Czech University of Life Sciences Prague

Faculty of Economics and Management

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Diploma thesis

Economic and selected environmental impact analysis of farming practices in the EU

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

DIPLOMA THESIS ASSIGNMENT

Bc. Rui Pedro Portugal Betencourt Adao, BSc

Economics and Management

Thesis title

Economic and selected environmental impact analysis of farming practices in the EU

Objectives of thesis

The goal of the diploma thesis will be to find the main restrictions and difficulties existent when attempting to achieve sustainability between environment and economy.
The main aim is to provide an added value for decision-makers within the farming sector in the EU. In order to do so, the research plan will follow different stages. In a theoretical perspective it aims to provide information about other economic sectors in order to allow a comparison with the agricultural sector (in economic and environmental terms). The main thesis´ outcome is expected to arise from analysing the farming practices´ selected environmental impact (GHG emissions), attempt to build a relation with the economic situation´s impact on the sector of agriculture, pointing the main weaknesses of the EU´s agricultural sector, as well as analysing the feasibility of actual EU´s goals for the future.

Research Questions:
How have economic growth and selected environmental impact (GHG emissions) been correlated within the EU´s sector of agriculture?
How have the EU´s economic situation and GHG emissions increasing control driven farming practices in the EU (2005-2014)?
What are the main greenhouse gases emitted by farming practices in the EU and how is the environmental degradation linked to economic growth?
Why do farming practices have to be studied through both environmental and economic perspectives?

Methodology

The time period used in this research will include the years between 2005 and 2014 (t=10 as well as t=40 for quarterly data). When concerning the dissertation´s purpose, it will be an applied research because the topic involves problems of the society and seeks to improve human condition. It will be illuminative in the sense of exploring each of the topic´s components, as well as directive, that means it aims to determine what should be done based on the findings. According to the investigation level, it will be exploratory in order to determine the problem´s nature as well as causal research to find correlations between GHG emissions and economic growth. The research will consist on a holistic type of analysis which means that it will begin with the whole EU economic sectors´ frame and develop into the specific field of agriculture in an economic and environmental perspective. The type of methods concerning time will be historical (what was) as well as descriptive (what is). The statistical content will include both quantitative and qualitative data. The data collection for both types of data will be secondary. The quantitative will be from statistical databases (Eurostat, FAO ...) and the qualitative from scientific documents or publications, in order to give a deeper meaning to the numbers. Data processing tools will include machine-aided research, relational analysis among the two main fields of research, sector analysis and forecasts.

The proposed extent of the thesis

60 pages

Keywords

Farming practices; Economic sector; GHG emissions

Recommended information sources

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Declaration

I declare that I have worked on my Diploma Thesis titled "Economic and selected environmental impact analysis of farming practices in the EU" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the diploma thesis, I declare that the thesis does not break copyrights of any other person.

In Prague on 28 March 2017

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Rui Pedro Portugal Betencourt Adão

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I take this opportunity to express my profound gratitude to Prof. Ing. Petr Procházka Ph.D., MSc, department of Economics, Czech University of Life Sciences, Prague, for all the support, advices, patience and immense knowledge. The outcome of my diploma thesis would have never been so meaningful without his serviceable and motivational character.

Economic and selected environmental impact analysis of farming practices in the EU

Analýza ekonomických a vybraných ekologických dopadů zemědělských praktik v EU

Abstract

The main purpose of this thesis was to evaluate the impact of several economic and environmental indicators on greenhouse gas emissions resulting from farming practices in all the EU-28 Member States. The recent and increasing concerns about food security and climate change were the main reasons for the execution of this paper, the gist of the thesis will be to provide a better understanding about the main drivers of such concerns. The theoretical part provides an insight on environmental economics, on the history of environmental awareness, and an overview of other source sectors` specificities concerning the selected environmental impact. The analytic section will rely on secondary data to provide future trends and find cause effect relationships between the chosen indicators over the past. The main methodological tools used in this paper include sector analysis, regression analysis, forecasts and comparisons between different indicators regarding both greenhouse gas emissions and agriculture's economy. The sector analysis was used in the theoretical chapter to provide information regarding other source sectors of emissions in the EU-28, and with more detail in the practical part about the agricultural sector. The forecasts are based on data from the period from 1991 to 2013 and predicted until the year 2050. The regression analysis was used to measure the significance of each of the chosen independent variables on agricultural emissions over the selected period.

Keywords: GHG emissions, farming practices, environmental economics, kuznets curve, CAP, regression analysis, forecast

Abstrakt

Hlavní účel této diplomové práce je vyhodnocení dopadů několika ekonomických a ekologických ukazatelů z hlediska emisí skleníkových plynů vznikajících v sektoru zemědělství ve všech 28 členských státech EU. Minulé a stále stoupající obavy o bezpečnost potravin a změny klimatu byly hlavními důvody této práce. Podstatným přínosem bude poskytnout lepší porozumění hlavních příčin těchto obav. Teoretická část umožní nahlédnout na stránku enviromentálně ekonomickou,na minulost enviromentálního povědomí a nabízí přehled dalších sektorových specifických zdrojů týkajících se vybraných ekologických dopadů. Analytická sekce užívá sekundární prameny k odhalení budoucích trendů a k nalezení vztahů příčina-důsledek ve zvolenách ukazatelých vzhledem k minulosti. Hlavní metodologické nástroje použité v tomto dokumentu zahrnují sektorové a regresní analýzy, předpovědi a porovnání různých ukazatelů týkajících se jak emisí skleníkových plynů, tak ekonomie zemědělství. Část analýz byla použita v teoretické kapitole poskytující informaci týkající se dalšího zdroje sektoru emisí v EU-28 a ve více detailech praktické části, které se týkají zemědělství. Předpovědi se opírají o ukazatele z období roku 1991 až 2013 a jsou predikovány do roku 2050. Zpětné analýzy byly použity k vyhodnocení významu každé nezávislé vybrané variability emisí vyprodukovaných zemědělskou výrobou v průběhu určitého období.

Klíčová slova: GHG emise, zemědělské pracovní postupy, enviromentální ekonomie, kuznets křivka, zpětná analýza, predikce.

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I. Introduction

Every being has either a positive or negative impact on the environment quality, however, the anthropogenic causes of pollution are by far the most significant negative impact. Many efforts have been done in the past, especially during the last 2 decades, to revert the increasing environmental degradation. As it will be explained in this paper, economic agents do not always make the best decisions regarding its impact on environment due to various factors. The increasing population size has been one of the main drivers of most environmental concerns, mainly those linked to the agricultural sector. Although the environmental degradation caused by farming practices is not the most significant among all the anthropogenic causes of the selected environmental impact (greenhouse gas – GHG – emissions), it deserves special attention due to its importance in terms of sustainable development and the need to solve worldwide disparities in food supply. The EU has put in place many efforts to develop towards a sustainable agriculture.

It is of the author`s opinion that it is of extreme importance to analyse both the economic and environmental characteristics of the agricultural sector in order to improve and evaluate political action. An overview of other anthropogenic causes of the selected environmental impact is crucial to allow both a comparison regarding the sectors` significance and to compare the different targets expected to be achieved by all the EU-28 Member States for each sector.

This paper will start by stating the research questions and aims in order to clarify its desired outcome and value added. It will be followed by a specification of the methodological tools needed throughout the paper. The next chapter begins with an overview of historical events which proved environmental awareness. The following subchapter includes definitions of environmental economics and the problems associated with balancing economic growth and environmental degradation. The third subchapter provides an overview of the various sources of greenhouse gas emissions besides those resulting from farming practices in the EU-28. The practical part`s main outcome will result from a regression model including economic and environmental data related with the agricultural sector in the EU-28 between 1991 and 2013 as well as from forecasts for each of the chosen indicators. The two types of analysis aim to draw conclusions regarding the significance and trends of each agricultural related indicators.

II. Research questions, Objectives and Methodology

1. Research questions

- How has the EU`s economy and agricultural sector been correlated to the selected environmental impact (GHG emissions) between 1991 and 2013?
    - How has the EU´s economic situation and GHG emissions increasing control driven farming practices in the EU when comparing to other source sectors?
    - What are the main causes of GHG emissions emitted by farming practices in the EU?
    - Why should farming practices be studied through both environmental and economic perspectives?

2. Objectives

The gist of this diploma thesis will be to find the main restrictions and difficulties existent when attempting to achieve sustainability between environment and economy. The main aim is to provide an added value for decision-makers involved in issues regarding the agricultural sector and the environment. In order to do so, the research plan will follow different stages. The theoretical part of the thesis has as its main goal to explore existent theories and literature regarding economics and the environment. The same chapter will also provide information about other source sectors in order to allow a comparison with the agricultural sector in an economic and environmental perspective. The main thesis´ outcome is expected to arise from analysing the farming practices´ selected environmental impact (GHG emissions), attempt to build a relation between economic and environmental characteristics of the agricultural sector, point the main weaknesses of the EU´s agricultural sector, as well as analysing the feasibility of actual EU´s goals for the future. The outcome of this paper is expected to clarify what types of farming practices or economic characteristics do significantly affect the emissions level from agriculture, as well as how each of the chosen indicators is expected to develop in the future for measuring the feasibility of the targets established for the EU-28.

3. Methodology

The period used for analyses in this research will include the years between 1991 and 2013. The forecasts will generate data until the year 2050. The thesis` structure will follow a sequence starting with a literature review concerning theories and definitions associated with environmental economics, followed by a historical analysis of GHG emissions by source sector. The main value added will derive from predictions of economic and environmental variables linked to the agricultural sector, as well as from the estimation of each of the indicators` significance on the sector`s emissions. This paper can be regarded as an applied research because the topic involves problems of the society and seeks to improve human condition. It will be illuminative in the sense of exploring each of the topic´s components on an economic and environmental perspective, including other sectors` analysis. According to the investigation level, it will be exploratory in order to determine the problem´s nature as well as causal research to find correlations between GHG emissions and other indicators related to the agricultural sector. The research will consist on a holistic type of analysis which means that it will firstly provide an overview of other source sectors of GHG emissions in all the EU-28 Member States and then develop into the analysis of the specific field of agriculture in an economic and environmental perspective. The type of methods concerning time will be historical (what was) and, from those values, forecasts will be provided for the most important indicators. The statistical content will consist of quantitative data. The data collection will be secondary from various online databases. Data processing will be done through machine-aided research tools including regression analysis and forecasts. The analyses will be done on a sectoral level in order to allow an understanding about agriculture`s significance on the total GHG emissions in the EU-28. Comparisons between data will be achieved through a relational analysis among the two main fields of the research.

III. Theoretical part

1. History of environmental awareness

The interaction between environment and the global economy has been one of the main issues worldwide, mainly since the 20th century. The concern about environmental quality has grown significantly after the Second World War, governments created initiatives to conserve nature. The very beginning of human environmental consciousness dates back to 10 000 years ago when agriculture started to be developed the most. The ancient classical Greek philosopher Plato wrote:

"*What now remains compared with what then existed is like the skeleton of a sick man, all the fat and soft earth having wasted away, and only the bare framework of the land being left*"
(Hunt & Johnson, 1995)

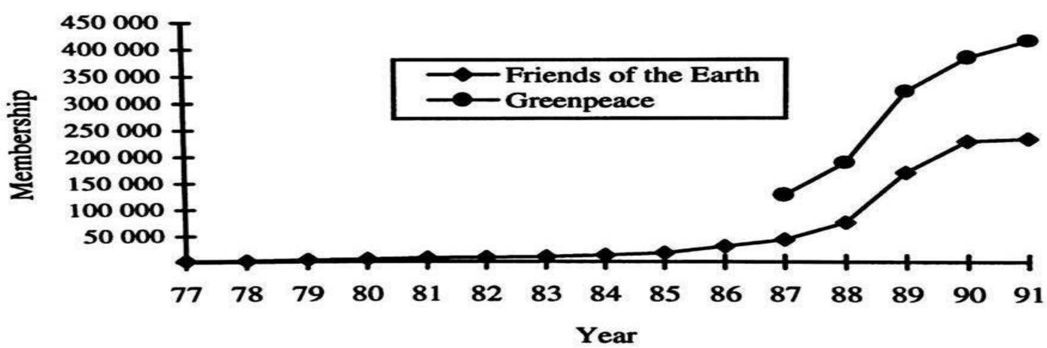
Before middle ages, human thought was more influenced by religion than by rational understanding. In the year 1306, Queen Eleanor attempted to ban the use of sea-coal after a visit to Nottingham where the smoke was visible, however, it was ignored. Sustainability was not a priority at the time as it is now. The most significant development of knowledge and understanding happened during the seventeenth century with the scientific revolution. The Royal Society of London for Improving Natural Knowledge was launched in 1663. Since then, the main consequences from the excessive exploitation of natural resources started to be more visible and recognized by scientists. There were great changes during the late eighteenth and early nineteenth centuries as well. The Industrial Revolution significantly boosted the use of non-renewable resources. Part of the population felt fast improvements in their material quality of life, while many people decided to move into urban areas where more jobs were easily found. However, the working conditions were still not a

Table 1 – Environmental groups formed during the twentieth century

Date	Group
1912	Royal Society for Nature Conservation
1924	Ancient Monuments Society
1926	Council for the Protection of Rural England
1931	National Trust for Scotland
1935	Ramblers' Association
1946	Soil Association
1961	World Wildlife Fund
1966	Conservation Society
1971	Friends of the Earth
1971	Greenpeace
1973	Ecology Party
1987	Whale and Dolphin Conservation Society

Source: Hunt & Johnson, 1995: *Environmental Management Systems* priority at the time. The late nineteenth and beginning of twentieth centuries were the most important in terms of environmental awareness. The industrial development allowed people to have a more prosperous life and opportunities for education, which consequently increased the awareness about human activities` impact on the environment. The science of ecology, the study of the interactions between beings and environment, started to be developed in the late nineteenth century. The table 1 shows the environment related groups created during the twentieth century. The two groups, Greenpeace and Friends of the Earth, were the ones which had the highest impact on people. As it can be seen in figure 1, the two groups saw their amount of memberships significantly increasing from the mid-1980`s. The rising amount of memberships can be explained by the beginning of the green consumerism period. This movement was characterized by an increasing number of people who were concerned about the way their consumption affected the environment. This shifting consumption patterns forced companies to pay more attention to environment as well. Many enterprises began to acquire environment related certificates in order to increase sales. The changing consumption can partly be proved by the increasing amount of memberships acquired by the two most important environment protection institutions at that time.

Figure 1 – Membership of Friends of the Earth and Greenpeace 1977-1991



Source: Hunt & Johnson, 1995: *Environmental Management Systems*

The changing climate, increasing waste and decline in biodiversity are the main outcomes from centuries of natural resources` exploitation. The word exploitation could be replaced by selfish utilization because natural resources are used abusively and by people who disregard future generations. The Intergovernmental Panel for Climate Change (IPCC) got to the conclusion in its Fourth Assessment Report (2007) that "there is high agreement and much evidence that with current climate change mitigation policies and related sustainable development practices, global greenhouse gas emissions will continue to grow over the next few decades" (Pachauri & Reisinger, 2007). However, the awareness about the importance of this issue is changing.

There have been many attempts to change the direction which the world is taking in terms of sustainability. There are many obstacles though, an individual`s decision between behaving more or less ecologically is highly influenced by the person`s capital and income level. Hansen et al., in his book "*Introduction to environmental management*" (1991), stated that the countries` priorities regarding production and environment are dependent on the material standard of living and the character of the environment in a certain country. "The fact that the rich countries attach a greater importance to the environment than poorer countries – even within a relatively homogenous area such as the European Community – may cause problems when these countries have to cooperate on issues which can only be resolved jointly" (Hansen et al., 1991). The wealth of a country can determine its ability to reduce the impact it has on environment, this can be mostly verified within developed nations as within the EU members. The policies created by the EU which aim to cope with climate change take into consideration each country`s ability when setting targets. The effectiveness of policies created by the EU in order to tackle environmental damage will be mentioned ahead.

The table 2 shows the most significant milestones in the development of environmental awareness during the second half of the twentieth century. This was the post-war period which was marked by an increasing intervention of governments to ensure nature conservation. The diagram includes disasters related with the environment, publications of influent studies, as well as governmental interventions. The establishment of the US Environmental Protection Agency in 1970, by the President Richard Nixon, came along with the National Environmental Policy Act (NEPA), 1969. This was the first of several major environmental laws passed in the 1970s. The Royal Commission on Environmental Pollution was created in the same year in the UK. In

1985, the size of the world`s population started to raise concerns in terms of sustainability, as it overpassed 5 billion people. The Chernobyl nuclear power station disaster, in 1986, was probably the one which impacted environment the most through radioactive materials.

Table 2 – Significant milestones in the development of environmental awareness 1950-1993

1950–1960	Mercury poisoning at Minamata, Japan
1952	London smog kills 4000
1957	Fire at Windscale nuclear reactor causes radioactive release
1962	Publication of Rachel Carson's *Silent Spring*
1966	Aberfan disaster
1967	Torrey Canyon oil tanker disaster off the Scillies
1968	Publication of Paul Ehrlich's *The Population Bomb*
1970	Establishment of US Environmental Protection Agency
1970	UK establishes Royal Commission on Environmental Pollution
1970	European Conservation Year
1972	Publication of *Limits to Growth*
1972	UN Stockholm Conference on the Human Environment
1972	European Community decides to adopt an environmental policy
1976	Publication of Gerald Foley's *The Energy Question*
1979	Near-meltdown at Three Mile Island nuclear power station
1980	US establishes 'Superfund' following Love Canal incident
1982	10–year moratorium agreed on commercial whaling
1984	Accident kills over 2000 at Union Carbide plant at Bhopal, India
1984	Liquefied natural gas plant explosion kills 452 in Mexico City
1985	Greenpeace ship *Rainbow Warrior* blown up by French agents
1985	World population passes 5 billion
1986	Chernobyl nuclear power station disaster
1986	Lead-free petrol available in UK
1986	Sandoz warehouse fire, Basel, pollutes Rhine
1987	Publication of *Our Common Future* (Brundtland)
1987	European Year of the Environment (EYE)
1988	Chico Mendes, defender of rainforest, assassinated
1988	Publication of the *Green Consumer Guide*
1989	*Exxon Valdez* tanker accident
1990	Shell fined £1million for oil pollution of Mersey
1992	Publication of BS 7750
1992	UN Conference on Environment and Development, Rio, Brazil
1993	*Braer* tanker accident

Source: Hunt & Johnson, 1995: *Environmental Management Systems*

Although the environmental awareness grew in the twentieth century, the interventions by various entities in order to tackle climate change have still been increasing in the recent past. If scientific developments in the past contributed to a better understanding about environment, then in today`s days, the facts about nature`s depletion are even more convincing. The population growth is a major concern due to the difficulty to guarantee the satisfaction of every individual`s basic needs. According to the estimates provided by The World Bank, about 767 million people (10.7% of the total population) lived on less than US$1.90 a day in the year 2013. However, in the year 1990, the estimates were higher. Nearly 35% of the total population lived in extreme poverty. Besides the growing population, the standard of living in developed countries has been exponentially rising. Thus, the levels of production are also forced to increase. The statistics provided by The World Bank also show that the world`s GDP per capita, measured through Purchasing Power Parity (PPP), almost tripled in 25 years (1991-2015) from $5 584 in 1991 to 15 546 in the year 2015.

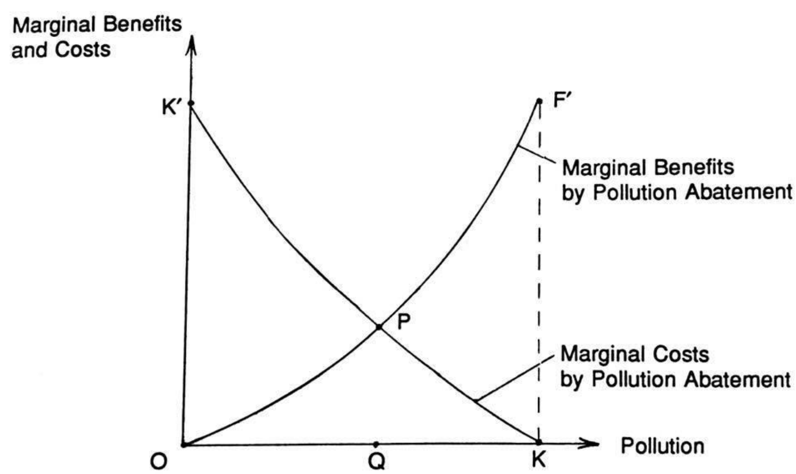
2. The environment within the economic spectrum

2.1. Environmental economics

The reason why it is so important to use economics in environment policy is that in our society, environment has become a scarce resource. Economic social science can be defined as the study of how to satisfy humans` unlimited needs and wants through the use of limited resources. Environmental economics is a sub-field of economics which is concerned with pollution, with the management of natural areas, and prosperity (e.g. quality of food, nutritional value of food). This sub-field was created “due to the fact that the national accounts only deal with economic values and not, for instance, esthetical values, recreational values, or values connected with greater prosperity” (Hansen et al., 1991). Environmental economists` perspective on environmental problems is mostly based on “The economics of welfare” (1946) written by Arthur Cecil Pigou. “Pigou`s central thesis was that pollution problems arise because enterprises` private costs, which form the basis for their actions and investments, do not correspond to the social costs. If an enterprise pollutes, the social cost will exceed the private cost by the cost incurred in preventing the pollution” (Hansen et al., 1991). The reason why our economic system fails to value social costs is both due to the fact that enterprises are not directly rewarded when contributing to society`s welfare, and because it is difficult to measure all the externalities resulting from pollution. The quality of environment is very difficult to be quantified. There are 3 types of pollution classified according to the part of the earth which is affected. They are the soil, water and air pollution. In order to evaluate environment quality, it is necessary to quantify the state of all the three dimensions.

Is it possible to achieve an optimal quantity of pollution regarding its impact on the environment quality? The book “Introduction to environmental management” (1991) stated that, “in practice it is usually not possible to find the optimal level of pollution” (Hansen et al., 1991). The main reason is that it is extremely difficult to determine marginal advantages of pollution abatement. The graph in figure 2 uses the two curves of marginal benefits and marginal costs by pollution abatement in order to determine the optimal level of pollution. It is important to keep in mind the fact that it is just an illustration, the curves do not necessarily look like in the graph nor does the pollution quantity have to start at O or finish at K. The optimal level of pollution is represented by Q, which is the interception between the two curves. At Q level of pollution, the money spent in pollution abatement equals the profit earned by limiting the consequences of the pollution. Any change in the levels of pollution will represent a change along the marginal costs curve (KK´) as well as in the marginal benefits curve (OF´). The area KOK´ represents the cost of not polluting at all. On the other side, the loss associated with the level of pollution OK, is represented by KOF´. As K moves to the left side, which means that pollution is being reduced, the costs logically increase. The cost of reducing pollution levels from OK to OQ would mean a cost of KPQ. The benefit of reducing pollution by the same amount (OK) is represented by QPKF´. After calculating the costs and benefits it is possible to assess the net advantage of polluting less which is represented by the area KPF´. However, in reality, it is extremely complex to determine what are the actual costs and benefits.

Figure 2 – Representation of marginal costs and benefits of pollution



Source: Hansen et al., 1991: *Introduction to environmental economics.*

2.2. Environment and Market failures

Economic theory tells us that markets are self-regulatory and, under certain conditions, resources are allocated in an efficient and optimal manner. That is what happens in an ideal perfectly competitive market system. The aforementioned conditions include the assumptions that: every market is competitive (firms or individuals are price-takers); all the participants in the market are fully informed; individuals always try to maximize profits and satisfaction; and resources or goods are individually owned. However, history does not confirm that resources have always been allocated in the best way. “A river can be used for waste disposal or to sustain a salmon fishery of high commercial and recreation value, but it cannot be used for both purposes. The choices are mutually exclusive, and using the river for one purpose has a cost, the foregone opportunity for the other use” (Freeman et al., 1973). The main point is that the choice of using the river for waste disposal has an opportunity cost which is very difficult to determine. The costs of pollution are subjective due to its long-term impact.

The prices of resources generate information for decision makers. They provide information about the quantity which a certain resource should be bought or sold according to its availability in nature. In other words, prices assist in determining how the good or service should be allocated. If a given market for a certain resource is not functioning properly or simply does not exist, then its allocation is inefficient. Market failure occurs when resources allocation is not efficient. “Such market failure occurs on a massive scale where environmental resources are concerned. Since environmental services do not pass through markets, markets fail to attach prices to them, and, hence, fail to guide their allocation to the highest value uses. As a first approximation, we can say that pollution is caused by market failure” (Freeman et al., 1973). This type of market failures should be tackled by the intervention of various institutions, usually appointed by governments. An economically efficient resource allocation occurs when at least one individual is better off without making someone else worse off.

From all the sources of market failures, there are two major within the environmental context. The first one is related with private property, no one owns environmental resources nor does market attach any price to them. That provokes a lack of information about the environmental impact incurred by the use of a certain resource. Resources cannot be efficiently allocated in terms of their environmental impact because prices do not reflect the potential prejudice they may bring to the earth. The second source of market failure derives from the fact that environmental resources are usually considered as public goods and, hence, are not possible to enter the market system. Pure public goods are those which: are available to everyone; consumption is not dependent on the ability to pay; and cannot be rejected by anyone. In sum, environment quality is a public good, therefore should be consumed in equal amounts by everyone. It is governments` duty to intervene in order to assure a certain level of environmental quality, since the market is not able to allocate environment quality.

2.3. Changing towards a sustainable socio-economic system

There are several mechanisms, which were implemented by protocols and agreements, to tackle climate change. The two most important and recent agreements, concerning atmospheric pollution, were the Doha Amendment of the Kyoto Protocol (2012) and the Paris Agreement (2015). Both of them were created during different United Nations Climate Change Conferences, which are held by the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC exists since the year 1992. Its purpose is to avoid dangerous anthropogenic interference with the climate system. The Convention entered into force on 21 March 1994 and now is represented by 192 parties.

The Doha Amendment (to the Kyoto Protocol) was adopted in Qatar, on the 8th December 2012, and was signed by 37 industrialized countries and the European community. The first commitment (Kyoto Protocol) was created in Kyoto, Japan, by the third Conference of the Parties (COP 3). The commitment consisted on a reduction of six types of GHGs emissions to an average of 5% against 1990 levels, between 2008 and 2012. The parties involved in the first commitment included industrialized countries as well as countries in transition to a market economy (EITs). From the year 2005, the UNFCCC conferences began to serve as the Conference of the Parties Serving as the Meeting of Parties to the Kyoto Protocol (CMP). The Doha Amendment was created in the 8th CMP. The second commitment, which resulted from the Doha Amendment in 2012, established that the committed parties should reduce their GHG emissions by at least 18% below the levels registered in the year 1990, from 2013 until 2020. However, the second commitment raised only 75 countries` ratifications (by the end of 2016) out of the 144 needed for the entry into force of the amendment. Although the commitment did not enter into force, the CMP recognized that Parties may provisionally apply the amendment pending its entry into force in accordance with Articles 20 and 21 of the Kyoto Protocol

The mechanisms aforementioned are aimed at facilitating the accomplishment of the commitments. The three market-based mechanisms introduced by the Kyoto protocol include: International Emissions Trading; Clean Development Mechanism (CDM); and Joint Implementation (JI). The first allows countries which did not reach the emissions` limit, to trade the spare emission permissions - Assigned Amount Units (AAUs) - with those which are over the targets assigned to them. The CDM creates Certified Emission Reduction units (CERs) which should correspond to the opportunity cost of an emission reduction project, in other words, the amount of emissions which could have been generated if the project wouldn`t occur. Those CERs can be traded with countries which exceed the emission`s limit. The last mechanism, Joint Implementation, allows Annex I countries (industrialized countries and economies in transition) to invest in an emission reduction project in any other Annex I country as an alternative to reducing emissions domestically.

The Paris climate conference in December 2015, which represented the 21st Conference of the Parties (COP 21), had as its main goal the adoption of a first global, legally binding, global climate deal. The Paris Agreement established that all the involved Parties should take action in order to assure that the global temperature rise stands below 2 degrees Celsius (2ºC) until the end of this century. One of the commitments made by the Parties was that each of them should report their intentions to reduce the anthropogenic impact on the environment through the nationally determined contributions (NDCs). From the 125 Parties which ratified the Paris Agreement, 119 already submitted their first NDCs according to the NDC Interim Registry. The Paris Agreement requires all Parties to put forward their best efforts through nationally determined contributions (NDCs), this includes requirements that all Parties report regularly on their emissions and on their implementation efforts. This instrument is still insufficient to keep global warming below 2ºC. However, it should trace the path for achieving the targets. The Paris Agreement is meant to be the beginning of a long cooperative process between the Parties to fight causes and consequences of climate change. “The 2015 Paris Climate Agreement specifies climate change action expected from all countries, yet solid metrics to evaluate performance remain elusive” (Hsu et al., 2016). In sum, the governments agreed to gather every 5 years to set more ambitious goals, track the progress towards the long-term goal, as it did also recognize the need to strengthen the developing countries` readiness to deal with the impact of climate change.

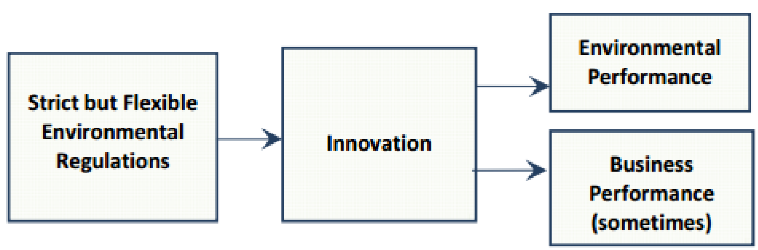
Although many agreements and protocols have been launched, the urge to tackle climate change still persists. The enforcement quality of all the commitments is one of the key factors for accomplishing the settled goals. The 5th assessment report (2014) stated that the "total anthropogenic GHG emissions have continued to increase over 1970 to 2010 with larger absolute increases between 2000 and 2010, despite a growing number of climate change policies" (Pachauri et al., 2014). The undeniable need for change, in terms of anthropogenic causes of climate change, has not been achieved yet. It is rather in the beginning of a long-term global cooperative process. "Adaptation and mitigation experience is accumulating across regions and scales, even while global anthropogenic greenhouse gas emissions have continued to increase" (Pachauri et al., 2014).

2.4. Environmental Management Systems (EMS)

Before the beginning of the 1990s, the investment in the reduction of anthropogenic impact on environment was seen as of little advantage for any business. However, in 1991, Michael Eugene Porter stated that "strict environmental regulations do not inevitably hinder competitive advantage against rivals; indeed, they often enhance it" (Porter, 1991). Later in 1995, the same author, together with Claas van der Linde wrote an article which contradicted most of other economists` opinions concerning environmental regulation on business. "The traditional view of environmental regulation held by virtually all economists until that time was that requiring firms to reduce an externality like pollution necessarily restricted their options and thus by definition reduced their profits" (Ambec et al., 2011). The article "Toward a New Conception of the Environment-Competitiveness Relationship" (Porter & Linde, 1995) had as its main goal to "argue that properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them" (Porter & Linde, 1995). The term "innovation offsets" (Porter & Linde, 1995) referred by both authors can be paraphrased as the compensation which derives from innovation. "Such innovation offsets, as we call them, can not only lower the net cost of meeting environmental regulations, but can even lead to absolute advantages over firms in foreign countries not subject to similar regulations" (Porter & Linde, 1995). When measuring the impact of environmental regulations, there are the social benefits, which consist on the contributions of a given regulation towards common welfare, and the private costs incurred to any business when implementing new practices which are aimed at preventing environmental damage. The article by Porter and Linde (1995) states that "our [their] argument is that whatever the level of social benefits, these [private] costs are far higher than they need to be. The policy focus should, then, be on relaxing the trade-off between competitiveness and the environment" (Porter & Linde, 1995) whereas additional costs incurred in complying with environmental policies do not necessarily mean a loss of competitive advantage.

Michael Porter built the Porter Hypothesis which defends the idea that profitability and pollution abatement are not mutually exclusive goals. The figure 3 represents the causal links inherent to the Porter Hypothesis. The Scheme basically illustrates how innovation can arise from strict but flexible environmental regulations, and consequently can lead not only to an improved environmental performance but (sometimes) to a better business performance.

Figure 3 – Schematic representation of the Porter Hypothesis



Source: Ambec et al., 2011: *The Porter hypothesis at 20*

The ISO 14000 is a set of standards which aim to allow all types of companies and organisations to manage their environmental responsibilities. The standards are developed by the International Organisation for Standardization (ISO) Technical Committee ISO/TC 207 together with its various subcommittees. The set of standards is divided according to the different approaches used to manage the environment. The ISO 14001:2015, along with its supporting standards, has its main focus on environmental management systems (EMSs) needed to tackle environmental challenges. More recently, the ISO 14004:2016 was created to provide guidance for any organisation to establish, implement, maintain and/or improve a robust environmental management system.

There have been many improvements in terms of environmental auditing and other environmental management practices. The environmental auditing started to be developed in the 1970s. Its aim is to evaluate whether the audited entities are complying with the environmental laws and regulations or not. The investment in this type of service brings many advantages (increasing over time) for organizations in terms of marketing. The certificates usually correspond to a certain logo which is placed in a visible way for consumers.

The European Commission developed an EMS called Eco-Management and Audit Scheme (EMAS) in 1993. Currently, more than 4 600 organisations and more than 7 900 sites are EMAS registered. The EMAS relies on a set of key performance indicators by which organisations can measure their environmental performance, as well as monitor the improvements needed to achieve targets. The creation of this instrument represents a great achievement due to its ability to inform decision-makers by both evaluating the feasibility of targets and tracking environmental performance regularly, thus enhancing global environmental performance. In September 2015, the UN developed a set 17 goals and 169 targets which constituted the United Nations Sustainable Development Goals (SGDs). The main tool adopted to quantitatively measure the environmental improvements was the Environmental Performance Index (EPI). "The EPI ranks countries` performance on high-priority environmental issues in two areas: protection of human health and protection of ecosystems" (Hsu et al., 2016). The usage of this tool facilitates the feedback from whether SGDs are being accomplished or not. "Aligning EPI`s indicators with the SGDs provides a baseline for evaluating national performance and shows how far countries are from reaching global targets" (Hsu et al., 2016). According to the full report by Yale University, *2016 Environmental performance index* (Hsu et al., 2016), in 2014 Switzerland was the country with the highest ranking in terms of environmental performance. It was followed by Luxemburg, Australia, Singapore and the Czech

Republic. The country with the lowest rank from all the 178 countries was Somalia, followed by Mali, Haiti, Lesotho and Afghanistan.

2.5. Economic growth vs GHG emissions

The evidences which prove that human (economic) activity has been a significant contributor to climate change are increasingly becoming more valid. As it was mentioned before, a total of 195 nations endorsed, in December 2015, a consensus on the view that the average global temperatures should not rise above 2ºC when comparing to pre-industrial levels. The meeting took place at the 21st Conference of Parties (COP21) to the United Nations Framework Convention on Climate Change (UNFCC) in Paris. The target committed by all the nations “implies that anthropogenic greenhouse gas (GHG) emissions have to be reduced by 41 to 72 percent in 2050 compared to emission levels in 2010, and by much as 78 to 118 percent in 2100” (Mir & Storm, 2016). A change towards energy efficiency and resource efficiency is inevitable in order to comply with the targets. The main question which this chapter is going to address concerns the possibility to stay below the 2ºC limit and, at the same time, keep or boost economic growth. The main doubt is whether economic growth can be decoupled from GHG emissions or not. In other words, this chapter aims to show the impact which a decarbonisation of the global economy may have on economic growth.

The Carbon Kuznets Curve (CKC) represents the relationship between income per capita and GHG emissions per capita. “The CKC hypothesis holds that GHG emissions per person do initially increase with rising per capita income (due to industrialization), then peak and decline after a threshold level of per capita GDP, as countries become more energy efficient, more technologically sophisticated and more inclined to and able to reduce emissions by corresponding legislation” (Mir & Storm, 2016). As it was mentioned before, this development has been verified since the Industrial Revolution from late 18th until early 19th. The environmental awareness has recently been significantly increasing, which leads to the creation of new systems in order to reduce emissions. The Kuznets Curve was originally created to illustrate the relationship between income per capita and economic inequality as an inverted U-shaped curve (inverted parabola) by Simon Kuznets. The curve was then adapted to explain the relationship between economic development (through income per capita) and environmental degradation. The Environmental Kuznets Curve started to be a standard feature for environmental policy in the early 1990s. However, it was a target of many criticisms. There is not enough evidence to hold the relationship true for all the types of environmental degradation. For instance, deforestation does not always result from high income or high consumption because it is possible to import raw materials from other nations. Some countries, mainly developing ones, export deforestation in the way that the raw materials which are extracted from forests are then sold usually to developed nations. Despite the insufficient evidence to validate the rising environmental degradation with wealth for all the types of degradation, it is known that the impact exists. The actual tendency is to reduce anthropologic environmental degradation. The main challenge in doing so is to decouple economic growth or wealth from its resource and energy dependency. A society`s desire to protect the environment is conditioned by the economic system which fails to value the social costs of products and services. The delinking between economic growth and GHG emissions is shown in the curve at some level of emissions. The relationship holds true for production-based GHG emissions, however, it is not fully clear that such decoupling also occurs in consumption-based GHG emissions. The GHG emissions are often calculated from national domestic production. “This geographical definition hides the GHG emissions embodied in international trade and obscures the empirical fact that domestic production-based GHG emissions in (for example) the EU have come down, but consumption-based emissions associated with EU standards of living have actually increased” (Mir & Storm, 2016).

The EU is a net importer of GHG in the way that the most pollutant industrial processes are usually outsourced to developing countries. “It is no great achievement to reduce domestic per capita carbon emissions by outsourcing carbon-intensive activities to other countries and by being a net importer of GHG, while raising consumption and living standards” (Mir & Storm, 2016). A significant part of the GHG emitted by developing economies is inherent to the consumption patterns of the developed nations. That justifies the importance of countries, as those which are members of the EU, to develop towards less carbon-intensive activities as well as more sustainable consumption patterns.

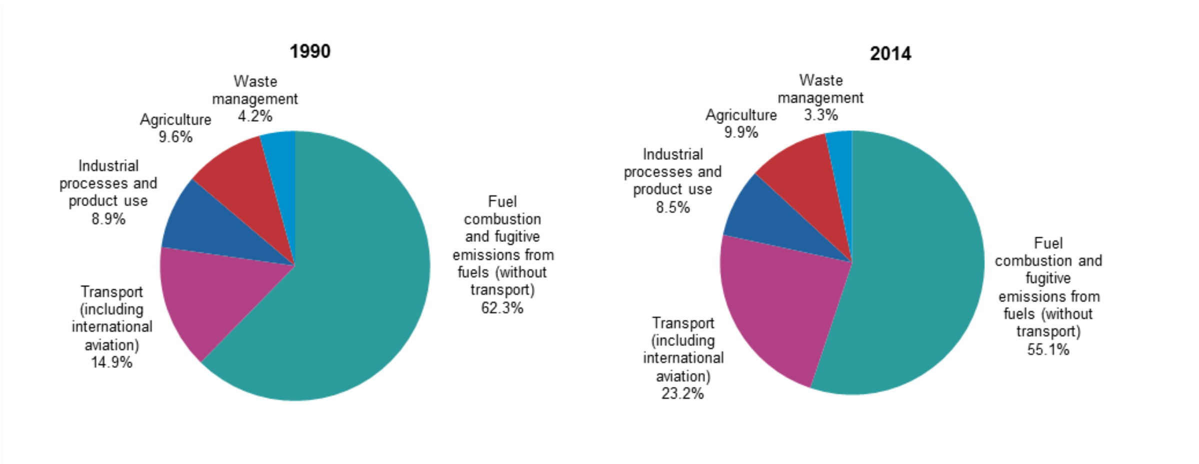
3. Main contributors to selected environmental impact - GHG emissions - within the EU, excluding agriculture

Most of the products or services we use are leaving an ecological footprint which we are not always aware of. We do not always have complete information about the whole value chain of each product nor do we always know about its impact on the environment and resources used before it is consumed. The economic decisions made by people do not always take environment as a main influence, mainly those people who have reduced monetary resources. Over time, it has become more common for people to either join environmentally friendly co-operatives or purchase ecologic products due to the increasing awareness about this issue. It has also become usual for companies to either join campaigns, fund environment related NGOs, or seek environment related certifications. This is done in order to build an image of environmentally responsible which consequently has a big impact on customers, because people are more aware about their ecological footprint. That is why Environmental Management Systems (EMS) are used in many firms. However, many ecologic certificates are still dubious due to the still flexible requirements needed to acquire them.

The actual economic system does not include the cost of environmental degradation in everything we buy. The price is more often influenced by the level of the raw materials` scarcity. If it would do so, the products which provoke the degradation of natural resources would become more expensive than those which are environmentally friendly. Most of the times, the opposite case is true, whereas people pay more to get environmentally friendly products.

The figure 4 shows the difference between the greenhouse gas emissions by source sector in the years 1990 and 2014. The data is displayed for each sector as a percentage of total emissions. In 24 years (between 1990 and 2014), the only sector which increased its share of the total GHG emissions is the transportation one. That can be explained by the improvement of certain practices in other sectors since the 1990s, as well as the increasing use of private transportation. The characteristics of each sector within the EU will be provided ahead.

Figure 4 – Greenhouse gas emissions, analysis by source sector in EU-28, % - 1990 and 2014



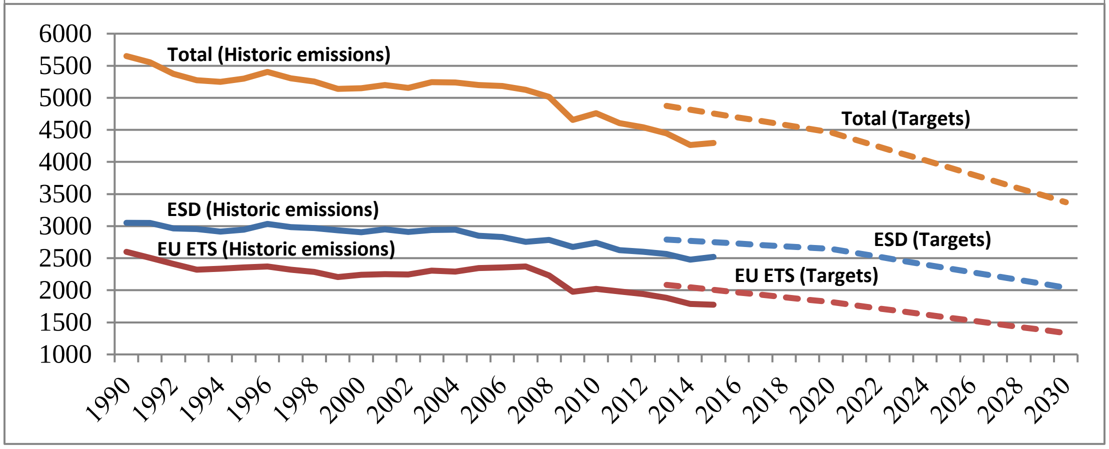
Source: Eurostat, 2016

The European Environment Agency (EEA) released the *Trends and projections in Europe 2016 – Tracking progress towards Europe`s climate and energy targets* (EEA, 2016) which stated that "despite a slight setback in 2015 concerning greenhouse gas (GHG) emissions and energy efficiency, GHG emissions have already decreased below the 20% target" (EEA, 2016). The report by the EEA justified the increased energy consumption with the exceptionally warm 2014, which reduced the need for heating and so emissions where exceptionally lower. The EU established the energy and climate goals for 2020 in the year 2007. The 2020 package included the targets of 20% reduction in GHG emissions (from 1990 levels), 20% improvement in energy efficiency and 20% of EU´s energy use from renewable sources. All the targets are expected to be achieved by 2020. The total targets are a result of an average from each country's different targets. It ranges from 10% in Malta and 49% in Sweden.

The positive expectations about the accomplishment of the targets resulted in the adoption of new goals by the EU. The energy and climate goals for 2030 have already been proposed on 30 November 2016 as a set of measures to make the EU a leader in renewable energy use. The EU members already agreed on a renewable energy target of at least 27% of final energy consumption by 2030. The proposal also includes a 40% cut in GHG emissions (from 1990 levels) and at least 27% energy savings, when compared to the business-as-usual scenario. The main tool proposed to be used in complying with the targets is a reformed EU emissions trading scheme (ETS). The ETS is based on the principle cap and trade, whereas a cap is the amount of emissions allowed. The emission allowances can be traded between companies in order to build a market for pollution. Those companies which are not able to have enough allowances to cover their own emissions are subject to heavy fines. The Effort Sharing Decision (ESD) is another tool which was created to cover almost all the GHG emissions which are not included in the ETS. It covers various sectors as agriculture, energy consumption in buildings, road transport and waste management. It also establishes annual GHG emission targets. Those targets are determined according to the Annual Emission Allocations (AEAs), whereas wealth (measured by GDP per capita) determines whether if a country should increase or decrease their emissions. Some of the countries (e.g. Bulgaria, Croatia) are allowed to increase their emissions due to the expected economic growth which consequently forces GHG emissions to rise. The commitments range from 20% reductions in Denmark, and Luxemburg, as well as 20% increase allowance for Bulgaria. The strategy of different targets among members lays the ground for the main difference between the ESD and EST. In the case of the emissions included by the ESD, the overall average GHG emissions abatement from all the member states is about 10% (from 2005 levels) for the period between 2013 and 2020. The target of 10% is expected to be achieved, while the emissions covered by the EST are expected to reach 21%. Altogether allows the EU member states to comply with the climate and energy package (20% reduction below 1990 levels by 2020).

The graph in figure 5 shows the difference between the total GHG emissions which can be traded in the ETS and those covered by the ESD. The amount of emissions is measured in million tonnes of CO_2 equivalent ($MtCO_2e$). Each of the indicators includes both its historic development and the targets established by all the EU Members` agreement. Both ESD and ETS amounts of emissions have decreased since the year 1990. However, the sectors covered by the EU ETS reduced their emissions at a higher rate than did those covered by the ESD. It is possible to see that the targets have always been achieved for the given time period (2013-2015). The ease to achieve the targets can be both a sign of success for the Member States, or it could also show that the goals should be more ambitious. The trading system (ETS) used by the EU covers a smaller share from the total than does the ESD. The targets established for both types of emissions require reductions at approximately the same pace, however proportional, due to the different emission amounts.

Figure 5 – History and targets of GHG emissions under the scope of the ESD and EU ETS in EU-28, 1990-2030 – $MtCO_2e$

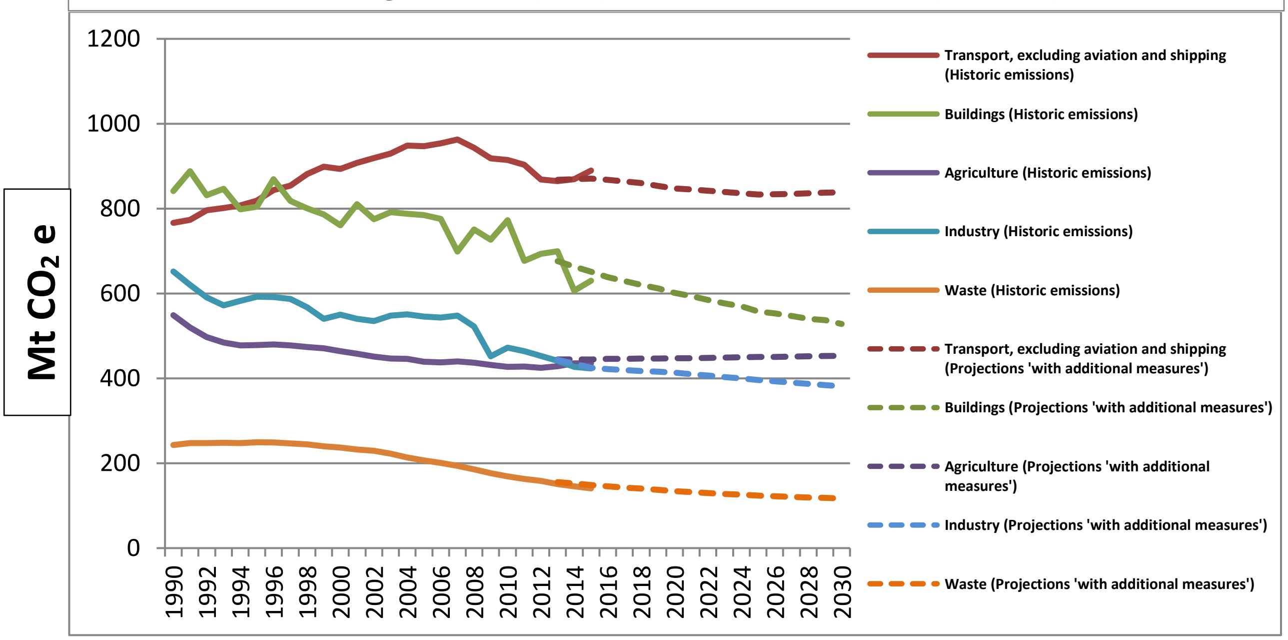


Source: European Environmental Agency (EEA), 2016. Own representation.

The graph in figure 6 shows a more detailed specification about the different sources of GHG emissions which are covered by the ESD. As it is possible to verify in the previous figure 5, the Effort Sharing Decision covers a larger amount of emissions when compared to those from the sectors under the ETS. “These [ESD] sectors account for almost 60% of total EU GHG emissions” (EEA, 2016). Each of the sectors indicated in the graph from figure 5 include both historic values and projections with additional measures. The additional measures mean that the predictions do not only rely on measures which were implemented prior to the preparation of the projections, but do also take into account those which were at planning stage. The measures which were being planned at the time of these projections (figure 6) include the EU`s amendments to both energy and climate goals for 2020 and 2030.

The transportation sector (excluding aviation and shipping) has been continuously increasing from the year 1990 until 2007. Even though the following years show a reduction (except for the years 2014 and 2015), the transportation sector is the main contributor to the total GHG emissions under the ESD from the year 1994. Until then, energy from buildings was the main contributor. The emissions from road transportation tend to stabilize according to the projections made ´with additional measures`. The buildings sector, as opposed to the transport one, has been decreasing over time (since 1990). This sector is expected to represent the largest reduction in the future due to improvements in the energy performance of buildings, energy labelling systems to inform consumers, and eco-design requirements for products related with energy. The GHG emissions registered from the agricultural sector exceeded those for industry for the first time (since 1990) in the year 2014. This is the only sector, within those covered by the ESD, which is expected to increase its emissions in the future. These projections are mostly based on the increasing food demand, which results from the rising population size. The other sector which could also be dependent on the population size is the one which includes emissions from waste generated. However, many developments have been done in terms of waste management since the 1990s. This fact could explain the GHG emissions` decreasing tendency. The last sector covered by the ESD is the industry one. It has been continuously decreasing from the year 1990 as a result of the technological advancement as well as from the higher control imposed by the EU.

Figure 6 – History and projections of GHG emissions under the scope of the Effort Sharing Decision (ESD) in EU-28, 1990-2030 – (MtCO2e)



Source: European Environmental Agency (EEA), 2016. Own representation.

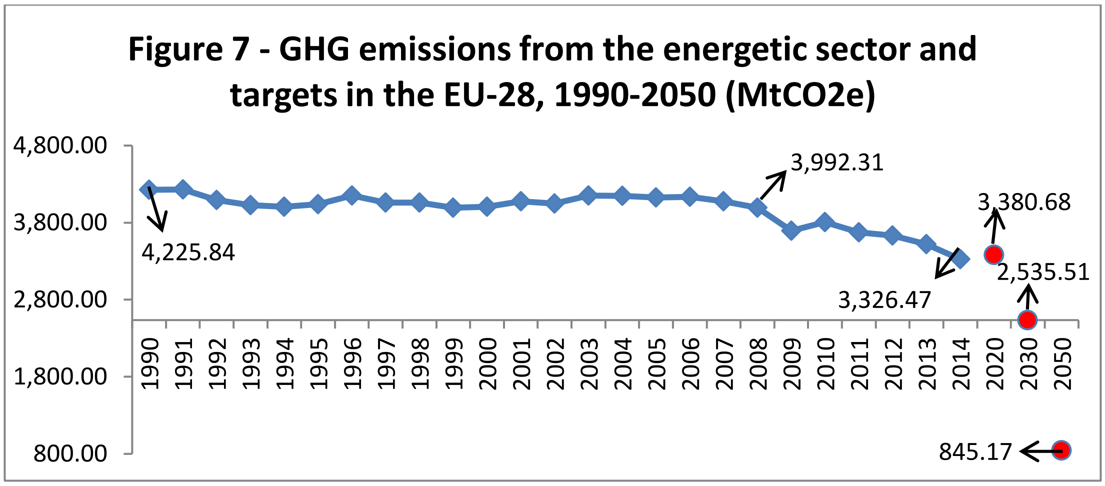
3.1. Fuel combustion and fugitive emissions from fuels (excluding transport)

The fuel combustion for electricity production has always been the biggest source of greenhouse gas emissions (GHG) in the EU, even if transportation sector is excluded. Together with the fugitive emissions from fuels (without transport), it has suffered a reduction from the year 1990 until 2014, however it is still the sector which emits GHGs the most. This sector produces more than half (55.1%) from the total GHGs emitted by the whole EU-28 (Figure 4). Electricity production results mainly from the combustion of oil, coal and natural gas. The source which impacts environment the most is coal, while natural gas (mainly composed by methane, CH_4) is a relatively clean fuel. Fuel combustion has many disadvantages, in other words, it has a very high opportunity cost. The choice of producing electricity through fuel combustion compromises human health as well as climate change which are caused by the excess of carbon dioxide in the atmosphere. The carbon dioxide forces the heat to stay close from the earth surface, which is the explanation for the term global warming. One of the main obstacles when attempting to act more sustainably is the difficulty to calculate the opportunity cost of fuel combustion associated with the environmental damage, due to its subjectivity and long-term impact.

The European Commission, on 25 February 2015, decided to propose the creation of an Energy Union among its Member States. In order to do so, the document entitled *A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy* was released. There may be two main reasons for the creation of a European Energy Union: the increasing western concerns about climate change; and the eastern conflicts concerning Russia (country by which the EU is highly dependent in terms of energy). The Union is meant to lay its ground based on five dimensions: A fully-integrated internal energy market (free flow of energy); Energy efficiency (reduce dependency on other countries); Decarbonizing the economy (mainly through the usage of ETS); Security, solidarity and trust; and boosting Research, innovation and competitiveness. Basically, the EU`s Energy Union aims to help EU members to become less dependent on energy imports, provide means to achieve both the targets settled for 2020 and 2030, and make the EU the number one in renewable energies. On 30 November 2016, the European Commission proposed a new governance under the Energy Union, the aim was to adapt planning, reporting and monitoring the performance of each Member State which are on the path to the new 2030 climate and energy framework.

The EU does not only settle short-term targets but it does also look to a further future by establishing long-term goals. The long-term targets are far more ambitious than those for 2020 or 2030. “Assuming the necessary emission cuts required to achieve the 2030 target actually take place, an even deeper reduction would still need to be achieved between the 2030 target level (40% below 1990 levels) and the EU objective for 2050 (at least 80% below 1990 levels)” (EEA, 2016). However, the forecasts based on emissions trends by the EU Member States revealed that the pace of GHG emission reductions after 2020 should slow down. The report by the European Environmental Agency (EEA) – *Trends and projections in Europe 2016* stated that for the 80% to be achieved by 2050, the “reduction will have to be two to three times greater than the decrease from current levels necessary to meet the 2030 target” (EEA, 2016).

The figure 7 shows the total amount of energy-related GHG emissions from the year 1990 (base year used by EU`s emission abatement targets) until 2014. It is important to highlight the fact that some values may seem negative due to the position of the horizontal axis which is not starting from 0 $MtCO_2e$. In 1990, all the EU members together emitted 4 225.84 million $MtCO_2e$. The unit carbon dioxide equivalent (CO2e) is a measure which quantifies all the types of GHGs` impact on global warming by measuring how many units of CO2 would have to be emitted in order to have the same impact on global warming as 1 unit of any other given GHG does (through each of the gases` global warming potential - GWP), usually over a period of 100 years. According to the United Nations Framework Convention on Climate Change (UNFCCC), methane (CH_4) has a GWP of 21, thus 1 unit of CH_4 has the same impact on global warming as about 21 units of CO_2. The same source states that the GWP for nitrous oxide (N_2O) is approximately 310. Those are the main greenhouse gases emitted by humans. The value of 2014 (3 326.47 MtCO2e) represents a reduction of approximately 22.3%. The steepest fall in the EU`s total GHG emissions from the energetic sector was from the year 2005 until 2014 when the reduction was of about 16.7%. “The reduction in emissions was largely the result of changes in the combination of fuels used to produce heat and electricity, in particular a decrease in the use of hard coal and lignite fuels, and a substantial increase in electricity generation from renewables, which almost doubled over the period [2005-2015]" (EEA, 2016) In order to achieve the target of 40% reduction (from 1990 levels) until 2030, the total amount of GHG emissions has to reach approximately 2 535.5 MtCO2e. The target for 2050 of 80% reduction would mean to reach about 845 MtCO2e.



Source: CAIT Climate data explorer, 2015 & Eurostat, 2016. Own representation.

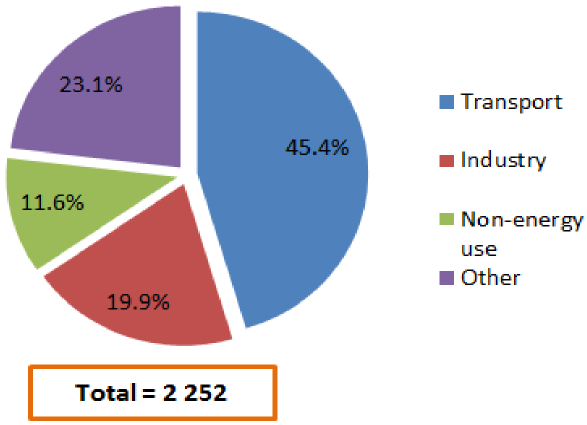
3.2. Transport

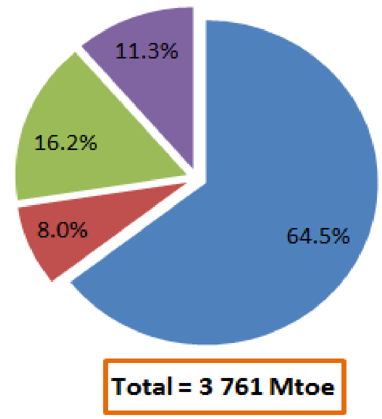
The transportation sector, in the spectrum of this chapter, includes any GHG emissions which result from fuel combustion by any type of vehicle used in order to transport either people or cargo. This sector can be divided into three different means used for transportation: aviation; shipping; and ground transportation. The two first are addressed by the EU emissions trading scheme (ETS), while the emissions resultant from road transportation are covered by the effort sharing decision (ESD). The increasing mobility of people provoked by globalization has significantly raised the levels of emissions registered in this sector. This applies for both people and cargo. Any individual is more likely to travel nowadays than he was 100 years ago, either if on business or holidays. On the other side, almost every good consumed by an individual was not produced in only one country neither was it produced near the place where it is consumed.

As it was mentioned in the beginning of this chapter, and in figure 6, the road transportation sector is the one with highest share within those which the ESD takes into account. Aviation and shipping GHG emissions are under the ETS. Perhaps this sector is the one which has seen the least technological development towards sustainability. Some alternatives are under development as the electric cars. However, there is still a long way until electric cars are used by everyone, mainly due to its price. The figures 8 and 9 show the sectoral consumption of oil as a percentage of the total for the years 1973 and 2014 respectively. It is important to mention two issues beforehand. The data is collected from all the IEA members, many of which are EU members. However, it also includes countries as the USA, Australia and Japan among others. The second important issue is that the percentages for each pie chart are taken from different total amounts of oil equivalent in million tonnes. The equivalence is done due to the existence of different types of crude oil which produce distinct amounts of energy. Thus, each million tonne of oil equivalent corresponds to a certain amount of energy produced. The transportation sector is the main oil consumer among all the other sectors in both 1973 and 2014. The main difference observed in the sector is that it now consumes almost two thirds out of the total oil consumption. The predictions for the transportation sector, as represented in figure 5, show stagnation in terms of GHG emissions until the year 2030. Despite the increasing regulations for the transportation sector, no significant improvements are expected to happen in terms of GHG emissions. The oil consumption share by industries has been significantly reduced (from 19.9% to 8%). Industry has shown this tendency mainly due to the massive technological development which has allowed a lower fossil fuels dependency. Although there is a low oil dependency, it is important to mention that, according to the same source, industry consumed 79.8% from the total coal consumption. The oil consumption which is not used for energy production refers to the oil consumption which is used as a raw input rather than as fuel (e.g. plastic). The Other section refers to the oil consumption by “agriculture, buildings, commercial and public services, residential, and non-specified other” (IEA & EC, 2016). The decreasing oil consumption by these other sectors can be explained by the significantly higher energy efficiency of new buildings compared to those in the 1970s.

Figure 8 – Total final IEA members` oil consumption by sector, % - 1973

Figure 9 – Total final IEA members` oil consumption by sector, % - 2014





Source: IEA & EC: *Key world energy statistics 2016*. Own representation.

In economic terms, the transportation sector is one of the main contributors to the EU`s economy. According to data from Eurostat, it has a share of 4.8% (≈ €548 billions) from the EU-28 overall gross value added. Transport is perhaps the key sector for the European integration process since the Treaty of Rome in 1957 which settled the free movement of individuals, goods and services. That was one of the first common policy areas established by the European Economic Community. The improvements were not seen immediately after the Treaty of Rome due to the need for every member`s agreement. It took 28 years until, in 1985, the European Court of Justice made advancements towards a common policy. The principle of sustainable mobility began approximately 7 years later, in 1992, when the Maastricht Treaty was established with the goal of incorporating environmental protection requirements into transport policy. The Treaty of Amsterdam in 1997 did also introduce new environmental protection measures into the transport policy. Even though many treaties were signed during the second half of the twentieth century, the real enforcement of the policies surged in the beginning of the twenty-first century. This does not only apply to the transports but also to other sectors, the awareness has exponentially been increasing over the recent past within all the sectors. The last 60 years, since the Treaty of Rome, represented a substantial improvement in terms of prosperity and employment within the transportation sector. The energy and climate goals for 2020 include a specific target of 10% use of renewable energy sources within the whole transportation sector, in order to comply with the 20% for all sectors. "However, progress in this [transportation] sector is much slower than if all sectors are considered together" (EEA, 2016). That explains the predictions made in the graph shown in figure 6, whereas GHG emissions should stagnate at least until 2030. The benefits of polluting more through the use of vehicles moved by non-renewable sources still outweighs the external costs associated with environmental damage as well as the costs associated oil prices. "As the International Energy Agency has recently pointed out, the less successful the world is in decarbonising, the greater will be the oil price increase" (European Commission, 2011).

This sector, likewise the energy production one, requires policies in order to assure that transports are safe, efficient and sustainable. Transport policies aim to boost competitiveness within the industry. The four different environmental areas which are addressed by the EU`s transport policy include the two areas where intervention is more urgent – climate change and air pollution – while the ones of lower urgency – noise and biodiversity. *The roadmap to a single European transport area – Towards a competitive and resource efficient transport system* (European Commission, 2011) established 40 concrete initiatives which aim to improve the EU`s dependency on imports of non-renewable resources, the EU`s commitment to achieve 60% reduction in GHG emissions from transport, and develop a competitive transport system. The report defends that "if we do not address this oil dependence, people`s ability to travel – and our economic security – could be severely impacted with dire consequences on inflation, trade balance and the overall competitiveness of the EU economy" (European Commission, 2011).

"Over the past decades, developments in European transport policy have helped to strengthen the wider EU internal market by opening up national markets previously dominated by public monopolies, such as in aviation and rail" (European Union, 2014). The improved transport policy does not only strengthen the EU`s internal market, it does also play a vital role in terms of foreign trade. The EU exports are 90% of the times done through shipping. The infrastructure related with all the transportation means is typically more developed in those countries which belong to the EU for longer time than for those which recently fully became EU members. The trans-European transport network (TEN-T) created by "the EU plans to establish a core network by 2030, filling in missing cross-border links and making the network smarter" (European Union, 2014).

3.3. Industrial processes and product use

The emissions generated by industrial processes and product use include mainly by-products of production. In other words, it relates to the emissions generated in the production of a certain good which is needed to produce the main output. The different GHG emissions sources within this sector include: metal production (e.g. iron, steel…); Chemical industry (e.g. ammonium); Mineral products (e.g. cement industry, smelting processes); Ozone depleting substances (e.g. refrigeration, air conditioning); Non-energy products from fuels (e.g. lubricant use); and others with minor impact as by-products from food and drink industry.

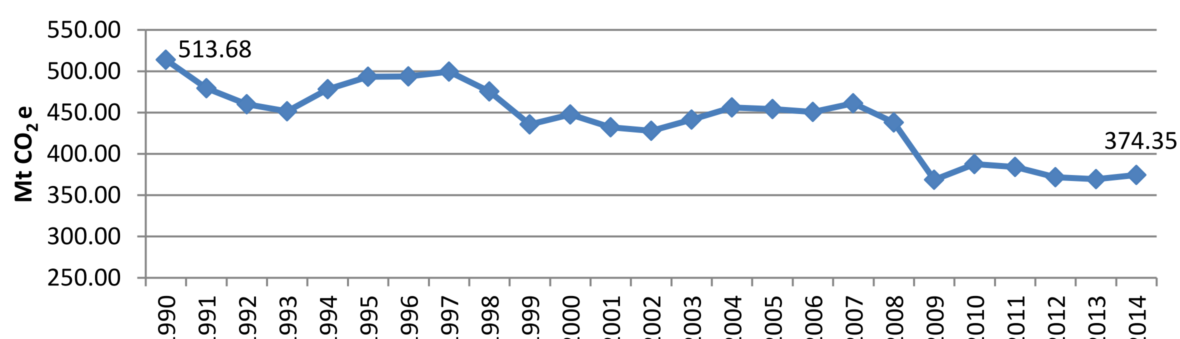
Over the past, economic growth has always been linked to the use of resources in an intensive manner so that jobs could be created and people could become wealthier. However, this paradigm is changing. The 7th Environment Action Plan (EAP), adopted by the European Parliament and the Council of the European Union in November 2013, had nine priority targets to achieve by 2020. The most important for the industry sector was the one to direct the union towards a resource efficient, green and competitive low-carbon economy. Governments began to take action through policies which aim to guarantee a sustainable growth of the global economy in accordance with environmental issues. The "Roadmap to a resource efficient Europe" (European Commission, 2011) sets the path required in order to use resources in a sustainable way within the EU while allowing economic growth at the same time. All the targets which have recently been set by the EU, aim at reducing the dependency between economic growth and environmental damage. These targets will force both producers and consumers to behave differently. "Businesses are facing rising costs for essential raw materials and minerals, their scarcity and price volatility are having a damaging effect on the economy" (European Commission, 2011). This situation explains the EU`s urge to become resource efficient. The actual environmental concerns are not only related with the natural conditions for human existence but also to the actual dependency on limited natural resources to which, mostly industry, is dependent on. The EU in general is highly dependent on imports of raw materials which are essential to guarantee employment in industry as well as economic growth. Among the aforementioned sources of GHG emissions from industrial processes and product use, the EU is mostly dependent on ores, metals and natural rubber. The Europe 2020 program consists of five headline targets as well as seven flagship initiatives. One of the flagship initiatives is related with the resource efficiency in the EU. The most important means needed in order to achieve the targets include: a close coordination with other Europe 2020 flagships; the importance of R&D and innovation; a better prices mechanism in order to allow consumers to see the true social costs; as well as addressing both supply and demand sides. The term resource efficient means using fewer inputs in order to achieve more outputs while, at the same time, using resources in a sustainable way through minimizing the environmental impact. The changes needed in order to move towards resource efficiency require policies which properly consider the interdependencies between human well-being, economy and natural capital. The shifting economic system is expected to "bring increased competitiveness and new sources of growth and jobs through cost savings from improved efficiency, commercialisation of innovations and better management of resources over their whole life cycle" (European Commission, 2011).

In the year 2008, the EU launched the Raw Materials Initiative which was later developed in 2011 and then was replaced by the Strategic Implementation Plan (SIP) of European Innovation Partnership on Raw Materials (EIP) in 2013. Since the beginning that the main goal is to improve the EU`s access to raw materials, either through better agreements with non-EU countries or through ensuring a sustainable supply of raw materials within Europe. There have been many negotiations with diverse non-EU countries which aim to facilitate the trade of raw materials which are essential for the EU`s industry sector. The main target is to reduce export duties on industrial raw materials. There is a very significant part of jobs within the EU which are directly dependent on the availability of raw materials. While the Raw Materials Initiative focuses more on a resource efficient Europe through improving its raw materials supply and ensuring sustainable practices within the industrial sector, the SIP of European Innovation Partnership on Raw Materials (EIP) focuses mainly on protecting the European industry. The main target is to increase the contribution of industry to the EU`s GDP to 20%. The more specific targets include, among others: up to 10 innovative pilot actions within the EU`s sector of industry, finding alternatives to at least 3 applications of scarce raw materials, enhanced efficiency in material use and waste prevention, and investment in research, education and training.

As it was demonstrated in the figure 4 in the beginning of this chapter, the GHG emissions generated from this sector do not show significant improvements between the years 1990 and 2014 (a reduction from 8.9% to 8.5%) when considering its share among the total GHG emissions from all the source sectors. However, the fact that the percentage is taken from the total GHG emissions does not allow a proper analogy of the sector. For instance, the increasing emissions from fuel combustion may undermine the decreasing emissions in this sector due to the different proportions.

The graph in figure 10 includes data about the total GHG emissions derived from industrial processes and product use in million tonnes of CO_2 equivalent ($MTCO_2e$). The data in the graph above (figure 9) does not include any emissions from fuel combustion. The time period from 1990 until 2014 was used in order to assess the impact of the regulations which mostly aroused in the 1990s. It is visible that the GHG emissions for this sector have been decreasing over time. The period when emissions were reduced the most was between 2007 and 2009 when the economic crisis began. Industries were impacted by the many factors including, decreasing demand and investment during the crisis, better enforcement of the EU`s policies, less carbon intensive industrial processes, usage of different fuels, as well as the shifting economy from a more manufacturing-based towards a more service-based economic system.

Figure 10 - GHG emissions from industrial processes and product use in the EU-28 (Million tCO2e), 1990-2014

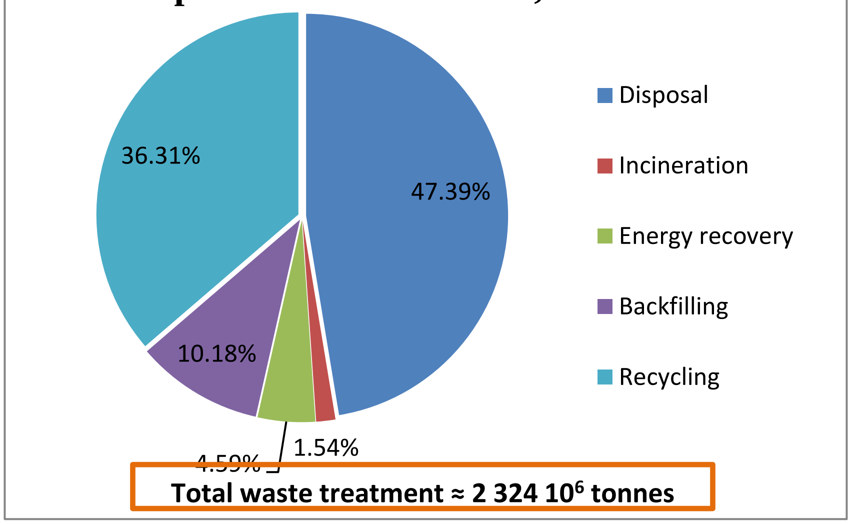


Source: Eurostat, 2016. Own representation.

3.4. Waste management

The increasing consumption and production levels have led to an undeniable rising awareness about waste management. Waste is not necessarily useless. It can also be a potential secondary raw material. According to data from Eurostat, in 2014, all economic activities and households generated approximately 2.5 billion tonnes of waste. The amount of waste has always been around this value since data is available for the EU (2004). Waste stream is the life-cycle of waste from its generation until its eventual disposal. The various types of waste streams may be classified according to how the waste was generated as well as how it was treated. Waste may be generated from various economic sectors along with households. The processing and treatment of waste may happen through either turning it into energy through various methods, recycling, backfilling, incineration or direct disposal. According to data from Eurostat together with my own calculations, the graph in figure 11 shows the percentage of waste for each type of operations used through waste treatment for the year 2014. Almost half (47.39%) of the waste generated by the EU-28 was subject to disposal operations other than incineration. In order to simplify, Eurostat names this type of waste operation as landfilling. Recycling is the second most used type of operation in waste treatment (36.31%). The high share of recycled waste can be explained by the increasing effort by the EU to find solutions for waste generated by products` packages. The EU introduced a directive in the early 1980s on packaging and packaging waste which was then revised in order to achieve the desired outcomes. The Packaging and Packaging Waste Directive and its amendments will be mentioned ahead. The three other types of operations used in waste treatment are of lower significance if compared to the two previously mentioned operations. In 2014, the quantity of waste backfilled represents 10.18% from the total treated waste (2 324 million tonnes). Waste backfilling consists on using waste in excavated areas for various purposes as engineering in landscaping or recovery of slopes. Almost a twentieth (4.59%) of the total waste treated was used for energy production through incineration, while the incineration which was not used for energy recovery represented only 1.54%.

Figure 11 - Treatment of waste by waste operations in the EU-28, % - 2014



Source: Eurostat, 2016. Own representation.

The waste management in the EU has been a concern for a long time. The first Waste Framework Directive (WFD) was created in 1975. This legislation has been revised in 1991 and remained unmodified until 2008 when a fundamental revision took place. The WFD is still a cornerstone of the waste policy in the EU. The last main legislative changes took action in the year 2015. The aim was to redefine the list of waste and hazardous properties. Recently, the 7th Environment Action Programme for 2020 highlighted the urge to increase the transformation of waste into a resource in order to reduce the impact of waste on climate change. The targets to be achieved by 2020 were set to help the EU to move towards a recycling society. The EU Member States committed to recycle 50% of their municipal waste and 70% of construction waste by 2020. A waste hierarchy has been created in order to rank the best waste management practices. The least preferred is the waste disposal, followed by other than the mentioned types of recovery, recycling, re-usage, and the focus is on waste prevention. In an economic perspective, the EU legislation imposed by the Action Programme would: save €72 billion a year; increase the EU waste management and recycling sector annual turnover by €42 billion; and create over 400 000 jobs until the end of the Programme. The EU Action Programme emphasizes the benefits inherent to the development of a circular economy. There was a specific circular economy package which was adopted on 2 December 2015. “In order to close the loop of product lifecycles, it also included an Action Plan to support the circular economy in each step of the value chain – from production to consumption, repair and manufacturing, waste management and secondary raw materials that are fed back into the economy" (European Commission, 2017).

The Packaging and Packaging Waste Directive aforementioned was first introduced in the early 1980s. It included rules on many aspects as production, marketing, recycling and the re usage of liquid containers (e.g. glass bottles). Each of the EU Member States was free to adopt different measures among them. Soon there was a need for the measures` harmonization among the EU members due to divergences mainly arising from the cross-boundary sale of secondary raw materials. The need for harmonization forced the implementation of a new directive (Directive 94/62/EC, 1994) which aimed to provide a high level of environmental protection as well as ensuring the proper functioning of the EU internal market (mainly concerning secondary raw materials). Although with some changes, this directive still exists today. The first amendment following its implementation happened in 2004 with the main goals of increasing the amount of packaging waste recovered or recycled, as well as redefining the term ´packaging`. In the following year efforts were done in order to assist new Member States in achieving the recovery and recycling targets. In 2013, the items considered to belong to packaging type of waste were revised in order to make the Directive clearer. In the year 2015, the Directive (EU) 2015/720 was implemented to replace the existent Directive 94/62/EC in terms of measures aimed to reduce consumption of lightweight plastic carrier bags.

4. Literature review

This chapter aims to provide an overview about previous authors who have already studied the environmental or economic characteristics of agriculture in the EU.

In the year 1977, Jones, wrote the book *Agricultural History* which had a chapter on the relation between environment, agriculture, and industrialization in Europe. The author described the purpose of this chapter as to "redirect attention to some consequences of Europe`s natural-resource endowment and topographical layout for its agriculture and early industrialization" (Jones, 1977). In the beginning of the 21^{st} century the "Ecological impacts of arable intensification in Europe" (Stoate et al., 2001) evaluated the European arable landscapes after a long period of mass industrialization and during a time of increasing awareness about anthropogenic environmental impacts. In the following year, in 2002, the "Organic agriculture, environment and food security" (Scialabba & Hattam, 2002) "presents scientific evidence of the impact of organic agriculture on environmental goods and services and offers an evaluation of its possible contribution to the implementation of international environmental agreements. It also reviews the current status, trends and prospective development of certified organic agriculture production and trade" (Scialabba & Hattam, 2002). In 2005, S. De Cara, M. Houzé and P. A. Jayet highlighted the significance of agricultural emissions among the total anthropogenic impact. The article "Methane and nitrous oxide emissions from agriculture in the EU: a spatial assessment of sources and abatement costs" (De Cara et al., 2005) stated that "agricultural activities contribute significantly to global emissions of greenhouse gases; agriculture is the major emitting sector of methane (CH_4) and nitrous oxide (N_2O) – the two main non-CO_2 GHGs included in the Kyoto basket; the impacts of climate change as predicted by climate models are expected to be stronger on agriculture than on other sectors" (De Cara et al., 2005). In the following year, H. van Meijl et al., released "The impact of different policy environments on agricultural land use in Europe" (Van Meijl et al., 2006) where the "results show that no drastic decrease in land for agricultural purposes is expected for the EU-25 in the coming 30 years, since the global food market will experience an increase in demand because of expected growth in GDP and population in many developing countries" (Van Meijl et al., 2006).

IV. Practical part

1. Farming practices in the EU

1.1. Overview of agri-environmental policy in the EU

The environmental concerns regarding the agricultural sector have been addressed from the very beginning of the EU. “A policy set at the European level ensures common rules in a single market; addresses market volatility where needed; safeguards the progress made in recent reforms towards increased competitiveness of European agriculture and provides for a common trade policy allowing the EU to negotiate as one, vis-á-vis our global trading partners” (European Union, 2014). The advantages of having a single entity regulating the agricultural policy is essential for the sector`s development.

One of the oldest policies in the EU is the Common Agricultural Policy (CAP). It was introduced in the late 1950s and early 1960s in response to the food shortages caused by the World War II. The first three European Communities (ECs) were created in the late 1950s and coincided with the first steps of the CAP creation. The CAP came into force in 1962 after a proposal by the European Commission in 1960. However, it was subject to many changes over time. The major reforms happened from the 1990s onwards. While in the beginning the policy was mostly based on price support and improvement of productivity in order to assure food security, the so called MacSharry reform of the CAP in 1992 represented a shift from supporting products (through prices) to supporting producers (through income support). The Agenda 2000 (signed on 26 March 1999) established new social, economic and environmental goals for the CAP. The inclusion of rural development into the policy has represented the main change. This reform was executed in order to comply with the Amsterdam Treaty (1999) which established that environmental protection should be integrated into all EU sectorial policies in order to boost a sustainable development. The Amsterdam Treaty reformulated the Maastricht Treaty (1993) which already included the commitment to take environmental protection as part of the EU policy. The CAP is based on two pillars which, despite some changes, still exist today. The first pillar regards the direct payments to farmers, while the second pillar concerns rural development policy. The CAP reform initiated in 2003 included the goals of enhancing competitiveness, strengthening rural development policy, as well as improving market orientation of the sector. The most innovative instruments created in this reform included, decoupling income support from price and production as well as the linkage of direct payments to the farmers` compliance with basic norms regarding food safety, environment, as well as animal and plant health. In 2008 there was a CAP health check which reinforced the 2003 reform. The latest CAP reform was reached in 2013 and took place in the discussions on the overall EU budgetary framework for 2014-2020. One of the main changes in the policy framework was the increasing awareness about the importance of environmental public goods. "Farmers should be rewarded for the services they deliver to the wider public, such as landscapes, farmland biodiversity, climate stability even though they have no market value. Therefore, a new policy instrument of the first pillar (greening) is directed to the provision of environmental public goods, which constitutes a major change in the policy framework" (European Commission, 2013). The CAP is still based on the aforementioned two pillars, however, the first pillar (direct payments to farmers) has been changed in order to strengthen rural development, be more equitable and green, and enhance food safety. The two pillars have become more linked with the last reform in order to offer a more holistic and integrated approach to policy support. "To achieve the long-term goals for the CAP, the reform focuses on the competitiveness and sustainability of the agricultural sector by improving the targeting and efficiency of policy instruments" (European Commission, 2013).

1.2. **Social, economic and environmental issues concerning farming practices in the EU**

As it was mentioned before, the agricultural sector has been a target to many interventions by the EU due to its importance in social, economic and environmental terms. However, the reduction of GHG emissions from farming practices is not at the top priorities of the EU policy agenda due to the higher impact from other sectors (e.g. energy production sector). According to data from the FAOSTAT database, in 2014 the agricultural area in the EU occupied approximately 42% from the total area from all 28 member states. "With its 28 Member States, the EU has some 12 million farmers with a further 4 million people working in the food sector.

The farming and food together provide 7% of all jobs and generate 6% of European gross domestic product" (European Union, 2014). As a result of the increasing food demand and consequent production intensification, the impacts of farming practices on the environment have significantly increased over the last decades. Although the amount of jobs in the agricultural sector represent a small part of the EU`s working population, it does occupy almost half of the EU`s land area. One of the main issues affecting the agricultural sector in terms of rural development is the aforementioned working population size as well as the rural population ageing. The recent reforms of the main agricultural policy tool (CAP) in the EU demonstrate that the sector is being strengthened in terms of sustainability and the farmers are acquiring more power in the food supply chain. While before the 1990s the sector was mostly regulated by governments in terms of production (e.g. through quotas), today the farmers are allowed to do their own production decisions based on market demand. The main challenge for the future of the EU`s agricultural sector is to double production by 2050 in order to satisfy the demand by the increasing population and, at the same time, to deal with its impact on climate change. The actual means used to tackle this issue are based on giving advices to farmers in terms of investment and innovation.

The EU member states have exceptional agricultural resources. The EU farmers play a vital role in accomplishing the challenge of increasing food production whilst protecting the existing resources. It is important that decision-makers within the agricultural sector think globally and act locally, thus information about existent problems is obtained in a clear and concise way in order to allow the most effective solutions.

2. Analysis of environmental and economic agricultural indicators for EU-28 Member States (1991-2013) and historical based forecasts until 2050.

The data used in this practical part of the thesis will be secondary (collected from statistical databases. E.g. Faostat, Eurostat…). The data collected for analysis is related to the agricultural sector in the EU-28 either through an economic or environmental perspective. The data period will be selected both according to its availability and its significance to this research. The description of each variable will be complemented with forecasts in order to allow a better understanding about the feasibility of the EU`s policies regarding the agricultural sector. As it was already mentioned, the 1990s represented the beginning of an active intervention by the European Commission in terms of tackling climate change through policies applied to all sectors.

As it was mentioned in the beginning, the indicators were chosen to provide an explanation about what are the main causes of GHG emissions from farming practices in the EU-28. The initial belief is that the agricultural sector`s environmental issues in the EU-28 are dependent on both the economic health of all Member States and on the innovation in farming practices towards sustainability. The farming practices will be divided into groups in order to assess which one has the highest impact in terms of GHG emissions. On the other side, the economic indicators will be related with production and value added.

2.1. **GHG emissions from agriculture in the EU-28 (1991-2050)**

The agricultural sector does not only have a significant impact on global warming through its GHG emissions, it also is one of the most affected sectors by climate change. The pollution which arises from farming practices does not only affect the earth`s air quality. It is responsible for water pollution, loss of biodiversity, as well as soil damage. However, this practical part will only address the GHG emissions from the sector.

The agricultural sector`s emissions include mostly gases as nitrous oxide (N_2O) or methane (CH_4). These emissions are generated by different farming practices. The emissions of N_2O derive from manure management and enteric fermentation, while the CH_4 is emitted by manure management and agricultural soils. “Methane (CH_4) is produced by the fermentation of feed and generally, the higher the feed intake, the higher is the methane emission. Feed intake is positively related to animal size, growth rate, and production” (Lazányi, 2010). However, methane can also arise from manure decomposition. “These conditions often occur when large numbers of animals are managed in a confined area (e.g. dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons" (Lazányi, 2010). According to the IPCC Fourth Assessment Report, the agricultural sector emits approximately 67% of the total human sources of N_2O emissions. This type of gas can be either originated directly or indirectly in agriculture. Direct emissions include the application of fertilizers (which are usually having a lot of nitrogen) and manure from livestock. The indirect sources include mainly the runoff and leaching of fertilizers, most of the N_2O emitted from rivers, estuaries and coastal waters are usually associated with farming practices.

Throughout the research, the various agricultural sources of GHG will be grouped as:

- Enteric fermentation
- Manure management
- Use of synthetic fertilizers
- Crop residues and its burning
- Other (rice cultivation, organic farming and burning of savanna)

The indicators concerning GHG emissions used in this practical part are measured by tonnes of CO_2 equivalent (tCO_2e). As it was mentioned before, all the gases which result from farming practices are translated into tCO_2e by measuring the Global Warming Potential (GWP) of certain gas. Then a correspondence is done in order to find how many tonnes of CO_2 are needed to have the same impact on global warming as a unit of the given gas (e.g. N_2O).

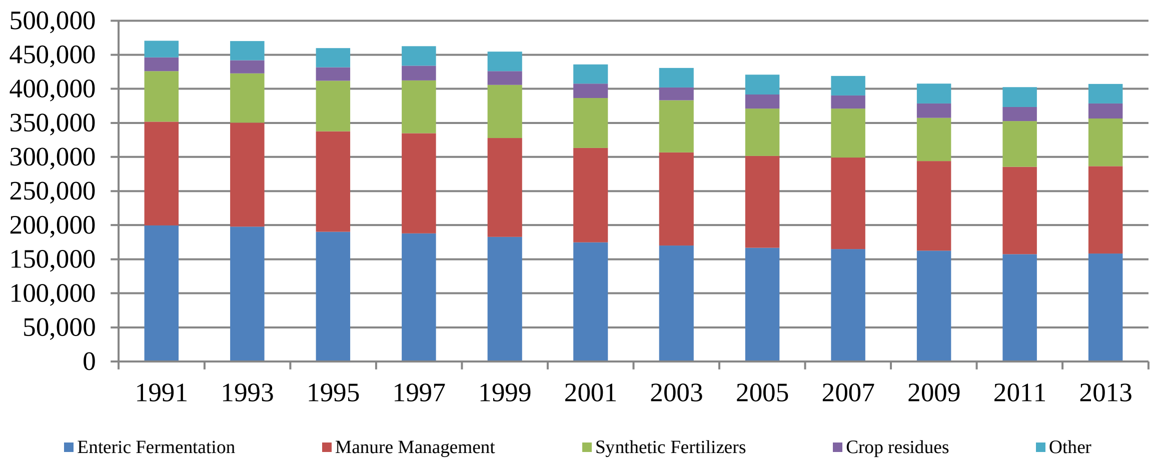
According to data extracted from Eurostat database and to my own calculations, agricultural emissions in the EU-28 represented in 2013 approximately 10.5% from the total GHG emissions from all sectors and indirect CO_2 (including emissions from land use, land use change and forestry). The graph in figure 12 includes data about GHG emissions from each of the farming practices mentioned above. The time-period used (1991-2013 biannually) was chosen due to the higher intervention by the EU in terms of environmental protection since the 1990s. The data was extracted from Eurostat and is presented in thousand tCO_2e. It is important to note that besides the EU`s need to decrease GHG emissions there is also the need to increase agricultural production and improve its quality in some of the member states in order to achieve the targets in terms of food security and safety. The agricultural sector`s characteristics vary throughout the various EU members. The increasing production, if not done with innovative technologies, will most likely lead to increasing GHG emissions.

It is visible in the figure 12 that GHG emissions have generally been decreasing over the last two and a half decades, however, the year of 2013 contradicted the decreasing tendency. The increasing agricultural GHG emissions in 2013 can be mainly explained by the increasing use and consequent impact of synthetic fertilizers. The use of synthetic fertilizers is the third most significant source of GHG emissions within the agricultural sector. Such fertilizers are commonly having large amounts of nitrogen which, through its oxidisation, then becomes N_2O. As it was earlier mentioned, according to the Global Warming Potential (GWP), the emissions of N_2O are having a significantly higher impact on climate change than does CO_2. If measured in a period of 20 years, the impact is 280 times higher. However, if the measuring is done for a period of 100 years, the impact is about 310 times higher than CO_2. The lifetime of N_2O is estimated to be around 120 years, while methane lasts about 12 years in the atmosphere. All the groups of farming practices presented in the graph below (figure 12) increased between 2011 and 2013 except for a slight decrease in the group of other farming practices. The most significant rise in GHG emissions was from the use of synthetic fertilizers which increased by approximately 15% according to the data shown in the graph. In fact, the levels registered in 2013 went back to about 98% of those in the year 1990.

Despite the increasing impact of synthetic fertilizers, the total GHG emissions from all the farming practices were reduced by 14% from the year 1991 until 2013. As expected, the farming practices which have the highest GHG emissions are those related to livestock. From the total GHG emissions within the agricultural sector, enteric fermentation is the farming practice which has the highest impact on environment followed by manure management. According to calculations based on the graph´s data, the two of them together account for almost 69% of the total GHG emissions for the year 2013. These statistics explain the recent concerns about the quantity of meat consumption worldwide.

The least impactful farming practices in terms of GHG emissions include crop residues and other. The group of other farming practices refers to GHG emissions from organic farming, rice cultivation and burning of savanna. The most significant from these three is the organic farming. Despite the lower GHG emissions in organic farming when compared to conventional, the doubts about its sustainability still exist. The organic farming practices have a lower impact mainly due to the absence of synthetic fertilizers, however, the output is significantly lower than what is obtained from conventional farming practices. The data extracted from the Faostat database shows a share of 5,75% of GHG emissions from organic farming out of the total agricultural emissions. However, the utilised agricultural area (excluding kitchen gardens) which is either fully converted or under conversion to organic farming represents 6,4% of the total area used for agriculture in the EU-28. When comparing to the rest of the world, according to the "Current statistics on organic agriculture worldwide: Area, producers, markets, and selected crops" (Lernoud & Willer, 2016), the EU-28 had 27% of the total agricultural land used for organic farming in 2013.

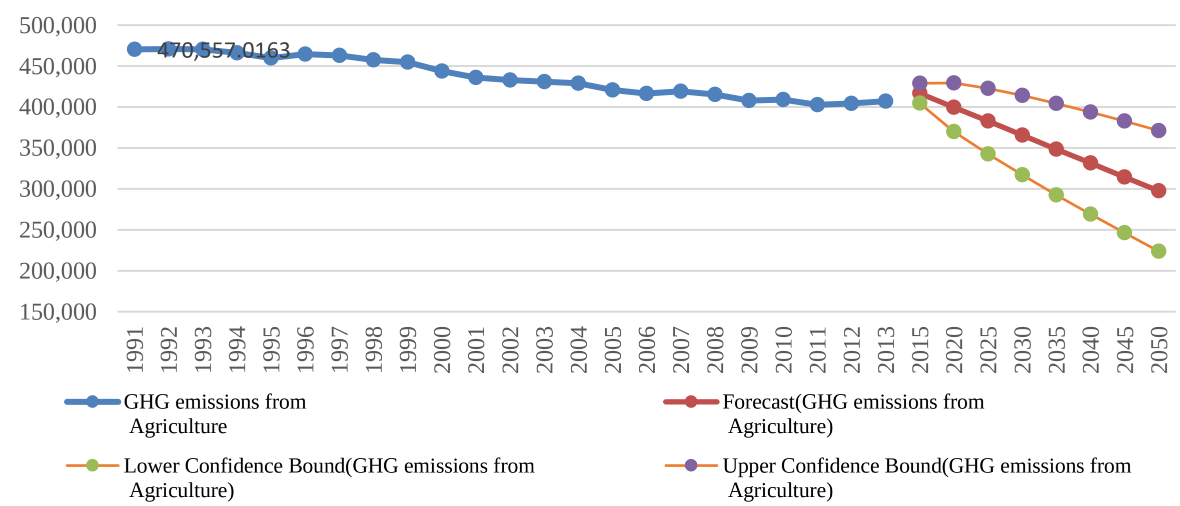
Figure 12 - GHG emissions by farming practice in EU-28, thousand tCO_2e (1991-2013 biannually)



Source: FAOSTAT, 2016. Own representation.

The graph in figure 13 shows the total GHG emissions from agriculture (in thousand tCO_2eq) which is a sum of the 5 groups shown in the previous figure 12 with data provided by FAO. The graph also includes a forecast for seven years for every fifth year between 2015 and 2050 which was created by the forecasting tool of Microsoft Office Excel 2016. The future values are predicted using the existing historical data and the AAA version of the Exponential Smoothing (ETS) algorithm. The figure 13 also shows 95% confidence intervals for the forecasts. It is important to highlight the fact that the forecasted data is decreasing at a fastest rate due to the larger period covered (5-year distance between each data point). The total emissions from agriculture were of about 407.233 million tonnes of CO_2 equivalent in 2013. As it was earlier mentioned, this value corresponds to approximately 10.5% of total anthropogenic GHG emissions. The data collected suggests that all members of the EU-28 have decreased their GHG emissions from agriculture on average in about 13.97% when comparing the values of 2013 with those of 1990 (most common base year used in the EU for the targets´ establishment). Despite the previously mentioned increasing emissions in 2013, the general tendency is of a substantial reduction. This decreasing tendency may be explained by the increased environmental regulation in the EU. Producers of GHGs have been subject to pressures which aim to force the adoption, in the case of agriculture, of more sustainable farming practices. It is fundamental to consider the population which is dependent on agriculture for their survival when it comes to the introduction of innovative practices to the sector, mainly due to the incapacity of many of them to compete with larger producers.

Figure 13 - GHG emissions from agriculture in EU-28 (thousand tCO_2eq), 1991-2013 and historical based forecast 2015-2050



Source: FAOSTAT, 2016. Own representation.

2.1.1. **Net emissions/removals by LUCF in the EU-28 (1991-2050)**

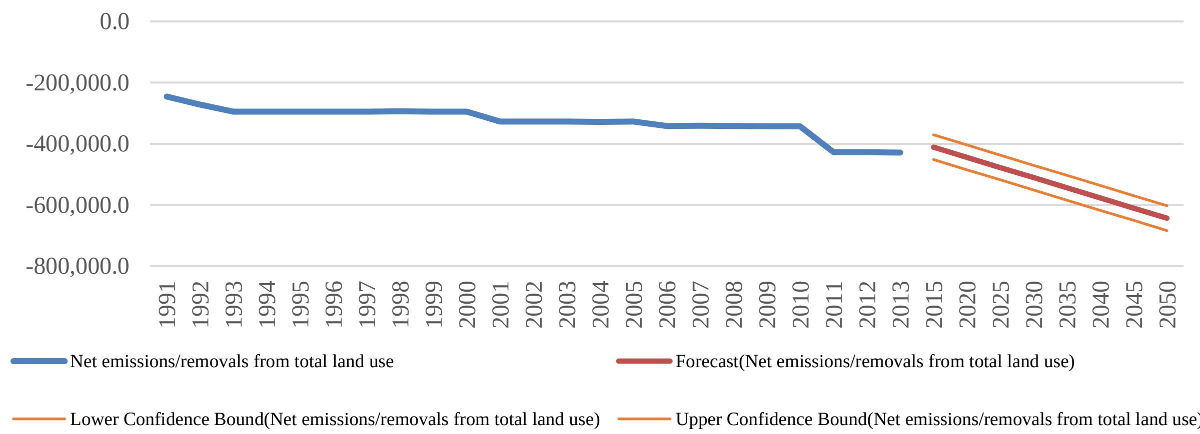
The net emissions/removals by land use change and forestry (LUCF) refers to changes in GHG emissions by land-use change and forest. The difference between this indicator and the ones previously mentioned is that instead of measuring the impact by certain farming practices, it aims to show the change in atmospheric levels of GHG emissions which result from the way how land is used. The indicator includes changes in forestland, cropland, grassland and burning of biomass.

In October 2014, all the EU Member States agreed that all existent sectors should contribute to the 2030 targets in terms of GHG emissions. As a consequence of this agreement, and in line with the Paris Agreement, the European Commission proposed, on 20 July 2016, to include GHG emissions and removals from land use, land use change and forestry (LULUCF) in the EU`s 2030 emission reduction target. It is extremely important to take the land use and forestry into account due to the insufficiency of looking only to emissions by farming practices. The quality of soils and quantity of forests have a direct impact on GHG emissions. The European Commission aims, with this proposal, to help farmers from all member states to develop climate-friendly farming practices, as well as to provide support to foresters. The foresters have an important role in fighting GHG emissions due to the advantages of wood products related with its capacity to store the carbon from the atmosphere.

The graph in figure 14 shows the net emissions/removals from total land use change and forestry (LUCF) in the EU-28. The units used are the same as those previously used to measure GHG emissions from agriculture (tCO_2e) in thousands. The decreasing value of this indicator mean that GHG emissions are being reduced through land use change and forestry. The graph shown in the next chapter (figure 15) concerning the area used for agricultural purposes and that occupied by forests explains the development of the graph below (figure 14) through the increasing size of forests and decreasing land use for agriculture. The historical part includes data from 1991 to 2013. It is followed by a forecast for every 5th year from 2015 until 2050. The graph suggests that changes in the land use and forests have been resulting in decreasing levels of emissions. From the year 1991 until 2010 the net emissions/removals have steadily been decreasing from approximately -245,637 thousand tCO_2e in 1990 to -428,843 thousand tCO_2e in 2013. In the form of percentage, emissions have been reduced in about 75% of the value in 1991. In the year 2011 the emission levels were significantly decreased. The reduction can be mainly explained by the increased control over deforestation in the EU. As it was mentioned before, forests play an important role in the carbon cycle due to its ability to absorb the gas.

The EU-28 Member State which contributed the most to the lowering of GHG emissions through its total land use in 2013 was Romania (-163,768.7 thousand tCO_2e). On the other side, Finland had the highest net emissions/removals from total LUCF in 2014 (5,714.8 thousand tCO_2e).

Figure 14 - Net emissions/removals from total LUCF in EU-28 (thousand tCO_2e), 1991-2013 and historical based forecast 2015-2050



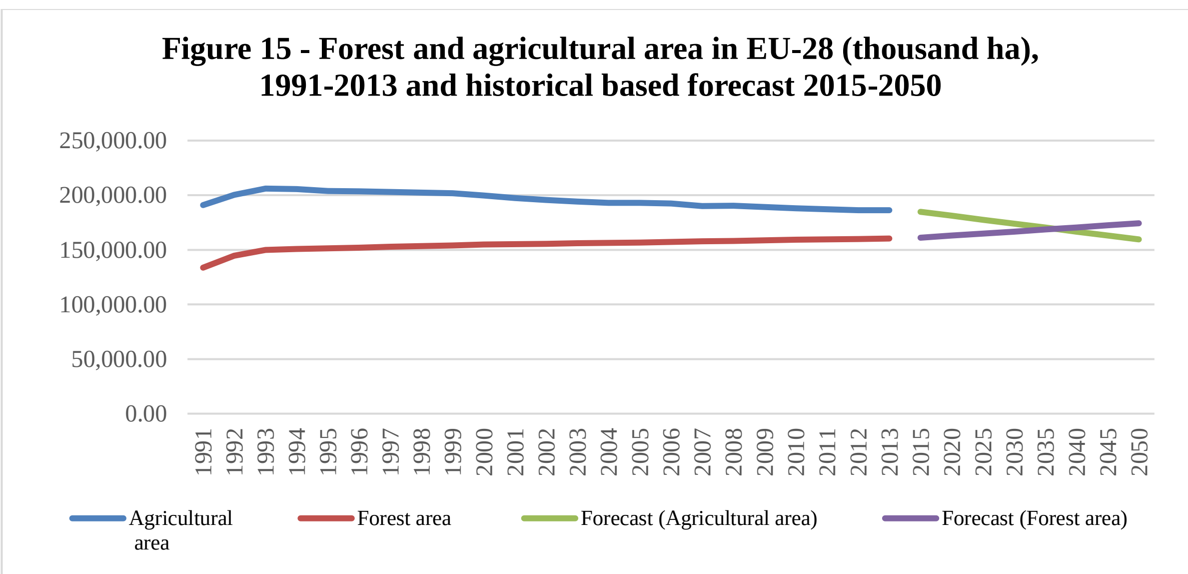
Source: FAOSTAT, 2016. Own representation.

2.2.Forest and agricultural area in the EU-28 (1991-2050)

The economic growth together with the population growth are the main causes of the pressure which exists to satisfy food demand throughout the world. The EU-28 Member States do not have such a problem to supply the required quantity of food as other less developed countries have.

The graph in figure 15 shows separately the number of hectares occupied by forest and by agricultural land. According to the data in shown in the graph, and taking into account the total area of the EU-28 for the year 2013 (4,381,376 Km^2), approximately 79% of the EU-28 is occupied by forests and land used for agriculture. The size of agricultural land is not strictly related with agricultural output due to possible different farming practices used now which can be more productive than in the 1990s. The two indicators in the graph below (figure 15) have generally been developing into opposite directions. While agricultural area has been decreasing (except for the years 1992 and 1993), the forests have been always increasing in their size across the EU-28. The development of both indicators is in accordance with the efforts which have been done by the EU to increase production efficiency and tackle climate change, especially from the 1990s.

The two curves starting from the year 2015 are forecasts which rely on the historical data collected. The area covered by forests is expected to overcome the agricultural land between the years 2035 and 2040. The increasing size of forests is caused by the increased control over deforestation which is done to use the forests` ability to absorb CO_2 from the atmosphere.



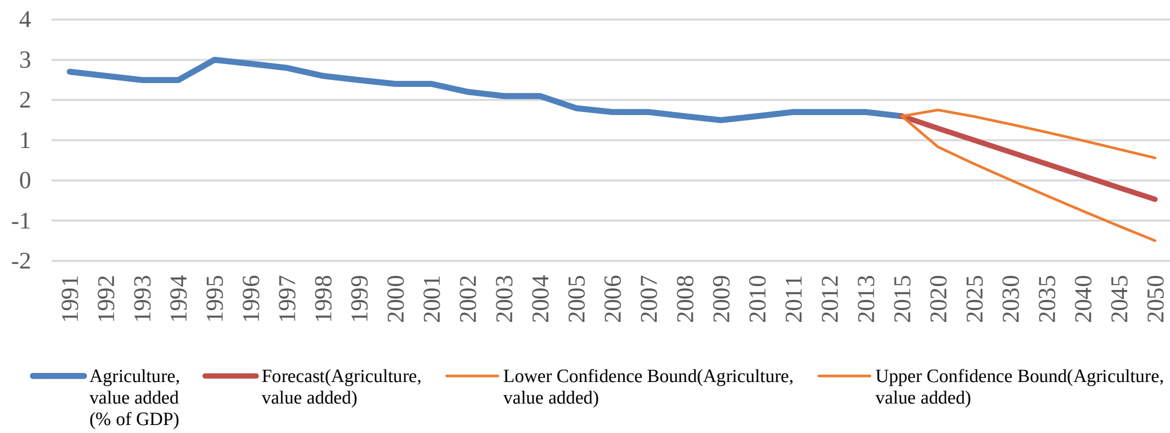
Source: FAOSTAT, 2016. Own representation.

2.3. **Agricultural value added in the EU-28 (1991-2050)**

It is of extreme importance to measure the value added of policies as the earlier mentioned CAP. The value-added analysis of agricultural expenditure has been discussed among the EU members in order to assess the efficiency of recent measures applied to the sector. The graph in figure 16 aims to provide both a historical perspective of the value-added in the agricultural sector by the EU-28 Member States (1991-2013) and a forecast for every 5th year (2015-2050) based on the same values and through the same methods as those used in the previous forecasts. It is important to mention the fact that the values expressed in percentages do not allow to see the increasing value in monetary terms. It does rather represent the agricultural sector`s share from the total value added by all EU-28 Member States in all sectors. The worldwide competition within the agricultural sector has been increasing over the last decades due to the higher contribution of Asia and the Pacific to the sector`s global value-added. Approximately half of the global agriculture`s value added (49.8%) was provided by Asia and the Pacific in the year 2013 according to data provided by The World Bank. However, the significance of agriculture within the economy of the same geographical group has been decreasing due to the growing industrial sector.

The agricultural value added has generally been decreasing since the year 1991 except for a significant increase in 1995 and a slight increase of 0.1% in 2010. The increased value-added in 1995 may be explained by the EU enlargement (Austria, Finland and Sweden became members) as well as by the aforementioned MacSharry reform in 1992 which shifted the measures used to support producers. Instead of supporting through the products` prices, the EU decided to support directly the producers through their income. The agricultural sector represented it`s smallest share in 2009 (1.5%) when the most recent global economic crisis took place. From 2009 onwards there was a slight improvement until the year 2013 when it reached 1.7%. However, the forecast done using the historical data presented below shows a clear decreasing tendency. The agricultural sector`s value added is expected to reach 1.29% in 2020 and 0.7% in 2030. These expectations are only based on the 23 time periods of historical data. Even though the EU`s economy is mainly dominated by the service`s sector, the interest in having higher value added in the agricultural sector would make sense in accordance with the established targets which have been mentioned earlier.

Figure 16 - Agricultural value added in the EU-28 (% of GDP), 1991-2015 and history based forecast, 2016-2050



Source: The World Bank, 2016. Own representation.

The future of the agricultural sector is expected to be challenging according to the figures which were already presented. The EU has been providing many efforts towards the achievement of the Europe 2020 strategy which, in this sector, consists on boosting competition through sustainable means. The differentiating aspect which the EU-28 Member States may benefit from is related to the strong investment on innovative farming practices which, in turn, has a direct impact on the sector`s value added. An example of an effort by the EU is the European Innovation Partnership for agricultural productivity and sustainability (EIP-AGRI). It was launched in 2012 and was one of the five EIPs launched by the European Commission concerning various sectors. At a glance, the EIP-AGRI`s goal was/has been to boost productivity, sustainable farming practices and competition through cooperation between both innovation and research partners in order to allow a better and faster response to the mentioned goals. When comparing to the rest of the world`s farming practices, the EU`s value added in the agricultural sector aims to be mostly created by innovative and environmentally friendly farming practices (which have a direct impact on costs and consequently on its prices) not only due to the urgency to act against climate change but also due to the consequent increasing demand and awareness.

2.4. **Agricultural gross production value in the EU-28**

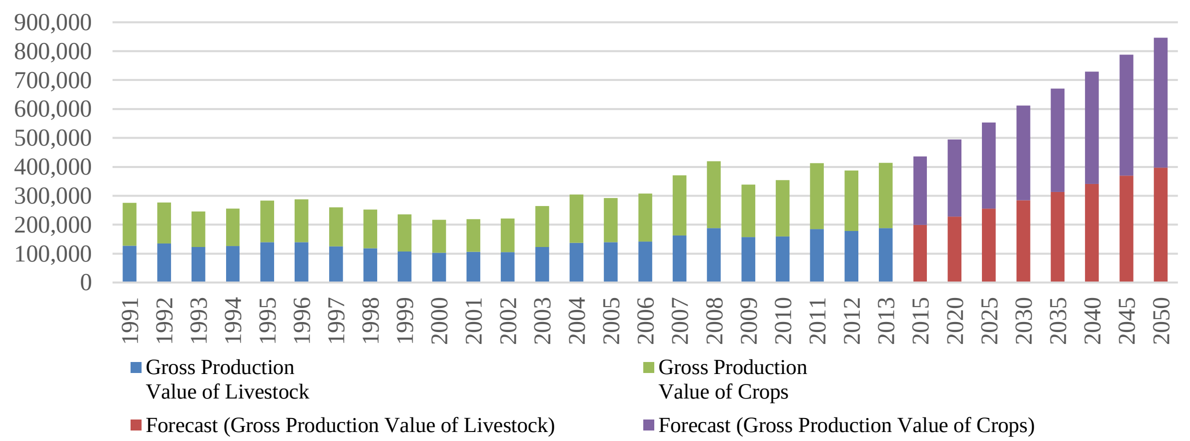
The choice of this indicator, as well as the previous one, is to give an economic perspective on agriculture in the EU-28 Member States. The gross production value may be influenced by various factors as the cost of inputs or the quality of the output. The fact that the EU-28 is one of the regions where organic farming is more significant affects the value of the output positively. The gross production value in agriculture is measured according to the output prices at the farms. The gross term is used when agricultural production is measured before subtracting the costs (e.g. feeding or seeding) associated with intermediate processes.

The graph shown in figure 17 shows the overall EU-28`s gross production value for livestock and crops. The sum of both indicators equals the gross agricultural production value which will be used in further analysis. Gross value of production includes all production output including production for own use, changes in inventory of finished products (excluding purchases of goods for resale), and other operating profits. The values are expressed in current million US$ and the period used ranges between 1991 and 2013. It is important to mention that the current production value means that it is not adjusted to inflation, that can be seen in the almost homogeneous growth of all indicators. The data for livestock production includes only indigenous meat (not imported).

The graph in figure 17 shows that the gross production value of crops has generally been slightly above the livestock value between 1991 and 2013. In 2013, the gross production value of crops represented about 55% of the total agricultural gross production value. The difference between the two indicators is that livestock production includes all primary products of animal origin while the crop production covers the rest. It is possible to see that the total agricultural production value was decreasing the most during the late 1990s (1997-2000) and in 2009. In the late 1990s, the consequences of a strong support to exports through subsidies began to be felt with the decreasing value of agricultural production. Such subsidies were used to allow farmers from the EU Member States to compete with other developing nations where costs of production were (and still are) lower. The significant decreasing value of production in the year 2009, after the growth verified between 2006 and 2008, can partly be explained by the global economic crisis.

The historical data presented in the figure 17 is followed by a forecast which was done using Excel`s exponential smoothing algorithm. The fact that the forecast is done for 8 years between 2015 and 2050 (every 5th year) explains the fastest growth of both indicators. The gross agricultural production value for livestock is expected to achieve approximately 284.5 billion US$ by the year 2030 while crop production is expected to reach 327.5 billion US$. It is important to remind the fact that the values are influenced by the expected inflation as well.

Figure 17 - Gross production value of crops and livestock (current million US$), 1991-2013 and historical based forecast 2015-2050



Source: FAOSTAT, 2016. Own representation.

3. Model analysis

The main practical outcome from this thesis will be provided by a regression model. Generally, panel data is used when there is the need to analyse indicators both in a time-series and cross-sectional perspective. While the first provides an analysis of certain indicators` development over time, the second observes many subjects/indicators at the same point in time. Panel data can be also called longitudinal, whereas a researcher is allowed to address more issues when compared to time-series and cross-sectional data. The data points are the result of a combination between time (T) and a certain variable (N). The consequent larger amount of data points (than in other types of analysis) increases the degrees of freedom and reduces the probability of collinearity between explanatory variables.

The multiple possible causes of GHG emissions by the agricultural sector explain the choice of this type of analysis. The indicators used to explain the dependent variable will vary, in terms of perspective, between economic, environmental and geographical. The panel data analysis ahead aims to provide a general understanding about the main factors influencing agriculture`s impact on air pollution through GHG emissions.

3.1. **Introduction of the model**

The econometric models shown in functions 1 and 2 were built to assess the dependency of GHG emissions from the agricultural sector on economic and environmental indicators for the EU-28 Member States. Each of the indicators include 23 observations from 1991 until 2013. The time period was chosen according to its availability as well as according to its significance when concerning the increasing measures applied by the EU in terms of agriculture and environment.

Function 1: Econometric model 1

$$AgGHG = \gamma_{11} + \gamma_{12}\ AgArea + \gamma_{13}\ FoArea + \gamma_{14}\ LiValue + \gamma_{15}\ CrValue + \gamma_{16}\ AgVAdd + u_1$$

Function 2: Econometric model 2

$$AgGHG = \gamma_{11} + \gamma_{12}\ EntFrm + \gamma_{13}\ ManMng + \gamma_{14}\ SynFrt + \gamma_{15}\ CrRsdu + \gamma_{16}\ NetEmi + u_1$$

Where,

γ – is a parameter of an exogenous variable which will be estimated to explain the relationship between endogenous and exogenous variables

AgGHG – GHG emissions from agriculture (thousand tCO_2 equivalent)

AgArea – Agricultural area (thousand hectares)

FoArea – Forest area (thousand hectares)

LiValue – Gross production value of livestock (current million US$)

CrValue – Gross production value of crops (current million US$)

AgVAdd – Value added from agriculture (% of GDP)

EntFrm – GHG emissions from enteric fermentation (thousand tCO_2 equivalent)

ManMng – GHG emissions from manure management (thousand tCO_2 equivalent)

SynFrt – GHG emissions from synthetic fertilizers (thousand tCO_2 equivalent)

CrRsdu –GHG emissions from crop residues and its burning (thousand tCO_2 equivalent)

NetEmi – Net emissions/removals from total land use (thousand tCO_2 equivalent)

3.2. **Assumptions**

All the indicators previously mentioned are linked to the agricultural sector either in an economic or environmental perspective. However, the main goal is to find the significance of each indicator on the GHG emissions generated by the sector in the EU-28. In order to do so, it is important to establish assumptions concerning the cause effect relationships between each of the independent variables and the dependent based on the historical developments of each indicator. Assumptions are statements formulated prior to any type of thorough examination concerning possible cause effect relationships based on existent facts. An assumption is used to lay the groundwork for action by creating "what if" scenarios of possible situations.

The assumptions are as follows:

- The higher portion of area used for agricultural purposes results in higher emissions while the higher forest area tends to lower GHG emissions (as it was previously mentioned).
- The higher livestock and crop gross value of production together with the agricultural value added tends to lead to increasing levels of agricultural GHG emissions.
- The increasing levels of GHG emissions from each of the farming practices (Synthetic fertilization, enteric fermentation, manure management, and crop residuals and its burning) lead to higher amount of GHG emissions from agriculture
- The net emissions/removals which result from the change in agricultural land use and forestry affect GHG emissions from the agricultural sector positively

3.3. **Parameters` estimation**

The estimation of the two models` parameters is done through the Ordinary Least Squares (OLS) method. The software used (Microsoft Office Excel 2016) allows the calculation of parameters through minimizing the sum of squares of residuals (which is the basis for OLS). The development of each of the previously mentioned secondary data allows the attribution of a certain parameter which explains how the dependent variable is likely to be affected by a one unit change of each of the independent. Each of the coefficients obtained through the OLS method will be followed by three other values which are used to verify its significance. The standard error is always a positive value which explains how precise the coefficient estimation is. The smaller standard error means a more precise estimate. The t statistic value and the p-value can be both used for supporting or rejecting null hypothesis, in this case, to find if the variables are significant within the model. The p-value will be used for this purpose by comparing it to the chosen α (alpha) which represents the probability of rejecting the null hypothesis when the null hypothesis is true. Along with the output concerning the regression coefficients, the whole regression statistics will also be shown below. The regression statistics include the coefficient of determination (R^2), the adjusted R^2, the standard error for the whole model, and the number of observations.

The first model aims to assess the impact of mainly economic indicators (however, agricultural and forest areas are also included) on the GHG emissions from the agricultural sector. The second model has its focus on how agricultural emissions are affected by GHG emitted by various farming practices. The past tendencies of most of them have already been analysed together with predictions until the year 2050. The main goal of this part is to provide a better understanding about cause effect relationships and its significance according to the 23 of observations collected for each of the indicators.

3.3.1. **Parameters` estimation and statistical verification of the first model**

The output from Microsoft Excel 2016 concerning the regression models will be presented with both a first section linked to the coefficients` estimation and its significance, and the second part evaluates the significance of the whole model together with its number of observations. As it is visible in the table 3, the regression model has an R^2 of 98.99%. The R^2 shows how the exogenous variables explain the endogenous one in the form of percentage. The high R^2 achieved in this model means that almost 99% of the variance of GHG emissions is explained by the other 5 variables of the period between 1991 and 2013 in the EU-28. The adjusted R^2 is useful in cases where the estimates are done from samples which is not this case. The adjusted R^2 only measures how significant independent variables affect the dependent variable. The standard error (which indicates the values dispersion within the set) is of approximately 2 821 thousand tonnes of CO_2 equivalent. According to the p values of each coefficient, it can be assumed that they are all significant at the 5% significance level except the gross production value of livestock and crops. For this reason, the two variables were excluded from the model.

Table 3 – Output from OLS method for the first model

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	260471.139	40895.45232	6.369195708	6.99E-06
Agricultural area	2.38321012	0.238190435	10.00548201	1.54E-08
Forest area	-2.0213094	0.161595364	-12.5084615	5.32E-10
Value Added, agriculture	7431.42774	3341.504721	2.223976429	0.03999

Regression Statistics			
R Square	0.989864762	**Adjusted R Square**	0.98688381
Standard Error	2821.13944	**Observations**	23

Source: Microsoft Excel 2016. Author`s computation.

The model can be shown in the form of an equation by replacing each of the parameters Gama (γ) by the coefficients shown in table 3. The equation of the estimated econometric model can be seen in the function 3 shown below.

Function 3: Estimated econometric model 1

$$AgGHG = 260471.139 + 2.38321012 * AgArea - 2.0213094 * FoArea + 7431.42774 * AgVAdd + u_1$$

3.3.2. **Parameters` estimation and statistical verification of the second model**

The table 4 includes the estimation of the second model which is linked to the environmental impact of various farming practices within the EU-28. The regression statistics indicate that the R^2 equals approximately 99.9%. The standard error for this model is significantly smaller than that shown in the first model`s output. The values dispersion in the data collected equals 841.7 thousand tonnes of CO_2 equivalent. In terms of the significance of each coefficient, according to the p values, all the coefficients are significant on a 5% significance level except the net emissions/removals from LUCF. That is the reason why it was excluded from the model.

Table 4 – Output from OLS method for the second model

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	24407.39887	12476.77564	1.956226479	0.066138134
Enteric Fermentation	0.809500157	0.170812204	4.739123656	0.000163801
Manure Management	1.252546117	0.304717649	4.110513844	0.00065668
Synthetic Fertilizers	1.041550139	0.065136899	15.99017079	4.40267E-12
Crop residues and its burning	0.969103996	0.173613497	5.581962308	2.68255E-05

Regression Statistics			
R Square	0.998953052	**Adjusted R Square**	0.998720396
Standard Error	881.1674081	**Observations**	23

Source: Microsoft Excel 2016. Author`s computation.

The equation of the estimated econometric model can be seen in the function 4 shown below.

Function 4: Estimated econometric model 2

$$AgGHG = -6541.16537 + 0.61384762 * EntFrm + 1.68515417 * ManMng + 1.01258896 * SynFrt + 1.05229831 * CrRsdu + u_{1t}$$

3.4. **Economic verification of the model**

The economic verification consists in an interpretation of the model`s coefficients in order to confirm, or not, the assumptions which were previously shown. However, the significance of each coefficient does not totally confirm the significance it has on the dependent variable. As the name suggests, this part aims to verify the model`s consistency with economic theory through evaluating the intensity and direction of the coefficients.

3.4.1. **First model**

- If all explanatory variables equal 0, the total GHG emissions from agriculture will be of 260 471.139 thousand tonnes of CO_2 equivalent.
- If the agricultural area is increased by 1 000 ha, then the total GHG emissions from agriculture will be increased by 2.38 thousand tonnes of CO_2 equivalent.
- If forest area is increased by 1 000 ha, the GHG emissions from agriculture will decrease by 2.02 thousand tonnes of CO_2 equivalent.
- If the value added in the agricultural sector increases by 1% of GDP, the GHG emissions from agriculture will increase by 7 431.43 thousand tonnes of CO_2 equivalent.

3.4.2. **Second model**

- If all explanatory variables would equal 0, then the GHG emissions from agriculture would be of - 6 541.17 thousand tonnes of CO_2 equivalent. However, the coefficient is not significant (p-value = 0.77).
- If GHG emissions from enteric fermentation increases by 1 thousand tonnes of CO_2 equivalent, the total GHG emissions from agriculture will increase by 0.614 thousand tonnes of CO_2 equivalent.
- If GHG emissions from manure management increase by 1 thousand tonnes of CO_2 equivalent, the total GHG emissions from agriculture will increase by 1.685 thousand tonnes of CO_2 equivalent.
- If GHG emissions from the use of synthetic fertilizers increases by 1 thousand tonnes of CO_2 equivalent, the total GHG emissions from agriculture will increase by 1.013 thousand tonnes of CO_2 equivalent.
- If GHG emissions from crop residues and its burning increase by 1 thousand tonnes of CO_2 equivalent, the total GHG emissions from agriculture will be increased by 1.052 thousand tonnes of CO_2 equivalent.

4. Evaluation of results and recommendations

It is now possible to evaluate what are some of the most impactful farming practices on GHG emissions as well as the economic aspects which influenced agricultural emissions over the period from 1991 to 2013. Starting from the first model, the independent variables chosen explain the agricultural GHG emissions in almost 99% of its behaviour. The first two indicators concerning the area occupied by forests and the area used for agricultural purposes fulfilled the expectations of negative and positive correlation, respectively. As it was mentioned, forests play an important role by absorbing part of the carbon in the atmosphere. The outcome from the regression model and the forecasts done for the two variables suggest that GHG emissions tend to be reduced in the future due to the increasing size of forests and decreasing land use for agricultural purposes. As it was demonstrated, the size of forests is expected to overcome the agricultural land size between the years 2035 and 2040. Still in the first model, the two economic variables regarding the gross production value of crops and livestock did not appear to have a significant impact on agricultural GHG emissions through the 23 observations used in the model. On the other side, the value added by agriculture in the EU-28 was proven to significantly increase GHG emissions. It was estimated that emissions increase by about 7 431 thousand tonnes of CO_2 equivalent by a 1% increase in value added. However, when comparing to the other variables, this significant change is explained by the much higher impact of 1% change in value added than, for instance, the impact from a 1 thousand tonne of CO_2e increasing GHG emissions.

The second model`s independent variables explain the dependent in more than 99% due to the relatedness of the GHG by type of farming practice and the total GHG emissions. The main goal of the second model was to assess which of the farming practices is the most significant. The lowest p-value (highest significance) was achieved by the GHG emissions from the use of synthetic fertilizers. It explains the increasing awareness about the harmful effects associated with the use of chemicals for intensifying production levels and the consequent movement towards alternative farming practices (e.g. organic farming, permaculture). The second most significant indicator was the GHG emissions from crop residues and its burning. If increased by 1 thousand tCO_2e, GHG emissions from agriculture are expected to increase by 1 052 tCO_2e.

The variable concerning GHG emissions from manure management was the third most significant, however, the one which increases total agricultural GHG emissions the most (due to its highest coefficient of 1 685 tonnes of CO_2 equivalent). The fourth and least significant explanatory variable among those which concern the types of farming practices was the GHG emissions arising from enteric fermentation. The explanatory variable including net emissions/removals from total land use was excluded due to its revealed insignificance in the model. In sum, all the farming practices used in the regression model fulfil the expectations of a positive correlation with the GHG emissions from agriculture in total.

It is clear from the outcome of this thesis that the EU`s efforts to reduce its impact on climate change are resulting in lower emissions in the agricultural sector. The source sectors which contribute the most to total agricultural emissions are those related with animal production (enteric fermentation and manure management), however, the emissions incurred by the use of synthetic fertilizers were proved have a significant impact on the dependent variable. Agricultural emissions were reduced by 13.97% between 1991 and 2013 and are expected to achieve a reduction of approximately 37% from 1991 until 2050. The only economic indicator which showed significance in the model (agricultural value added) showed a decreasing tendency over the period analysed. The gross value of agricultural production in general was predicted to increase by 104% from 2013 until 2050.

V. Conclusion

This thesis achieved one of its main objectives of showing how the agricultural sector has been both developing over the chosen period (1991-2013) and how it is expected to develop until 2050 in an economic and environmental perspective. The other main goal achieved was to provide a theoretical basis concerning environmental economics together with an overview of other GHG emission source sectors in the EU-28 (excluding those related with farming practices) in order to lay the ground for comparisons.

The author`s opinion is that this paper provided the theoretical background needed to analyse any sector`s problems to achieve both a good environmental performance and economic growth, a historical overview of the EU-28 source sectors of GHG emissions (to evaluate the significance and efforts done to cope with environmental issues), and a practical analysis concerning the environmental and economic characteristics of the agricultural sector.

The theoretical part`s main takeaways include the definitions of environmental economics, explanation about market failures which originate environmental degradation, and an analysis of the recent efforts to reduce anthropological impact on environment in the EU-28 together with its targets for the future. The main characteristic of the economic system which explains the levels of environmental degradation is associated with the inability to properly value social costs. However, the EU has shown to be one of the leading nations in tackling climate change mainly due to the instruments created for this purpose (e.g. Emissions trading scheme). The source sector which contributes the most to the total of GHG emissions is the fuel combustion and fugitive emissions from fuels (55.1%), however, the energetic sector included in fuel combustion has been reducing its emissions due to improved technologies for energy production. The transportation sector is the second most influent source of GHG emissions, however, the amount of CO_2e emitted has been decreasing from the year 2007. The agricultural sector represented 9.9% of total emissions in the EU-28 in 2014. However, despite the lower percentage, agriculture does not only impact the environment, it plays a key role in terms of food security and resource efficiency. Although the EU`s targets are ambitious, many improvements have been done in terms of more sustainable infrastructure (buildings) and technologies.

The practical part of the thesis provided historical and future analysis of indicators concerning agriculture in an environmental or economic perspective. The agricultural GHG emissions have been generally decreasing (14% from 1991 until 2013). According to the chosen variables, the decreasing tendency may be explained by increased size of forests and decreasing size of land used for agricultural purposes, as well as from the decreasing emissions associated with manure management. The economic value added in agriculture has been influencing emissions negatively. A possible interpretation of this correlation is that the economic development of the sector contributes to the investment in new technologies or methods causing a lower impact on environment. The gross value of agricultural production was not proven to have a significant impact on GHG emissions. The assumption made was that emissions could be reduced through increasing the value of agricultural production.

This paper allowed a better understanding about the possible relations between economics and environment in a theoretical and practical perspective. The EU is on a good path in fighting climate change when comparing to other countries, however, challenges as the population size are expected to raise problems in the future mainly in the agricultural sector. The agricultural sector is expected to reduce its emissions significantly until 2050 as a result of the investment made in new technologies and more sustainable farming practices.

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