level in terms of population, gross domestic product and other socioeconomic factors.

Socio-economic pathways have been developed to complement RCPs with changing socio-economic challenges for adaptation and mitigation measures (O'Neill et al., 2014).

Based on five narratives, SSPs describe alternative socio-economic futures in the absence of climate policy intervention that includes sustainable development (SSP1), regional competition (SSP3), inequality (SSP4), fossil-fueled development (SSP5), and a median.

The combination of SSP-based socio-economic scenarios and RCP-based climate projections provides an integrative framework for climate impact and policy analysis.

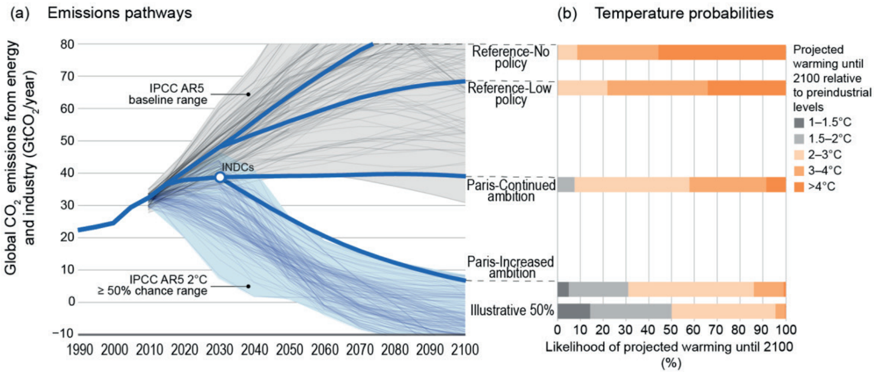
Climate Projections:

They are the simulated responses of the climate system (or a climate-sensitive system) to future emission or concentration scenarios of greenhouse gases and aerosols, often derived using climate models.

Climate projections often serve as raw materials for the creation of climate (change) scenarios, but these often require additional information such as the current climate observed.

For applications that inform important policy decisions or important investment decisions, it is recommended that decision makers use all available climate change (and impacts) scenarios and model information.

Figure 10: Projection of global carbon dioxide emissions and expected temperature changes by years



In Figure 10, the projection of carbon dioxide emissions originating from energy and industry during the period from 1990 to 2100 and the number of temperature changes that can be expected as a result of these emissions are shown. As can be seen here, uncertainties exist and climate change scenarios or Socioeconomic scenarios are used by analysts to assess future vulnerability to climate change.

Generating scenarios requires predictions of future population levels, economic activity, governance structure, social values, and technological change patterns.

Economic and energy modeling can be used to analyze and measure the effects of such drives.

5. WHAT ARE THE UNCERTAINTY FACTORS?

Uncertainty management is an integral part of risk management, as the lack of complete information is a common feature in all areas of science and policymaking.

Decision-makers must be aware of the degree of uncertainty associated with particular data sources in order to take into account reasonable improvements in their decisions.

Uncertainties should not prevent decisions from being made (EEA, 2017).

Different approaches have been developed to deal with planning uncertainty.

Some useful approaches and principles to apply when making compliance decisions with natural uncertainty may include:

<u>Scenario Planning:</u>

- Adaptive Management,
- Robust or Durable Strategies,
- Options that minimize application costs
- Faced with uncertainty, decision makers may choose to consider more than one reasonable outcome.
- The scenarios offer a range of different, plausible future conditions.
- Then, decision analysis is done to compare how well the scenarios are performing under different future conditions.
- In addition to providing a useful definition of uncertainty, scenarios can provide clarity in the decision-making process.

Adaptive Management:

It involves choosing a strategy that can be changed to achieve better performance as you learn more about the issues at hand and how the future will emerge.

A key feature of adaptive management is that decision makers seek strategies that can be changed after gaining new insights from experience and research.

Learning, experimentation and evaluation are essential elements of this approach and must be actively planned in decision making.

Robust or Durable Strategies:

This approach determines the range of possible future conditions that may be encountered in the future.

It then tries to identify strategies that will work quite well in this range.

A solid strategy can be defined as one that performs well over a wide variety of alternative futures.

Options that minimize application costs:

There are different options for decision makers when planning climate adaptation under uncertainty.

The most suitable option will depend on the nature of the decision made, its sensitivity to specific climate impacts and the level of risk that can be tolerated.

However, when determining adaptation options, decision makers may prefer to prioritize those that minimize implementation costs.

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UNCERTAINTY AND RISK MANAGEMENT: RISK

Prof. Dr. Erdem Görgün

1. IS CLIMATE CHANGE A RISK MANAGEMENT PROBLEM?

Since the 1850s, temperatures have been increasing steadily compared to the averages of the previous 30 years. According to recent studies by the Intergovernmental Panel on Climate Change (IPCC), the world's average surface temperature is expected to continue to rise for the rest of the 21st century.

According to the pre-industrial period, the global average surface temperature increase is predicted to be in the range of 1,5-4,8 °C until 2100. Greenhouse gas emissions released into the atmosphere until today will continue to contribute to global warming until 2050.

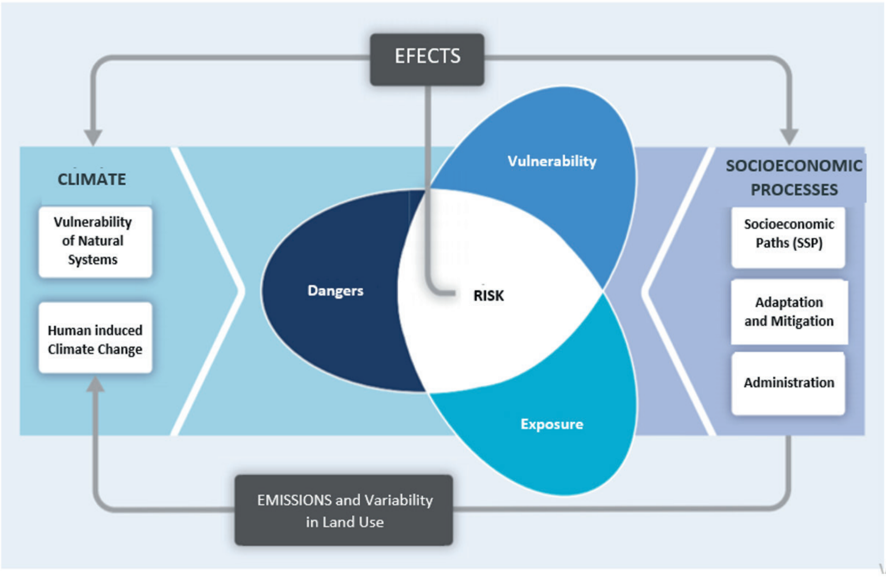
Even if greenhouse gas emissions are completely stopped today, warming will continue.

2. WHAT IS THE RISK?

Climate risks arise as a result of the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems.

As could be seen in Figure 1, adaptation and mitigation, including both the climate system and socio-economic processes, cause exposure and vulnerability.

Figure 1: Diagram of the interaction between the physical climate system, exposure, and risks that produce vulnerability



Risk is a state of uncertainty where some possible consequences create an undesirable effect or significant loss.

Risk can also be identified as potential for adverse consequences on life, livelihoods, health, ecosystems, economic, social and cultural assets, services and infrastructure when the outcome is uncertain.

The concept of risk integrates the dimensions of probability and uncertainty with the material and normative dimensions that shape social responses to threats (Renn, 2008).

Risk is also subjective. It is based on the knowledge and perception people have about a particular situation.

Adjustments in climate policies may pose risks. Major risks in climate change lead to instability and insecurity in economic systems that threaten adequate social welfare due to the inability to adapt to changes in the environment.

The risk of climate change depends on the decisions (intentional or unintentional) of the decision-makers who manage the interdependencies between climatic and socio-economic-environmental systems as well as climatic factors.

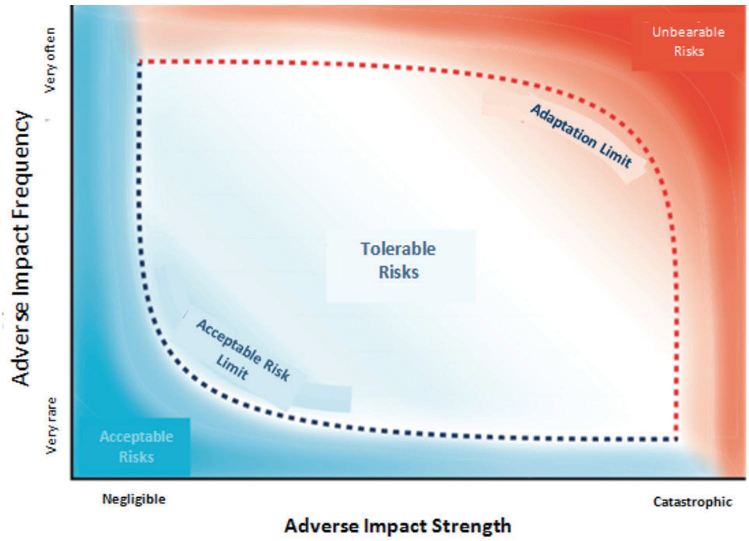
Inadequate decisions can spread systemic risk across all systems.

3. RISK CATEGORIES

Generally, 3 broad categories of risk are used (Klinke and Renn, 2002):

- Acceptable risks,
- Tolerable risks,
- Intolerable risks (exceeding the socially negotiated norm)

Figure 2: Conceptual model of determinants of acceptable, tolerable and intolerable risks and their impact on compliance constraints.



In the conceptual diagram shown in Figure 2, it is seen that adaptation efforts keep the objectives and risks within the tolerable risk area. Opportunities and constraints affect actors' capacity to keep risks within a tolerable range.

The dashed lines show that individual or collective views on the frequency and intensity of climate-related risks and risk tolerance are not fixed, but may change over time.

Shaded areas represent potential differences in perspective between actors.

Acceptable Risks:

Risks that are considered low so that additional risk reduction efforts are not considered necessary.

Tolerable Risks:

It relates to situations where adaptive risk management efforts are required and effective to keep risks at reasonable levels.

The extent of risks that fall into the tolerable area is affected by opportunities and constraints for adaptation.

The classification of risks varies in spatial, judgment and time.

Opportunities and constraints can be physical, technological, economic, institutional, legal, cultural or environmental in nature.

Intolerable Risks:

Risks that exceed the socially negotiated norm (eg availability of clean drinking water) or a value (eg continuity of a lifestyle).

Intolerable risks may be related to threats to key social goals associated with health, well-being, security or sustainability (Klinke and Renn, 2002; Renn, 2008; Dow et al., 2013a, b).

When feasible or affordable adaptation options are not available to avoid increased risks, the risks become intolerable.

Some adaptive transformations should be performed to avoid intolerable risks.

The type of risk depends on the degree of potential impact as well as its probability (frequency).

Low probability catastrophic events can have the same high degree of risk as very likely events of moderate impact.

The boundaries have a fuzzy nature due to the qualitative definition of acceptable, tolerable and intolerable risks.

Adaptation can be seen as an action aimed at maintaining the position of a valuable target (such as a technical flood protection norm) given within a tolerable area relative to the risk area shown in the figure.

In complex integrated systems, acceptable risk in one industry can spread to a catastrophic event in a different industry, thus posing an intolerable risk in the entire system.

4. UNDERESTIMATING THE RISK

Models are inevitably simplifications and approaches, so there is no single climate change model.

Models tend to underestimate uncertainty.

Most models tend to ignore a wide variety of effects that are difficult to measure.

They likely tend to systematically underestimate risk. Therefore, the probability of warming up to 4 °C or 6 °C may be higher than models estimate.

The development of climate policy over the last 30 years is based on Integrated Evaluation Models (IEM), which attempt to combine physical climate effects with social and economic models.

No matter how low the consideration value of a probability is, decision-makers can only assess the degree of risk by understanding all scenarios, especially worst-case scenarios.

5. RISK ANALYSIS FOR ADAPTATION TO CLIMATE CHANGE

Risk analysis first includes identifying malfunctions, operational errors and external events that could lead to accidents in the system (for example, excessive flooding may cause dam failure).

Then, it requires analyzing in a more detailed manner the accidents that are more critical in terms of frequencies and/or results (e.g., to reduce the crop yield of product due to reduced precipitation systemically or rare droughts that destroy crops completely).

The ultimate goal of risk analysis is to define and measure the impact of accidents and failures of the systems examined.

Risk analysis contributes to estimating the potential impact of climate change and to the process of evaluating the capacity to adapt to local vulnerability.

Major risks in climate change lead to instability and insecurity in economic systems that threaten adequate social welfare due to the inability to adapt to changes in the environment.

Risks are affected from climatic and anthropogenic uncertainties, i.e. dependencies between natural and human systems, representatives' decisions, etc.

Improper adaptation decisions can further trigger the spread of risk in dependent economic systems, thereby causing systemic risks that magnify “initial” risks.

The risk assessment of a system can be determined by five analytical processes:

- Definition and modeling of integrated systems (e.g. integrated climate and land-use systems),
- Identification of natural (droughts, floods, heatwaves, etc.) and man-made (non-compliance policies) events that trigger systemic risks and jeopardize the operation of safe systems,
- Numerical analysis of accidents caused by the initiation of events (i.e. estimation of their probability/frequency and consequences)
- Introduction of appropriate risk measures (security, safety, reliability, etc.) that ensure the operation of safe systems,
- Evaluation of viable robust, interdependent adaptation options.

According to IPCC 5. Evaluation Report, risk levels are defined as:

- Medium
- High
- Very High

(IPCC WGII AR5 Summary for Policymakers)

Additional risk levels due to climate change have been estimated for different climate change impacts, depending on global mean temperature change.

Figure 3: Historical and projected global annual mean surface temperature change

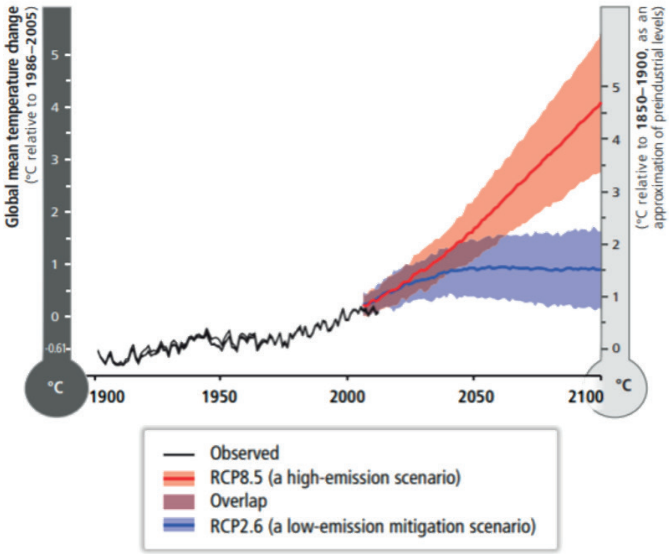
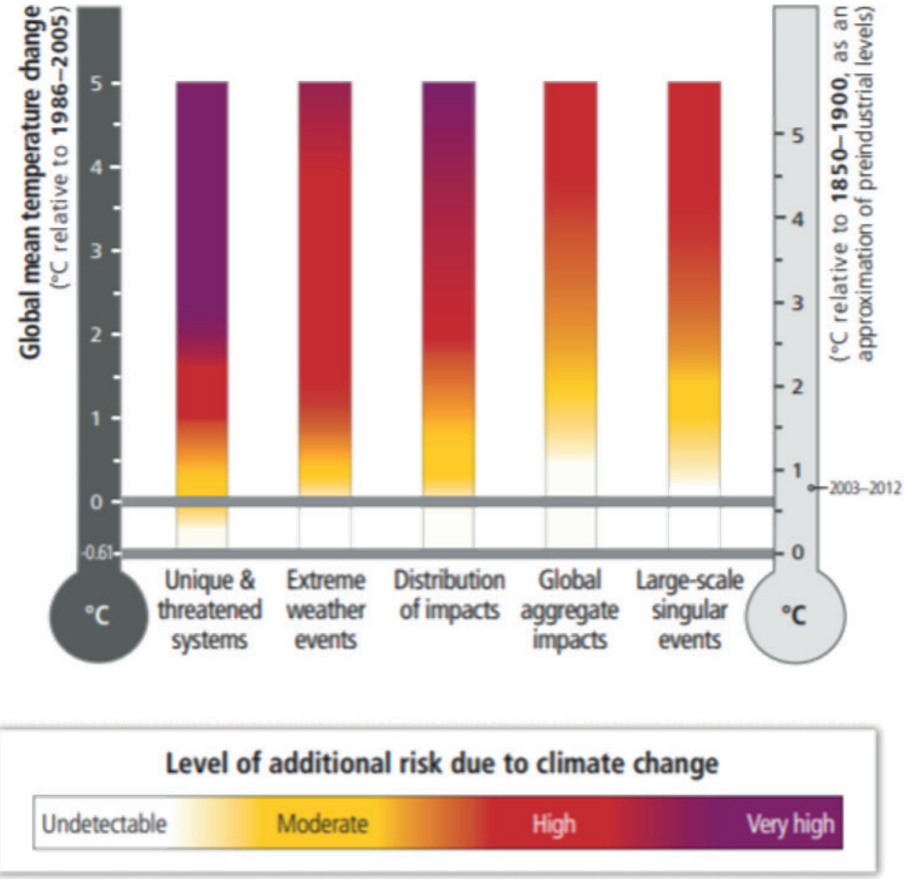


Figure 3 shows three different paths. The part shown in black represents the global average temperature changes measured so far. The scenario with a dramatic increase is the pessimistic scenario, where the surface average temperature change is foreseen to increase up to 5ºC. On the other hand, the scenario showing that the increase will stop after a certain year is an optimistic scenario and it foresees a maximum temperature increase of 2ºC.

Five holistic reasons for concern (Reasons For Concerns-RFC) provide a framework for summarizing key risks across industries and regions. RFCs first defined in the IPCC 3rd Assessment Report , illustrate the effects of warming and adaptation limits for people, economies and ecosystems.

Figure 4: RFCs and risk levels against climate change



The x-axis of the graph in Figure 4 "Reasons For Concerns (RFC)" represents five holistic reasons for concern. In the figure, from light to dark, the risk levels caused by climate change increase.

RFCs provide a starting point for evaluating dangerous anthropogenic interactions with the climate system.

Five holistic reasons for concern (Reasons For Concerns-RFC):

- 1Unique and threatened systems
- Extreme Weather Events
- Distribution of effects
- Global aggregate effects
- Large-scale single events

1. Unique and threatened systems

Some unique and threatened systems, including ecosystems and cultures, are already at risk from climate change.

With additional warming of about 1 °C, the number of such systems with serious risk is higher.

Many species and systems capable of adaptation are subject to very high risks with additional warming of 2 °C, particularly Arctic-sea-ice and coral reef systems.

2. Extreme Weather Events

The risks associated with climate change from extreme events such as heatwaves, extreme rainfall and coastal floods are already moderate and high with 1 °C additional warming.

The risks associated with certain extreme events (e.g. extreme temperatures) increase further at high temperatures.

3. Distribution of effects

Risks are unevenly distributed and are generally more for disadvantaged people and communities in countries of all development levels.

Risks are already moderate, especially due to regionally differentiated climate change impacts on crop production.

Due to projected decreases in regional crop yields and water availability, the risk of unevenly distributed impact is high for additional warming above 2 °C.

4. Global aggregate effects:

The risks of global aggregate impacts are moderate for additional warming between 1-2 °C, reflecting impacts on both Earth's biodiversity and the overall global economy.

Excessive loss of biodiversity, along with the loss of ecosystem goods and services, causes high risks with around 3 °C additional warming

Overall economic losses accelerate with increasing temperature, but several quantitative estimates have been completed for additional warming of 3 °C or more.

5. Large-scale single events:

With increasing warming, some physical systems or ecosystems may be at risk of sudden and irreversible changes.

As the temperature increases with additional warming of 1-2 °C, the risks increase disproportionately due to the potential for a large and irreversible sea level rise from ice sheet loss.

Additional risk levels due to climate change have been estimated for different climate change impacts, depending on global mean temperature change.

Undetectable risk (White): It shows that the associated effects cannot be detected and can be attributed to climate change.

Moderate risk (Yellow): It shows that the associated effects are both attributable to climate change with at least moderate confidence, and also could be related.

It also takes into account other specific criteria for key risks.

High risk (red): It shows serious and widespread effects.

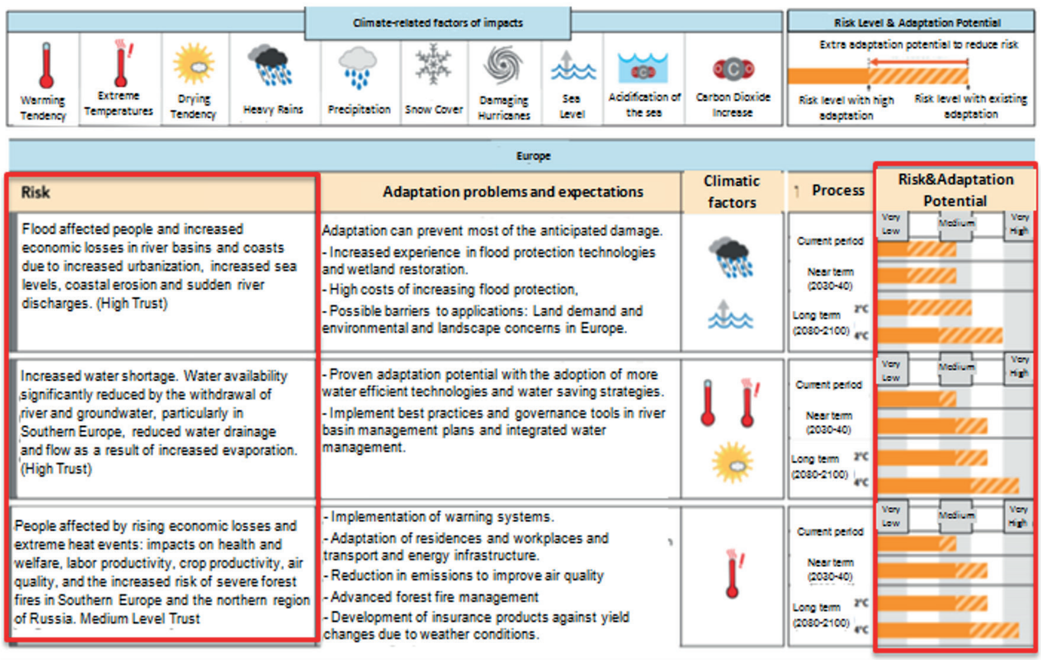
It also takes into account other specific criteria for key risks.

Very high risk (Purple): It shows that very high risk is specified by all specific criteria for key risks (IPCC, 2014).

6. REGIONAL RISKS AND ADAPTATION ARISING FROM CLIMATE CHANGE

Each key risk is characterized by very low to very high for three-time frames. The current period, near-term 2030-2040 and longer-term 2080-2100. In the near term, projected global average temperature rise levels do not differ significantly for different emission scenarios. In the long run, risk levels are presented for two scenarios of global average temperature increase (2 °C and 4 °C above pre-industrial levels). These scenarios show the potential for mitigation and adaptation to mitigate the risks associated with climate change.

Figure 5: Regional risks arising from climate change and the potential to reduce risks through adaptation and mitigation



Climate Risk Management and Adaptation Tools

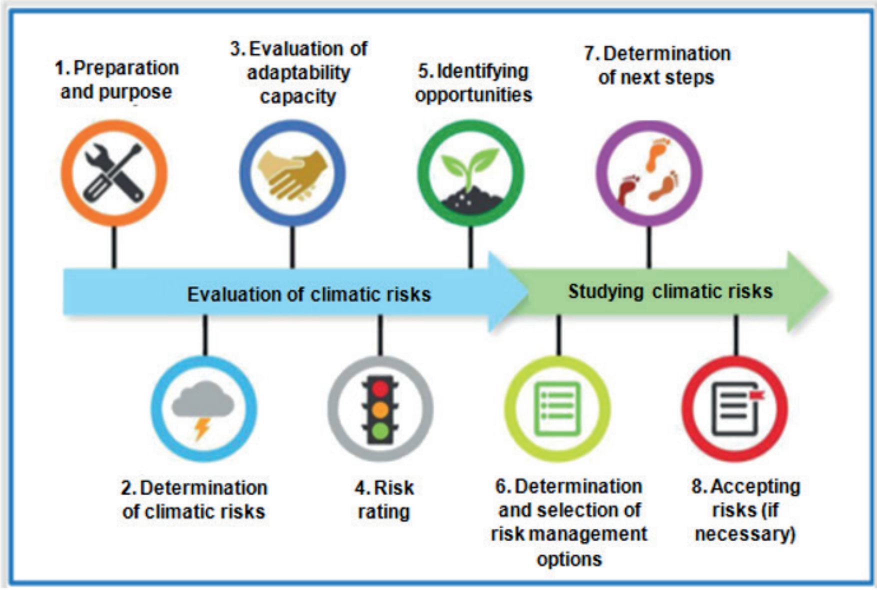
There are two basic goals in combating climate change. The first is the reduction of greenhouse gas emissions (GHG), the other is the process of combating the effects of climate events, developing, strengthening and implementing climate risk management and benefit strategies (IPCC, 2007). This process is called the adaptation process in short. The stages of this process are represented visually in Figure 6 with an example taken from the ClimateADAPT Platform.

Figure 6: ClimateADAPT Platform, visual representation of the stages in the adaptation policy cycle

Resources: Makinen et al., 2018

USAID (USA International Development) has developed tools to support climate risk screening and management in strategy, project and activity design. These tools aim to increase the effectiveness and sustainability of development interventions by helping the user assess and address climate risk.

Figure 7: An example of an adaptation process from USA International Development



Resources: USAID, 2017

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