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GREENHOUSE GAS EMISSIONS AND CLIMATE CHANGE VULNERABILITIES OF CERTAIN EUROPEAN COUNTRIES

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Abstract

Climate Change is the most important and the most complex environmental problem. There are two ways to deal with climate change: mitigation of Greenhouse gases (GHG) emissions and adaptation to new climatic conditions. To achieve mitigation goals, accurate quantification of GHG is required. For this reason, GHG emission inventories are prepared. In order to calculate all GHG emissions in the same unit (carbon dioxide equal) Global Warming Potential (GWP) is used. Adapting to new climatic conditions is more difficult. It must be known that, which sectors will be affected from climate change. Vulnerabilities of sectors are important in climate change adaptation.
In this article, we firstly gave information about GWP. Then, GHG emission inventories of European Union member states and Turkey are represented and evaluated for the years 1990 and 2014. Finally, climate change vulnerabilities of certain European Union countries and Turkey are discussed. We mainly focused on the vulnerabilities of agriculture, forestry, water resources and human health sectors as a result of temperature and precipitation changes under the influence of man-made climate change.

***Key words**: climate change vulnerabilities, Europe, greenhouse gas emissions, national communication reports, Turkey*

INTRODUCTION

Two or three decades ago, air pollution was considered as a local environmental problem (Ramanatan and Feng, 2009). However, today we know that air pollutants are transported via long range transport and air pollution has no boundaries. It can create regional and global environmental problems.
Climate change, global scale air pollution, affects all of the Earth. Greenhouse gases (GHG) absorb and emit thermal infrared radiation and enhance the natural greenhouse effect. Therefore, these gases keep the temperature in the atmosphere and warm the planet (Shine and Forster, 1999; Ramanatan and Feng, 2009). Carbon dioxide (CO_2), methane (CH_4), dinitrogen monoxide or nitrous oxide (N_2O) and water vapour are natural greenhouse gases. Tropospheric ozone (O_3) and other synthetic gases like sulphur hexafluoride (SF_6), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and perfluorocarbons (PFCs) are other greenhouse gases.
Stratospheric ozone and aerosols (except black carbon) have cooling effects on atmosphere (Shine and Forster, 1999). Increasing temperatures, changing precipitation patterns and extreme weather events alter the climate. Tol (2009) stated that climate change affects many aspects of the nature including agriculture, energy use and human health which in turn affects everything and everyone.
Fossil fuel use and destruction of forests (sinks of carbon dioxide) are the main causes of man-made climate change (Tunç et al., 2007). There are two ways to cope with climate change: reducing GHG emissions and adaptation to new climatic conditions. In order to reduce emissions, quantification of GHG is important. To do this, GHG emission inventories are prepared and some target values are set. After that, emission reduction is achieved by using cleaner fuels (shifting from fossil fuels to alternative energy resources), cleaner production, CO_2 capture and applying the principles of sustainable development. Adaptation to new climatic conditions is more difficult. To be adapted to new conditions, it must be known that how climate change affects our lives. Following sectors will be affected from climate change: coastal resources, agriculture, forestry, marine ecosystems, terrestrial ecosystems, water resources, human

health, tourism and energy (Hitz and Smith, 2004).

In the next sections in this paper, we focused on how to quantify GHG emissions in common unit and how GHG emissions inventories are prepared. Global Warming Potential term is discussed in Materials and Methods section. Also, the information is given how GHG emission inventories are prepared according to the Intergovernmental Panel on Climate Change (IPPC) methodology. Furthermore, the Vulnerability term is explained to understand the effects of climate change.

In Results and Discussion part, we represent the GHG emission inventory of European Union (EU) countries and Turkey. Then, we focused on the climate change vulnerabilities of some EU countries and Turkey. The sectors will be affected from climate change are discussed in detail. At the end of the paper, there exists a brief conclusion.

MATERIALS AND METHODS

Global Warming Potential (GWP)

In order to quantify the greenhouse gas emissions a common scale is needed. Generally CO_2 is taken as a reference gas. The amounts of other gases are converted into "CO_2-equivalent" by means of their Global Warming Potential (GWP) values.

IPCC defines GWP as "an index of the total energy added to the climate system by a component in question relative to that added by CO_2".

Global Warming Potentials of some greenhouse gases are represented in Table 1 (Myhre et al., 2013). According to the Table 1, GWP of CH_4 is 28, which means a single methane molecule is effective as 28 molecules of CO_2 in radiative forcing (the net change in energy balance between two reference years).

Table 1.Global warming potentials of some greenhouse gases (Myhre et al., 2013)

Gas	Lifetime (years)	GWP (100 years horizon)
CO_2	5 ~ 200	1
CH_4	12.4	28
HCF-134a	13.4	1300
CFC-11	45	4660
N_2O	121	265
CF_4	50000	6630

GHG Emission Inventories

Emission inventory is defined as systematic collection of all emissions from all sectors within a known boundary for a certain period of time (Elbir et al., 2000).The amount of emission is calculated by simply multiplying the activity with emission factor (Salt and Moran, 1997).

Intergovernmental Panel on Climate Change (IPPC) studies the effects of climate change. It is responsible for building worldwide GHG emission inventory.Each member state of United Nations has to use "Guidelines for National Greenhouse Gas Inventories" or "IPCC Guidelines" reference document to report GHG emissions. IPPC developed three approach named as Tier 1, Tier 2 and Tier 3. Tier 1 is basic approach and applied if data is insufficient (El-Fadel and Bou-Zeid, 1999). Tier 1 approach is generally for underdeveloped countries. When more data is available, Tier 2 or Tier 3 methodologies are used. Since nitrogen oxides (NOx), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) are tropospheric ozone precursors; these gases are also included in inventory.

GHG emissions from following source categories are calculated in emission inventory:

- Public electricity and heat production;
- Residential fuels;
- Commercial/institutional fuels;
- Road transportation;
- Production of aluminum, cement, nitric acid, fluorochemicals, iron and steel, acidic acid;
- Coal mining and handling;
- Refrigeration and air conditioning;
- Fugitive emissions from natural gas;
- Enteric fermentation: dairy cattle;
- Agricultural activities;
- Waste disposal sites;
- Manufacturing industries (excluding iron and steel).

In order to evaluate GHG emissions of EU countries, emission inventory is directly taken from "Annual European Union greenhouse gas inventory 1990-2014 and inventory report 2016" (EEA, 2016).

GHG emissions of Turkey are added for comparison. Emissions of 1990 and 2014 are

compared. 1990 is the reference year according to the Kyoto Protocol and latest data is available for 2014. Population statistics are obtained from EuroStat for the year 2014 (EuroStat, 2017). Per capita GHG emissions are calculated by dividing emissions to population.

Climate Change Vulnerabilities

GHG emissions are needed be reduced to avoid the adverse effects of climate change (EEA, 2017a). However, if all CO_2 emissions are cut today, climate change will still take place due to the irreversible CO_2 concentration in atmosphere for 1000 years (Solomon et al., 2008). Therefore, we need to adapt to a new climatic conditions. In order to apply necessary precautions for climate change adaptation, climate change vulnerabilities of each sector must be estimated.European Environmental Agency defines "vulnerability" as "The degree to which a system is susceptible to and unable to cope with, injury, damage or harm" (EEA, 2017b). De Lange et al., (2010) defines vulnerability as a function of exposure, effect and recovery. Each member state of UN has to submit "National Communication Report on Climate Change" to UN. These reports are downloadable from UN web site (http://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php). In 6th section of these reports,"effects, affectability and vulnerabilities"subjects are discussed. We have selected some of the EU-28 member states (Austria, Bulgaria, Finland, France, Germany, Italy, Lithuanian, Netherlands and Romania) and Turkey. We examined the latest reports of these ten countries and evaluated the climate change vulnerabilities of Europe and Turkey.

RESULTS AND DISCUSSION

GHG Emission Inventory

GHG emissions of EU member states (28 countries), Iceland and Turkey are shown in Table 2. 1990 is used as a base year. Unless otherwise stated, all emissions are in CO_2-equivalent. In 2014, the highest amount of GHG is emitted from Germany (900.2 million tonnes). United Kingdom (523.7 million tonnes), Turkey (467.6 million tonnes) France (458.9 million tonnes) and Italy (418.6 million tonnes) follow Germany. On the other hand, all of these countries except Turkey have reduced their GHG emissions according to 1990 level. GHG emissions of Turkey have been increased by 148% in this period. Turkey has still using coal as a primary fuel in both heating and electricity production. Apart from Turkey, only 6 countries (Spain, Portugal, Ireland, Cyprus, Malta and Iceland) have emitted more GHG as compared to the reference year's emissions. However, in 2014 total emissions of these 6 countries are nearly the same as the emissions of Turkey. Lithuania, Latvia and Romania have achieved more than 50% reduction in their GHG emissions in 2014 relative to 1990 emissions.In 2014, approximately 78% of GHG emissions of EU-28 plus Iceland come from energy sector (EEA, 2016). 67% of GHG emissions of Turkey emitted from energy sector in 2013 (6thN.C. Turkey, 2016).

The amount of total GHG emission is not the only criterion to compare the contribution of countries. If we look at per capita emissions Luxembourg (19.6 tonnes), Estonia (16 tonnes), Iceland (14.1 tonnes), Ireland (12.7 tonnes) and Czech Republic (12 tonnes) are top 5 countries. Per capita emissions of 15 EU member states and Turkey are below EU average (8.4 tonnes). GHG emission per person value is 6.1 tonnes for Turkey. Romania has lowest per capita emission, which is 5.5 tonnes.

Climate Change Vulnerabilities

The regions that are vulnerable to current or future climate change are called "hotspots". Hotspots indicate that variability in temperature and precipitation, climate related disasters (cyclones, droughts, floods, wildfires and landslides), agriculture and food security, water scarcity and migrations (de Sherbinin, 2014). Giorgi (2006) stated that the Mediterranean and North Eastern European regions are primary hotspots. Decrease in precipitation and increase in temperature in dry season will make Mediterranean most vulnerable to climate change. Increase in winter precipitation and increase in mean temperature will be observed in North Eastern Europe (Giorgi, 2006). Increases in temperatures, variability in

precipitation, reduced snow and ice cover will make mountainous and coastal areas of Europe more vulnerable.

Vulnerabilities of some European Union member states and Turkey are listed in Table 3 (6th N. C. of Austria, Bulgaria, Finland, France, Germany, Italy, Lithuania, Netherlands, Romania and Turkey). Because of the space constrains we tabulated only temperature and precipitation change and vulnerabilities of agriculture, forestry, water resources and human health. Other sectors are discussed briefly.

Table 2.GHG emissions in million tonnes CO_2-equivalent (EEA, 2016)

Member State	1990 (million tonnes)	2014 (million tonnes)	Change 1990-2014 (%)	Population (2014)	Emission per capita (tonnes)
Austria	78.8	76.3	-3.2	8506889	9.0
Belgium	146.0	113.9	-22.0	11180840	10.2
Bulgaria	104.0	57.2	-45.0	7245677	7.9
Croatia	34.8	24.5	-29.7	4246809	5.8
Cyprus	5.7	8.4	47.9	858000	9.8
Czech Republic	199.3	125.9	-36.8	10512419	12.0
Denmark	70.7	51.2	-27.6	5627235	9.1
Estonia	40.0	21.1	-47.3	1315819	16.0
Finland	71.3	59.1	-17.1	5451270	10.8
France	548.1	458.9	-16.3	65942093	7.0
Germany	1246.1	900.2	-27.8	80767463	11.1
Greece	104.8	101.4	-3.3	10926807	9.3
Hungary	94.1	57.2	-39.2	9877365	5.8
Ireland	56.2	58.3	3.7	4605501	12.7
Italy	521.9	418.6	-19.8	60782668	6.9
Latvia	26.2	11.3	-56.9	2001468	5.6
Lithuania	47.1	19	-59.6	2943472	6.5
Luxembourg	12.9	10.8	-16.3	549680	19.6
Malta	2.0	3	49.1	425384	7.1
Netherlands	222.2	187.1	-15.8	16829289	11.1
Poland	472.9	380.3	-19.6	38017856	10.0
Portugal	60.7	64.6	6.5	10427301	6.2
Romania	251.9	109.8	-56.4	19947311	5.5
Slovakia	74.7	40.6	-45.6	5415949	7.5
Slovenia	18.6	16.6	-10.9	2061085	8.1
Spain	285.9	328.9	15.0	46512199	7.1
Sweden	71.9	54.4	-24.4	9644864	5.6
United Kingdom	796.6	523.7	-34.3	64351155	8.1
EU-28 (Total)	**5665.5**	**4282.1**	**-24.4**	**506973868**	**8.4**
Iceland	3.6	4.6	26.5	325671	14.1
Turkey	188.43	467.6	148.2	76667864	6.1

All investigated countries reported increasing temperatures in the future except Italy. No information about temperature or precipitation is given in Italy's report (Table 3). Precipitation estimates are different among the continent. Some countries like Austria and Finland reported rising precipitations. Bulgaria, France, Germany and Lithuania estimated variable precipitation patterns from season to season. Decreasing in precipitation amount is expected in Romania, Netherlands and Turkey. Turkey reported significant reduction in precipitation (Table 3). Reduced precipitation will create further problems salinization of aquifers, costal subsidence, water pollution and increase in water demand in agriculture. Water scarcity may also cause water use conflicts, human health related issues and reduced crop yields (Francés et al., 2017).

Tol (2009) studied economic effects of climate change and mentioned that 1 or 2°C warming may have a positive effect on welfare. Further

increase in temperatures will resulted in economic losses. Faster growing plant due to more CO_2 in atmosphere, reduction in heating costs and cold related diseases are initial benefits of early stage climate change, however, Tol (2009) called this benefits as "sunk benefits". Bulgaria and Germany reported that there may be some benefit from climate change in their agriculture. Most countries reported that agriculture is vulnerable because of water shortages, droughts, desertification, invasive species, diseases and pests (Table 3). Bär et al., (2015) investigated the vulnerability of agricultural water resources due to climate change in Black Sea catchment. Climate change may positively or negatively affect agriculture. Increasing temperature reduces freezing risk and enhances plant growth. On the other hand, extreme weather events, water scarcity, pests and diseases cause poor harvests. According to the results of this study, some countries (Turkey, Ukraine, Romania, Moldova, Hungary and Bulgaria) will benefit from climate change whereas some (Montenegro, Austria and Bosnia-Herzegovina) will suffer from worse climatic conditions. Catchment will become more suitable for natural plant growth, but less precipitation will reduce irrigation potential and agriculture will be affected negatively.

Effects of climate change on forests are similar to that of agriculture. Climate change may increase tree productivity whereas extreme weather events, risk of forest fires, droughts, pests and insects have adverse effects (Lindner et al., 2014). Hanewinkel et al., (2012) developed a model based on interest rate and climate scenario. They mentioned that in 2100, between 14 and 50% (mean: 28%) of European forest lands (excluding Russia) will be lost and that will result in several hundred billion Euro economic losses. All of the countries investigated reported the risk of forest fires (Table 3).

Sea level rise creates some problems in coastal areas and salinization in groundwater. Sea level rise is an important problem in Netherlands, which is located below sea level. Lithuania reported the invasion of sea water masses in to the Curonian Lagoon. Other vulnerabilities on water resources include floods, increasing evaporation from water masses, decreasing flow regimes of rivers, reduced water quality (Table 3).

Another important impact of climate change is human health related issues. Heat waves and cold related deaths are the most important effects of climate change on human health. Also, vector-borne diseases and water-borne disease after floods or water pollution affects human health (Haines et al., 2006; Thornton et al., 2014). Most countries reported the risk of heat waves related risk especially for children and elderly people. Vulnerabilities of allergens, food or water borne diseases, vector borne diseases are also mentioned (Table 3).

Many other sectors that are not mentioned here in detail will be affected from climate change. For example, summer tourism is vulnerable in Mediterranean region of Europe and Turkey as a result of heat extremes. Ski tourism in mountainous areas of Europe and Turkey is again vulnerable due to diminishing snow cover (EEA, 2017a). Although, the demand of energy for heating will be decrease in Northern and Western part of the continent, the demand of energy for cooling will rise in Central, Eastern and Mediterranean regions of Europe (EEA, 2017a).

CONCLUSIONS

Climate change is the most important and the most complex environmental problem. In order to deal with it, both mitigation of GHG and adaptation to a new climatic conditions are equally important. Mitigation of greenhouse gas release to the atmosphere can be achieved by either fuel change or using alternative energy resources. This also results in reduction in air pollutant emissions as a co-benefit (Bollen and Brink, 2014). However, many of the countries are not ready for fighting climate change even in Europe. Reckien et al., (2014) performed an analysis of 200 cities of Europe among 11 countries and reported that only a quarter of cities have both adaptation and mitigation plans. 35% of cities have no mitigation plans and 72% of cities have no adaptation plans. According to the Reckien et al., (2014) these actions will be insufficient to meet the goal of avoiding global mean temperature rising 2°C above pre-industrial levels.

Table 3. Vulnerabilities of some European Union member states and Turkey

Country	Temperature	Precipitation	Agriculture	Forestry	Water resources	Human health
Austria	• 0.25°C increase per decade	• Increase in the western and south-eastern parts	• New invasive species and pathogens may affect crop production	• Forest fires risk	• In southern and eastern Austria, a decrease in groundwater recharge is likely	• Vulnerability to heat stress is high for children, elder people and people with heart diseases
Bulgaria	• Increase between 5° and 8°C over most of the countries in the Balkan Peninsula (HadCM3 model for 2080)	• Winter precipitation will increase • Summer rainfall is expected to decrease	• Variation of gross agricultural outputis positive (11 % and 23 % for the different climate scenarios)	• Most of the Bulgarian forests would be vulnerable to the drastic climate change	• Annual river runoff is likely to decrease	
Finland	• Increase 2.4°C by 2040 and 3.6°C by 2080 (RCP4.5 scenario) • Increase 2.9°C and 5.8°C (RCP8.5 scenario)	• Increases in wintertime	• Improve crop productivity • The risk of animal diseases may also increase • Diseases associated with the poor quality of water may become more common	• Increase significantly both the growth and production of Finnish forests • Risk of forest fires may also increase in southern Finland • Damage caused by numerous pest insects and pathogenic fungi will likely increase	• Floods caused by spring snowmelt will decrease • Autumn and winter floods caused by precipitation	• Increase heat-related mortality and morbidity in summer
France	• Rise of between +1.4°C and +3 °C by the end of the 21st century	• Difficult to highlight, vary fromterritory to territory	• Losses for the agricultural	• Increased productivity of plants • Forest fires	• Decline in water resources in zones already under pressure • 10 to 25% decrease in water recharging a sea-level rise end of the 21st century	• Heatwaves
Germany	• Increase at least 0.5 °C for 2021-2050 • Increase at least 1.5 °C and at most 3.5 °C in Northern Germany and 4 °C in Southern Germany for 2071-2100	• Decrease in the summer whereas increase in the winter • 15% decrease for 2021-2050 • Up to 25% decrease for 2071-2100	• Agricultural yields will be affected • Central German Uplands or Northern Germany could benefit from gradual warming and longer vegetation periods.	• Heat and drought stress in summer • Extreme weather events can cause early leaf drop and slow growth • Wild fire may also increase		• Morbidity and infectious diseases • New health risks (e.g. posed by the oak processionary moth)
Italy			• Water shortages may reduce the productivity of most crops	• Possible reduction of about 50% of the habitats at the national level	• Reduced water availability and quality • Summer droughts, Limited groundwater recharge	• Elderly people and children are vulnerable to impacts
Lithuania	• Increase depending on the scenario can be 4-8 °C	• Small increase of precipitation amount per year • Decrease in summer precipitation	• Current species are not adapted to climate change	• Plant productivity will increase • Risk of forest fires	• Heavy showers, sudden thaws and frosts, long-lasting droughts • Rising sea level • Invasions of sea water masses in to the Curonian Lagoon	• Natural aerial-allergens will increase • Heat waves may cause serious health problems
Netherlands	• 80% chance of the average winter temperature will rise by between 0.9 and 2.3°C in 2050	• Dry summers will occur more frequently	• The agricultural sector is particularly wary of increasing risks for diseases and pests	• There is an increased risk of natural fires in summer.	• Rising sea level and salt water penetrating further inland pressure the rivers and groundwater • Vulnerable to flooding	• Flooding • Allergies • Summer smog • Infectious diseases • Heat stress, Water- and foodborne diseases

Table 3. Vulnerabilities of some European Union member states and Turkey (continue)

Romania	• Up to 1.3 °C increase in Eastern and Southern regions	• 10% decrease in South Eastern and South Western regions (A1B scenario)	• Extended droughts will likely affect Romanian territory in the growing season, with significant impact on agriculture activities.	• In the south and southeast desertification process will lead to unfavourable conditions for forest vegetation development • Risk of forest fires	• Increase of the evapotranspiration in summer • 10-20% decrease in flowing conditions of the rivers • Increase stress on water as needs for irrigations in agriculture	• Heat waves effects are more severe in high populated urban areas, Young people and older one are most vulnerable
Turkey	• Rise by 2-3°C in average	• Precipitation will significantly reduce	• Food production will be affected due to factors like desertification, increase in fire risk, fast spread of pests	• Forest fires	• Coastal erosion, flood and inundation • Algal blooms will also deteriorate the ecological balance in the lakes	• Deaths and injuries related to extreme climate events • Diseases transmitted via water and food • Respiratory diseases • Allergic diseases • Diseases transmitted by vectors and rodents

In this study, we evaluated the GHG emissions of European Union member states and Turkey. In 2014, Germany, United Kingdom, Turkey, France and Italy have biggest contribution on GHG emissions. Turkey has the greatest increase in GHG emissions between 1990 and 2014 since Turkish energy sector still depends on coal.

Many sectors seem to be vulnerable to climate change. In this paper, we only focused on agriculture, forestry, water resources and human health as a consequence of temperature and precipitation changes. Vulnerabilities vary from region to region. Some countries reported some benefits in agriculture and forestry. The most of the countries reported forest fire risk. Water resources are under the pressure of decreasing precipitation and increasing evaporations. Flow regimes of rivers, groundwater and water resources in coastal regions will certainly be affected. Finally, countries reported that human health is vulnerable because of heat waves.

REFERENCES

6thN.C. Austria, Sixth National Communication of Austria, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/aut_nc6.pdf, 2014

6thN.C.Bulgaria, Sixth National Communication of Bulgaria, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/vi_nc_bulgaria_2013_22102014_final_-_resubmission.pdf, 2014

6thN.C.Finland, Sixth National Communication of Finland, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/fi_nc6[1].pdf, 2013

6thN.C. France, Sixth National Communication of France, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/nc6_fra_english.pdf, 2015

6thN.C. Germany, Sixth National Communication of Germany, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/national_communication_eng_bf.pdf, 2014

6thN.C. Italy, Sixth National Communication of Italy, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/nc6_jpn_resubmission.pdf, 2014

6thN.C.Lithuania, Sixth National Communication of Lithuania, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/lithuania_6_nc_1br_unfccc_v_0.1[1].pdf, 2014

6thN.C.Netherlands, Sixth National Communication of Netherlands, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/the_netherlands_nc6[1].pdf, 2013

6thN.C.Romania, Sixth National Communication of Romania, http://unfccc.int/files/national_reports/annex_i_natcom/submitted_natcom/application/pdf/6th_nccc_and_1st_br_of_romania[1].pdf, 2013

6thN.C. Turkey, Sixth National Communication of Turkey, http://unfccc.int/files/national_reports/non-annex_i_natcom/application/pdf/6_bildirim_eng_11_reducedfilesize.pdf, 2016.

BärR., Rouholahnejad E., Rahman K., Abbaspour K.C., Lehmann A., 2015. Climatechangeandagriculturalwaterresources:AvulnerabilityassessmentoftheBlackSea catchment. Environmental Policy, 46, p. 57-69.

BollenJ., Brink C., 2014. Air pollution policy in Europe: Quantifying the interaction withgreenhouse gases and climate change policies. Energy Economics, 46,p. 202-215.

De Lange H. J.,Sala S., Vighi M., Faber J. H., 2010. Ecological vulnerability in risk assessment - A review and perspectives.Science of the Total Environment, 408,p. 3871-3879.

deSherbinin A., 2014. Climate change hotspots mapping: what have we learned?Climatic Change, 123, p. 23-37.

EEA, Annual European Union greenhouse gas inventory 1990–2014 and inventory report 2016. EEA Report No 15/2016, Luxembourg, 2016

EEA, Climate change, impacts and vulnerability in Europe 2016, An indicator-based report. EEA Report No 1/2017, Luxembourg, 2017a

EEA, European Environment Agency, Environmental Terminology and Discovery Service (ETDS), http://glossary.eea.europa.eu/terminology/concept_html?term=vulnerability, 2017b

Elbir T., Müezzinoğlu A., bayram A., 2000. Evaluation of some air pollution indicators in Turkey. Environment International, 26, p. 5-10.

El-Fadel M., Bou-Zeid,E., 1999. Transportation GHG emissions in developing countries.The case of Lebanon. Transportation Research Part D, 4, p. 251-264.

EuroStat, http://ec.europa.eu/eurostat/web/population-demography-migration-projections/population-data/database, 2017

Francés G. E.., Quevauviller P., González E. S. M., Amelin E. V., 2017. Climate change policy and water resources in the EU and Spain.A closer look into the Water Framework Directive.Environmental Science & Policy, 69, p. 1-12.

Giorgi F., 2006. Climate change hot-spots.Geophysical Research Letters, 33, L08707.

Haines A., Kovats R. S., Campbell-Lendrum D., Corvalan C., 2006. Climate change and human health: Impacts,vulnerability and public health. Public Health, 120, p. 585-596.

Hanewinkel M., Cullmann D.A., Schelhaas M.J., Nabuurs G.J., Zimmermann N.E.,2013. Climate change may cause severe loss in the economic value of European forest land. Nat. Clim. Change, 3, p. 203-207.

Hitz S., Smith J., 2004. Estimating global impacts from climate change.Global Environmental Change, 14,p. 201-218.

Lindner M., Fitzgerald J. B., Zimmermann N. E., Reyer C., Delzon S., van der Maaten E., Schelhaas M., Lasch P., Eggers J., van der Maaten-Theunissen M., Suckow F., Psomas A., Poulter B., Hanewinkel M., 2014. Climate change and European forests: What do we know, what are the uncertainties, and what are the implications for forest management?. Journal of Environmental Management, 146 (15),p. 69-83.

Myhre G., Shindell D.,Bréon F.-M., Collins W., Fuglestvedt J., HuangJ., KochD., LamarqueJ.-F., LeeD., MendozaB., NakajimaT., RobockA., StephensG., TakemuraT., ZhangH., 2013.Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., QinD., PlattnerG.-K., TignorM., AllenS.K., BoschungJ., NauelsA., XiaY., BexV., MidgleyP.M. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Ranamatan V., Feng Y., 2009. Air pollution, greenhouse gases and climate change: Global andregional perspectives. Atmospheric Environment, 43, p. 37-50.

Reckien D., Flacke J., Dawson R. J., Heidrich O., Olazabal M., Foley A., Hamann J. J. P., Orru H., Salvia M., De Gregorio Hurtado S., Genelleti D., Pietrapertosa F., 2014. Climate change response in Europe: what's the reality?Analysis of adaptation and mitigation plans from 200urban areas in 11 countries. Climatic Change, 122, p. 331-340.

Salt J.E., Moran, A., 1997. International greenhouse gas inventory systems: A comparison between CORINAIR and IPCC methodologies in the EU. Global Environmental Change, 7(4), p. 317-336.

Shine K.P., Forster P.M.F., 1999. The effect of human activity on radiative forcing of climatechange: a review of recent developments. Global and Planetary Change, 20,p. 205-225.

Solomon S., Plattner G.K., Knutti R., Friedlingstein P., 2008. Irreversible climate change due to carbondioxide emissions. PNAS, 106 (6), p. 1704-1709.

Thornton P. K.,Ericksen P. J., Herrero M., Challinor A. J., 2014. Climate variability and vulnerability to climate change: areview. Global Change Biology, 20, p .3313-3328.

Tol R. S. J., 2009. The Economic Effects of ClimateChange.Journal of Economic Perspectives, 23 (2), p. 29-51.

Tunç G.İ., Türüt-Aşık S., Akbostancı E., 2007. CO_2 emissions vs. CO_2 responsibility: An input–outputapproach for the Turkish economy. Energy Policy, 35, p. 855-868.

SECTION 02
SUSTAINABLE DEVELOPMENT OF RURAL AREA