

THE CLIMATE CHANGE AND AGRICULTURE – DIMENSIONS AND CORRELATIONS

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Abstract: Global climate changes are taking place and its impacts on economy are already occurring in fields like tourism, agriculture, forestry, infrastructure, insurance industry or capital market. Specialists draw attention that climate change has negative effects and positive effects. For example, in some parts of Europe, especially in north, the agricultural may benefit from temperature rise increasing carbon dioxide levels in the atmosphere. The most important part of these changes is due to greenhouse gas (GHG) emissions from human activity. Between greenhouse gases, carbon dioxide (CO₂) is the largest contributor with a weight around of 80% of total GHG emissions. The agriculture is the most affected sector by the climate change, but agricultural activities have many negative implications on environment through emissions of methane and nitrous oxide that result from changes in land use. Besides the negative impact, the agriculture may play a positive role to environment protection through the production of bio fuels.

Because of the huge implications of climate change on human activities, the public authorities have made important steps in order to control this phenomenon, to reduce and prevent the negative impact.

Key words: climate change, agriculture, greenhouse gas emissions, environment

Introduction

The climate change is a complex and global phenomenon with many implications in economic, social and political life, because it has effects on agriculture; water resources, water supply and water quality; on energy use, ecosystems, human health and impacts of sea level rise or from drought; flooding; storm damage and extreme weather (including costs to infrastructure) etc. In addition, the climate change affects the depletion of the ozone layer and biodiversity and, in the future, it will be the main driver of biodiversity loss.

Materials and Methods

1. Climate change – an economic, social and political challenge

It is difficult to measure the economic impact of climate change but, there are available some statistics that demonstrate that the climate change has many consequences, for example:

- Since 1980 until 2004, 64% of catastrophic events are directly correlated to weather and climate extremes;
- In the hot dry summer of 2003, a loss of 10% of glacier mass in the Alps had been registered;
- In Spain, the droughts of 1999 caused losses over euro 3 billion;

- In northern Europe, in period of 1990–2000, the annual precipitation has increased by 10–40% with high implications on flooding and landslides;
- The economic annual losses from climate events increase in the last 20 years from USD 5 billion to USD 11 billion;
- Climate extreme events have caused 82% of death determined by catastrophic events;
- Climate extremes are responsible for 79% of economic losses caused by catastrophic events.

The main manifestations of climate change are the temperature's increase and the rise of sea level. The global warming is due, to some extent, to natural factors, but the most important determinant is the human activity through the emission of greenhouse gas. The climate change has many effects on economic and social life, because it affects human health, natural ecosystems, biodiversity etc.

The specialists are not concerned only in the past climate change impact but also in projected climate change impacts. Some climate changes like higher CO₂ concentrations, higher temperatures, sea level rise, storms, floods, droughts will have multiple consequences:

- The increase in tick borne diseases caused by the rise of temperature;
- The increase of vulnerability in insurance industry

due to the increase in intensity and frequency of climate change events;

- The agricultural area will expand northwards, in long terms;
- The increase of CO₂ concentrations and the rise of temperatures will have a positive impacts on European agriculture;
- The rise of sea level will determine flooding and costal erosion;
- The increased crop yield in northern areas and the cut of s crop yield in hotter and dryer regions from Europe.

For these reasons, at international level, there are scientific and political concerns regarding the climate change and the measures that have to adopt in order to limit these climate problems. The efforts made at international and regional level are important. The main results is the conclusion of Kyoto Protocol, under the United Nations Framework Convention on Climate Change, that sets binding emission targets for a basket

of six GHGs. This protocol has three mechanisms: Joint Implementation (JI), Clean Development Mechanism (CDM) and international emissions trading (EEA, 2007, p. 169). In addition, at international level, many green investments schemes (GIS) have been promoted (for example, the EU emissions trading scheme introduced in 2005 and the Carbon Pollution Reduction Scheme from Australia starts in 2010).

The European Union is highly implicated in international negotiations and takes many measures in order to support the fulfillment of Kyoto Protocol commitments. In addition, on European continent, we remark the adoption of multiple programs and measures in order to reduce the GHGs emission. For example, in Turkey and Ukraine, the important efforts have been made for modernization of the steel and cement industry, in European Union, the use of fertilizers is reduced and the number of cattle is decreasing, but the cattle productivity is increasing in order to contribute to the decline of CH₄ emissions.

Table 1. Emissions of greenhouse gases in the European Union countries

Year	Emissions of carbon dioxide (million tones)		Emissions of carbon monoxide (million tones)		Emissions of methane (million tones)		Emissions of sulphur oxides (million tones of SO ₂ equivalent)		Emissions of nitrogen oxides (million tones of NO ₂ equivalent)	
	1995	2005	1995	2005	1995	2005	1995	2005	1995	2005
EU-27	4,165.2	4,269.0	51.08	31.89	25.73	19.94	17.16	8.28	14.60	11.29
Belgium	123.7	123.3	1.11	0.88	0.51	0.37	0.26	0.15	0.37	0.29
Bulgaria	65.9	54.8	0.85	0.74	0.71	0.49	1.48	0.90	0.27	0.23
Czech Republic	132.1	125.9	1.00	0.51	0.64	0.52	1.09	0.22	0.37	0.28
Denmark	60.5	50.4	0.71	0.61	0.28	0.27	0.14	0.02	0.26	0.19
Germany	921.2	872.9	6.53	4.03	3.88	2.27	1.73	0.56	2.17	1.44
Estonia	20.1	18.0	0.21	0.16	0.10	0.09	0.12	0.08	0.04	0.03
Ireland	35.5	47.3	0.32	0.23	0.65	0.62	0.16	0.07	0.12	0.12
Greece	87.4	111.7	1.32	0.64	0.44	0.40	0.54	0.53	0.32	0.32
Spain	255.6	368.3	3.22	2.38	1.46	1.77	1.81	1.36	1.33	1.53
France	390.1	412.5	9.57	5.68	3.30	2.68	0.97	0.47	1.65	1.21
Italy	445.7	493.4	7.17	4.21	2.10	1.91	1.32	0.50	1.81	1.17
Cyprus	5.6	7.8	0.10	0.04	0.04	0.05	0.04	0.04	0.02	0.02
Latvia	9.1	7.6	0.32	0.34	0.10	0.09	0.05	0.00	0.04	0.04
Lithuania	15.0	14.2	0.29	0.19	0.18	0.16	0.09	0.04	0.07	0.06
Luxembourg	9.2	11.9	0.11	0.04	0.02	0.02	0.01	0.00	0.02	0.01
Hungary	61.9	61.8	0.76	0.59	0.39	0.37	0.70	0.13	0.19	0.20
Malta	2.3	3.0	:	:	0.02	0.02	0.03	0.02	0.01	0.01
Netherlands	170.6	175.9	0.86	0.60	1.13	0.80	0.13	0.06	0.47	0.34
Austria	63.7	79.7	1.01	0.72	0.41	0.34	0.05	0.03	0.19	0.23
Poland	377.5	326.5	4.55	3.33	2.04	1.82	2.38	1.22	1.12	0.81
Portugal	53.1	67.9	0.85	0.65	0.59	0.53	0.33	0.21	0.27	0.28
Romania	134.8	110.5	2.09	1.41	1.49	1.23	0.89	0.73	0.32	0.31
Slovenia	14.9	16.7	0.09	0.08	0.10	0.10	0.13	0.04	0.07	0.06
Slovakia	43.8	39.9	0.42	0.30	0.23	0.20	0.25	0.09	0.18	0.10
Finland	58.2	57.0	0.44	0.52	0.29	0.21	0.10	0.07	0.26	0.18
Sweden	58.0	52.6	0.90	0.60	0.32	0.27	0.07	0.04	0.28	0.20
United Kingdom	549.8	557.6	6.30	2.42	4.30	2.36	2.32	0.71	2.38	1.63

Source: Eurostat, 2009

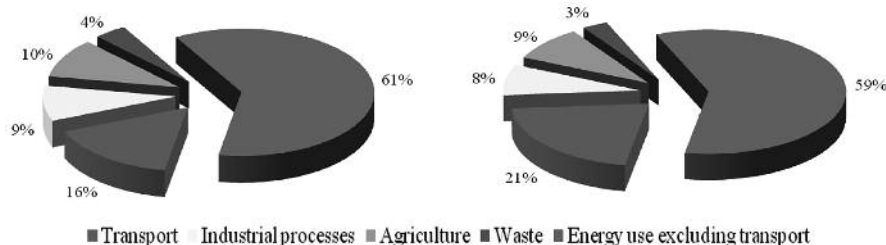


Figure 1. Greenhouse gas emissions by sector, EU-15, 1990 (based on data in million tones CO₂ equivalent)
Source: Adapted from Eurostat, 2009

Figure 2. Greenhouse gas emissions by sector, EU-15, 2005 (based on data in million tones CO₂ equivalent)
Source: Adapted from Eurostat, 2009

The results of these efforts can be observed in the *table 1*; the figures available for countries from European Union demonstrate the commitment of European authorities in order to respect the protocols and agreements signed.

The impact of economic activities on the emission of GHGs is not the same in all the countries from the European Union. The „contribution” of each country depends on the structure of economy and the dynamics of this structure taking in account the importance of sectors to the production of GHG.

If the emissions of greenhouse gases presented in table 1 are converted in emissions of carbon dioxide (*table 2*), we observed that the most important emissions belongs to developed countries from European Union like Germany, France, Italy and United Kingdom. So, we could say that the emission of GHGs is an indicator of development. In the top presented above, two new members of the European Union are presented due to their industrial development.

If we analyze the emission of carbon monoxide and carbon dioxide per capita, the situation is different, the first places being occupied by small countries, many of them being new members of the European Union. *This fact demonstrates that these countries use pollutant installations and equipments and they do not make important steps in order to meet environment’s standards.*

Table 2. Weighted emissions of greenhouse gases (million tones of CO₂ equivalent)

	1995	2000	2005	Share in EU-27 (%)
EU-27	5,249.4	5,099.7	5,176.9	–
Germany	1,095.7	1,019.8	1,001.5	19.3
Spain	318.4	384.4	440.6	8.5
France	558.9	559.7	553.4	10.7
Italy	532.5	553.8	582.2	11.2
Netherlands	225.1	214.4	212.1	4.1
Poland	453.2	405.1	399.0	7.7
Romania	187.0	138.6	153.7	3.0
United Kingdom	710.1	674.0	657.4	12.7

Source: Eurostat, 2009

In European Union, a comprehensive energy and climate change package has been adopted in 2007. The European Council has committed to cut GHG emissions by at least 20% by 2020 compared with 1990 and adopted an „Energy Policy for Europe” in order to improve the use of energy, to increase the share of renewable energy to 20%, to reduce to carbon emissions. The main objective is the limitation of global temperature increase to 2 degrees Celsius above preindustrial levels by 2100.

At European Union level, the public authorities promote not only mitigation actions but also adaptation actions. The adaptations measures are promoted in order to cope with climate events like higher temperatures, increased rainfalls; frequent storms etc. These adaptation actions may consist in

Table 3. Emission of carbon monoxide and carbon dioxide in European Union countries (kg per capita)

Rank	Emissions of carbon monoxide	kg per capita	Rank	Emissions of carbon dioxide	kg per capita
	EU-27	65.0		EU-27	8,696
1	Latvia	147.4	1	Luxembourg	26,088
2	Estonia	118.7	2	Estonia	13,358
3	Denmark	112.7	3	Czech Republic	12,321
4	Finland	99.3	4	Belgium	11,807
5	Bulgaria	95.3	5	Ireland	11,508
6	France	90.9	6	Finland	10,887
7	Luxembourg	87.9	7	Netherlands	10,788
8	Austria	87.7	8	Germany	10,581
9	Poland	87.2	9	Cyprus	10,398
10	Belgium	84.2	10	Greece	10,076
11	Italy	72.0	11	Austria	9,706
12	Sweden	66.6	12	Denmark	9,319
13	Romania	65.1	13	United Kingdom	9,283
14	Portugal	61.7	14	Spain	8,557
15	Hungary	58.4	15	Poland	8,553
16	Greece	57.7	16	Italy	8,439
17	Ireland	56.0	17	Slovenia	8,345
18	Slovakia	55.7	18	Malta	7,500
19	Lithuania	55.5	19	Slovakia	7,417
20	Spain	55.3	20	Bulgaria	7,061
21	Cyprus	53.4	21	France	6,597
22	Czech Republic	49.9	22	Portugal	6,451
23	Germany	48.8	23	Hungary	6,121
24	United Kingdom	40.3	24	Sweden	5,834
25	Slovenia	40.0	25	Romania	5,103
26	Netherlands	36.8	26	Lithuania	4,134
27	Malta	NA	27	Latvia	3,282

Source: Eurostat, 2009

the efficient use of scarce water, the selection of species less vulnerable to climate changes, the development of drought tolerant crops, construction of flood walls, the increase of dykes' levels against sea level rise, relocation of ports. For these reason, in 2007, the European Union has been adopted the Green Paper „Adapting to climate change in Europe – options for EU action” that examines climate change impact on Europe and propose and adaptation strategies that must be promoted by local and regional authorities. This process of adaptation has many consequences because it creates new jobs and markets for innovative products and services (CEC, Green Paper, p 10);

- The development of climate-proof building techniques and products and the set up of new markets for these merchandises;
- The change of time period of beach tourism in Mediterranean countries because the summers will be to hot;
- The growing season will lengthen in Nordic areas, so it is necessarily to adapt the local agricultural management practices;
- The financial sector will develop new instruments in order to reduce the risks due to climate change.

The climate change has many implications on financial market. The development of financial market is dramatic and the pace of innovation is intense. On American continent, at Chicago Mercantile Exchange Group, the futures and options contracts on temperature, snow falls, frost and hurricanes are available for hedging and speculative strategies. New specialized exchanges like Chicago Climate Exchange, Chicago Climate Futures Exchange, and European Climate Exchange have been established. These exchanges have been developed a range of climate and environmental products, like derivatives or contracts for physical delivery. So, new merchandises traded on exchanges have been appeared: allowances like EU allowances (EUAs) issued under the EU Emissions Trading Scheme and Certified Emissions Reductions units (CER) generated from CDM projects.

The impact of climate change on countries is different because the geographical position plays an important role, but his most dramatic aspect is that the level of development has a great influence on their capacity to promote mitigation and adaptation actions to climate change. The most vulnerable countries to climate change are the least developed countries because of their low financial and technical capacity.

2. The connection between climate change and agriculture

The agriculture depends in a high extend by the climate, but other determinants like management practices, technological changes, market prices, policies related to subsidies or international trade patterns are important. For example, in the European Union, the Common Agricultural

Policy (CAP), that is an important instrument of European authorities, drives the agriculture crops. Even if the European authorities try to protect the local agricultural production from foreign competition, they must respect the conditions imposed by the World Trade Organization in order to liberalize the international commercial exchanges.

It is very difficult to determine the exact influence of the climate change of agriculture. In addition, the impact of climate change can have positive and negative effects on agriculture, and the extension of these effects is correlated with other factors. The temperature's increase affects the temporal and spatial distribution of precipitation and evaporation, and these phenomena has direct impact on agriculture because water is crucial in food production.

At international level, over 80% agricultural land is rain-fed. In region like Australia or South America, the climate change has a huge impact on agricultural production taking in account the technical aspect like water evaporation and soil moisture distribution. In addition, available water resources for irrigation are important for agriculture.

The irrigated land represents at international level, around 18% of agricultural land, and its produces 1 billion tones of grain annually, that means half the world's total supply; (this situation is due to high yield of irrigated crops that is 2–3 times more than rain-fed lands. (WMO, UNEP, IPCC 2008, p. 59).

The European authorities consider that the agriculture is a victim of climate change and the European Economic and Social Committee is very concerned by the negative effects of this phenomenon on agriculture. (EESC 2008, p. 1). The most affected region is Southern Europe, because in this region, there are expected long periods of drought and water scarcity, and the worst predicted result is the total cessation of agricultural activity. This aspect has social implication because in Europe, the agriculture is an important source of employment.

The climate change affects agriculture, and agriculture affects climate change. Taking in consideration the IPCC definition, at international level, emissions of GHG from agriculture represent 10–12% of total emissions. The European Commission estimates the share of agriculture in GHGs emission, around 9%. The impact of agriculture on CO₂ emission is small because the plants absorb this gas and transform it.

Speaking about GHG emission, the agriculture has negative effects on climate through emission of methane and nitrous oxide that result from changes in land use and agricultural production. In Europe, 40% of methane and nitrous oxide emissions are due to agricultural activities.

The main problem is that methane and nitrous oxide are stronger warming potential, about 23 and 296 times than CO₂. Another important problem is that there are many ways of methane and nitrous oxide emissions: conversion of woodlands and grasslands in arable lands; the use of nitrogen fertilizers; the decomposition of organic matter in soils, the existence of ruminant animals that is correlated with meat consumption.

Besides these negative effects, the agriculture has a contribution to prevention of climate change. One way is the production of bio energy (figure 3). The production of bio energy will solve, in some extent, the problem of GHGs emissions and will create new jobs. In the European Union, the authorities try to direct the use of agriculture lands for bio energy crops. In this way, the Common Agricultural Policy is adapted to new challenge of this time: environmental issues and climate change. In addition, all member states are encouraged to use bio fuels in order to reduce the dependence on oil that is around 98% in the transport sector from Europe. This directive is important because according with The European Commission White Paper “European transport policy for 2010: time to decide”, the CO₂ emissions from transport is expected to rise in the next years. The road transport is guilty of a huge share of the CO₂ emission-around 90%), so, the promotion of Bio fuels Directive is an important step in order to increase the use of these fuels through different instruments like tax exemption, financial assistance for the processing industry, the establishment of a compulsory rate of bio fuels for oil companies.

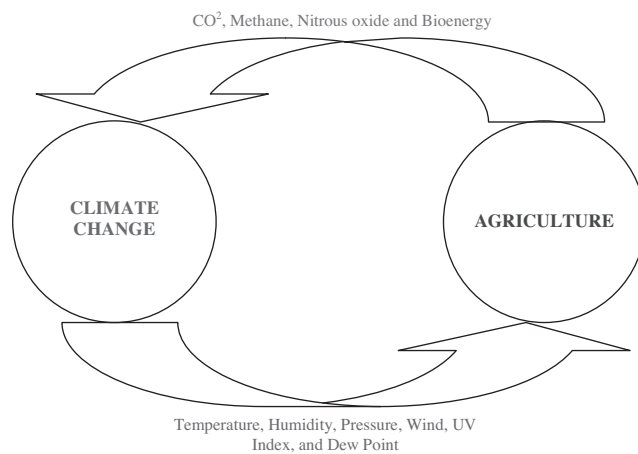


Figure 3. The connection between climate change and agriculture

All these problems determined in agricultural sector by climate change has many implications, even in scientific field because researchers must develop new varieties of plants that are more adaptable to the new climate conditions: warm in north regions and aridity in south regions and that need small quantities of nitrogenous fertilizers in order to facilitate the control of GHG emissions.

Results and Discussion

The agriculture is most dependent economic sector by natural conditions and climate change. The climate change has direct and indirect effects on agriculture, and agriculture, in some extends, has negative impact on environment. In European Union, this challenge called climate change is a

new issue for Common Agricultural Policy. The battle against climate change is tough and climate change is considered, by European authorities (EESC 2006, p. 8), the biggest challenge for Europe and all continents. The implication of public authorities is crucial because they must promote two types of measures: adaptation measures and mitigation measures. The citizens must be implicated in the process understanding climate change because this phenomenon affects different communities in many ways. So, educational, informational and training measures must be adopted.

At international, regional a national level, many agreements and protocols were concluded and many programs are running in order to maintain climate changes under control. The Kyoto Protocol is the most important measure at international level, and in Europe, the EU carbon dioxide Emission Trading Scheme (EU ETS) was adopted in 2005 in order to reduce GHGs emissions. The immediate result of the EU ETS is the established of a new market: the carbon market or market for CO₂ allowances. The set up of this market has many implications. For example, the price of CO₂ emissions will affect the economic performance of producers covered by the European scheme, because the cost of production will be increased by the actions of reduction of CO₂ emissions (ECD-GE, 2005, p. 8).

In Europe, supply and use of energy is the most important source of GHGs emissions (80%). The agriculture has a share around 9%. So, the impact of agriculture on climate change is modest, but we remark the efforts made in EU in order to reduce the share of agriculture from 22% in 1990 to 9% in 2004. In this field, greenhouse gases like nitrous oxide (N₂O) from soils, due to the use of mineral nitrogen fertilizers and methane (CH₄) from enteric fermentation, mainly from cattle, are guilty of climate change. So, agriculture is not a victim of climate change because it generates climate change. For this reason, in the European Union, some reforms of CAP, like the decrease of livestock numbers and fertilizer use, had been adopted. The legislative efforts had been materialized in the adoption of the Nitrates Directive, the Landfill Directive and legislation on F-gases¹ and mobile air conditioning.

The agriculture can have an important role in combating the climate change through bio energy – energy from biomass. Biomass is the world's fourth largest energy source and it provides 10% of the energy used at international level. So, the use of bio energy can have major economic and political consequences. For example, the replacement of imported fuels from Russia with bio energy could contribute to ensuring the security of EU's energy supply.

In addition, biomass production is in a strong interdependence with environment. Cultivation, harvesting and collection of biomass and the use for heat, electricity and transport have consequences like soil erosion, emission of green house gas, and threats to biodiversity and water resources. So, bio energy can have negative impact on

¹ F-gases or fluorinated gases are a group of GHG have a very high influence on climate change.

environment and the main goal – reducing greenhouse gas emissions could not be achieved. Because of these interactions, we try to find the right way in order to use bio energy and to reduce the emission of GHGs.

Taking in consideration the interdependence between climate change and agriculture, in the European Union, the authorities try to promote a new type of agriculture: climate-friendly agriculture.

References

Peter Russ, Tobias Wiesenthal, Denise van Regemorter, Juan Carlos Ciscar, (2007): *Global climate Policy Scenarios for 2030 and beyond, JRC Reference Reports, European Commission*

Paul Watkiss, Tom Downing, Claire Handley, Ruth Butterfield, Commissioned by European Commission DG Environment, 2005, *The Impacts and Costs of Climate Change*, “Modeling support for Future Actions – Benefits and Cost of Climate Change Policies and Measures”. ENV.C.2/2004/0088

Commission of the European Communities, (2007): *Green Paper from the Commission to the Council, the European Parliament, the*

European Economic and Social Committee and The Committee of the Regions – Adapting to Climate Change in Europe – Options for EU action

Directive 2003/30/EC of the European Parliament and of the Council *on the promotion of the use of bio fuels or other renewable fuels for transport (Bio fuels Directive)*

European Economic and Social Committee, (2006): *Sustainable development in agriculture, forestry and fisheries and the challenges of climate change, NAT/276*

European Environment Agency, (2008): Maximizing the environmental benefits of Europe's bio energy potential, No 10/2008

European Environment Agency, (2007): *Europe's environment. The fourth assessment, Copenhagen, www.eea.europa.eu*

European Economic and Social Committee, (2008): *The link between climate change and agriculture, NAT/384*

European Commission Directorate-General Environment (ECD-GE), (2005): *Interactions of the EU ETS with Green And White Certificate Schemes*, NERA Economic Consulting London, www.nera.com

WMO, UNEP, Intergovernmental Panel on Climate Change, (2008): *Climate change and water*