Hungarian University of Agriculture and Life Sciences

The Analysis of Relevant Indicators and the Effects of Multilateral Environmental Agreements on the Economy

PhD Dissertation

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1. INTRODUCTION

1.1. The importance of the topic

In this chapter I would like to present the importance and the brief history of my topic.

For our world the Sun is by far the largest source of ultraviolet radiation. Solar emissions include radiation from the visible light, heat, and ultraviolet (UV). Much as visible light consists of different colours that are apparent in a rainbow, the spectrum of UV radiation is divided into three regions called UVA, UVB, and UVC. When sunlight moves through the atmosphere, ozone, water vapour, oxygen, and carbon dioxide absorb all UVC, and much UVB. UVA is not absorbed by the environment as greatly.

The three types of UV radiation are divided by their wavelength. They differ in their biological activity and in how much they are able to penetrate the skin. The shorter the wavelength, the warmer the UV radiation would be. Shorter wavelength UV radiation, however, is less capable of penetrating the skin.

The most damaging form of UV radiation is the short-wavelength UVC. This is completely absorbed by the atmosphere and does not touch the surface of the Earth.

Medium wavelength UVB is very active biologically but cannot penetrate beyond the superficial layers of the skin. It is responsible for delayed tanning and burning; in addition to these short-term effects it increases skin ageing and greatly promotes skin cancer growth. The bulk of solar UVB is absorbed into the atmosphere.

The relatively long-wavelength UVA accounts for approximately 95 per cent of the UV radiation reaching the Earth's surface. It can penetrate into the deeper layers of the skin and is responsible for the immediate tanning effect. Furthermore, it also contributes to skin ageing and wrinkling. For a long time it was thought that UVA could not cause any lasting damage.

The ozone layer serves as a natural shield, blocking most ultraviolet rays from the Sun. The depletion of stratospheric ozone leads to an increase in UV-B which reaches the surface of the Earth where it can disrupt biological processes and damage a number of materials.

UVB causes non-melanoma skin cancer and plays a major role in malignant melanoma development. In addition, UVB has been linked to the development of cataracts, a clouding of the eye’s lens.

UVB radiation affects plant processes in both physiology and growth. Notwithstanding strategies to mitigate or restore these effects, and the ability to adapt to elevated UVB levels, UVB radiation may impact plant growth directly.

Indirect changes induced by UVB (such as changes in plant structure, how nutrients are distributed within the plant, timing of developmental phases and secondary metabolism) can be just as important or even more important than UVB's damaging effects. These changes can have important implications for plant competitive equilibrium, herbivory, plant diseases, and biogeochemical cycles.

Phytoplankton forms the base of marine food chains. The productivity of phytoplankton is restricted to the euphotic zone, the upper layer of the water column in which the Sunlight is

adequate to sustain net productivity. Solar UVB radiation exposure has been shown to affect both phytoplankton orientation and motility, resulting in lower survival rates for these species.

Early developmental stages of fish, shrimp, crab, amphibians and other marine species have been found to suffer from UVB radiation. The worst effects are reduced reproductive capacity and impaired larval development. Small increases in exposure to UVB may lead to population losses for small marine species with consequences for the entire marine food chain.

Increases in UVB radiation may influence terrestrial and aquatic biogeochemical processes, altering both greenhouse sources and sinks, and chemically significant trace gasses (e.g., carbon dioxide, carbon monoxide, carbonyl sulphide, ozone, and probably other gasses). Such potential improvements will lead to input from the biosphere-atmosphere that mitigates or amplifies the atmospheric concentrations of certain gasses.

The UVB radiation adversely affects synthetic polymers, naturally occurring biopolymers, and certain other products of commercial interest. Materials today are often protected by special additives against UVB. Nevertheless, changes in UVB levels can intensify their degradation, reducing the amount of time they are useful outdoors.

Human-produced chlorofluorocarbons (CFCs)—molecules containing only carbon, fluorine, and chlorine atoms—is a major source of chlorine in the stratosphere. Chlorine could destroy extensive amounts of ozone after it was liberated from CFCs by UV radiation. Free chlorine atoms and chlorine-containing gases, such as chlorine monoxide (ClO), could then break ozone molecules apart by stripping away one of the three oxygen atoms. Bromine and certain bromine-containing compounds, such as bromine monoxide (BrO), were even more effective at destroying ozone than were chlorine and its reactive compounds. Subsequent laboratory measurements, atmospheric measurements, and atmospheric-modelling studies soon substantiated the importance of these findings.

Human actions since before the 1980s have had a major impact on the production and distribution of stratospheric ozone globally. Measurements from satellites, aircraft, ground-based sensors and other instruments suggest that overall integrated column ozone levels decreased globally by approximately 5 per cent between 1970 and the mid-1990s, with little improvement afterwards. In the high latitudes (toward the poles) the greatest declines in ozone took place, and the smallest declines occurred in the lower latitudes (the tropics). The global decline of stratospheric ozone is well associated with increasing levels of chlorine and bromine from the manufacture and release of CFCs and other halocarbons in the stratosphere. Halocarbons are produced by industry for a wide variety of applications, such as refrigerants, aerosol cans propellants, plastic foam blowing agents, firefighting agents, and dry cleaning and degreasing solvents

When the extent of ozone depletion over Antarctica was revealed, the international community quickly came to an agreement on what needed to be done. If the problem had been left unchecked, ozone-depleting chemicals would have continued to accumulate in the atmosphere, increasing the size of the Antarctic ozone hole and thinning the ozone layer elsewhere: if the problem had been left unchecked, populated areas in the south, such as New Zealand and Australia, and in the north, would have seen significant increases in UV radiation exposure.

Through the 1970s and the 1980s, the international community became increasingly concerned that ozone depleting substances (ODS) would harm the ozone layer. In 1985, the Vienna Convention for the Protection of the Ozone Layer formalized international cooperation on this issue. This cooperation resulted in the signing of the Montreal Protocol on Substances that Deplete

the Ozone Layer in 1987. The Montreal Protocol is the landmark multilateral environmental agreement governing the production and use of nearly 100 man-made chemicals, known as ozone depleting substances. Such chemicals destroy the stratospheric ozone layer, the protective shield of Earth that protects humans and the world from harmful levels of ultraviolet radiation from the Sun when released into the atmosphere. The Protocol is to date the only UN treaty ever ratified by any country on Earth-all 197 UN member states. The Montreal Protocol phases down the use and development of the various ODS in a step-by-step way, with separate timetables for developed and developing countries. Under this treaty, both parties have clear obligations related to phasing out the various ODS groups, tracking ODS trade, annual data collection, national licensing systems for regulating ODS imports and exports and other matters. Developed and developing countries have similar but separate obligations, but most importantly both groups of countries have binding, time-targeted and measurable commitments. The Parties to the Montreal Protocol have amended the Protocol to require, inter alia, regulation of new chemicals and the creation of a financial mechanism to help developing countries to comply. The Montreal Protocol also provides a specific provision of adjustment that allows the Parties to the Protocol to respond quickly to new scientific knowledge and agree to accelerate the reductions needed on chemicals already covered by the Protocol. Then, these changes will immediately applicable to all countries that have ratified the Protocol. Since then, the Montreal Protocol has been reiterated on a number of occasions both by monitoring new ozone-depleting substances and by pushing up the date by which already controlled substances will be phased out. In addition to the changes and modifications to the Montreal Protocol, the Parties meet annually and take a number of decisions to allow this essential legal instrument to be effectively enforced.

In the late 1980s, climate-change plans coalesced into two somewhat different strategies, one focused on environmental priorities, and the other based on political and economic viability. The feasibility strategy was inspired by the 1987 Montreal Protocol (BENEDICK 1998; AGRAWALA 1999).

Global warming and climate change are often used interchangeably, while the latter is favoured because the consequences we experience include a warmer atmosphere and oceans.

Emissions of greenhouse gases, particularly carbon dioxide and methane, are the primary cause of present climate change. When fossil fuels are burned, these are mostly discharged. Meat and dairy farming, cement manufacture, and other industrial operations, such as fertiliser production and consumption, all produce greenhouse gases. The Sun's energy falls on our globe and is generally reflected as infrared radiation. Rather than escaping into space, this radiation is absorbed by greenhouse gas molecules, which subsequently release it in all directions. The temperature of the air and sea is monitored by measurement stations all over the world. Temperatures are rising, according to these measurements. It is known that greenhouse gases cause global warming. There is a scientific understanding of how the earth might warm as a result of emissions. This has enabled climate scientists to dismiss theories such as the one that global warming is driven by an increase in the Sun's intensity.

Climate change has different effects in different places. Although the earth is generally warming, some locations and seasons might be briefly cooler. Seasons will be longer in certain regions, while extreme weather will be concentrated in others.

Hurricanes, heat waves, droughts, wildfires, and floods are expected to become more violent and common in the future.

'There are numerous more evidence that the Earth is warming. Polar ice caps and glaciers, for example, are expected to melt as the world warms. Ice melts as the planet warms. In a warmer world, Arctic sea ice might vanish totally, and the ice sheets of Greenland and Antarctica could become unstable. This would cause vast parts of the ice to melt, adding more liquid to the oceanIce also reflects the Sun's radiation, so the ocean absorbs more heat without it. Thermal expansion occurs when water expands as it warms. This phenomenon causes sea levels to increase as the water takes up more area. Large number of the population live in locations that are predicted to be under high tide levels by 2100 owing to rising sea levels. This could result in huge population displacement. Hundreds of millions of people eat fish as their primary protein source. Warming and acidifying oceans have the potential to devastate marine food chains by disrupting their foundations, such as krill and coral reefs. A longer drought can cause problems on agriculture, jeopardising food security. The retreat of glaciers and the drying up of reservoirs might make drinking water scarce. Increased rainfall can lead to dangerous flooding as well as a reduction in indoor air quality. This could be harmful to our health because mould and fungi thrive in moist environments. Food and water are typically obtained from rural areas by urban inhabitants. If climate change interrupts these vital links, it will have a significant impact on people living in cities. Natural catastrophes disproportionately affect poor and vulnerable populations, highlighting the repercussions of disregarding social inequities. These populations are at greater risk when extreme weather becomes more common. The natural world is in a precarious equilibrium. No species, including our own, is totally self-contained. Many plants are blooming earlier this year. Migrating birds are arriving earlier, leaving later, and some are even shrinking in size. Butterflies are beginning to emerge earlier. Amphibians and birds are laying their eggs earlier this year. Some species are expanding their range. Insects are one of the most vulnerable groups, as they have less ability to escape warmer temperatures than mammals or birds. Insect loss, which is a primary food source for many animals and a key pollinator of plants, and whose numbers are already in decline, could bring the ecosystem to its knees. Activities to minimise the negative effects of climate change, such as building strong flood defences, can have detrimental consequences in aquatic ecosystems. Sea walls restrict the amount of space available for intertidal habitats when sea levels rise. Important coastal habitats like sand dunes and cliffs could be harmed by rising sea levels. Climate change is just one of the many stresses that environment is currently facing. The threat to nature includes elements like sea use, invasive species, pollution, and organism exploitation. Without substantial adjustments, biodiversity and ecosystems are anticipated to suffer severe consequences.

For more than 30 years, climate change has been recognised as an issue. Starting to address it sooner would have made this difficult process much easier.

The Framework Convention on Climate Change is the first binding international instrument to address the issue of climate change directly. The Convention was adopted at the 1992 Rio Earth Summit and entered into force in 1994, when it was ratified by more than 160 nations.

The Kyoto Protocol is the next major milestone in climate legislation. The Kyoto Protocol was signed in 1997. It took effect in 2005 after a lengthy ratification procedure. The Kyoto Protocol now has 192 signatories. The Kyoto Protocol puts the United Nations Framework Convention on Climate Change (UNFCCC) into action by committing industrialized countries to restrict and reduce greenhouse gas (GHG) emissions in accordance with individually agreed-upon targets. The Convention merely requires those countries to implement mitigation policies and actions, as well as to report on a regular basis (UNFCC 2020).The Kyoto Protocol follows the principles and rules of the Convention and keeps the annex-based structure. It only links developing countries and

imposes a heavier burden on them under the " common but differentiated responsibility and respective capabilities" concept, as it acknowledges that they are primarily responsible for the current high rates of atmospheric GHG emissions (KYOTO PROTOCOL 1997). The Doha Amendment to the Kyoto Protocol was adopted in Doha, Qatar, in 2012, for a second commitment duration, beginning in 2013 and lasting until 2020. Nonetheless, the Doha amendment has not yet entered into force; a minimum of 144 approval instruments are required for the amendment to enter into force.

Parties to the UNFCCC reached a historic agreement in Paris in 2015 to tackle climate change and to speed up and accelerate the steps and investments required for a sustainable low carbon future. The Paris Agreement builds on the Convention and brings all nations into a common cause – for the first time – to pursue concerted measures to combat climate change and adapt to its consequences, with expanded funding to assist developing countries in this. As such, it sets a new path in the global initiative on the environment. The Paris Agreement is seen as a diplomatic achievement and an important historical milestone in the history of global climate negotiations BODANSKY 2016; BRUN 2016; DIMITROV 2016; DOELLE 2017, RAJAMANI 2016). Insiders describe the Paris Agreement as "the culmination of decades of climate diplomacy" and "a historic achievement in multilateral diplomacy" which is "the most optimistic outcome possible in a deeply discordant political setting" **(**RAJAMANI 2016**)**.

The Paris Agreement combines a top-down approach that imposes legally binding responsibilities on countries with a bottom-up approach to formulating policy that leaves much up to the governments of the state. This leaves policymakers with full control over domestic policies, and relies on nationally determined contributions (NDCs) to global climate policy. At the same time, it imposes clear commitments to establish, enforce and improve these actions on a regular basis, while subjecting national policies to a comprehensive international oversight mechanism. Main provisions include a global target of keeping the temperature rise "well below 2 C" and a promise to "continue efforts to restrict temperature rise to 1.5 C"(UNITED NATIONS 2015). The long-term policy targets are to "as soon as possible" peak global emissions and to reach null net emissions in the second half of this century (UNITED NATIONS 2015). The Paris Agreement is a treaty, although unorthodox under international law (BODANSKY 2016; BODLE 2017). Lawyers stress that the Paris Agreement implies comprehensive, binding legal obligations on countries (BODANSKY 2016; RAJAMANI 2016; MACE 2016). This result is especially important considering that there were all legal options on the table, and that the legal essence of the agreement was not decided until the second week of the Paris negotiations. Many experts also agree that the Paris Agreement is not a traditional treaty that meets the top-down international law pattern. It is an instrument which is more facilitative than prescriptive. Legal experts involved in negotiations are of the opinion that the agreement has a strong potential to be successful. Recently, members of the UNFCCC concluded that the Paris Agreement is ready to attain its ambitious targets (KLEIN 2017). Although many regard the Paris Agreement as a major pillar of the global climate policy system, the uncertain existence of its future effect is stressed. Many believe that telling is too early, and the outcome depends on domestic developments (WINKLER 2017).

2. OBJECTIVES TO ACHIECE

In this chapter I will clarify the goals of the research, I will state the problems to be solved and I will present the research questions, with my hypotheses.

The world faces old and new problems that are more complicated than our currently capable multilateral and national institutions. To face these challenges, international cooperation is becoming ever more important.

An international environmental agreement is a kind of treaty that is binding in international law, allowing it to accomplish an environmental goal. Bilateral environmental agreement is defined as an agreement between two countries. If the agreement is signed between three or more nations it is called a Multilateral Environmental Agreement (MEA). These agreements, mainly drawn up by the United Nations, include issues such as environmental policies, freshwater policies, hazardous waste and material policies, aquatic environment, wildlife conservation policies, noise pollution and nuclear safety.

International agreements in general set a number of objectives: Informal agreements may formulate action plans for sovereign states or international institutions; they may establish or alter international organizations or bodies; and legally binding agreements may demand that sovereign states change their actions.

T Least developed nations face enormous mitigation and adaptation issues that must be addressed through successful agreements. Through technology transfer, finance, and technical assistance, certain climate agreements provide mechanisms for boosting implementation and enforcement. Agreements can speed up the process of developing a shared vocabulary and understanding of a problem. States have frequently taken actions within their own borders that anticipate what they are willing to agree to on a global scale.

2.1. Problems to solve and the research questions

The objective of the dissertation is to deal with the economic impact of international environmental agreements. In the first segment I explore the development, function, characteristics and the problems of international agreements. I put special emphasis on the environment-related agreements. In the following section I will focus on the economic effects of these agreements by analysing GDP growth.. The dissertation covers two specific environmental problems. The first one is ozone depletion, the second is greenhouse gas emission. Both environmental problems were caused by human activities. The impact of these phenomena can be disastrous for our planet. Fortunately we recognised the importance of these issues and measures were taken to prevent the harmful effects. These measures were defined in legal documents, this paper concentrates on the economic impacts of the regulation. The world had a difficult choice in 1987, between the costs of protecting and restoring the ozone layer and the costs of doing nothing and living with the consequences. Costs occur when limits on the usage of CFCs and halons are imposed. There are also costs of implementing and dealing with policy enabling regulations.

Economic trade relations between countries would transmit the impact of greenhouse gas reduction steps taken by a group of nations to countries that may not have agreed to share the regulation burdens. For example, pollution restrictions under the Kyoto Protocol would increase the cost of using carbon-emitting fuels to developed regions, thus increasing the cost of exporting their

energy-intensive products, some of which may be exported into developing countries. The restrictions would also limit global demand for carbon-emitting fuels, pushing down their international prices. Furthermore, emission controls that depress economic activity in countries subject to emission restrictions, reducing the demand for imports from those countries, some of which come from developing countries. Such changes in trade volumes and prices may have dynamic effects in turn, affecting some developed countries while benefiting others.

The mechanism, process, institution, practise, or norm that supports the equality of all citizens before the law, secures a nonarbitrary form of government, and, more broadly, prevents the arbitrary use of power is known as the rule of law. In general, the rule of law implies that the creation of laws, their enforcement, and the relationships between legal rules are all legally regulated, so that no one—not even the most powerful official—is above the law. The legal constraint on rulers means that the government, like its citizens, is subject to existing laws. Thus, a closely related concept is the concept of equality before the law, which holds that no "legal" person shall enjoy privileges not extended to all and that no one shall be immune from legal sanctions. Furthermore, the application and adjudication of legal rules by various governing officials must be impartial and consistent across comparable cases, made without regard for the class, status, or relative power of disputants. Not only does the rule of law imply such fundamental requirements for how the law should be applied in society, but it also implies certain characteristics and content of the laws themselves. Laws should, in particular, be open and clear, general in form, universal in application, and understandable to all. Furthermore, legal requirements must be able to guide people; they must not place undue cognitive or behavioural demands on people to follow. As a result, the law should be relatively stable and contain specific requirements that people can consult before acting, and legal obligations should not be imposed retroactively. Furthermore, the law should be internally consistent and, failing that, should provide legal mechanisms for resolving contradictions that may arise (CHOI 2017).

The literature presents various perspectives and evidence on the development functions performed by the rule of law, as well as the pathways by which the rule of law contributes to development. In general, rule of law policy influences the rules of the game that allow people to transact. There is compelling evidence of a link between strong property rights protection and long run economic growth. On the other hand, it is unclear whether property rights protection is a result of growth or a cause of it. Furthermore, while property rights are important, enforcement is a challenge. A critical variable that is frequently overlooked debates are also centred on the regulation's content, the level of enforcement, and the consequences for the poor growth. There is substantial evidence for a link between rule of law and economic development. However, some aspects of this relationship require further investigation. It is unclear, for example, why and how much the rule of economic growth is influenced by law. Some countries and industries, for example, have grown as a result of a favourable industrial policy for certain industries companies have benefited from equal treatment under the law, while others have not.

I have formulated my research questions as follows:

1. What is the relationship between oil price and economic growth on countries with different development level?

2. Do carbon abatement policies have impact on GDP growth?

3. Have carbon abatement policies had impact on petroleum, natural gas, coal and renewable energy use?

4. Has the ratification of Montreal Protocol had an impact on the atmosphere?

5. Has the ratification of Kyoto Protocol had an impact on the atmosphere?

6. Is there a relationship between the development level of a country and the number of international agreements the country ratified?

7. Is there a relationship between the rule of law status of a country and the number of international agreements the country ratified?

To answer my research questions I have defined my hypotheses. Under each hypothesis I give a brief explanation on the reasons and the background of my assumptions.

H1: The impact of oil price changes on GDP growth is less significant in developed countries, and this impact is more significant in developing countries.

I assumed that developed countries are less exposed to oil price shocks when they are more energy efficient and more dependent on other energy sources, for example renewable energy. Oil and gas have contributed to the wealth of some countries in the past, but they are not a prerequisite for future economic development. Oil and gas can have a direct or indirect impact on economic development, both positively and negatively. Because energy systems can take time to adapt to technological change, oil and gas will continue to play a role in the short term. However, the availability and lower cost of renewable energy make the development of economies reliant on oil and gas unlikely in the medium and long term. Investment and extraction activities in oil and gas producing countries can directly increase economic activity from the oil and gas sector, but they can also have indirect negative effects that impede economic development. Oil and gas, for example, can lock countries into polluting energy systems or harm the development of other industries if they are prone to or promote corruption. It is difficult to demonstrate a clear relationship between economic development and oil and gas consumption. According to the majority of researches, energy consumption and economic activity are strongly positively correlated in developing countries (i.e., energy consumption rises as GDP does), but the causal relationship is unknown. It is not always the case that an increase in GDP leads to an increase in energy consumption, and it is unclear whether increasing GDP leads to an increase in energy consumption or vice versa. The impact of oil and gas consumption on economic growth varies depending on the type of economy, its primary economic activities, and how these use various energy sources. Energy consumption is linked to GDP in cases where it powers activities that generate economic output. This direct link is strongest in the industrial sector, which has higher productivity (output per unit of input) than other sectors.

H2: Applying carbon abatement policies will reduce GDP growth in developed countries, but it will rise GDP growth in developing countries.

A lot of factors influence the rate of economic growth and development in any country at any given period. Different economic strategies have involved development based on each specific country's peculiarities and accessible natural resources to stimulate a high rate of growth. Development can have negative environmental consequences in a variety of ways, including pollution, overexploitation of natural resources, destruction and loss of wildlife habitat, and climate change. As countries transition to a new climate economy, there is disagreement over whether growth will drive or even coexist with climate stabilisation. On the other hand, there is a controversy concerning whether climate stabilisation can harm development. I believe that there is a link between per capita GDP and per capita carbon dioxide emissions. The relationship is positive, implying that rising per capita GDP causes rising carbon dioxide emissions. While the

relationship is complicated, we can suppose that when emission trends and GDP growth diverge, the two variables become unrelated.

H3: By applying carbon abatement policies total petroleum and coal use will drop and natural gas and renewable energy use will intensify in both developed and developing countries.

Crude oil, coal and gas supply about 85 per cent of the world's energy consumption. Fossil fuels are valuable as sources of energy because they contain hydrocarbons and other carbon-based materials. The main anthropogenic impact affecting climate change is carbon-based fuel combustion. The initial response to this is to decrease or stop the use of carbon-based fuels, thereby minimizing the effect on environment. Natural gas is a fossil fuel but its combustion emissions from global warming are far lower than those from coal or oil. When combusted in a modern, powerful natural gas power plant, natural gas emits 50 to 60 per cent less carbon dioxide compared to emissions from a conventional new coal plant. A significant CO2 emission is prevented by the classic renewable energy sources, biomass and hydro power. Growing more biomass at relatively low cost will play an immediate role in absorbing excess CO2. Passive solar techniques have tremendous energy saving potential, wind power is the cheapest source of electricity, and solar energy provides good options for long-term substitution of a large amount of fossil fuels. In my hypothesis I will examine the impacts of carbon abatement policies on energy use.

H4: The Montreal Protocol and its extensions on Substances that Deplete the Ozone Layer have reduced ozone depleting substances in the atmosphere and have produced significant environmental benefits to protect the earth's ozone layer.

The Montreal Protocol on Substances Depleting the Ozone Layer is a global agreement aimed at protecting the ozone layer on Earth by phasing out the pollutants that deplete it. The phase-out strategy involves both the production of ozone depleting substances and their use. The ground-breaking agreement was signed in 1987 and became effective in 1989. The parties to the Protocol meet once a year to take measures and ensure that the Agreement is successfully enforced. Which include modifying or amending the Protocol six times since its development. The new amendment, the Kigali Amendment, in 2016 called for the phase-down of hydrofluorocarbons (HFCs). Such HFCs have been used as substitutes for a batch of ozone depleting substances extracted by the original Montreal Protocol. While the ozone layer is not destroyed, they are considered to be important greenhouse gases and therefore contributors to climate change. The Montreal Protocol presented a collection of concrete, actionable tasks that had been agreed on unanimously. So far, the Protocol has achieved its goals effectively and today it continues to safeguard the ozone layer. The ozone layer is well on its way to recovery, due to the collective effort of nations around the world.

H5: The Kyoto Protocol and its extensions to the United Nations Framework Convention on Climate Change have reduced greenhouse gas substances in the atmosphere and have produced significant environmental benefits to protect global warming. The Protocol has played a significant role in the reshaping the economy of developed and developing economies.

The Kyoto Protocol was the first agreement among nations to require greenhouse gas emission reductions on a country-by-country basis. Kyoto originated from the UN Framework Convention on Climate Change (UNFCCC), which was signed at the 1992 mega-meeting popularly recognized as the Earth Summit by almost all the nations. Under Kyoto, developed nations vowed to reduce their annual carbon emissions by varying quantities, as measured in six greenhouse gasses, by an

average of 5.2 percent, compared to 1990, by 2012. That equates to a 29% cut in the values that would have otherwise occurred. After years of negotiation the treaty was signed in Kyoto, Japan, in 1997, and entered into force in 2005. The treaty has now been ratified by almost all countries, with the notable exception of the USA. Developing countries, including China and India, have not been forced to curb emissions because they have contributed a relatively small proportion to the current century-plus CO2 build-up. The effect of the Kyoto Protocol may be direct for developed countries, but has an indirect impact on developing countries The Protocol does not make it binding for developing countries to reduce their emissions, nor does it provide them with any reduction targets.

H6A: Developed countries are more involved in international environmental agreements than developing countries.

H6B: Participation in international environmental agreements is related to the rule of law in a country. Countries with higher rule of law index are involved in larger amount of international agreements.

I assumed that GDP, distance and preferential trade agreements are good predictors of the probability of countries getting a multilateral environmental agreement as well as the number of agreements they have. In my opinion Countries which trade more among themselves are more likely to be parties to at least one environmental agreement. Countries reducing pollution or preserving endangered species can suffer economic losses. Perhaps the most widely accepted claim in opposition to pollution-restraining agreements is that limiting pollutant emissions such as carbon dioxide could harm the competitiveness of companies in global markets as new regulations raise production costs. In addition, participating in some environmental agreements, given new regulations, can result in less trade between states. As a result, countries that trade more with each other will stop entering MEAs together, because this could have a negative effect on their trade. On the other hand, when the economic relations are strong, it could be easier for countries to align their economic and environmental policies. Two countries can address environmental and economic concerns at the same time because their connections allow them to work together more effectively on both issues. Non-environmental costs will be imposed by countries that refuse to participate on environmental agreements. If a country fails to comply with an environmental agreement, it may be excluded from a possible trade deal. Foreign trade will expand as a result of an environmental deal. This can happen when one of the signatories signs an agreement committing to follow the higher environmental standards in place in the other signatory. In this setting, one country raises its standards and allows its enterprises to enter markets that were previously restricted to them, resulting in more trade.

3. LITERATURE OVERVIEW

In this chapter I will review the literature in connection with my research questions and hypotheses.

3.1. The need for international regulation

Environmental protection has been a major issue around the globe since the middle of the 20th century. Air pollution, lack of clean drinking water, and disposal of toxic materials, soil degradation, global climate change and the loss of biodiversity have created widespread demands for preventive and remedial action to ensure that natural conditions remain conducive to life and human well-being. Policymakers reacting to these demands have accepted the need to tackle environmental protection in a comprehensive and inclusive way. Local issues cannot be isolated from developments at state, international, or even global levels (SHELTON-KISS 2007).

Such an evolution corresponds to a biosphere's physical nature, composed of interdependent elements which do not recognize political boundaries. These elements are influenced by human activities which are increasingly transnational in themselves. Market internationalization and the development of a global civil society have presented both new opportunities and new challenges. Communication networks allow quicker understanding of the nature and complexity of environmental concerns, but the widespread movement of people and goods may also lead to these problems, for example by introducing alien species and spreading contaminants. Over-consumption continues to consume living and non-living capital while rising greenhouse gas emissions harm the global environment. Communication networks allow for a faster understanding of the existence and complexities of environmental issues, but rapid movement of people and objects can also contribute to these problems, for example by introducing alien species and spreading pollutants. Environmental legislation seeks to reduce anthropogenic sources of harm to the environment through altering human conduct. Environmental law potentially covers all human activities and falls within the domain of each government agency and legislative level. Such environmental law characteristics increase the probability of a jurisdictional multiplicity across entities and locations. Firstly, unlike most international law, environmental policy tackles non-state actions as well as state actors. Second, environmental issues show the interdependence of states and populations, even more than economic activities. Without trans-border cooperation, no state, however strong, can protect its environment. Therefore preservation of the environment necessarily has an international aspect (SHELTON-KISS 2007).

The best way to understand the value of international environmental law is to consider that it is important to apply international law in general. Each country's legal structure operates within certain regional boundaries. Only within their sovereign territories, which stretches to the outer limit of their territorial waters, can each government pass and enforce its laws. In its atmosphere or outer space, it still has authority over matters, but only within the boundaries of international law. The parliament of a country may control its citizens or companies both domestically and when they work outside the country. However, where a problem is not limited to a single country's jurisdiction, intergovernmental cooperation is necessary. Environmental problems do not respect territorial frontiers. When two countries' border waters are polluted, those countries would need to collaborate, because neither of them can handle the problem by themselves. When the dominant

airflows bring heavy metals from one area to another, those in the contaminated region would be encouraged to control the offending jurisdiction policies of the countries.

When several countries have an environmental crisis and impacts all of them, then global solutions should be pursued. Many governments are aware that the best national environmental policy can be to try to influence the environmental protection measures or industrial policy of a neighbouring country, particularly if this country is intensively focused on economic development. We know that pollution does not respect borders, and that only international solutions can be found to our own environmental problems. If we were to ask what kind of political structure the world would have in order to efficiently address global problems, many people will respond that it would be a global government or at least an international administrative framework with the ability to enjoin governments to meet international law obligations. There is currently no such scheme, or in the near future. A world government would be a good idea to address the challenges of climate change, but since it does not exist, the best way to tackle global and regional environmental problems is to establish international environmental law in a purposeful way (KOIVUROVA 2014).

3.2. History of international environmental regulation

A de facto 'framework' of international environmental law and governance has widely been recognized (FREESTONE 1994; BOYLE 1999; NAJAM 2004; BODANSKY 2006). However this recognition has not always existed. From the fourteenth century on the European continent, environmental diplomacy evolved cautiously through bilateral agreements (between England and Portugal, England and France, etc.) for the management of fishery resources. Several of those deals examined the access to some territories and rivers in Europe and North America during the seventeenth and eighteenth centuries. In addition to these particular resource and territorial arrangements, it was only in the nineteenth century that the world took on a more multilateral aspect (BALZACQ et al. 2020).

Nonetheless, bilateral efforts are frequently inadequate to handle endangered, non-exclusive, non-rival, public goods. In fact, most of the tools and main environmental concerns do not know boundaries. In 1857, the first multilateral agreement—which involved more than three countries—committed states bordering Lake Constance to handle the water pumping of the lake. During the nineteenth century, multilateral agreements gradually developed and began to address environmental issues more directly, such as the transport of hazardous substances or the protection of endangered species (BALZACQ 2020).

States and groups of states had already decided on various steps to protect individual animal species and habitats long before the real international movement for the conservation of the environment started. The key goals were either the sustainable use of aquatic resources (mainly various types of fish and whales), or the survival of animals that were useful to humans. The 1902 Convention for the Protection of Birds Useful to Agriculture, which is considered the first multilateral environmental treaty, was among the first early protection measures (CONVENTION FOR THE PROTECTION OF BIRDS USEFUL TO AGRICULTURE 1902).

There were also several transboundary river treaties which included articles on environmental protection, such as, for example, the United States-Canada 1909 International Boundary Waters Treaty. In 1954, one early intergovernmental environmental protection scheme, the International Convention for the Prevention of Sea Pollution by Oil, perhaps the most ambitious of its day, was meant to reduce oil pollution into the sea. In the background of the international politics of the

time it is important to understand environmental protection initiatives before and after the Second World War.

After the war, international diplomacy centred on the development of the first genuinely global intergovernmental organization. The world's governments, having learned from the experiences of the war, founded the international body, the United Nations (UN). The UN is an international organization which was established in 1945. At present it is composed of 193 Member States. The United Nations' mission and work is driven by the aims and values embodied in its founding charter. The UN should take action on challenges facing humanity in the 21st century, such as peace and stability, climate change, sustainable development, human rights, disarmament, terrorism, humanitarian and health crises, gender equality, governance, food production, and more. The UN also offers a forum for its representatives in the General Assembly, the Security Council, the Economic and Social Council, and other bodies and committees to share their views The Organization has become a forum for governments to identify areas of consensus and solve problems together by facilitating communication between its members and hosting negotiations.

The League of Nations, which existed between the World Wars, comprised only some of the international community (for example, it did not include the USA). While intended to deter wars by imposing arbitration obligations on states on the verge of war, the League of Nations did not go as far as prohibiting war as the last resort of foreign policy or providing a mechanism for intervention in the event of a war crisis. The UN tried to learn from the shortcomings of the League of Nations and assigned five permanent Security Council members with upholding international peace and stability (USSR, USA, France, UK and China). The Cold War between the Soviet bloc and the United States, however, has for a long time prevented any significant involvement by the UN in wars between states.

When it began advocating human rights the UN became more successful. The massacres of the Second World War meant that people no longer trusted government policy alone to form the development of their communities, and so the UN Charter was formed which expressed its commitment to the promotion of human rights. This was followed by the UN Declaration of Human Rights in 1948 (UNIVERSAL DECLARATION OF HUMAN RIGHTS 1948). Many binding international human rights, accords have been signed under the auspices of the UN over the years. However, not one of these international agreements expressly refers to the right to a fair or healthy environment, although some regional human rights agreements, such as the African Charter on Human and People's Rights, clearly address the right to a healthy environment. It demonstrates how little attention was paid to security of the environment in the wake of World War II. It was understandable, because at this time the importance of biodiversity and biosphere to human populations was not yet generally recognized and other priorities were being discussed by the international community. On the other hand, World War II events revealed far too well that mankind had created horrific destructive forces which could destroy our entire planet.

Various occasional multilateral agreements – also in the field of environmental protection – were signed before the 1972 United Nations Conference on Human Environment in Stockholm, but it can be stated that the Stockholm Conference was the first to integrate current and proposed international environmental regulatory frameworks under one umbrella with its declaration and action plan. The establishment of the UN Environment Program (UNEP) has made it possible also from the institutional perspective to coordinate international environmental regulation into a dedicated separate stream (KOIVUROVA 2014).

The summit has been one of the largest international conferences ever held, due to the active involvement of developed countries. Delegations from 114 countries participated, although at the time only 131 member states were in the United Nations and the environment had not yet become a central topic in international relations. Following the participation of developed countries, the summit highlighted environmental issues as a priority but also acknowledged the importance of economic growth in the same breath. This connection between the environmental and growth goals remained highly present at other environmental protection summits.

It gives a fast response, in particular, to developing countries concerned about introducing policies that are technically costly or restrictive to their economic growth. Although the developed countries were initially sceptical of multilateral environmental protection programs, the summit showed that it was possible to negotiate. The final declaration specified twenty-six general environmental principles. In particular, it supported the creation of the United Nations Environment Program (now known as the UN Environment) and urged states to develop the first environment-specialized national ministries (BALZACQ 2020).

Other summits, held every ten years after the 1972 summit, set the standard for environmental diplomacy (MORIN 2015; ORSINI 2010), provide an opportunity to take stock, formulate general concepts embedded in official statements and establish international organizations committed to the environment (DEATH 2011).

Several multilateral climate agreements were signed between the late 1960s and the early 1980s. From a very early point, nuclear power was seen as a controversial source of energy. The members of the Organization for Economic Co-operation and Development (OECD) had negotiated a national convention on nuclear liability as early as 1960 (PARIS CONVENTION ON THIRD PARTY LIABILITY IN THE FIELD OF NUCLEAR ENERGY 1964). In 1963, under the auspices of the International Atomic Energy Agency (IAEA), the Vienna Convention on Civil Liability for Nuclear Harm was negotiated, (CONVENTION ON SUPPLEMENTARY COMPENSATION FOR NUCLEAR DAMAGE 1963) and in 1971, the International Maritime Organization (IMO) adopted the Convention on Civil Liability in the Carrying of Radioactive Material (NUCLEAR 1971) The Convention came into force 20 years later in 1991. At the time, the main emphasis was on the implementation of marine environmental legislation, both regionally and globally. This time resulted in the ratification of the United Nations Convention on the Law of the Sea, Section XII on marine environment security. Prior to this and until the early 1970s, the protection of the marine environment centred largely on tanker oil pollution: the first such convention was the 1954 International Convention on the Prevention of Oil Pollution, (INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL 1954) preceded by the Convention on Civil Liability for Oil Pollution Damage, (CLC 1969) and the INTERNATIONAL CONVENTION ON HIGH SEAS INTERVENTION 1969. The main global agreements on the safety of the marine environment were the 1972 London (CONVENTION ON THE PREVENTION OF MARINE POLLUTION BY DUMPING OF WASTES AND OTHER MATTER 1972), and the 1973 (INTERNATIONAL CONVENTION ON THE PREVENTION OF POLLUTION FROM SHIPS), followed by a 1978 Protocol (together known as MARPOL). The MARPOL system aims to reduce and mitigate ship-related marine emissions, both from collisions and routine operations. The Convention contains six annexes which focus on controlling and preventing the oil spill into the sea, noxious liquid substances transported in bulk and harmful substances in packaged form. The Convention also seeks to regulate solid waste and water emissions, as well as the air pollution caused by ships. UNCLOS adoption was a significant achievement as it established general guiding principles in relation to all activities that contaminate the sea. The regulation of no other part of the biosphere has matched

it, although a law of the atmosphere was debated without result in the mid-1980s. Globalization has also had an impact on many biodiversity conservation areas. The 1971 (RAMSAR CONVENTION) laid the groundwork for the conservation of waterfowl important wetlands, while the 1972 WORLD HERITAGE CONVENTION preserves natural heritage sites. The 1979 Bonn and Bern conventions seek to protect and European wildlife from migratory wild animals (CONVENTION ON THE CONSERVATION OF MIGRATORY SPECIES OF WILD ANIMALS). CITES from 1975 and its annexes seek to protect flora and fauna species by restricting their international trade: the premise is that if organisms or sections of organisms cannot be sold commercially, the economic incentive for capturing or killing endangered species would be removed. The first real process of international environmental legislation was tentative; the initial goal was to protect the world from major threats including oil tankers, nuclear power plants and intentional disposal of waste. Nevertheless, at the same time hybrid organisations such as the International Union for the Conservation of Nature (IUCN), shortly after the Stockholm Conference, started to establish a new field of international environmental law with a single specific objective: to avoid and ultimately eradicate international environmental problems (KOIVUROVA 2014).

In 1992 a second summit, the United Nations Conference on Environment and Development, was held in Rio to consolidate the gains made in Stockholm. The summit reiterated the environmental-development linkages. Indeed it was determined that this time the conference would take place in a developing world, in this case Brazil (TOLBA 1998). It was a large-scale summit that brought together 108 heads of state, 187 delegations, around 10,000 government delegates, over 1400 officially accredited NGOs, and almost 9,000 journalists. This Conference was particularly successful. Countries supported a political declaration that outlined general values inherited from those introduced in Stockholm and decided on an ambitious action plan called Agenda 21 to recognize issues, establish priorities and outline the means of action on subjects as diverse as hazardous chemicals, access to clean drinking water and transportation. The principle of shared but separate obligations was one major declaration adopted. According to this theory, all states must make an effort to protect the environment but this effort must be measured in proportion to their obligations and capacities. In other words, the efforts expected of developed countries must be much greater than those needed of developing countries in accordance with these criteria. The summit also witnessed the adoption of two international treaties: the (UN 1992) and the Convention on Biological Diversity (UN 1992) while two international diplomatic processes on desertification and forests were introduced. With regard to institutional arrangements, the summit saw the establishment of the Global Environment Facility and the Sustainable Development Commission, in order to ensure follow-up to Agenda 21. Finally, the Summit reported a major trend: environmental liberalism. The pattern highlighted the economic value of the environment that would help sustain it by developing markets, as in the carbon market approach, or by payments for ecosystem services (BALZACQ 2020).

The 1992 Rio Conference on the Environment was in many respects historic. The entire international community was able to agree on standards for supporting environmental conservation and sustainable growth for the first time; it was also able to conclude an ambitious action plan, Agenda 21, to address the problems of sustainable development. The conference introduced policies to bring about more successful enforcement of international environmental agreements. The ensuing meeting of the 1997 Earth Summit acknowledged that it was high time to make the transition from signing agreements to actually enforcing them (KOIVUROVA 2014).

The World Summit on Sustainable Development which took place in Johannesburg in 2002 shifted partly from environmental priorities, opening the door to non-state players. In addition, the organizers of the summit actively promoted the conclusion of "Type II partnerships," or agreements made not only between states, but between different kinds of partners, including businesses, intergovernmental organizations, NGOs, and states. In Johannesburg, more than two hundred Type II agreements were reached, for investments of over 23 million dollars. The pattern emerged within the dynamics of environmental liberalism but also marked a desire to enhance the efficacy of environmental initiatives by delegating their implementation to actors in the region (BALZACQ 2020).

Twenty years after the Rio Summit, leaders of the UN tried to achieve a new political breakthrough by organizing the Rio+20 Summit on Sustainable Development in Rio de Janeiro (FOYER 2015).

Despite a less favourable international context (with the economic downturn of 2008 and the growth of emerging economies), Rio+20 was once again revolutionary in many respects, implementing the idea of 'green economy.' According to the declaration 'The Future We Want' adopted at Rio+20(UNEP 2012), the green economy is 'one of the essential instruments available for achieving sustainable development'. Another major innovation of the Summit was to stress the value of collecting and disseminating information to promote more environmentally friendly behaviour. From the point of view of institutional developments, the Commission on Sustainable Development, founded in Rio in 1992, was replaced by the High-Level Political Forum on Sustainable Development involving "high-level decision-makers," with the goal of giving it greater visibility and decision-making power

Parallel to these global summits, a multitude of environmental treaties have been signed, to name but a few, on widely varied issues such as toxic waste, chemical products and marine pollution. Such treaties do not have a single institutional association (e.g. with the United Nations Environment) but step by step the institutionalization of environmental treaties in the international organizational context took place. In certain cases, pre-existing international organisations, rather than delegating their role to foreign environmental organizations, chose to extend their own areas of operation. For example, the United Nations Educational, Science, and Cultural Organization (UNESCO) took the 1972 Convention on the Protection of the World Cultural and Natural Heritage under its wing and thus also controlled natural sites. Additionally, some organisations and their conventions, which originally had no environmental targets, slowly embraced some. Many environmental treaties have a regional aspect and are also connected with national organisations (BALZACQ 2020).

Despite their distinct roots and institutional relations, environmental treaties form a family of treaties under which numerous agreements have survived those provisions (KIM 2013a).

The lack of a common institutional commitment to these numerous environmental conventions helped to broaden environmental standards and values to non-environmental diplomatic bodies. Therefore, in a dual context, environmental diplomacy has spread to other fields: first, it is extending its expertise and applicability to non-environmental themes; second, it is interested in spreading its own values (BALZACQ 2020).

If we look more closely at the evolution of international environmental law we might identify some opposing patterns. There is no doubt that international environmental law has seen considerable change in every field of international law and policy. The number of international treaties and instruments of soft law is remarkable, taking into account the relatively short period of time in which the discipline has grown. The sheer number of treaties and other instruments in itself has

become problematic; as a result, many treaty regimes are now doing overlap research. Consequently, there have been growing demands over the past decade for the enforcement of established international environmental commitments and for ways to prevent overlaps and finding synergies between treaty regimes. Major UN Environment and Development Conferences led the political impetus and course for international environmental law, where resolutions and action plans were adopted.

International environmental law has improved at least in the way it reacts to international environmental concerns; it has contributed to reducing the damage caused by international environmental issues. Vast numbers of international environmental agreements are now being enforced in practice. International environmental law has given rise to substantial study, but this alone cannot solve environmental problems. For all our best intentions, the environmental situation has progressively worsened during the same time over which international environmental law has developed (KOIVUROVA 2014).

3.3. The major principles of environmental law

Environmental law concepts are expressed in conventions, inter-national binding laws, state practice and soft law commitments. They may be applicable to all foreign community members. (SANDS 2003) These are widely recognized and even approved in the practice of the state.

Article 38 of the Statute of the International Court of Justice (ICJ 1920) acknowledges as a source of law 'general principles of law that are recognized by civilized nations.' Specific concepts fill the gaps in international law that have not been filled by a treaty or a tradition already. Hence, in the absence of a treaty or customary law, the courts depend on general principles.

The political, industrial and scientific situation of the world changed drastically after World War II. The rise of modern industrial society and the consequent urbanization had an overwhelmingly negative effect on the global climate (RAO 2001). The international community has been concerned and has recognized certain legal principles to control the harm, and also to improve the environment.

3.4. Sustainable development

Sustainable development is undoubtedly the most influential principle and most recognized concept of environmental regulation and policy making. Even though the widespread use and recognition of sustainable development would imply that the concept is easily defined, it is clear that ambiguity comes with recognition for sustainable development (SAUNIER 2007).

Sustainable development was referred to in the 1985 ASEAN Agreement on the CONSERVATION OF NATURE AND NATURAL RESOURCES. Prior to that, the World Conservation Strategy gave credence to the term 'sustainable development' when it was published in 1980 (IUCN). However, it was not until the World Commission on Environment and Development (WCED) published Our Common Future in 1987 (UN 1987) that the word 'sustainable development' was adopted. It was defined as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’. It essentially drew attention to two things: (1) the basic needs of the world’s poor, and (2) the technological and social limitations on the ability of the environment to meet present and future

needs. ‘Needs’ were given overriding priority. IUCN maintains that quality of life or living standards can be sustained over several centuries by maintaining ecological sustainability, economic stability, and social desirability. This is the principal definition of sustainable development according to the IUCN.

Besides these very general international (non-binding) agreements, the concept of sustainable development can also be found in more specific (binding) treaties, such as the Kyoto Protocol.

It is true that the concept of sustainable development, as formulated in the various legal documents, does not lay down simple rules without which an ordered society is impossible or without which an ordered society aimed at any particular goals will fail to create its mark (morality of duty), but rather that it is a incomplete, ambiguous and indeterminate general idea of the perfection that we should strive for. We, as well as future generations, would need to commit to achieving the goal of sustainable growth, without expecting it (FULLER 1974).

While there is no widely agreed definition of sustainable development, global and regional treaties on international watercourses, wildlife conservation, habitat preservation, endangered species, and cultural and natural heritage also indicate that a broader legal meaning in terms of biodiversity and sustainable development has been achieved. (BIRNIE 1992) It is clear that the importance of sustainable development, which involves actions to be carried out without damaging the environment, is widely recognized by the international community.

3.5. The precautionary principle

Throughout time, government action to mitigate environmental degradation has experienced many phases of transition. The first stage focussed on remedial action, which materialized after an accident in the form of government intervention to remedy the damage. The preventive method needed to be included in the second stage of the policy plan, in the sense that it required the authorities to intervene before harm occurred. This stage comes to the fore because environmental pollution risks are considered real and therefore preventive steps should be taken in a timely manner to avoid damaging consequences (FAURE-NIESSEN 2006).

The new environmental policy trends are characterized by a need for anticipation. It differs from the second stage in that it is mainly aimed at dealing with harm risks that are deemed serious or permanent, and thus requires proactive action, although there is still scientific uncertainty as to whether the risks will materialize (SUNSTEIN 2002).

The existence of uncertainty and irreversibility has policy implications that require decision-makers to take preventive action and acknowledge our lack of knowledge that is always part of the scientific analysis. Consequently, lack of scientific evidence, should not be a legitimate excuse for postponing the preventive action. The potential harm to society resulting from a proposed activity should not be ignored simply because there is uncertainty about the exact nature of the risks associated with the activity (GEISTFIELD 2001).

This new approach in the decision-making process has marked the development of a legal instrument, particularly with regard to human health and protection of the environment. The emergence of this principle arose especially from the recognition that most environmental degradation processes are irreversible. There is also concern that actions that carry a substantial risk of permanent environmental damage should be reported to avoid the damage, even though there is still empirical doubt as to the extent of the harm that is likely to result from it. The

precautionary principle stems from a growing concern for environmental protection, which in turn encourages states to take steps to avoid degradation of the environment even though the deleterious effects of this deterioration remain unproven. Careful application of such a strategy would, of course, imply that the risks of the foregone benefits should be balanced against the risks of the costs incurred by implementing unnecessary protection (FAURE-NIESSEN 2006).

The precautionary principle has its origins in the early 1970s with respect to the Vorsorgeprinzip in German environmental policy. Harald Hohmann notes that the aim of the Vorsorgeprinzip is to avoid possible foresight contamination and through careful use of available resources to maintain the ecological basis for future generations (HOHMANN 1994).

The 1985 Vienna Convention on the Defence of the Ozone Layer is considered to be the first international treaty specifically referring to precaution in this way (CAMERON 2001).

The year 1992 represented a major advancement for the precautionary principle, embodied in the implementation of the principle in at least four international conferences, one treaty and one international declaration. Such a development indicates that in many international conventions, especially after the adoption of the Rio Declaration, the precautionary principle has been increasingly adopted and accepted (FREESTONE -HEY 1996).

The UN Framework Convention on Climate Change was adopted in 1992. In combating climate change, the Convention has expressed international acceptance of the implementation of the precautionary principle. The Rio Conference has concluded a declaration on Environment and Development, which reaffirms the recognition of the precautionary principle.

SANDIN 1999 outlined a detailed description of the precautionary principle. Some variations of the precautionary principle are discussed by the author, based on four elements of the principle. The first item is the threshold. The precautionary principle demands that a threshold be set in accordance with the harmful potential of a behaviour before taking a preventive action. If this threshold is crossed, it requires or indicates the preventive steps. The threshold levels are set in a very broad terminology as well as in very specific terms. The harder the threshold to cross, the stronger the definition would be in this respect. Additionally, the threshold can also clarify that the precautionary principle is intended as an unusual principle that only applies for those threats considered to be of extraordinary magnitude. Hence, a very broad threshold definition may inevitably undermine the intent to apply the precautionary principle. 'Uncertainty' is the second dimension. Sandin observes that the less accurate the definition of uncertainty, that is, the less plausible the threat must be, the stronger the principle is.

If the danger is scientifically definite or not they will be taken away. This implies that preventive measures will be taken under uncertainty, as if the threat is known for sure. The precautionary principle is therefore closely linked to the preventive principle. The only difference between the two concepts is that the former applies to all unknown threats, while the latter applies to certain threats. the fourth element is the command dimension of the precautionary principle. In this regard, the strength of the precautionary principle will be determined by the status of the measures. A mandatory status of the precautionary principle is typically expressed in phrases such as ‘shall strive to adopt’, or ‘must not wait’. However, most of the status is expressed in a vague formulation, namely that uncertainty ‘shall not be used as a reason for postponing’ preventive measures. It is unclear whether the measures are mandatory or not, because its only stated that uncertainty does not justify inaction (SANDIN 1999).

Academics do not agree with the precautionary principle as to its legal status. CAMERON and ABOUCHAR 2001 suggest that the proof of state practice is adequate to make a strong case that the principle has become a rule of international law.

There is no doubt that the precautionary principle is now generally accepted and taken into account by states and international organizations if large-scale environmental change is undertaken. This is also integrated into numerous foreign treaties, and the concept has been adopted by several States at national level. Despite the disagreement between academics about the legal status of the precautionary principle, the extensive support and proof of state practice in instruments such as the Rio Declaration, the UNFCCC and the CBD warrant a clear claim that it constitutes a principle of customary international law (SANDS 2003).

3.6. The polluter pays principle

The polluter pays theory for reducing environmental pollution is essentially based on a common sense approach. It simply means that the person who damages the environment will bear the cost of compensating for that damage. In a wider context, manufacturers of products and other things should be responsible for any emissions caused by the manufacturing process and must thus therefore compensate for mitigating or rectifying the harm caused by such emissions to the environment (BALL 1994). Underlying the essence of the polluter pays concept is the assumption that the individual responsible for the emissions will bear the costs incurred when public authorities take action to avoid possible and real environmental harm (SMETS 1994). The theory can be extended in the event of environmental degradation to allow the manufacturer and/or consumer of the resource to meet the costs of enforcing an environmental norm. The resource consumer should also meet the requisite expenses for enforcing technical regulations where appropriate. The implementation of liability laws is often proposed to make resource consumers responsible for causing environmental damage and therefore compensate for the emissions caused by their authorities.

Whereas the precautionary principle developed out of national legislation, the concept of polluter pays emanates from the international domain. The polluter pays theory came to light in 1972, when a series of recommendations were made by the Organization for Economic Co-operation and Development (OECD) on international economic aspects of environmental policies (OECD 1972).

Following the OECD Recommendation, the principle gained prominence in other international settings. In 1973, the polluter pays principle made it into the First Environmental Action Programme of the EC and has since reappeared in all of its following programmes.

One field of microeconomics, known as welfare economics, has paid a great deal of interest in exploring how the market can combine the decisions of utility-maximizing consumers and profit-maximizing producers to generate an efficient resource allocation spontaneously. This efficiency is known as Pareto optimality, a condition where real resources can no longer be placed in such a way that we can make one person better off, while making someone else worse off at the same time (GRIFFITHS-WALL 2000). Without any kind of government intervention, this condition must be reached in a competitive market. But most economists would agree that there are several factors that contribute to the existence of market failures, including externalities.

An externality arises when an economic agent's actions directly influence the decisions made by others, rather than by market prices. In this situation, a consumer's consumption or a producer's

output has a direct impact on others' consumption or output which is not expressed in the market price (PINDYCK- RUBENFIELD 2001).

Costs incurred by the agent carrying out an economic operation are called private costs, while all costs levied on certain citizens by that agent's consumption or development operation are called external costs. The sum of private and public costs is called social costs, representing all societally borne costs. An effective output level occurs when a product's price is equal to the marginal social cost of production, that is, the marginal cost of private production plus the marginal external social cost. The disparity between private costs and social costs is proving to be unsustainable in the presence of externality (SOLBERG 1982).

Environmental problems are considered a typical example of externality.

In general, environmental emissions and other externalities to the atmosphere are negative. They reflect the absence of markets (no supply and demand exchange) and market rates for (some) environmental or service resources (GROSMAN 2001). In addition, the prices of many commodities still do not reflect the full costs associated with their use. The use of environmental resources and their impacts has not been adequately considered by the decision-makers of the company in this regard. As a result, the organization should generate output that maximizes its private income, irrespective of the high external costs it may impose on society. Clearly, the externalities scenario shows a situation where unregulated competitive markets contribute to inefficiency. The main objective of the polluter-pays principle is the internalization of environmental externalities. Economists believe that only when external costs are fully taken into account will firms act to prevent market failures and move to a socially optimal level of output (TURNER et al 1997). Therefore, from an economic point of view, the presence of environmental legislation or regulation should be mainly aimed at remedying externality, namely by requiring the company to internalize external costs in order to minimize the gap between marginal social costs and marginal private costs (HUNTER et al 1998). The fact that in the absence of law there will be no adequate incentive for the firm to internalize the externality indicates that the goal of environmental law seems to be a simple one: to induce the potential polluter to take into account the pollution it might cause in its decision-making process ((FAURE 2001).

The polluter-pays principle has been adopted in several international conventions, among them (DE SADELEER 2002) the 1980 Athens Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and Activities, the 1992 Helsinki Convention on the Transboundary Effects of Industrial Accidents, the 1993 Lugano Convention on Civil Liability for Damage resulting from Activities Dangerous to the Environment, the 1992 Helsinki Convention on the Protection and Use of Transboundary Watercourses and International Lakes, the 1996 London Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

3.7. Soft and hard law

Growing awareness that humanity has entered the Anthropocene — a new age in which humanity is the key driving force of planetary change — presents new challenges to the theory and design of global institutions (PATTBERG-WIDERBERG 2015). Among these challenges is the need for such institutions to foster what DRYZEK 2016 refers to as ecological reflexivity, involving 'a more efficient listening to an active Earth system, the ability to rethink core values such as justice in this context, and the ability to try, obtain and respond to early warnings about possible ecological shifts.

'This illustrates the need to better understand how international legal frameworks are able to protect long-term interests, such as those of ecosystems and future generations, while still retaining adequate flexibility to respond to evolving environmental and social conditions" (EBBESSON 2010).

Legal institutions within global environmental governance are formed and operate through a variety of standards, i.e. "standards of appropriate behaviour for actors with a given identity" (FINNEMORE-SIKKINK 1998). Standards can be positioned along a continuum of 'legalization' from very hard to very soft law, associated with specific characteristics such as degree of obligation, precision and delegation (ABBOTT et al 2000).

A special feature of international environmental law is that many environmental issues are governed by non-binding soft-law instruments that allow faster responses to international environmental issues. Governments tend to resist legally binding treaty regulation for different reasons but are much more likely to adopt a written action plan or resolution, at least voicing a political will to address an issue. The numerous constitutional standards of several countries must be followed when negotiating international agreements: for example, the way the national parliament must approve and enforce a treaty. These problems should not be addressed when using methods of soft law. Governments use soft-law instruments in certain cases to check how they can respond to a new environmental problem or how to implement a new environmental policy before continuing with negotiations on the treaty. Many instruments which enact international environmental law are in fact non-legally binding instruments. Even if the instrument itself is not legally binding, this does not mean that it will be without legal relevance to follow the instrument. Nevertheless, many significant advances in international environmental law were achieved by non-legally binding instruments. The 1972 Stockholm and 1992 Rio Declarations provide some clear examples, the latter of which is generally recognized as the most authoritative codification of the principles of international environmental law. UNCED has developed Agenda 21, which has driven the establishment of international environmental law, while not binding in international law. In international environmental law, decisions taken during the meetings of the parties to multilateral environmental agreements were also especially important. Such decisions are usually adopted by consensus, even though they are not legally binding, and therefore affect the degree to which states establish and enforce the treaty regime. Although soft-law instruments can affect changes in the actions of states and other stakeholders, it is necessary to note that they are not legally binding from a purely legal point of view. They can be politically or morally binding but not legally binding on states and their members. It is necessary to note that soft-law instruments as such are not legally binding, as opposed to hard-law sources such as international treaties, customary international law or judgments of those intergovernmental organizations which have the power to enact legally binding judgments. Legal repercussions can only result from breaches of the laws of hard law, which are defined in the international law sources (KOIVUROVA 2014).

Non-legal arrangements have different purposes, and can be modelled in various ways. One concept is a dilemma posed by the iterated prisoner. Two nations, or even more, under threat of mutual retribution, reciprocally refrain from behaviours that otherwise would be in their immediate self-restraint to reap mutual benefits from cooperation. The coordination game is another model in which states earn higher payoffs if they participate in similar or symmetrical acts than if they do not. A classic example is driving: if both parties cooperate driving on the right, or driving on the left, they do better than if they take different actions.

If two or more States can produce collective gains by coordinating their actions, then their gains can be sustained without threats of retaliation, since the agreement is self-enforcement (GOLDSMITH.-POSNER 1999).

3.8. The sources of international law

Since there is no world government, there is no world Congress or parliament to make international law the way one country is formed by domestic legislatures. As such, there can be some difficulties in deciding precisely what international law is. There is no "Code of International Law". Although there is an International Court of Justice and a number of specialized international courts and tribunals, their authority is fundamentally dependent on state approval and they lack what can properly be defined as compulsory jurisdiction of the kind that national courts possess. The consequence is that the acts of the 192 states that make up the international community make international law essentially on a decentralised basis. THE STATUTE OF THE INTERNATIONAL COURT OF JUSTICE (UN 1945), Art. 38 identifies these sources:

- Treaties between States;
- Customary international law derived from the practice of States;
- General principles of law recognized by civilised nations; and, as subsidiary
- Judicial decisions and the writings of "the most highly qualified publicists".

Although this article is only directed at the International Court of Justice, it has developed over the years into a widely accepted definition of what the origins are in international law. It also explains how States should establish new international law and enforce it.

Treaties are the strongest and most binding category as they represent consensus agreements among the signatory countries. Treaties are similar to contracts between countries; agreements are shared, negotiated in writing, and signed between states. States may discuss the interpretation or implementation of a treaty, but the treaty's written provisions are binding. Treaties can address a variety of areas such as trade relations, such as the North American Free Trade Agreement, or nuclear arms control, such as the Nuclear Non-Proliferation Treaty. They can be either bilateral (between two countries) or multilateral (between many countries). They can have their own rules for enforcement, such as arbitration, or refer enforcement concerns to another agency, such as the International Court of Justice. The rules concerning how to decide disputes relating to treaties are even found in a treaty themselves- the Vienna Convention on the Law of Treaties (United Nations, 1969). Strictly speaking a treaty is not so much a source of legislation as a source of lawful duty. Treaties are only binding on States who are parties to them and choosing whether or not to become a party to a treaty is solely one for the State-there is no obligation to sign a treaty. Customary international law, pacta sunt servanda, requires all States to respect their treaties. That is why treaties are defined more accurately as sources of lawful obligation. But as authoritative statements of customary law, several treaties are relevant too. A treaty that is openly signed between a large number of states is also seen as writing down what previously unwritten customary law rules were. Clearly this is the case where a clause of the treaty is meant to codify existing law. In principle, where a provision of a treaty codifies a rule of customary law the basis of law is the original practice and opinio juris – the provision of a treaty is merely evidence. But this overlooks the fact that it updates the rule by writing down a rule that was previously unwritten. From that point on, it is the written law that everybody must look at, and questions about the nature of the regulation must concentrate mostly on interpreting the text rather than examining the underlying procedure.

In reality the fact that a large number of States agree on a clause of a treaty is itself an important piece of state practice. If subsequently those and other states enforce the provision of the treaty – particularly where they are not parties to the treaty – then it can quickly become part of customary international law.

The rules of customary international law slowly developed to reflect the changing international community. Before the Second World War – and before international law was specifically documented after the war as written international agreements – customary law was deemed to develop gradually and involve sincere action from the majority of States. The notion was that when a certain foreign practice is considered by the majority of states to be legally binding (opinio juris), it eventually transforms into a lawfully binding statute.

Such a custom shall be universal and essentially systematic and shall endure for some time. States will always believe they follow a custom as they are bound by a legal rule to do so. In comparison, in other fields of international cooperation, other rituals and procedures are practiced, but not because States find them legally binding.

It is more difficult to determine customary international law (CIL) than the terms of a signed treaty. CIL is created by the actual acts of states (called "state practice") as they show that certain states believe it would be unlawful to behave otherwise. Even if the CIL rule isn't written, it still links states and expects them to obey it. For example, countries have provided ambassadors protection for thousands of years. As far back as ancient Greece and Rome, when on their diplomatic missions, ambassadors from another nation were not affected, even though they represented a country at war with the country in which they were situated. Many countries have publicly stated throughout history that they agree that this protection should be granted to the ambassadors. So if a country hurt an ambassador today it would be in breach of customary international law. Similarly, in modern history, governments have accepted by their acts and comments that killing civilians deliberately during wartime is unlawful under international law. However, deciding CIL is complicated, as it is not written down in relation to a treaty. Certain rules are so commonly followed and accepted by many states as law, that there is little question that CIL exists with respect to them; but other laws are not as generally known and there are disagreements as to whether or not they are actually CIL.

If states negotiate a legally binding global convention, they are actually signalling their willingness to be bound by certain rules. States are continually sharing their opinions about how other states will act within international organizations, and in other forums. The manner in which states 'talk' and the formal commitments they make are becoming increasingly relevant for the implementation of modern international law. International laws are being drawn up at a increasing rate, both by treaties and through other international instruments.

Customary international law is not an effective method for reacting to threats to the environment since it is always subject to interpretation. Environmental issues should be tackled as soon as possible and handled in a manner that is fluid and capable of being adjusted to the latest science.

One advantage of customary international law is that it binds every country in the world, while treaties bind only the parties to them: thus, for example, if 150 states are parties to a global convention, more than 40 states remain outside the system. If it can be proved and tested that most of the principles of the convention have evolved into customary international law, then the principles will be legally binding on all the world states. Even if a state withdrawn from the treaty in question, the customary international law will still remain legally binding (KOIVUROVA 2014).

The third source of international law is focused on the "natural law" principle, which claims that laws are a result of the instinctual conviction that certain actions are right and other actions are wrong. "General principles of law accepted by civilized nations" are the common legal values and traditions in all existing legal systems (UN, 1945). For example, most legal systems respect "good faith," that is to say the idea that everyone intends to abide by the agreements they make. In certain countries, courts will investigate whether the parties to a case have behaved in good faith, and take this question into account when determining a matter.

The last two sources of international law are considered to be "subsidiary means for deciding rules of law." Although these sources are not international law by themselves, when combined with proof of international practice or general principles of law, they may help to prove the existence of a particular rule of international law.

Judicial rulings, both at the International Court of Justice (ICJ) and at national courts, are especially important. The ICJ, as the main legal body of the United Nations, is considered to be an authoritative expounder of law, and when other countries' national courts begin to recognize a certain principle as a legal rationale, this may signal a wide-ranging acceptance of that principle, such that it can be considered part of international law.

Legal scholarship, on the other hand, is not in itself completely authoritative, but may characterize rules of law commonly followed around the world. Thus, law professors may consult articles and books to find out what international law is.

3.9. International agreements

Since World War II, the primary source of international law has been international treaty law, as States have signed a large number of conventions. For the international community that had previously been governed largely by customary international law this was a significant shift. States will now read the laws regulating their actions in written treaties. The previous ambiguous and unwritten laws of customary law were far from perfect, since the exact responsibilities of states were still undefined.

There are several terms of international written multilateral agreements: pact, treaty, convention, agreement and protocol. All of them are governed by customary international law applicable to all treaties; these principles apply in situations where the parties themselves do not categorize a matter in an agreement. The Vienna Convention regulates the adoption, modification, interpretation and many other matters relating to all written treaties. As of April 2020, the Convention includes 116 parties and a further 15 states have signed but have not ratified the convention (Figure 1). The International Court of Justice has noted in many rulings that all of its articles codify customary international law. By virtue of Article 18 of the Vienna Convention, when states conclude a treaty, they undertake 'not to defeat the object and purpose of a treaty before it enters into force.' This is an important point to recognize. Newspapers and newspapers often refer to the parties to a treaty as their signatories, which is an incorrect term indeed. Signing a treaty is not synonymous with being a party, although states often agree that it is only by signature that an agreement is binding. A procedure is generally accompanied by a first signing of an agreement by states to show their goodwill and intention to become a party in the immediate future. Following signing, the agreement joins each state's national legislative framework according to its domestic constitutional law. When the State is prepared to be bound by the treaty, it shall be deposited with the body defined in the agreement.

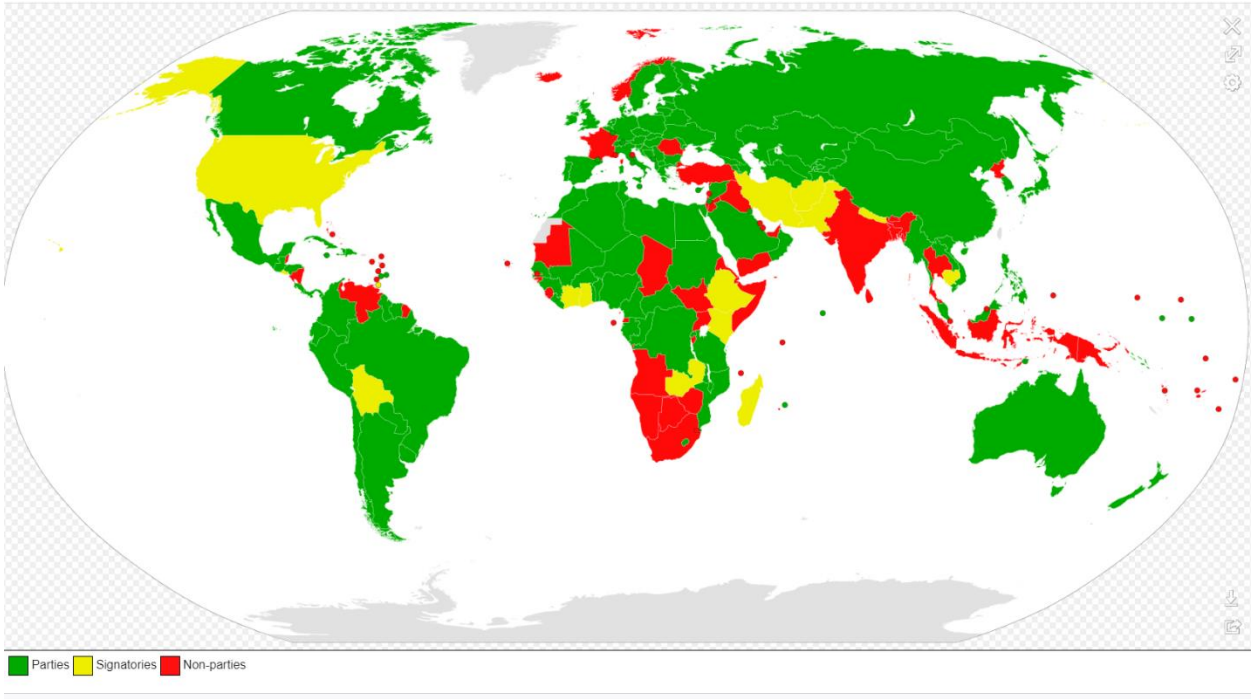

Figure 1: Vienna Convention on the Law of Treaties
Source: wikidata.org

However, even ratifying an environmental treaty cannot automatically result in the immediate binding of a state or states. An international treaty must also come into effect. Some treaties may define a minimum number of states that are expected to become parties to the agreement before they can enter into force.

In general, a multilateral environmental treaty proceeds as follows:

- *At the negotiation stage:* In addition to drafting the substantive obligations, it also addresses how to implement the final text in the treaty, how to convey the will to become a member, when the treaty is binding on a state, and the conditions under which it can enter into force internationally. A particular article also defining how states become a full party to a treaty. If a state signs a treaty, it must abstain from acts that would undermine the aim and intent of that treaty, even before it enters into force. Because a state does not become a party to a treaty by merely signing it, the treaty does not yet become fully legally binding on that state.

- *After signing*: several states have to send the treaty for approval to their own national Parliament. The state then signals its agreement to be bound by a treaty depositing the instrument of ratification with the depositary defined in the treaty (as provided for in the treaty). The treaty also specifies a limited period of time between depositing the ratification instrument and accepting the state as a member. Specifically in the case of global environmental treaties, states may become directly parties, bypassing both the negotiation stage and the signing act. Typically the process is referred to as accession.

- *Entry into force***:** several treaties also prescribe a minimum number of ratifying states needed to put the treaty into international force. This is primarily because adopting the treaty is pointless before a sufficiently significant number of states have engaged in the fight against the international environmental problem at problem (KOIVUROVA 2014).

Modern environmental treaty parties appear to define in more and more detail how the terms are to be interpreted, thus reducing the ability of states to interpret them in such a narrow way as to reduce their obligations. Most environmental treaties do not recognize reservations, for the same reason. On the other hand, most environmental treaties are fairly weak; in the case of a conflict, they do not impose an obligation to account for environmental harm or include compulsory dispute resolution between the parties. Most of the documents were designed to be so ambiguous they were merely a very open-ended obligation.

Before the 1970s, it was considered sufficient to define formal obligations without any follow-up or compliance mechanisms in international legal agreements. The representative of a state would sign a treaty and return to their country to get it ratified, and the presumption was that states should comply with the pacta sunt servanda principle.

This attitude towards environmental treaties was slowly discontinued as ineffective. In its position, the principal norm was a new model:

1. Throughout the negotiating point, an agreement is created setting up a daily 'meeting of the parties' (sometimes referred to as the 'conference of the parties' representing all the parties of the states), which has the authority to establish a treaty system. At this point, a funding model for the functioning of the treaty regime is also planned.

2. Such parties' meetings, made up of members of each state, discuss how to establish the treaty regime and what, if any, treaty bodies should be set up. All the decisions in the agreement framework are usually taken by consensus at the parties' meetings

3. The meeting of the parties provides a monitoring process for compliance with the treaty, consisting generally of a limited number of representatives representing the parties. In general, the committee's role is limited to assisting any breaching party in enhancing enforcement rather than imposing any penalties, although such penalties can be included under the treaty regime.

4. In this way it can be said that the parties have formed a permanent management system to effectively respond to a evolving environmental issue. This is only possible if new scientific information on the environmental issue and potential solutions are still included in the scheme

5. The regime should also be able to monitor and support that the parties are effectively establishing their own domestic policies and enforcing what the parties and other sub-bodies of the regime have already agreed upon.

6. The parties' meeting should also continue to improve the treaty regime in various ways, depending on the new challenges posed, through soft-law and hard-law measures. (KOIVUROVA 2014).

Most environmental agreements do not set up a formal international organization but rather a kind of mini-organization based on the contract. The mini organization can then be connected to established international organizations; a prime example of this are the environmental treaties negotiated within the UN Economic Commission of Europe (UNECE).

States usually pick the parties' meetings as the primary venue for decision-making. The meetings discuss how the treaty structure is created, and whether any treaty bodies would need to be formed. In general, the meetings also take consensus decisions relating to the treaty system. Sub-

committees are regularly set up to ensure that the treaty system is updated on a regular basis to address new challenges and to ensure that new scientific / technical work is introduced into the system.

The funding mechanism is another important mechanism which must be developed. The funding model is also subject to significant political quarrels. The developing countries forced through a resolution on the financing of international environmental protection which was of great importance to them at the 1992 Rio Environment Conference. (KOIVUROVA 2014).

3.10. Implementation of the international agreements

International environmental law varies from traditional international law in the way it compels the parties to an international environmental agreement to meet their commitments in action. In general international law, the principal rule is that if state A violates its duty, the injured state B can take the following measures:

- State B can first attempt at a political settlement of the dispute: that is, through negotiation, or through third party mediation.

- If still unsatisfied, state B may, with the consent of the parties to the dispute, bring the dispute before an arbitration court or an international court of justice; in most cases, states will seek to resolve the dispute themselves by negotiation rather than sending it to court proceedings.

- In certain situations, the injured state can respond only by countermeasures to a breach of the treaty. Countermeasures are acts taken by the injured state that would ordinarily be contrary to international law; they are rendered lawful because they are a justified reaction to the earlier violation of statement A. In many cases, the obvious result is a vicious spiral: state A denies having breached its obligations towards state B, and in turn takes its own countermeasures in response to state B's measure.

These procedures can hardly push international legislation on the environment forward. The goal is to combat or even remove an external threat to the Therefore, it is vital to avoid mutual disputes as far as possible relating to non-observance of the regulations of the treaty. Most of the environmental treaties do contain a dispute resolution paragraph. But usually this only allows states to settle their differences by the means they find acceptable themselves.

Environmental treaties take a different path and seek to resolve violations by joint commissions of enforcement. A meeting of the parties usually sets out the monitoring protocols and nominates an implementation committee responsible for developing ways of managing breaches such that they do as little harm as possible to the overall functioning of the agreement framework. Implementation of a treaty (and potential breaches) is reviewed by the negotiating committee and/or at the parties' meetings. Such committees will work only if they are briefed on how states are dealing with their obligations. They will obtain the information as unbiased as possible. This is a difficult system, but environmental treaties have slowly succeeded in establishing processes that at the very least provide clearer details about how treaties are implemented and enacted by states. The state reports go either to the parties' conference, to the treaty secretariat, or directly to the implementing committee. Expert panels can be used on the most ambitious environmental

treaties. For example, in the climate regime, Annex I states' greenhouse gas emissions and sink inventories are first certified by the secretariat, and then by the panel of experts. When the panel of experts is dissatisfied with the inventory of a department, queries will be referred to the compliance committee (KOIVUROVA 2014).

The total number of international environmental agreements is impressive: Since 1945, more than 2,000 environmental agreements and protocols have been signed (MITCHELL 2020). Some of the oldest IEAs regulate fisheries, endangered species, agriculture and wetlands, but an growing proportion of IEAs now tackle habitat protection, energy generation, hazardous waste, and pollutant emissions (EGGER et al. 2013).

In addition to those international environmental agreements, preferential trade agreements (PTAs) are gradually contributing to global governance of the environment. Modern PTAs usually provide a fully-fledged environmental protection portion, with responsibilities that are often more precise and strict than those found in IEAs (JINNAH 2011); 94.3 % of PTAs concluded since 2000 contain at least one environmental clause, and 78.4 %t include at least one clause addressing particular environmental concerns such as whaling, waste management, etc. (MORIN et al. 2018, 2019). Thus PTAs can be considered a subset of environmental agreements. The combined abundance of IEAs and PTAs is so prevalent that some experts in environmental governance do not hesitate to speak about "treaty congestion" (ANTON 2013).

Not all the treaties, however, have equal incentives for their enforcement. For two key reasons it is expected IEAs to have a different impact from that of the environmental clauses of PTAs. Firstly, PTAs with environmental provisions by their very nature connect trade and the environment. If this relation is essential for one party to a PTA, the other party may be given an opportunity to follow environmental legislation to protect this PTA and to obtain preferential access to a foreign market. Some multilateral IEAs do have trade controls, but they are limited to some goods, and only have clear incentives for domestic legislation to be implemented. Second, PTAs usually rely on compliance mechanisms more efficient than IEAs. In certain cases, if it fails to enforce its environmental commitments (JINNAH 2011), a party to a PTA may potentially face monetary or trade sanctions. This is almost unheard of when it comes to making environmental treaties. Instead, most IEAs rely on enforcement management processes, such as capacity building, accountability, and political dialogues (CHAYES 1995; TALLBERG 2002). Such soft mechanisms are mostly included in PTAs, but many of them do have strict compliance mechanisms (BASTIAENS-POSTNIKOV 2017).

Previous empirical research reviewing multilateral environmental agreements either centred primarily on factors affecting the decision of a single country to ratify a particular environmental treaty (FREDRIKSON-GASTON, 2000; NEUMAYER, 2002; EGGER et al., 2011, 2013; MILLIMET-ROY 2015) or considered a subset of agreements (DAVIES-NAUGHTON 2014). General findings indicate that richer countries have a more competitive political structure, are more open to trade and are more likely to collaborate and ratify a MEA.

GDP, distance and preferential trade agreements, variables that generally clarify well bilateral international trade flows, are also strong predictors of the probability that two countries will have a multilateral agreement on the environment and the number of agreements they have. Countries which trade more among themselves are more likely to be parties to at least one environmental agreement. Countries reducing pollution or preserving endangered species can suffer economic losses. Perhaps the most widely cited claim in opposition to pollution-restraining agreements is that limiting pollutant emissions such as carbon dioxide could harm firm competitiveness in global

markets as new regulations raise production costs. In addition, participating in some environmental agreements, given new regulations, can result in less trade between states. As a result, countries that trade more with each other could avoid entering MEAs together, as that could have a negative effect on their. On the other hand, when the economic relations are strong, it could be easier for countries to align their economic and environmental policies. Two countries can jointly address environmental and economic concerns, because these linkages can ensure greater cooperation on both concerns. A nation which is not interested in protecting the environment can be able to do so if it can enjoy benefits from reduced trade barriers from its trading partners. Countries with large economic interactions have more chances of such relations than countries with less interactions. In addition, countries may suffer non-environmental costs if they choose not to cooperate on an environmental agreement (HOEL-SCHNEIDER, 1997). A nation may be disqualified from a potential trade deal for example if it fails to comply on an environmental deal. Conversely, due to an environmental agreement, foreign trade will increase. It may happens when an agreement is signed by one of the signatories promising to comply with the higher environmental requirements already in force in the other signatory. In such a environment, one country is increasing its standards and allowing its businesses to enter a market that used to be inaccessible to them, leading to increased trade between the two nations. (BESEDES et al 2019).

Environmental agreements tend to concentrate on fairly broadly defined environmental issues, while trade agreements tend to be much more extensive, but not always completely complete. This aspect leads us to the second point about multilateral environmental agreements, which is that they come in all shapes and sizes due to their fairly narrow emphasis. Theoretical papers investigating the development of multilateral environmental agreements predict that self-enforcing environmental agreements will support a large number of signatories only when there is a very small difference in net benefits between non-cooperative and fully cooperative outcomes (BARRETT, 1994). In a clear theoretical result, GELVES and MCGINTY (2016) are adding consistent conjectures to the canonical Barrett (1994) model of international environmental agreements. They find that large coalitions cannot grow, but that small coalitions can lead to substantial increases in reductions over non-cooperative performance. EICHNER and PETHIG (2013) extend the Barrett (1994) model with a composite consumer good and fossil fuels created and consumed in each country to a general equilibrium environment. Allowing foreign trade results in broad, permanent environmental agreements being self-strengthened but resulting in a limited reduction in emissions. SANDLER (2017) argues in a comparative analysis of global and regional agreements that transaction costs of major global treaties are high due to the number of participating countries. Regional smaller agreements are easier to shape, despite their lower transaction costs. In the context of asymmetric national incomes and nationally defined contributions, SILVA (2017) considers the endogenous composition and stability of the agreements.

Although stable coalitions of different sizes are possible under a variety of conditions, they appear to offer too little reduction in relation to the first-best outcome. HOVI et al. (2015) suggest that lack of trust may be an obstacle to agreements and explore ways to improve confidence. If lack of trust is a problem, it is more likely to be a problem in larger agreements as more countries need to agree on a similar set of priorities and commitments. Agreements with few signatories can resolve trust issues either because all signatories trust each other, or because it is easier for fewer parties to resolve trust issues. Based on these theoretical projections, we would expect countries to bear lower economic costs when ratifying large treaties than they do when ratifying small treaties. Furthermore, several major treaties, such as the Framework Convention on Climate Change, are signed by virtually all countries around the world but have no clear obligations. In other words,

these agreements will at some stage be an indication of a willingness to do something about a problem, but they do not mean an actual commitment to do anything by themselves. On the flip side it is more likely that smaller agreements would include binding commitments. When we examine both large and small agreements together, analysing the determinants of the probability of a pair of countries getting a MEA that obscure those nuances. Our findings do also indicate that such an approach obscures major variations between these two forms of agreements. Environmental and large agreements also deal with environmental problems of various kinds. Agreements with a few signatories deal mainly with regional environmental concerns such as transboundary air pollution or coastal sea overfishing. Agreements with large number of signatories often deal with global issues such as climate change or endangered species. Environmental agreements with fewer signatories are signed by countries wanting to deal with common resource issues, while larger ones are more likely what could be called 'statement' or 'preference' agreements in which countries communicate a willingness to resolve the problem but do not commit to it. SANDLER (2017) suggests that the lower the real obligations, the greater the number of participants. As a result, large agreements may be expected to have fewer commitments to allow more countries to agree to them. According to SANDLER (2017), large agreements involving nearly all countries can involve substantial transaction costs, making them typically feasible in cases where each member's commitments are either not large or unenforceable. Considering such a demarcation of agreements, economic and geographic factors are far more likely to be a driving force behind smaller agreements being created. Theoretically, EICHNER and PETHIG (2015) are exploring a environment in which a self-enforcement arrangement would consist of at most two nations, raising their mitigation efforts as they liberalize the bilateral trade ties. While enhancing cooperation on both the environmental and commercial dimensions, they cannot prevent an increase in emissions and a reduction in overall welfare (BESEDES et al 2019).

Implementation of the treaties may vary with the political ability of states may abide by their foreign commitments. This is why the impact of the treaties varies between developing countries and high-income ones. Given economic and power asymmetries, developing countries are more likely to pursue regulatory reform in order to improve their chances of seeking a new trading partner and gaining market access (BACCIN -URPELAINEN 2014) or capacity building support (VANDEVEER-DABELKO 2001). These resource benefits are more desirable in comparison to the GDP per capita for developing countries. High-income countries, on the other hand, are unlikely to consider paying the costs of environmental changes to improve their market access or get assistance. In addition, developing countries appear to have less strict environmental policies than high-income nations, and thus need to catch up further. High-income countries are usually the main market for unique environmental treaty content (BECHTEL-TOSUN 2009; SPRINZ - VAAHTORANTA 1994), making them more likely to meet the prescriptive obligations of a treaty already (VON STEIN 2005).

Developing countries must meet their commitments before the treaties enter into force. Several obligations under the treaty are not subject to transitional periods and are legally binding as soon as the treaty comes into effect. Developing countries may be especially worried about the possibility of non-compliance and therefore promote early legal adjustments to be on the safe side once the treaty comes into force (BASTIAENS-POSTNIKOV 2017; KIM 2012). It is especially likely to be the case when the entry into force is conditional upon a number of ratifications from the treaty. This is especially likely to be the case when the entry into force is conditional upon a number of ratifications from the treaty. This condition induces confusion about the exact date of entry into force, and encourages early implementation.

There are several game-theory articles investigating the nature and features of international environmental agreements (BARRETT 1994, 1997, 2001; CARRARO-SINISCALO 1993, 1998; HOEL 1992; HOEL-SCHNEIDER 1997; RUBIO-ULPH, 2003; FINUS et al, 2005). The literature focuses on how to form a stable coalition (LIBECAP, 2014). Most non-cooperative MEA theoretical game models draw a rather pessimistic picture of the prospect of successful cooperation (FINUS 2008). The number of papers examining the formation of multilateral environmental agreements is empirical (FREDRIKSSON AND GASTON, 2000; NEUMAYER, 2002; BERON et al., 2003; MURDOCH et al., 2003; EGGER et al., 2011, 2013; MILLIMET and ROY, 2015; DAVIES and NAUGHTON, 2014). EGGER et al. (2011) explores the impact of trade liberalization on the involvement of countries in multilateral environmental agreements.

Besides these considerations, material incentives in developing countries may favour early implementation. If a state expects a treaty to benefit, it may increase the probability of international ratification by adopting policies that favour key domestic players within its partner country (BACCIN -URPELAINEN 2014). Such benefits can include development assistance, capacity building support, and preferential market access. Because high-income countries are also concerned about their competitive advantage owing to less strict environmental policies in developed countries, they would welcome the signal of early adoption in developing countries, which can help them soothe domestic resistance to treaty ratification.

Adopting practices can arise after a treaty takes effect. A treaty that is already in force will increase political pressure to adhere to concrete treaty commitments by increasing awareness, providing scientific knowledge, fostering expertise and capacity, and encouraging civil society, thus facilitating post-entry implementation activities (BASTIAENS-POSTNIKOV 2017)). However, any activities that occur after a treaty enters into force are expected to be dispersed over a long period of time, while enforcement is supposed to be more localized and therefore more easily detected prior to entry into force. We expect that if the treaties are signed with high-income countries, the effect of treaties on legislative change in developing countries would be greater. Despite the degree that high-income countries have more strict environmental policies than developing countries, the former have a strong interest in "exporting" their environmental policies (DESOMBRE 2000) with laxer policies despite their partner countries to relieve competitive pressure. Following the above-mentioned rationale linked to economic and power asymmetries, we expect developing countries to be especially interested in receiving support from and gaining market access to high-income countries and fostering legislative reform to favour swift treaty ratification, thus making North – South treaties especially successful. A division of power in favour of pushers increases productivity in the system (MILES et al. 2002).

The implementation across various areas of environmental issues is distinguished. Variance across issues is highly anticipated because countries are likely to give priority to enforcing the least costly initiatives. Three factors, which are well known in the literature, contribute to making certain areas of concern more expensive to control than others. First, is the framework of the ecological problems at the root (MITCHELL 2006). Regulating common global resources, such as the ocean and atmosphere, does not offer a nation the same immediate benefits as regulating local environmental concerns, such as the quality of water, air and soils. Second, the problem areas differ with regard to the immediate social costs and benefits that regulations cause SPRINZ - VAAHTORANTA 1994). Some laws, such as the implementation of fishing quotas, will generate high marginal abatement cost. Many environmental policies can bring major social benefits, such as improving air quality in cities or reducing the risk of property loss in the event of a natural disaster. Third, each problem area's domestic political economy affects the government's tendency

to control it (CAO-PRAKASH 2012). If the interests of influential actors diverge, an issue is malignant, but it is benign if those influential actors converge or remain indifferent (UNDERDAL 2002). Regulating industries such that profits are cut creates strong resistance from powerful interest groups, while establishing natural reserves in remote areas is more likely to be opposed by vulnerable communities. For issues that are global, socially expensive and malignant, we expect the connection between treaties and domestic legal change to be weaker than for those that are local, socially desirable and benign. The relative regulatory costs associated with a given area of environmental concern vary from country to country (SPRINZ-VAAHTORANTA 1994). For this purpose, we cannot have a standardized ranking of the least costly areas of concern and the most likely execution of international commitments. Nevertheless some issue areas tend to have almost identical features. In particular, the conservation of freshwater and air quality appears to be issue areas usually associated with relatively low regulatory costs. They can be regulated effectively at regional level; they provide significant benefits in various sectors, including health; and they unite interest groups, including NGOs, companies, and local authorities. Combating climate change and protecting fish populations, on the other hand, is distinguished by limited property rights and fairly open access.

3.11. Amendment system

A model has been developed in international environmental regulation to flexibly modify an agreement in order to be compliant with current scientific studies on a specific threat and its severity. The model was developed first with the LRTAP framework convention (LRTAP 1979); it initially adopted general principles and guidelines, which were then expanded as awareness increased by incorporating new protocols into the treaty structure. The key problem is that governments, as sovereigns, must embrace each amendment according to classical international law. Because this can lead to untenable situations: there is an immediate need for an update to an international environmental agreement, but the only way to do that is to establish a protocol or make a formal update. There are two downsides to this:

- If an amendment needs approval by a certain number of states, it may take a long time to come into effect, even if it has been desperately required for some time (or may never enter into effect).
- And if an amendment takes effect, certain states can be party to one amendment but not to others. This is fragmenting the treaty structure by setting out separate obligations for each side. Such a condition is untenable from the treaty regime's standpoint of cohesion.

This is why the environmental treaties have started to establish rapid adjustment processes that can respond rapidly if necessary to new knowledge about an environmental danger. Such regimes tend to differentiate between routine commitments and substantive modifications, the latter being subject to accelerated modification. The ozone regime, which can allow technological improvements by qualified majority, is a prime example. Consequently, a state may become legally bound to a technical amendment without its consent. Another clear example of this is the MARPOL Convention (MARPOL 1973) amendment protocol (on ocean pollution). Unless one-third of all parties object to an amendment or the parties controlling 50 per cent of merchant fleet tonnage, the amendment to the Annex shall be adopted automatically. In practice, changes are usually made by consensus such that there are no objections; states are given a defined time limit under the MARPOL Annex to register their opposition to a proposed reform. Another way to improve and simplify the amendments is by making crucial decisions at the parties' meetings. This

is an interesting process because in general the decisions are taken by consensus. While these decisions are not considered legally binding in themselves, they can also have distinct legal implications. For example, the implementation rules of the Kyoto Protocol (the Marrakesh Accords) were applied internally in Finland via the presidential decree in the same way as many other treaties, while in practical terms they reflect decisions taken by the parties to the treaty (and unique cations of the general rules in the Kyoto Protocol). It seems obvious that foreign environmental regimes need to find ways to respond to rapidly evolving environmental issues. With decisions being made at the meetings of the parties and members of the parties sitting in the compliance committee, this decision process – although technically non-binding – tends to be increasingly the mode by which parties establish their regimes. It is also important to notice the development in implementation committees. Such committees seem to have, to some degree at least, imitated the monitoring committees of the human rights treaties. An increasing number of compliance committees work in an analogous manner to the courts to the extent that they consistently continue to observe their own earlier Treaty interpretations. The bodies monitoring human rights treaties provide general statements on how a certain clause of a treaty should be interpreted on the basis of individual country studies. The environmental treaties implementation committees do not issue official general statements but some of them have started to publish overview reports of the most relevant findings in their earlier decisions as a guideline on how to interpret the treaty. In general, the decisions of these compliance committees are sent for approval to the parties' meetings, which gives the parties a high degree of legitimacy because they themselves contributed to the decision. Regardless of how their legal status is determined – whether legally or politically binding in any way – the parties usually abide by their conditions. These meetings of the parties are the efficient way of making quick decisions in the international community, as the agreement system will in every case have to react to updated information about the environmental threat on the basis of scientific research (KOIVUROVA 2014).

The International Environmental Agreements Data Base (IEADB), launched in 2002, catalogues the documents, memberships, and design features of more than 3,000 multilateral and bilateral environmental agreements. Using IEADB data, we can have a thorough overview of the evolution of international environmental law, including how the number, subjects and IEA state membership has changed over time (MITCHELL 2020).

While the 1972 United Nations Conference is frequently viewed as having kick-started international environmental law (JOYNER 2005), by 1950, states had signed over 250 IEAs. Figure 2 shows the five-year moving average of the of signed original agreements, protocols and amendments, showing states agreeing far more original bilateral environmental agreements (BEAs) than multilateral environmental agreements (MEAs) but changing them less regularly through protocols and amendments.

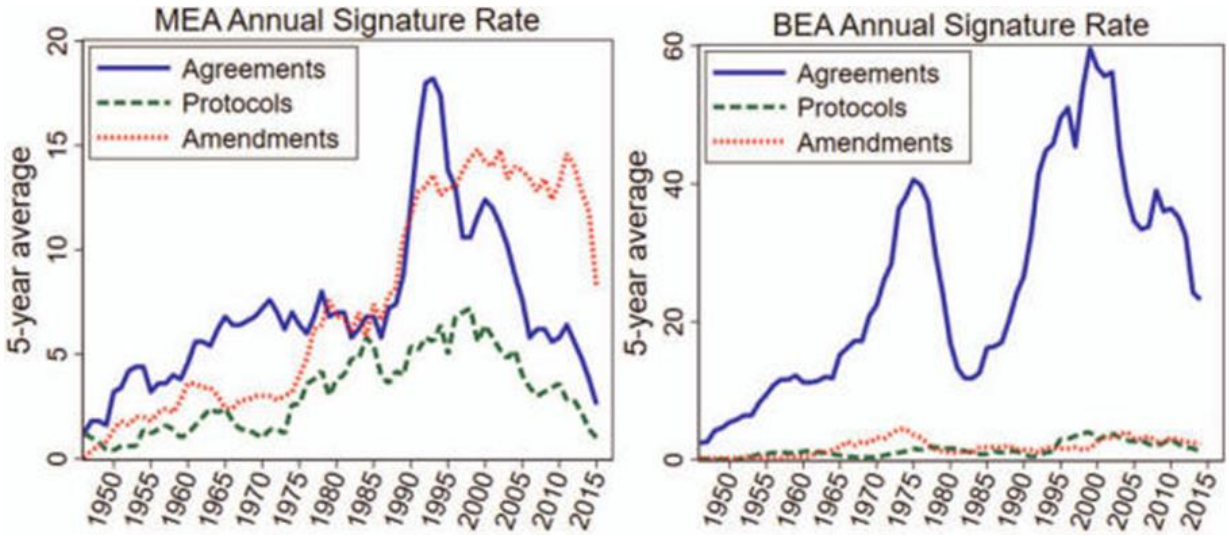

Figure 2. Rates of Successfully Completed IEA Negotiations
Source: MITCHELL et al (2020)

Around the time of UNCHE, states negotiated several BEAs, and both MEAs and BEAs around the time of the 1992 UN Conference on Environment and Development. Early MEAs and BEAs were dominated by species-related issues about overfishing, marine mammals and other wildlife, and trade threats to agricultural plants and animals, with pollution and freshwater resources only gaining serious attention after the 1970s (BALSIGER-VANDEVEER 2012). Subjects have continued to diversify, with one third of IEAs now addressing animals, one third addressing pollution and energy, and the remaining third covering a number of other concerns (Figure 3).

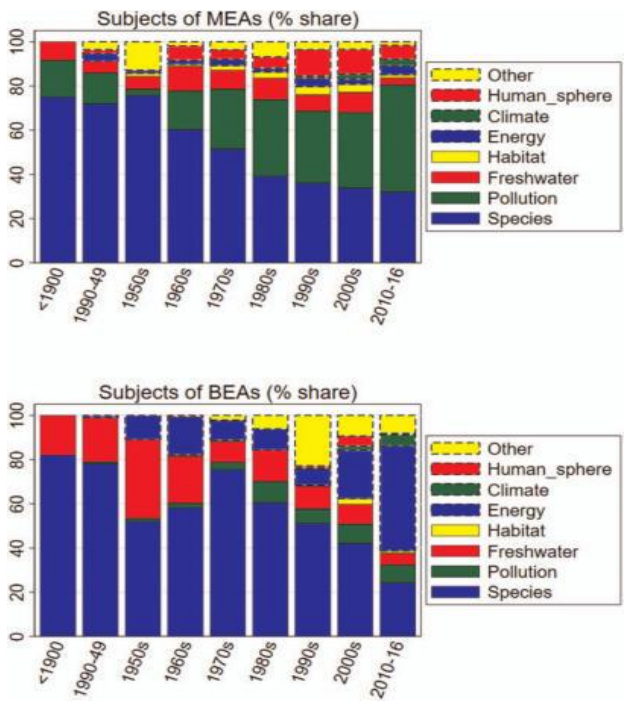

Figure 3: Share of Subjects Covered by MEAs and BEAs
Source: MITCHELL et al (2020)

When counting lineages rather than individual IEAs, the IEA landscape appears different. MITCHELL (2003) coined the term lineage as a legal counterpart to the definition of a system, describing it as a series of "agreements, protocols, and amendments that alter, expand, substitute, or directly originate from one or more original agreements. The IEADB put more than 1,300 MEAs into 290 such lineages, with BEAs to be assigned in the future. These groupings record when a collection of states first discusses an environmental issue and how they over time alter their efforts. Thus the tradition of "ozone protection" started with the Vienna Convention in 1985 and was amended by the Montreal Protocol of 1987 and eighteen modifications and changes.

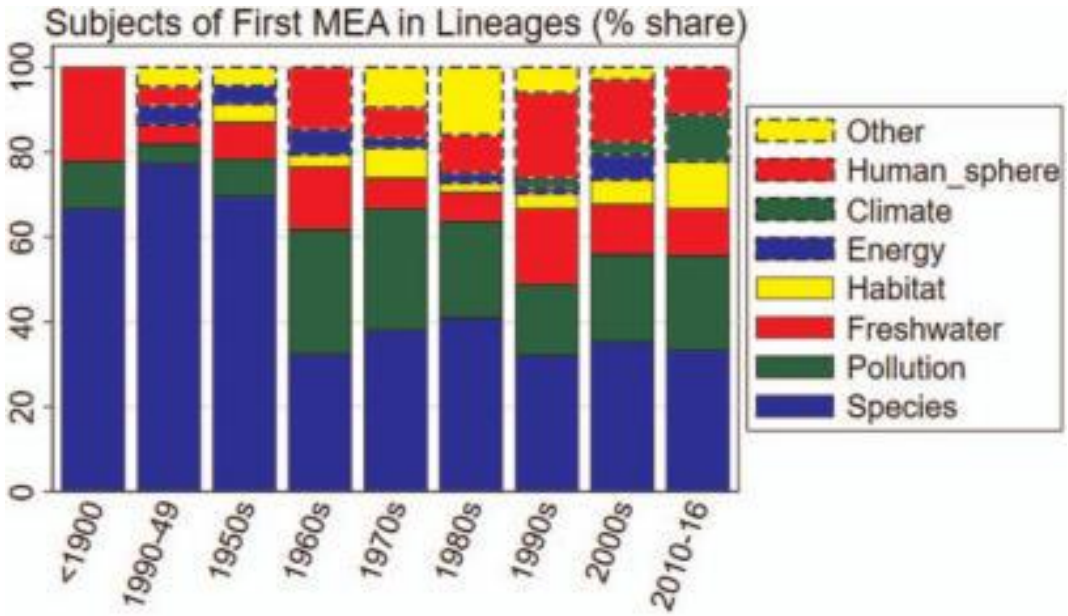

Figure 4: Subject emergence
Source: MITCHELL et al (2020)

As IEAs usually deal with the same subject within a lineage, we use the subject of the initiating agreement of each lineage as a proxy for when a group of states first effectively discuss a subject within a regional or global environment. Figure 4 graphs lineage-initiating agreements, showing how the range of subjects discussed by lineages has shifted, as either states take on new environmental issues or states in one region emulate initiatives in other regions to resolve a given problem. Lineage sizes (the number of IEAs each includes) represent very different approaches to governance. Of the 290 lines most (70 percent) are not complex regulatory initiatives and include only one initial MEA and one or two modifying protocols or amendments. In comparison, each of the ten largest lineages comprises twenty or more MEAs, representing up to one-third of the 1,300 MEAs collectively. This variation probably reflects various factors, including the age of the lineage; changes in scientific knowledge; state preferences that favour strong initial action or prefer to make adjustments as support for action increases; adjustments in domestic and international concern about an environmental issue; and provisions in lineage-initiating IEAs that may allow, encourage or hinder frequent modifications.

In recent decades, the level of state participation in international environmental law, proxied by IEA membership counts, has increased rapidly. Total IEA membership growth reflects more states-negotiated MEAs and BEAs, more states in the international system (UN membership rose from 51 in 1945 to 193 in 2020), and more states entering more MEAs. Most IEAs are small: 80% are BEAs, 90% of MEAs have 10 members or fewer and only 30 MEAs have more than 100 members. Many MEAs are open to new members indefinitely, with membership usually increasing

over time; thus, to accurately compare changes in MEA size over time, the memberships of each MEA is counted nine years after signature.

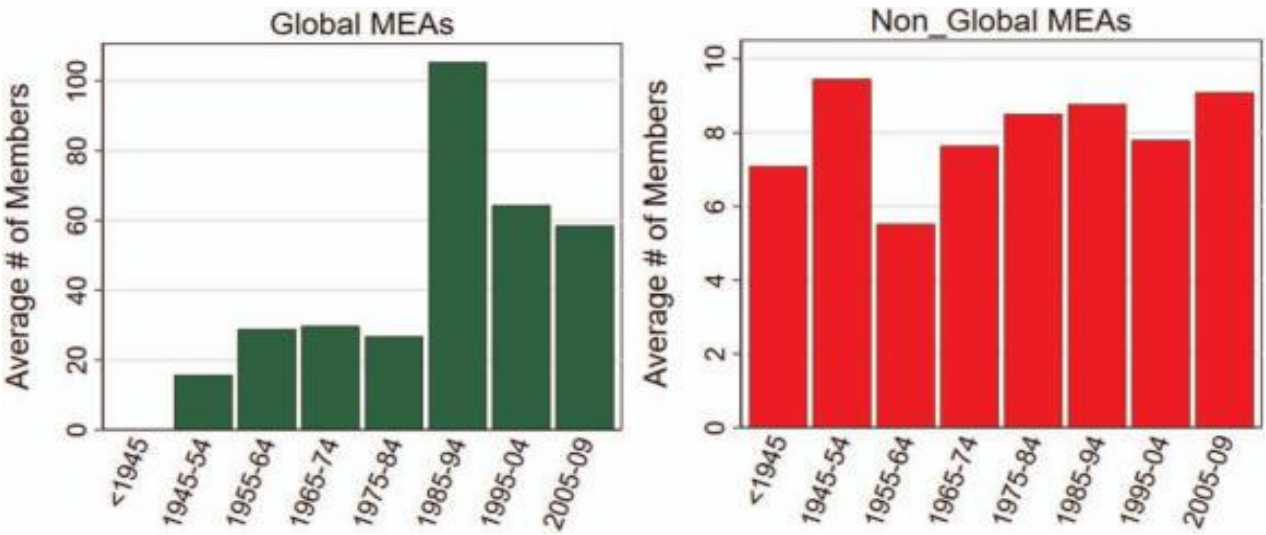

Figure 5: Average Year 9 Memberships in 69 Global and 388 Non-global MEA Agreements Source: MITCHELL et al (2020)

To resolve the fact that membership in protocols and amendments is mostly limited to members of the underlying agreement and is automatic for them, 457 MEA agreements were reviewed that have come into force and have at least nine years of membership data. Distinguishing 69 "global" MEAs (open to all UN members) from 388 MEAs limiting membership, reveals that, in their ninth year, global MEAs usually averaged less than thirty members until the 1980s, but have since averaged more than fifty. In comparison, MEAs limited to designated states, states in a specified area, or states with specified characteristics have never averaged more than 10 members (Figure 5).

Using these same MEAs to classify MEA memberships in the average state indicates that more IEAs are joining states. The approximately 140 UN members in the 1970s had ten MEA memberships; the total number of 180 or more UN members since the early 1990s has reached 50 memberships, with some approaching 100 and even new states having 10 to 20. The 10 states with the most MEA memberships are all European states in the high-income group of the World Bank, with each of the 457 MEAs assessed having joined 25%.[1] At least 15 % of these MEAs have entered another 28, including states from all continents and 9 that are not high in revenue. This geographic and economic diversity represents various pressure on states to join IEAs including domestic environmental issues, foreign political pressure, and financial opportunities included in some MEAs (MITCHELL 2020).

Researchers used data regarding IEADB membership to examine state behaviour. For example, ANDONOVA et al. (2017) consider that state IEA ratifications provide a specific proxy for cooperation on the environment that helps explain the form of transnational climate governance. Scholars have integrated IEA membership counts into an index of vulnerability-resilience (KOLCAVA et al. 2019) used to clarify mutual resource collaboration (KALBHENN 2011) and environmental resilience (ANGEON - BATES 2015). PRAKASH - POTOSKI (2014) use IEA membership as a measure of state stringency in environmental policy, finding that ISO-14000 laws only affect policy in states with few IEA membership. States, especially low-income states, tend to introduce new environmental regulations during periods when they join other IEAs (BRANDI

[1] These are Italy and Finland (116), Spain (118), Sweden and the United Kingdom (133), Belgium (134), Denmark and the Netherlands (144), Norway (153), and France (166).

et al., 2019), and the annual environmental reputation score of a state (the share of MEAs that it has joined) predicts better than its economic power if its trade agreements contain environmental provisions (MORIN et al. 2019).

The IEADB census particularly encourages work involving systematic collection and coding of IEAs. Green, alone and with Colgan, examined the delegation by drawing up stage 1 codes for the IEADB to differentiate between the policy roles that MEAs provide and the actors they delegate to (GREEN 2014, 61; GREEN-COLGAN 2013). States tend to delegate to public actors and to exchange delegations if they delegate to private actors, and delegations are better predicted by common preferences between states than by the number of MEA members or voting rules (GREEN 2014; GREEN-COLGAN 2013). Scholars also examined arguments concerning the effect of the problem structure on IEA architecture (KOREMENOS et al., 2001; MITCHELL, 2006). Coding nineteen IEA processes has shown that states prefer centralized, globalized, and structured IEAs when addressing environmental concerns in the manufacturing sector as opposed to problems in the agricultural or land use sectors (OVODENKO 2016; OVODENKO 2017). BALSIGER-PRYS (2016) found that the geographical characteristics of an issue affect how likely states are to negotiate IEAs and the institutional form and compulsory accuracy of IEAs, with countries strongly preferring regional over global cooperation (BALSIGER-PRYS 2016). SPILKER-KOUBI (2016) and MOHRENBERG et al. (2019) show that states take longer to ratify MEAs not only when domestic legislation needs a supermajority, but also when the MEA includes provisions relating to dispute resolution, supervision, compliance, objective objectives and financial mechanisms.

Comparing 67 MEAs to a set of non-environmental UN treaties, AXELROD (2011) considered the former to be more deferential to trade and other areas of international law. Analysing 300 IEAs chosen to include health-related provisions, MORIN et al. (2019); MORIN-BLOUIN 2019) revealed the significant, previously unrecognized contributions of IEAs to global health governance, and HENCKENS et al. (2018) found that the current MEAs provide clear normative foundations for negotiating a new treaty on sustainable mineral resource use.

The IEAs have helped reshape the content and mechanisms of global environmental governance, encouraging the participation of transnational and sub-national environmental actors and incorporating environmental concerns into trade agreements, development banks and other non-environmental institutions (ANDONOVA-MITCHELL 2010). BIGAGLI (2016) found that the heterogeneity of the IEA possibly impedes the development of a "adaptive, complex system approach" to ocean management. Others have shown that IEA fragmentation has deteriorated over time in ways that promote polycentric governance and adaptive potential (KIM 2013b, 2013c) and that, given the gaps, the IEA network could support strong global policies on emerging nitrogen and phosphorus pollution problems (AHLSTRÖM-CORNELL 2018).

3.12. From the ozone hole to the Montreal Agreement

Ultraviolet is a 10 nm wavelength electromagnetic radiation, shorter than that of visible light but longer than X-rays (Figure 6). UV radiation is found in sunlight, which reflects around 10 % of the Sun's overall electromagnetic radiation output. Electric arcs and specialized lights such as mercury-vapour lamps, tanning lamps, and black lights are also UV sources. While ultraviolet long-wavelength is not considered an ionizing radiation since it lacks the ability to ionize atoms in its photons, it can cause chemical reactions and cause several substances to glow or fluoresce. As a result, UV's chemical and biological effects are greater than simple heating effects, and many practical UV radiation applications are derived from its interactions with organic molecules. The

amount of UV light emitted by the Sun means that if much of that light were not filtered out by the atmosphere, the Earth would not be able to support life on dry land (NASA 2018). More intense, shorter-wavelength "extreme" UV below 121 nm ionizes air so strongly that it is absorbed before it reaches the ground (HAIGH 2007).

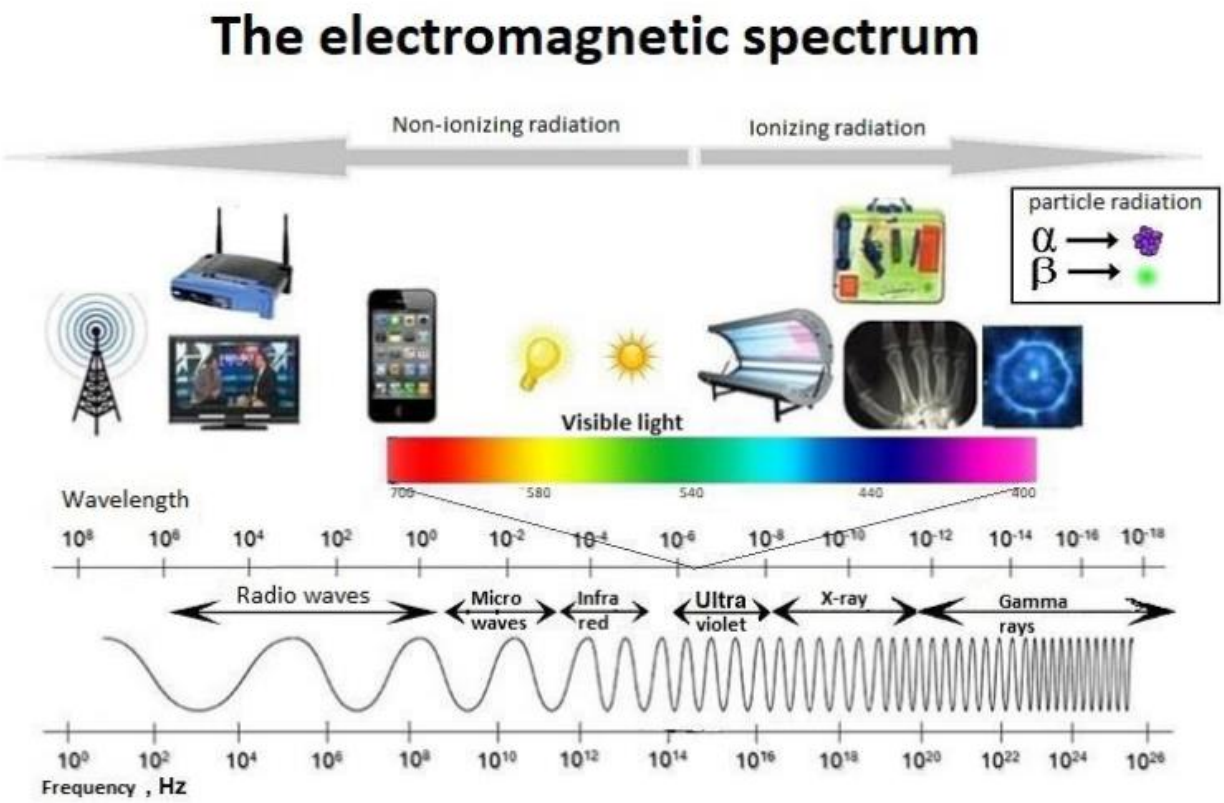

Figure 6: The electromagnetic spectrum
Source: uib.no

However, ultraviolet light (specifically, UVB) is also responsible for the formation of vitamin D in most land vertebrates, including humans. The UV spectrum thus has effects both beneficial and harmful to life. Ultraviolet light (specifically UVB) is also responsible for the production of vitamin D in most terrestrial vertebrates, including humans (WACKER-HOLICK 2013). Thus the UV spectrum has beneficial and life-threatening effects.

The electromagnetic spectrum (Figure 7) of ultraviolet radiation (UVR), defined most broadly as 10–400 nanometres, can be subdivided into a number of ranges recommended by the ISO standard ISO-21348(ISO 2013).

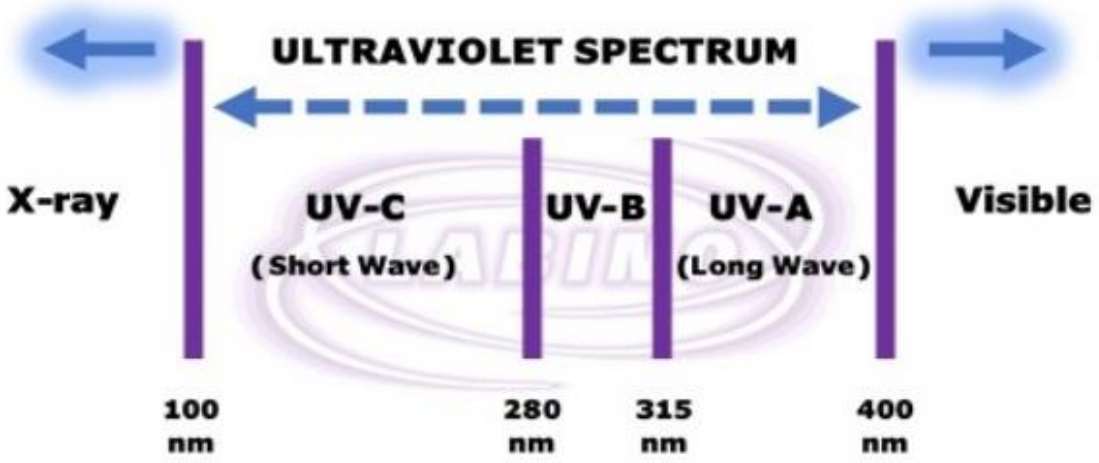

Figure 7: The UV spectrum
Source: labino.com

The Sun emits ultraviolet radiation at all wavelengths including the ultraviolet extreme where it passes at 10 nm into X-rays. Extremely hot stars emit more UV radiation than the Sun, in proportion. Sunlight in space at the top of the Earth's atmosphere consists of approximately 50 % infrared light, 40 % visible light, and 10 % ultraviolet light, for a total vacuum intensity of approximately 1400 W / m2 (QIANG 2003).

Once the Sun is highest in the sky, the atmosphere blocks about 77 % of the Sun's UV, with absorption increasing at shorter UV wavelengths. At ground level with the sun at zenith, sunlight is 44 % visible light, 3 % ultraviolet and the remaining infrared. Of the ultraviolet radiation entering the surface of the Earth, more than 95 % is the longer wavelengths of UVA, with the minimal remaining UVB. Essentially, there is no UVC. The amount of UVB that remains in UV radiation after passing through the atmosphere depends heavily on cloud cover and atmospheric conditions (NASA 2010). Patches of blue sky appearing between clouds in "partially cloudy" days are also sources of (scattered) UVA and UVB, created by Rayleigh scattering in the same way as the visible blue light from those parts of the sky. UVB also plays a major role in plant growth as it affects most plant hormones.[24] The amount of absorption due to clouds during total overcast is highly dependent on cloud thickness and latitude, with no direct measurements correlating actual thickness and UVB absorption(CALBÓ et al 2005).

The shorter UVC bands, as well as the more intense UV radiation generated by the Sun, are absorbed by oxygen and create the ozone in the ozone layer as single oxygen atoms formed by the dioxygen photolysis react more dioxygenically. Solar ultraviolet radiation is largely absorbed by the ozone in the atmosphere—especially the harmful, high-energy UVA and UVB. (Figure 8).

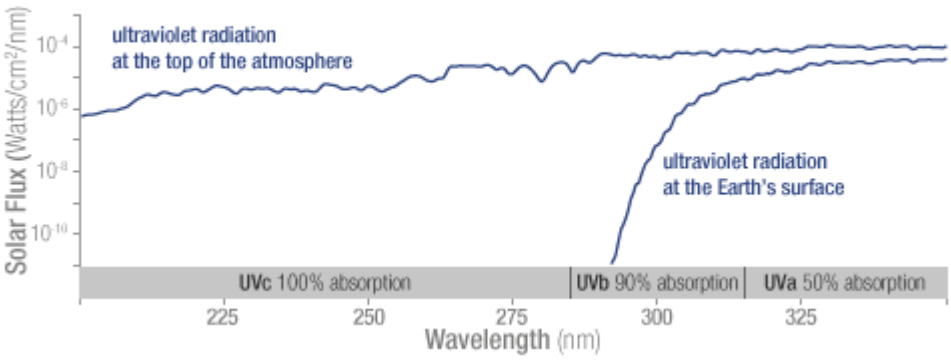

Figure 8: Solar flux
Source: NASA 2018

Ozone is a gas consisting of three atoms of oxygen (O3). This exists naturally in the upper atmosphere (the stratosphere), in small (trace) quantities. Ozone preserves life on Earth from ultraviolet (UV) radiation from the Sun. Throughout the lower atmosphere (the troposphere) near the surface of the Earth, ozone is produced by chemical reactions from vehicle exhaust, gasoline vapours, and other pollution of air pollutants. High concentrations of ozone at ground level are harmful to humans and plants (NASA 2018).

The ozone layer is vital to shielding the earth from ultraviolet radiation from the sun and is necessary to absorb ultraviolet B radiation, which could seriously affect all plant, human, and animal life in significant quantities (SOLOMON 2008). The ozone layer is particularly important in blocking most UVB and the remaining portion of UVC that is not already blocked by ordinary air oxygen. Both UVC is effectively blocked in the atmosphere by diatomic oxygen (100–200 nm), or by ozone (triatomic oxygen) (200–280 nm). Afterwards the ozone layer blocks much UVB. Meanwhile, ozone barely impacts UVA and much of it gets to the atmosphere. UVA constitutes nearly all the UV light that penetrates the Earth's atmosphere.90 % of the atmospheric ozone sits in the stratosphere, the atmospheric layer between about 10 and 50 kilometres altitude. The stratosphere's natural ozone level results from a balance between sunlight, which creates ozone and chemical reactions that destroy it. Ozone is formed when the form of oxygen that we breathe — O2—is broken into single oxygen atoms by sunlight. Single oxygen atoms may re-join to create O2, or they may re-join ozone (O3) molecules to form O2. Ozone is destroyed by reaction with oxygen, hydrogen, chlorine, or bromine-containing molecules. Some of the molecules that destroy ozone naturally exist while many have been produced by humans. The average ozone mass in the atmosphere is around 3 billion tons per metre. That may sound like a lot but it's just 0.00006 percent of the atmosphere. The highest ozone concentration occurs at an altitude of about 32 kilometres above Earth's surface. The concentration of ozone at that level can be as high as 15 parts per million (0.0015 per cent) (Figure 9).

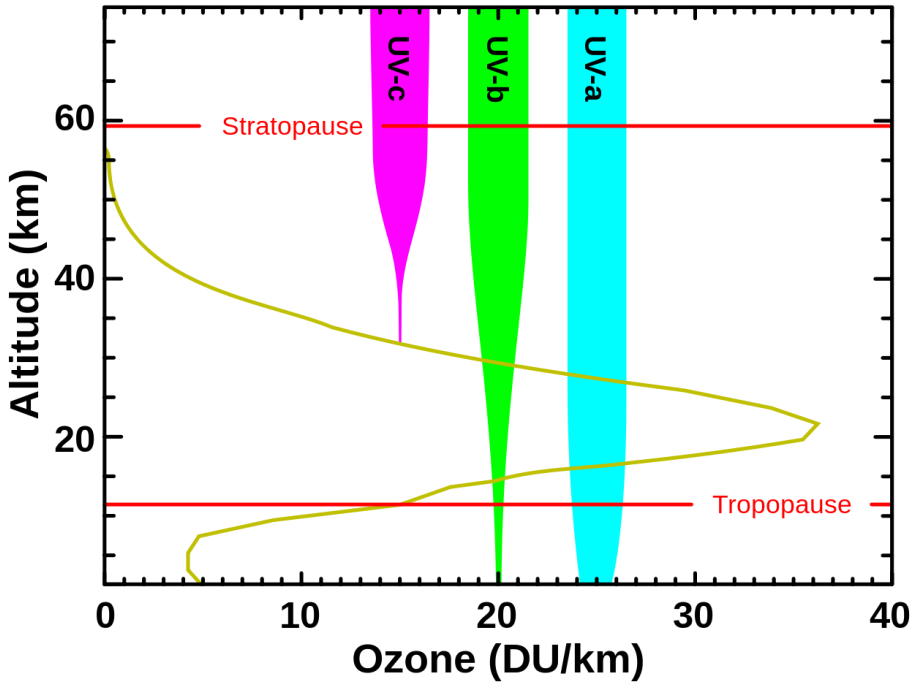

Figure 9: Ozone levels at different altitudes (DU / km)
Source: ozonewatch.gsfc.nasa.gov

Although stratosphere-high ozone provides a shield to protect Earth's life, direct contact with ozone is harmful to both plants and animals (including humans). Ground-level, "bad," ozone occurs when vehicle nitrogen oxide gases and industrial emissions react with volatile organic compounds (chemicals containing carbon that quickly evaporate into the air, such as paint thinners). The total concentration of ozone in the troposphere above the Earth's surface is around 10 parts per billion (0.000001 per cent). According to the Department for Environmental Protection, exposure to ozone levels above 70 parts per billion for 8 hours or longer is unhealthy (NASA 2018).

3.13. Effects of UV radiation on human health

Higher UV radiation exposure raises the prevalence of skin cancers and other human UV-induced diseases, such as cataracts and photo-sensitivity disorders. Increases in skin cancer over the last century tend to be primarily due to lifestyle changes that increase exposure to UV radiation. For many developing countries, skin cancer is the most common cancer with mainly light-skinned populations. Skin cancer in many of those countries is also the most expensive cancer. In 2012, approximately 168,000 new melanomas were reported to be attributable to 'excess' exposure to UV radiation (above that of a typical population with reduced exposure) due to demographic shifts in lifestyle, from sun avoidance to sun-seeking behaviour (ARNOLD et al. 2018). Exposure to UV radiation leads to cataract formation, the leading cause of vision loss worldwide (12.6 million blind and 52.6 million visually impaired by cataract in 2015). (FLAXMAN et al. 2020). Concern over high levels of UV-B radiation due to the loss of stratospheric ozone has been an important catalyst in many countries for the implementation of sun protection programmes. These programs focus on facilitating behavioural improvements in individuals, accompanied by systemic and policy-level interventions (SANDHU et al.) Sun protection programs have been shown to be extremely cost-effective in the prevention of skin cancer (GORDON-ROWELL 2015).

UV radiation induces photochemical reactions of many released chemical compounds, producing secondary contaminants including ozone at ground level and certain forms of particulate contaminants. Future recovery of stratospheric ozone and climate will alter ozone at ground level through reductions in UV radiation and rises in stratospheric ozone downward transport, with potential implications for human health and the environment.

3.14. Effects of UV radiation on air quality

Modelling experiments suggest that decreases in UV radiation due to recovery of stratospheric ozone in some metropolitan areas would result in reduced ground-level ozone but minor increases elsewhere (HODZIC–MADRONICH 2018). Changes in UV radiation and atmosphere can have major effects on human health by affecting air quality. A number of recent international reports have found that poor air quality is a significant global health problem and is estimated to be the primary cause of death worldwide due to an environmental factor; for example, fine particulate matter pollution (FP2.5) caused 4.2 million deaths in 2015.(COHEN et al.2017). Since large populations are already impacted by poor air quality, even minor relative increases in UV radiation may have major public health implications.

3.15. Effects of UV radiation on agriculture and food production

There is no evidence that small rises in solar UV radiation have any major negative effects on crop yield and productivity of plants. According to BALLARÉ et al (2011) a 20% rise in UV radiation equal to a 10% reduction in stratospheric ozone would reduce plant production by only about 6% (i.e., a 1% decrease in growth for every 3% rise in UV radiation)

It is now clear that ozone depletion in the southern hemisphere is altering regional air circulation patterns in this part of the globe (WMO 2018), which in turn affect weather, sea surface temperatures, ocean currents, and wildfire frequency (CLEM-MCGREGOR 2017; HOLZ et al. 2017; KOSTOV et al.2017;LIM et al.2017;OLIVEIRA-AMBRIZZI 2017). At a regional scale, increases in rainfall in the southern hemisphere, led by stratospheric ozone depletion and climate change, have been linked to increases in South America's agricultural productivity; however, these beneficial effects may reverse as the stratospheric ozone 'hole' recovers. Significant, albeit smaller, effects of stratospheric ozone depletion on climate can occur in the northern hemisphere, but there are no studies yet that relate these changes to environmental effects.

Factors of climate change, including drought, high temperatures and increasing levels of carbon dioxide can alter how UV radiation affects crop plants, but results are complicated and often dependent on growth conditions. In certain cases, these factors may increase exposure to UV radiation (e.g., elevated carbon dioxide may weaken UV radiation defences in maize. (WIJEWARDANA et al 2016).

In other cases, exposure to UV radiation may alter the effects of climate change, such as increasing crop plant tolerances to drought (ROBSON et al 2015). Reduced UV radiation resulting from recovery of stratospheric ozone may lead to increased ozone levels in rural areas that could negatively affect crop yields. Understanding these and other encounters with UV-climate change will inform growers and breeders about appropriate farming practices to sustain crop yields in the face of evolving environmental changes

UV radiation can also have beneficial effects on plants and these effects are often mediated by different photoreceptors that control plant growth and development (JENKINS 2014). Such non-damaging effects include changes in plant chemistry that result in improvements in food nutritional quality (SUKLJE 2014) and plant resistance to pests and pathogens (ESCOBAR et al 2017). Consequently, decreases in exposure to UV radiation as a result of changes in stratospheric ozone and climate or changing agricultural practices, can reduce plant defences and thereby affect food security in ways other than just the direct effects on yield (BALLARÉ et al. 2001).For certain vegetable crops, UV radiation is increasingly being used to manipulate plant hardiness, food quality and pest resistance (WARGENT 2001).

3.16. Effects of UV radiation on water quality and fisheries

Changes in exposure to UV radiation and mixing depths change the basic structure of aquatic environments and subsequently their ecosystem services (e.g., water quality, fishery productivity) in a regionally specific way. The larvae of many commercially significant species of fish are clear-bodied and sensitive to UV-induced damage. Combined with the distribution of these larvae in surface waters with high exposure to UV radiation, this susceptibility has the potential to minimize first-year fish survival and subsequent fish harvest potential (HUFF-WILLIAMSON 2004). By contrast, reductions in the t transparency of clear-water lakes to UV radiation may increase the potential for invasions of UV-sensitive warm-water species that may adversely affect native species (TUCKER-WILLIAMSON 2014).

Climate change related precipitation and melting of glaciers and permafrost are increasing the concentration and colour of UV-absorbing dissolved organic matter and particulates. This is contributing to the “browning” of many inland and coastal waters, with consequent loss of the valuable ecosystem service in which solar UV radiation disinfects surface waters of parasites and pathogens (WILLIAMSON et al 2017). Regional-specific changes in the frequency and length of droughts have the opposite effect, enhancing the visibility of the water and improving solar disinfection, as well as altering the depth distribution of plankton that provides essential fish food supplies. (URMY et al. 2016; WILLIAMSON et al 2016).

3.17. Effects of UV radiation on biogeochemical cycles, climate system feedbacks

Alterations in stratospheric ozone and climate affect biogeochemical cycles driven by sunlight and, in turn, greenhouse gases and water quality. Exposure to solar UV and visible radiation may accelerate the decomposition of natural organic matter and the transformation of contaminants (AUSTIN-BALLARÉ 2016; CORY et al 2014). Increases in droughts, wildfires and thawing of climate-driven permafrost soils have the potential to increase photo degradation, thereby fostering a positive impact on global warming. Aquatic and terrestrial organism organisms vary in their susceptibility to UV radiation, and these variations can lead to changes in the composition and distribution of ecological populations under elevated UV radiation conditions. UV radiation also changes herbivorous and predator-prey relationships, which then alter ecosystem trophic relationships, energy flow and food webs (LINDHOLM et al. 2016).

Currently, ozone-driven changes in regional climate in the southern hemisphere (ARBLASTER et al 2011; CLEM et al. 2017; HOLZ et al 2017; KOSTOV et al 2017;LANGEM?ATZ et al. 2018; LIM et al 2016; OLIVEIRA-AMBRIZZI 2017; ROBINSON-ERICKSON 2015) endanger the habitat and survival of a number of species that develop in the rare high-altitude forests of the South American Altiplano (CUYKENS et al 2016), as well as in Antarctica's mosses and other

plant communities (ROBINSON et al. 2018) but increase the reproductive success of certain marine birds and mammals.

3.18. Effects of UV radiation on contaminants and materials

The proliferation of contaminant releases into the atmosphere coupled with changes in climate and stratospheric ozone have an impact on human health and on terrestrial and aquatic ecosystems.
UV radiation is one of the main factors affecting contaminant biogeochemical cycling and its degradation by direct and indirect photo-reactions. However, climate change effects, such as heavy precipitation events or droughts, can have significant impacts on contaminant photo degradation by reducing or increasing their exposure to solar UV radiation. In addition, increased or decreased runoff of coloured organic matter influences the equilibrium between direct and indirect photoreactions in aquatic environments. Such climate change impacts depend on local factors and pose challenges for predicting and mitigating contaminant impacts on human health and the environment. UV-B radiation exposure plays a key role in altering contaminant toxicity. Exposure to Ultraviolet radiation increases contaminant toxicity for marine species such as fish and amphibians, such as pesticides and polycyclic aromatic hydrocarbons (PAHs). Conversely, exposure to UV-B radiation converts the most toxic form of methylmercury into less harmful forms, reducing mercury accumulation in fish. But possible long-term rises in dissolved organic matter in some areas, such as southern Norway, may decrease underwater exposure to UV radiation in inland waters. This may then lead to the already reported increases in methylmercury in fish which are likely to occur as a result of decreased clarity of water to UV radiation (POSTE et al 2015). Solar radiation also plays a significant role in many organic contaminants and waterborne pathogen degradation. Changes in stratospheric ozone can affect this cycle of photo degradation by solar UV radiation, but other factors such as dissolved organic matter are more important in regulating UV radiation underwater, and thus have a greater impact on photo degradation. Advances in modelling methods allow better quantification of the effects of global changes on aquatic pollutant fate.

Sunscreens are in common use as part of the collection of solutions to human sun protection, particularly in cosmetics. Nevertheless, sunscreens are now known as flowing into coastal waters, with possible effects on marine environments. The toxicity of artificial sunscreens to corals sea urchins, fish, and other aquatic species has led the state of Hawaii, USA, to enact legislation banning the use of such sunscreens, and the European Union to propose similar legislation (TSUI et al. 2017; CORINALDESI et al. 2017; FONG et al. 2016; WILLENBRINK et al. 2017).

Microplastics (plastic particles < 5 mm) are now omnipresent in the oceans of the world and pose an increasingly severe threat to aquatic environments with many species now known to consume them (CLARK et al 2016). Microplastics are created by UV-induced degradation and breakdown of plastic products and sunlight-exposed waste. Microplastic contaminants exist in up to 20 % or more of the fish globally sold for human consumption) UNEP 2016) While the toxicity of microplastics and smaller nanoplastics is uncertain, higher temperatures and levels of UV radiation increase plastic breakdown, potentially threatening food health.

Solar UV radiation exposure affects the functional integrity and shortens the service life of organic materials used in building, such as regularly exposed plastics and wood, e.g. in roofing and pipelines. Until quite recently, the selection and optimisation of plastics used in packaging and construction was based on toughness and efficiency. However, the growing emphasis on increased sustainability, such as the 'green buildings' movement, now demands that these choices are also environmentally appropriate. This includes increased usage, where possible, of wood, which is

green, carbon neutral and low in embodied energy in place of plastics. Many of those products are vulnerable to accelerated ageing under UV radiation treatment. Present initiatives are going forward to find and create new, safer, more durable and 'greener' additives for plastic materials and wood coatings (colourings, plasticisers, and stabilizers). Harsher weathering conditions, as expected as a result of climate change, will require even greater efforts along this path.

3.19. Exposure to UV radiation and effects of climate change on exposure

Future variations in solar surface UV radiation of all wavelengths may depend on variations in clouds, aerosols, and surface reflectivity. Climate change is shifting the cover of the atmosphere, with some areas being more cloudy and others less cloudy (STOCKER 2013).Improved cloud coverage typically helps to minimize UV radiation on the surface of the Earth. Aerosols suspended in the atmosphere decrease and disperse UV radiation. The type and quantities of atmospheric aerosols are influenced by air pollutant pollution, volcanic activity, as well as the frequency and severity of wildfires and dust storms, and many other factors that are affected by climate change (BAIS et al. 2019; SULZBERGER et al. 2019; WILLIAMSON et al.2016). In heavily polluted areas, expected improvements in air quality are predicted to result in levels of UV radiation increasing towards pre-industrial levels, with the extent of changes contingent on curtailing the emissions of air pollutants.

High surface reflectance from snow or ice cover may increase incident UV radiation as some of the reflected UV radiation is transmitted back to the surface by air molecules, aerosols and clouds in the atmosphere (KAUKO 2017). Climate change-driven decreases in ice or snow cover in polar regions and mountains, however, reduce the reflection of UV radiation from the surface of the Earth and thus may result in a reduction in the UV radiation.

The effect of radiation from UV on organisms (including humans), natural organic matter, pollutants, and materials depends on their radiation exposure (Figure 10). This is influenced by a variety of factors, including the impact of global climate change, besides stratospheric ozone depletion (BAIS et al. 2019; SULZBERGER et al. 2019; WILLIAMSON et al. 2014). Like the loss of stratospheric ozone, these climate-change-driven impacts alter exposure not only to UV-B radiation but also to the ultraviolet A and visible portions of the solar spectrum. Such improvements are significant, as many of the environmental and health effects of UV-B radiation exposure are often affected by UVA and visible radiation to varying degrees.

Behaviour is an important control of UV radiation exposure for human health. Individuals' sensitivity to UV radiation ranges from one-tenth to ten times the population average, (GIES et al 1999) depending on how long people spend indoors vs. outdoors, and under shade structures. Sun or eyes sensitivity also depends on using sun protection such as sunglasses or clothing. Warming temperatures and changing precipitation as a result of climate change will alter human attitudes in relation to sun exposure, (XIANG et al.2015) but the degree and extent of impact is likely to vary widely across the globe.

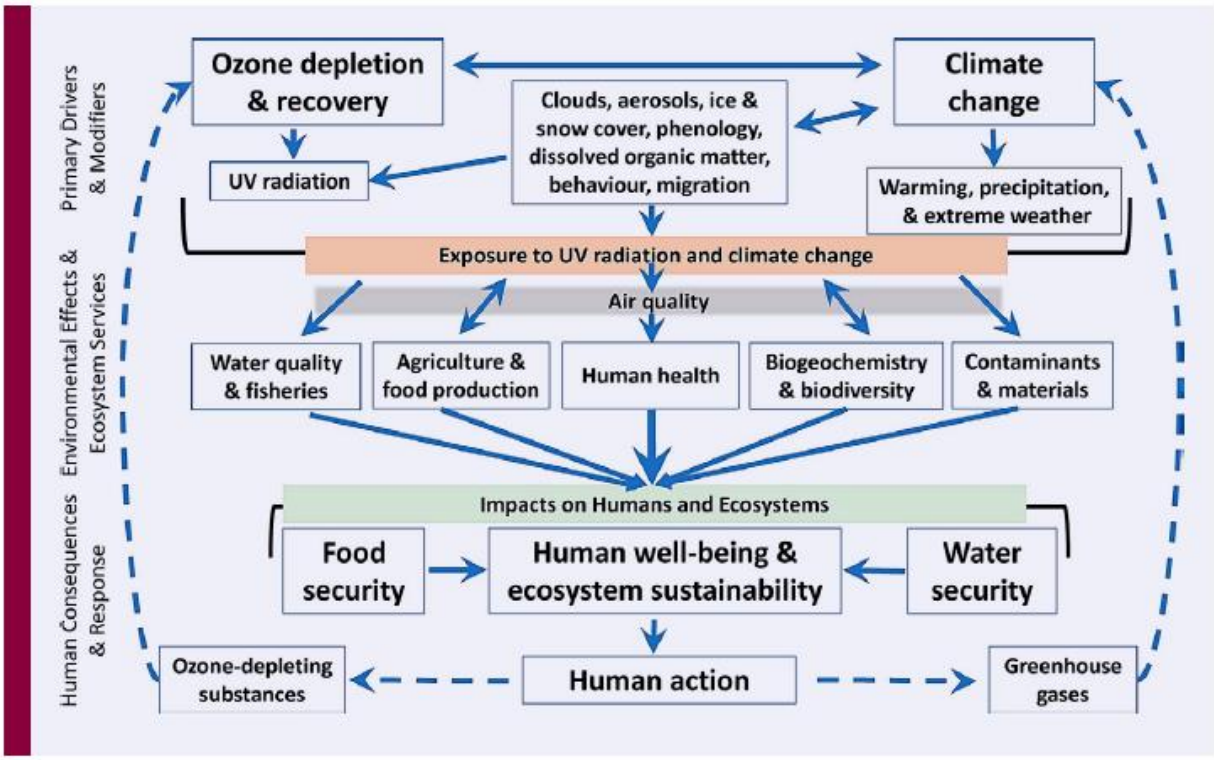

Figure 10: Linkages between stratospheric ozone depletion, UV radiation, and climate change
Source: EEAP (2019)

Vegetation cover reduces the amount of sunlight entering many terrestrial species, and shading affects the sensitivity of building materials to UV radiation. Modifications of the cover, for example as a result of drought, fire and pest-induced die-back of forest canopies triggered by climate change, would have significant effects on the exposure of terrestrial species to UV radiation (PREDICK et al. 2018). However, changes in the seasonal timing of essential life cycle events such as plant flowering, spring bud bursting in trees, and animal emergence and breeding will change exposure to UV radiation as UV radiation naturally varies with season (COHEN et al. 2018; FIELD et al. 2014; TOMOTANI et al.2017).

As plants and animals migrate upward, (FIELD et al.2014) into higher elevations, (STEIBAUER et al. 2018) or deeper into lakes, and as a response to climate change, (URMY et al.) oceans are subjected to UV radiation levels that may vary from those to which they are accustomed. In addition, decreases in ice or snow cover in polar regions as a result of global warming will increase soil and aquatic ecosystem exposure to UV radiation that would have previously been below snow or ice.(KAUKO et al.).

The penetration of UV radiation into aquatic ecosystems depends on the transparency of water, the amount of dissolved organic matter, and ice cover. Increases in extreme weather events that increase the input of dissolved organic matter and sediments into coastal and inland waters can reduce water clarity, reducing exposure of aquatic ecosystems to UV radiation WILLIAMSON et al 2016; WILLIAMSON et al 2017). Reductions in snow and ice cover thickness and length, and global changes in depth of colder, surface mixed layers of lakes and oceans, alter rates of exposure of aquatic species to UV radiation. Climate change was historically predicted to increase exposure to UV radiation by creating shallower mixed layers, but recent data indicate deeper mixed layers in some regions in lakes and oceans and shallower mixed layers in others.

These climate-change-driven effects can result in either increases or decreases in solar UV radiation exposure, depending on place, time of year, individual organisms, and other factors. Changes in exposure and susceptibility to solar UV radiation, caused by ongoing changes in stratospheric ozone and climate, have the potential to impact humans, life on Earth and the environment, including materials used for infrastructure and other uses, with implications for people's health and well-being and protection of the ecosystems.

3.20. On the way to Montreal Protocol

Discoveries and discoveries trickled throughout the 20th century that would allow scientists to understand how human-made chemicals such as chlorofluorocarbons each spring produce a hole in the ozone layer above Antarctica.

Antarctic explorers reported observations of peculiar veil-type clouds in the polar stratosphere as early as 1912, although they could not have realized how important those clouds would become at the time. In 1956, in preparation for the 1957 International Geophysical Year the British Antarctic Survey established the Halley Bay Observatory on Antarctica. Measurements of the ozone using a Dobson spectrophotometer started that year. Such measurements provided the initial hints that the ozone layer was having trouble (NASA 2018).

Instruments on the field (at Halley) and far above Antarctica (Complete Ozone Mapping Spectrometer [TOMS] and Ozone Monitoring Instrument [OMI]) measured an extreme decrease in overall atmospheric ozone (Figure 11).

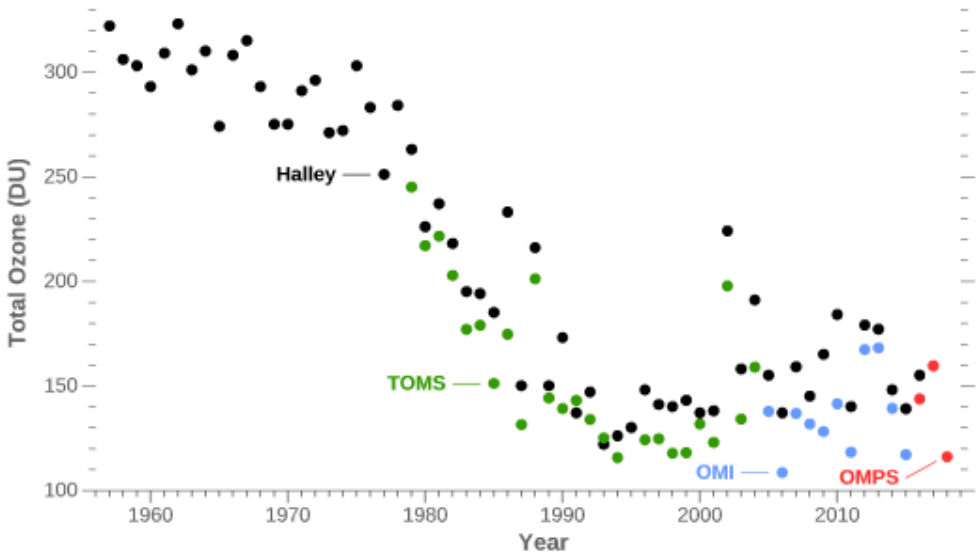

Figure 11: Amount of atmospheric ozone
Source: ozonewatch.gsfc.nasa.gov

Concerns about the possible destruction of the ozone layer by human activities were first raised about supersonic transport in the early 1970s. While initial scientific research on stratospheric chlorine did not draw conclusive conclusions in Europe and the United States, they gained public interest, and a political debate on ozone erupted. One of the problems and contradictions between actors was that there was a need for scientific evidence to justify policy action to protect the ozone layer (PARSON 2003).

In the years that followed, focus moved from supersonic transport to the position of CFCs and their possible adverse effect on the ozone layer. Early research, such as MOLINA and ROWLAND's (1974) discovery of the impact of ozone depleting substance (ODS) on the ozone layer, showed that ozone in the stratosphere was negatively affected by CFCs, but still did not quantify or predict the ozone loss. Representatives of the aerosol and halocarbon industries had strongly questioned the Rowland-Molina hypothesis (COMPTON-HART 2019).

Nevertheless, much of Rowland and Molina's basic observations were confirmed by laboratory measurements and direct observation in the stratosphere within three years. The concentrations of the source gases (CFCs and related compounds) and the chlorine reservoir species (HCl and ClONO2) were measured in the stratosphere and showed that CFCs were indeed the main source of stratospheric chlorine, and that almost all of the CFCs released would eventually enter the stratosphere (NORMAN J 2020).

This work prompted a rapid increase in scientific interest and sparked policy responses in Canada, the European Economic Community, Sweden and the United States to regulate the use of CFCs, especially in aerosols (ANDERSEN-SARMA 2002; PARSON-2003).

Scientific awareness can be an essential factor in educating policy-makers about the nature of an emerging issue and adding the necessary energy to solve issues of collective action (EPSTEIN et al. 2014). Nonetheless, users of a shared pool resource will always resist control and propose conflicting interpretations of unknown information before a clear scientific consensus is reached (STERN 2011). It was definitely the case in the ozone-protection debate and made it exceedingly difficult to create international controls. The difference in scientific estimates about potential depletion has prompted many countries to resist the need for an international policy to control the use of ODS. For example, the United Kingdom was doubtful as to whether regulation would be necessary as ozone layer depletion estimates had been reduced between 1978 and 1982. In addition, Japan rejected repeatedly any plan to protect the ozone layer before more scientific evidence was gathered (ANDERSEN-SARMA 2002).

Scientists wanted accurate information about the concentrations and accumulation levels of CFCs in the global atmosphere. Many nations, especially Australia, the United Kingdom and the United States, responded to this challenge quite quickly. In a range of strategic, clean-air locations around the world, they developed CFC monitoring facilities, partly funded by the global CFC industry. By the early 1980s, the atmospheric evidence, combined with industry estimates of global output and emissions of CFCs, showed that CFCs were long-lived, in the atmosphere for over 50 years. This long life meant that they could enter the stratosphere where they broke down, releasing reactive chlorine species which destroyed ozone catalytically. Scientists also discovered that CFCs were not the only essential substances released into the environment that depleted ozone (ODS). The carbon tetrachloride chlorinated solvents, and former methyl chloroform dry-cleaning agents, have been reported as major ODS. There were the halons – bromine containing chemicals for firefighting – and methyl bromide, an industrial and structural fumigant. The latter chemicals have been described as especially potent ODS because they contain bromine, which is much more harmful than chlorine in stratospheric ozone. To rapidly phase out CFCs, the industry developed the already existing HCFCs as interim replacement refrigerants and foaming agents. Hydrocarbons were developed as long-term replacements for CFCs in aerosol propellants. HCFCs were themselves ODSs, but because of their relatively short atmospheric lifetimes they were significantly less potent than the CFCs they replaced (FRASER-KRUMMEL 2012).

A breakthrough in public debate and discussions was achieved when work presented additional hard evidence that loss of ozone posed a danger to the atmosphere and to public health. The experimental discovery of the so-called 'ozone hole' in 1985 found that the loss of ozone was

substantially greater than could be accounted for with existing scientific models (FARMAN et al. 1985; SOLOMON et al. 1986). This discovery served as a dramatic focusing event, and the resulting increase in global public attention to the ozone depletion issue generated a sense of urgency about the need for a robust global policy solution.

Through scientific evidence and the discovery of the 'ozone hole' have created an international public debate on the matter and how to fix it. Researchers had already shown in the late 1970s that a 1% reduction in ozone would eventually lead to a 4% rise in the incidence of skin cancer (ANDERSEN-SARMA 2002). The relation between a weakened ozone layer and increased risk of skin cancer, together with the discovery of a hole in the ozone layer, ignited international debate. The loss of ozone was presented as a public health problem (ARMSTRONG 1994; MARTENS 1998). Fears of a drastic rise in the occurrence of melanomas and glaucoma associated with increased exposure to solar radiation as a result of ozone layer thinning was a significant factor generating public support for an agreement to protect and restore the ozone layer. In the end, the weakened ozone layer became a 'hot issue' in the media and in the general public (UNGAR 1998).

Sweden, Finland, and Norway played a leading role in the early talks and in 1983 drafted the Nordic Proposal to ban the use of all CFCs in non-essential aerosols. The first proposal was the draft that would be incorporated into the Montreal Protocol over the next four years. The plan met with both support (Denmark, the U.S., and Australia) and resistance (Japan and the U.K.). The Vienna Convention, the first international agreement on the protection of the ozone layer, was signed by 20 countries and the EEC in 1985. However, the framework did not place any reduction responsibilities on the parties and rather served the purpose of providing ozone layer monitoring and data exchange (SKJAERSETH 1992). The Convention set out potential efforts to be pursued by the Convention members, which consisted of collaboration to implement legislative and administrative steps for the preservation and healing of the ozone layer (ANDERSEN-SARMA 2002).

Figure 12 shows the progression of global parties that have signed on to the Vienna Convention. There were only 29 parties registered to the agreement in its first year (1988). This growing rapidly in subsequent years, reaching 174 parties by 2000. In 2009 the Vienna Convention was the first to achieve universal ratification of any Convention.

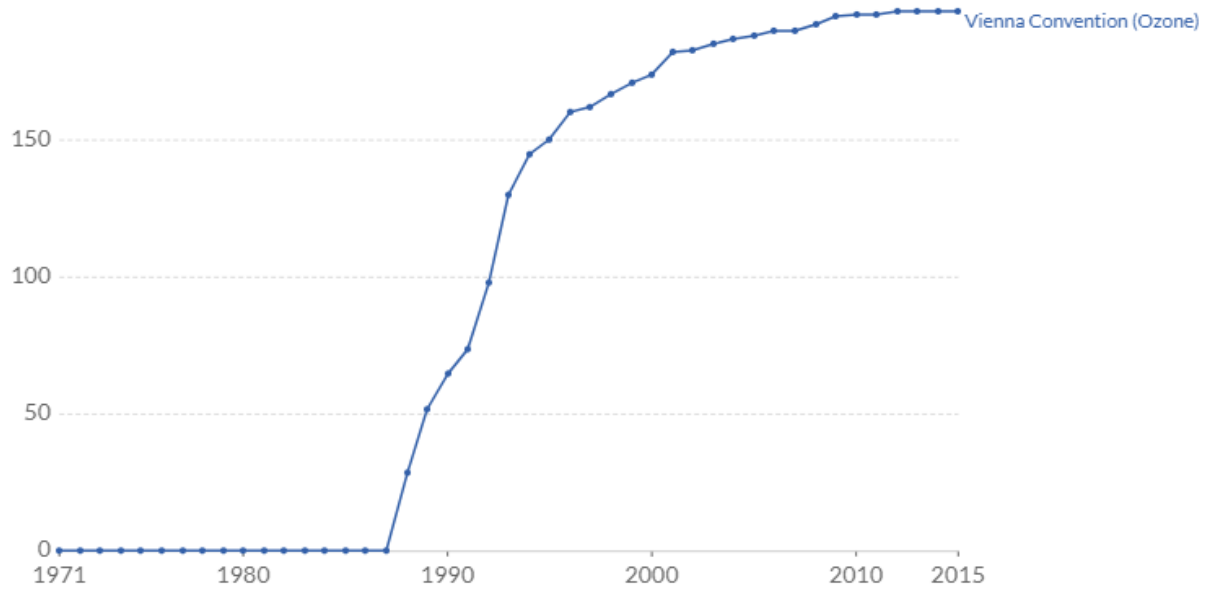

Figure 12: The number of parties of Vienna Convention
Source: UNCTAD 2020

Despite not having required the parties to take substantive measures on the security of ozone, the Vienna Convention laid the groundwork for implementing The Montreal Protocol.

The negotiations reached a breakthrough in 1987. Over time, the emerging interpersonal respect and confidence between members also encouraged negotiations (ANDERSEN-SARMA, 2002). More than fifty countries, multiple industry organizations, environmental NGOs, the UN, and a host of other actors participated in the final, intense negotiations in 1987 that concluded with an agreement.

The Montreal Protocol aimed to achieve a 50 % reduction in both output and consumption of the ODSs. This target was upgraded in 1990 to achieve a complete phase-out of these ODSs by the year 2000. In addition, the protocol gave developing countries special conditions so as not to hinder progress in their growth. Repeated international agreements, consultations on different draft proposals, and compromises in the final agreement to meet individual countries' unique needs and desires can be viewed as a effective diplomatic mechanism (ANDERSEN-SARMA 2002). One year after the entry into force of the protocol in 1990, fifty-eight parties had signed it, which accounted for 90 % of global CFC and halon production and consumption. Over time, new countries have joined, and the Montreal Protocol has at present achieved universal adoption by 197 parties. One critical feature of the Montreal Protocol was its effectiveness in resolving the issues of collective action. Widespread involvement was essential, as no major consumers or producers of ODSs could remain outside the agreement if the agreement was to work. The treaty contained trade provisions to avoid the transfer of production facilities to countries that did not join the agreement, and to create an opportunity to participate. Those regulations restricted trade with non-parties in CFCs and ODSs (WETTESTAD 2002).

Ozone-depleting substances can be emitted from natural and anthropogenic (man-made) sources. From 1960 on we see emissions of ozone-depleting substances in Figure 13. The chart shows the level of natural emissions (which over this period was approximately consistent), and total emissions, which is the sum of natural and man-made emissions. Here we see a clear growth-peak-reduction trend in ozone-depleting emissions, with a rapid (greater than threefold) increase in

emissions from 1960 to the late 1980s, followed by a similarly rapid decrease in the decades that followed. Emissions had returned to their 1960 rate by 2010.

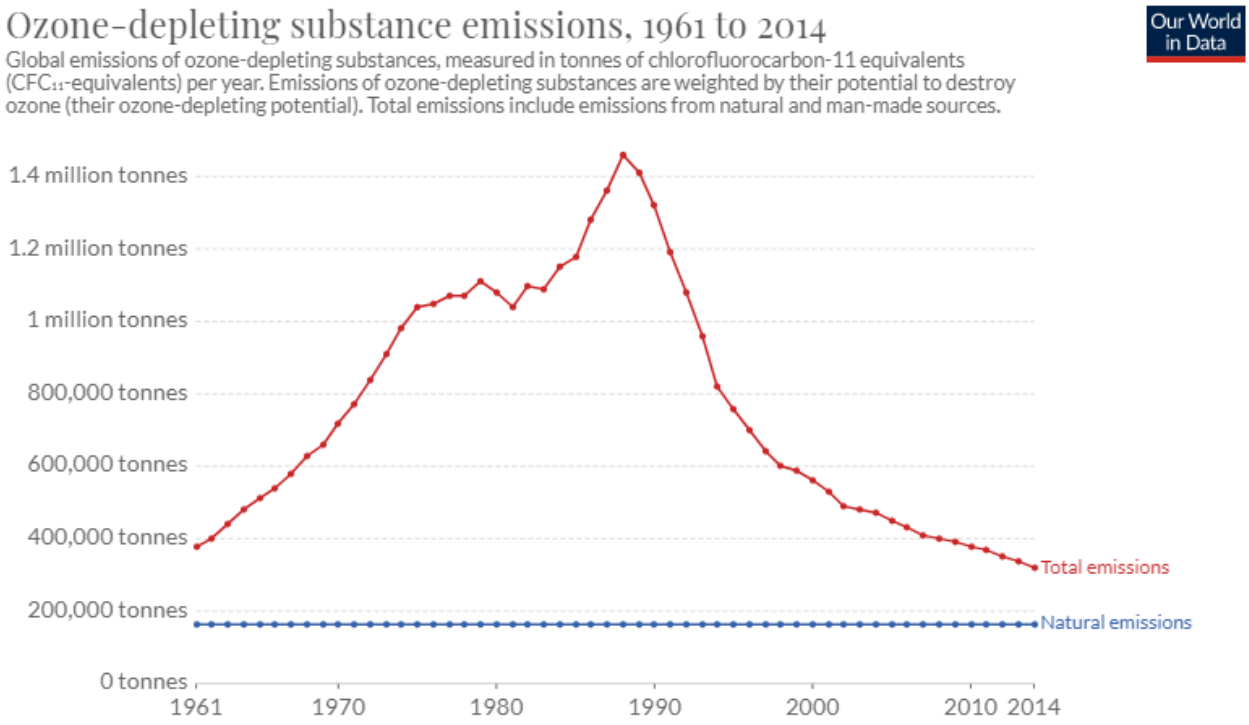

Figure 13: ODS emissions 1961-2014
Source: Ritchie-Roser (2020)

Ozone-depleting substances production / consumption refers to the primary production of new materials or goods containing some of the halogen gasses noted as ODS. The important aspect to note here relates to the manufacture or release of new / recent substances. Figure 14 shows the extent of global decrease in ODS use since 1986. This data tests ODS 'indexed consumption to the 1986. We can see a rapid consumption of global pollution after a 28 % increase in 1987. By 1995, consumption decreased by over 60 %; by 2000, 80 %; and by 2016, by 98-99 %.

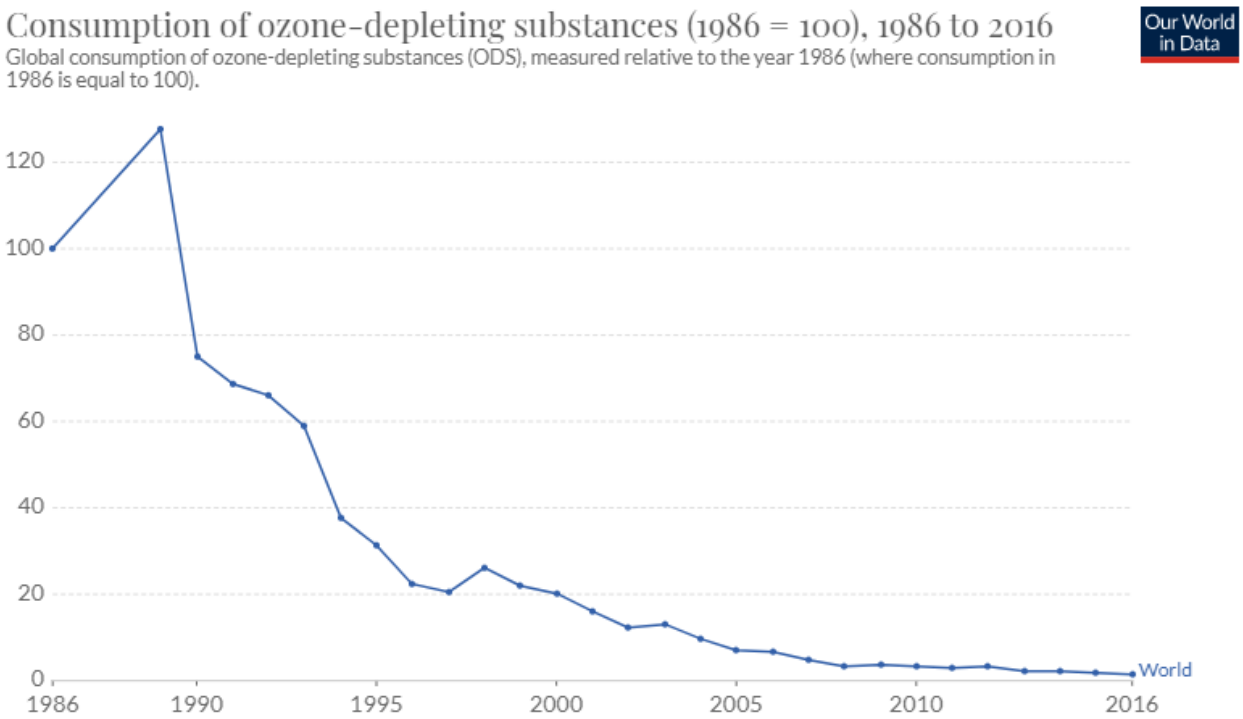

Figure 14: ODS consumption 1986-2016
Source: Ritchie-Roser (2020)

The quantity of ODS consumption per country is shown in Figure 15. This is expressed in tonnes of all weighted ozone-depleting compounds compared to their depleting potential.

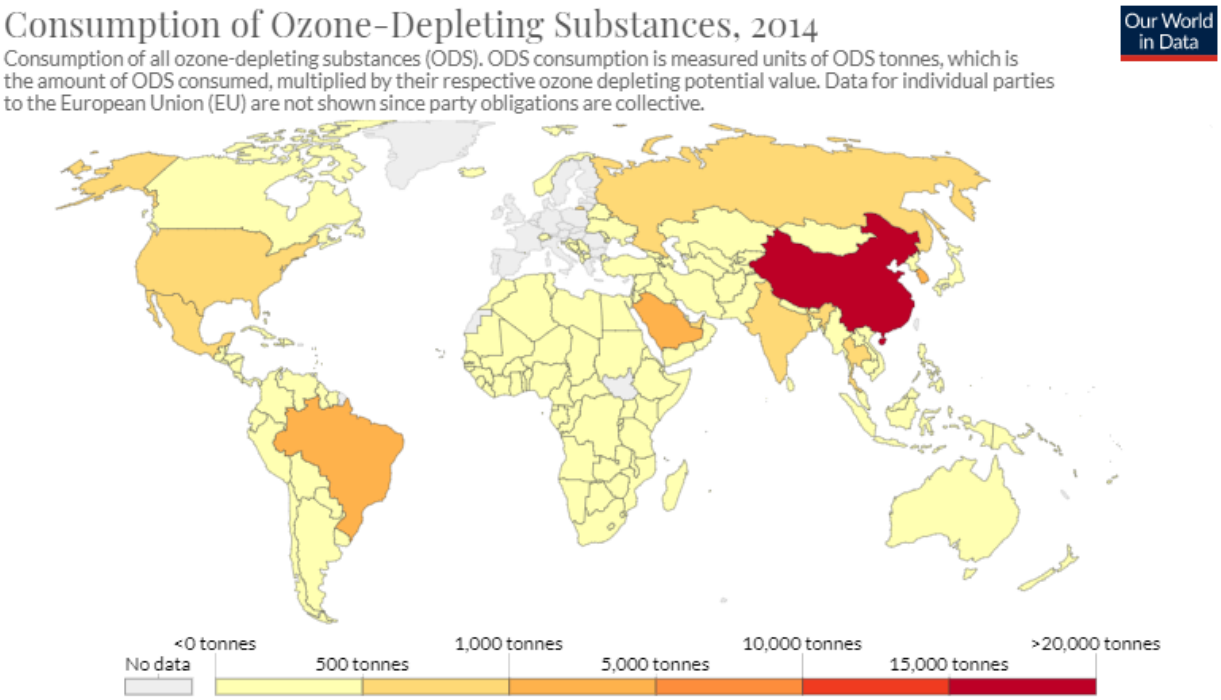

Figure 15: ODS consumption 1986-2016
Source: Ritchie-Roser (2020)

3.21. The environmental effects of replacements for ozone depleting substances

One of the advantages of chlorofluorocarbons (CFCs) was that in the lower atmosphere, they were inert and had no direct impact on air quality. Their replacements were specifically chosen to be less stable, and since these compounds are directly relevant to the implementation of the Montreal Protocol, it is necessary to consider their impact on air and environmental quality. Such substitutes rely on refrigeration and include hydrofluorocarbons (HFCs) and hydrofluoroolephins (HFOs), hydrocarbons, and ammonia.

Trifluoracetic acid (TFA) is a persistent substance that is formed in the atmosphere from several HCFCs, HFCs, and HFOs. There are also many other sources of TFA in the environment, but since they are unregulated, there are virtually no data on global production and release to the environment (SCHEURER 2017 HFCs degrade slowly in the atmosphere (1–100 years) and so become globally distributed. By contrast, HFO-1234yf degrades to TFA rapidly (days – weeks). This will result in a breakdown nearer to the regions where HFO-1234yf is released. This potential results in localized, higher TFA concentrations in surface waters than in HFCs (KAZIL et al. 2014; LUECKEN et al. 2010; WANG 2018 et al,) However, there is no evidence to date to indicate that these local TFA deposits may result in environmental risks, particularly when subsequent ocean dilution occurs.

The release of hydrocarbons (such as propane and n-butane) used as substitutes for ODS would add to the pressure of atmospheric hydrocarbons, and possibly increase ground-level ozone concentration.

Ammonia in the atmosphere responds to the aerosol output with many compounds and therefore increases particulate air pollutant concentrations. However, complete removal of existing ammonia emissions from CFCs, HCFCs and HFCs is low compared to estimated annual ammonia emissions from agriculture or from industrial and residential activities (MENG et al. 2017).

The above patterns in consumption were aggregated to total ODS consumption. That quantifies a number of substances in aggregate. In Figure 16 we can see the breakdown of substance consumption.

The above patterns in consumption were aggregated to total ODS consumption. That quantifies a number of substances in aggregate. In the diagram we see the breakdown of substance consumption. At global level, since 1989, we can see the pattern of rising consumption — as described above. It's also interesting, though, to note the relative decrease and increase in the amount of individual substances. Chlorofluorocarbons (CFCs) dominated global consumption in the 1990s and first half of the 2000s (counting for 60 %, down to 50 %). However, we have seen a growing prevalence of hydrochlorofluorocarbons (HCFCs) in the 2000s; in 2014, HCFCs accounted for 94 % of global consumption.

This transition represents the replacement of CFCs with HCFCs to reduce the overall ozone depletion. Comparing the ozone-depleting potential (ODP) of CFCs and HCFCs, we see that one ton of HCFCs' depleting potential is 10 to 100 times less than that of one ton of CFCs. Therefore this replacement was an significant reduction strategy (especially where complete phase-out of ozone depleting substances was not readily available). Chlorofluorocarbons (CFCs) were almost phased out, decreasing from more than 800,000 tons in 1989 to 156 tons in 2014 (RITCHIE-ROSER 2020).

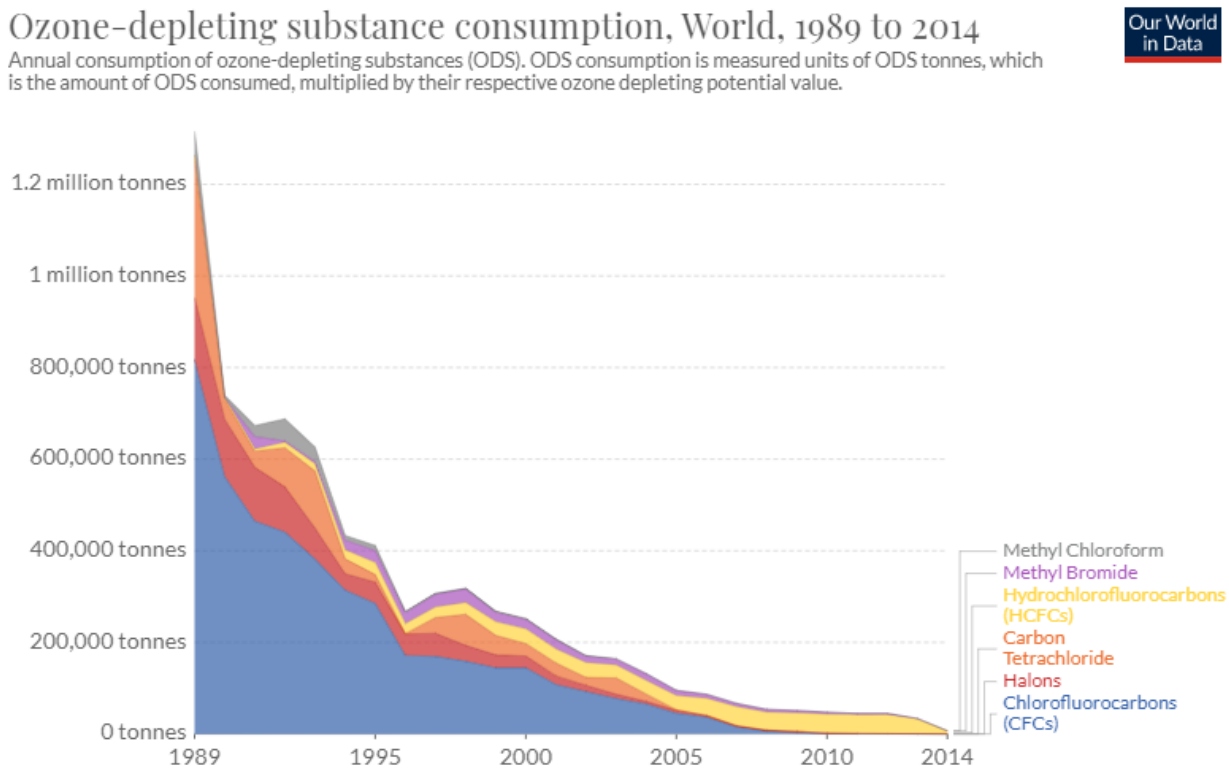

Figure 16: ODS consumption by substance 1986-2014
Source: Ritchie-Roser (2020)

Since its birth there was 9 revisions of Montreal Protocol in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2016 (Kigali) (McGARTH 2016).

The most recent amendment happened in 2016, during the 28th Meeting of the Parties to the Montreal Protocol. In Kigali/Rwanda, more than 170 countries agreed to amend the Protocol.

The Kigali Amendment seeks to phase down the production and use of hydrofluorocarbons (HFCs) by reducing them. HFCs are commonly used as substitutes for hydrochlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs) due to their zero effect on the degradation of the ozone layer, but they are strong greenhouse gases. The amendment entered into force on 1 January 2019. The goal is to achieve over 80% reduction in HFC consumption by 2047. The impact of the amendment will avoid up to 0.5 °C increase in global temperature by the end of the century. Furthermore, it could reduce the emission of CO2 equivalents in the atmosphere by 70 billion tons by 2050. The main features of the amendment are the following:

- There are two groups of Article 5 Parties with separate baseline years and timetables for phasing out (Figure 21).

- Some non-Article 5 Parties have different baseline calculations and different initial phasedown steps from the main group of non- Article 5 Parties (Figure 17).

- A new Annex F has been added to the Protocol. This lists the HFCs, separated into two groups:
    - Annex F, Group I: all HFCs (except HFC-23, and HFOs
    - Annex F, Group II: HFC-23.

- Global warming potential values have been added to the Protocol text for HFCs, and selected HCFCs and CFCs
- Production, consumption, imports, exports and emissions as well as consumption baselines of HFCs shall be expressed in carbon dioxide (CO2) equivalents
- Baselines are to be calculated from both HFC and HCFC production/consumption.
- There is an exemption for high ambient temperature countries
- Trade with Parties that have not ratified the Amendment ("non-Parties") will be banned from 1 January 2033

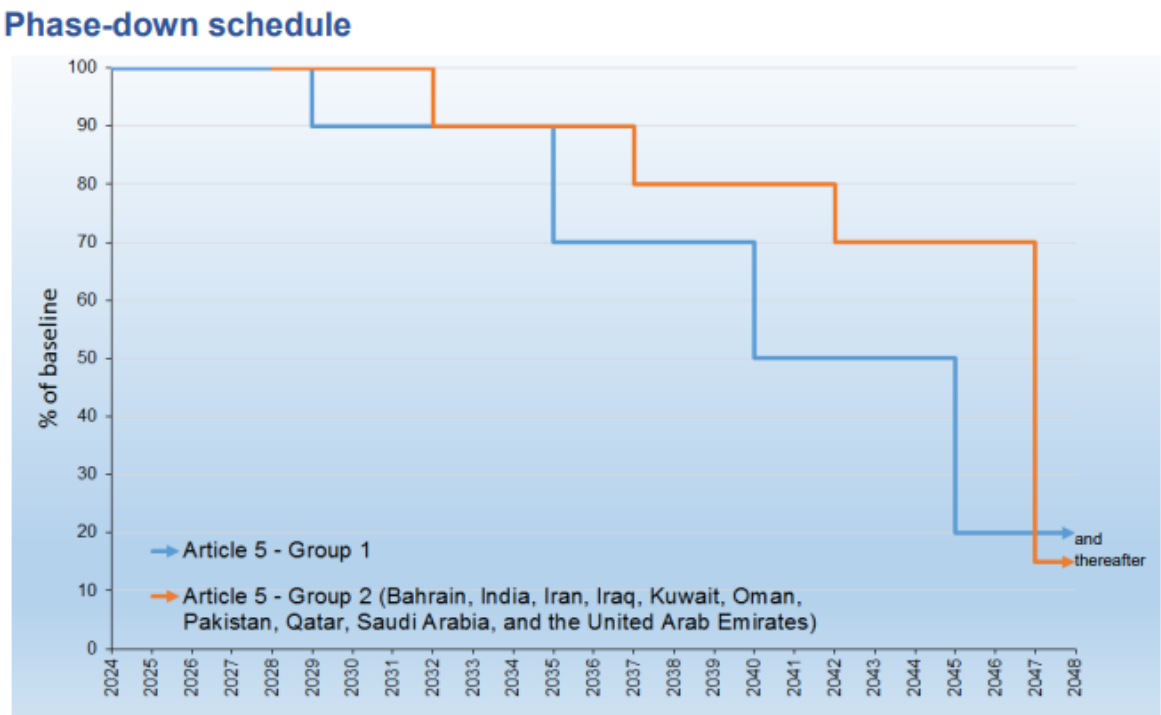

Figure 17: Phase down schedule for Article 5 and non-article 5 Parties
Source: UNEP 2016

The new deal contains concrete goals and timetables to substitute HFCs with more planet-friendly alternatives, measures to prohibit or prevent countries that have ratified the protocol or its modifications from trading in controlled substances with states that have yet to ratify it, and an agreement by rich countries to help fund the transition from poor countries to alternative, healthier goods. In particular, African countries have opted to phase down chemicals faster than expected, citing the region's serious threats to climate change (Figure 18).

Also in Kigali were top chemical industry officials including chemicals suppliers, machinery manufacturers using HFCs; a sign that businesses around the supply chain of HFCs are promoting effective global action on certain hazardous substances.

The final deal split the economies of the world into three categories, each with a phasedown target date. The wealthiest nations, including the U.S. and those in the European Union, must reduce HFC production and consumption by 2019. Most of the rest of the world will freeze use of HFCs by 2024, including China, Brazil and all of Africa. A small number of the hottest countries in the

world such as Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, and the United Arab Emirates have the most lenient schedule and will freeze usage of HFCs by 2028.

The modification also underlines the value of energy efficiency. Demand for refrigeration and air-conditioning is growing rapidly in developing countries. Demand currently accounts for over 40% of total electricity consumption, which is expected to increase due to economic and demographic growth, urbanization and global warming. Worldwide, the growing demand for refrigeration and air conditioning may raise electricity usage by 80 % between 2010 and 2100. HFCs can contribute to global warming through direct refrigerant leakage and indirect emissions from refrigeration equipment. Improving the energy efficiency of refrigeration systems therefore plays a key role in climate change mitigation, and represents an essential goal for future projects.

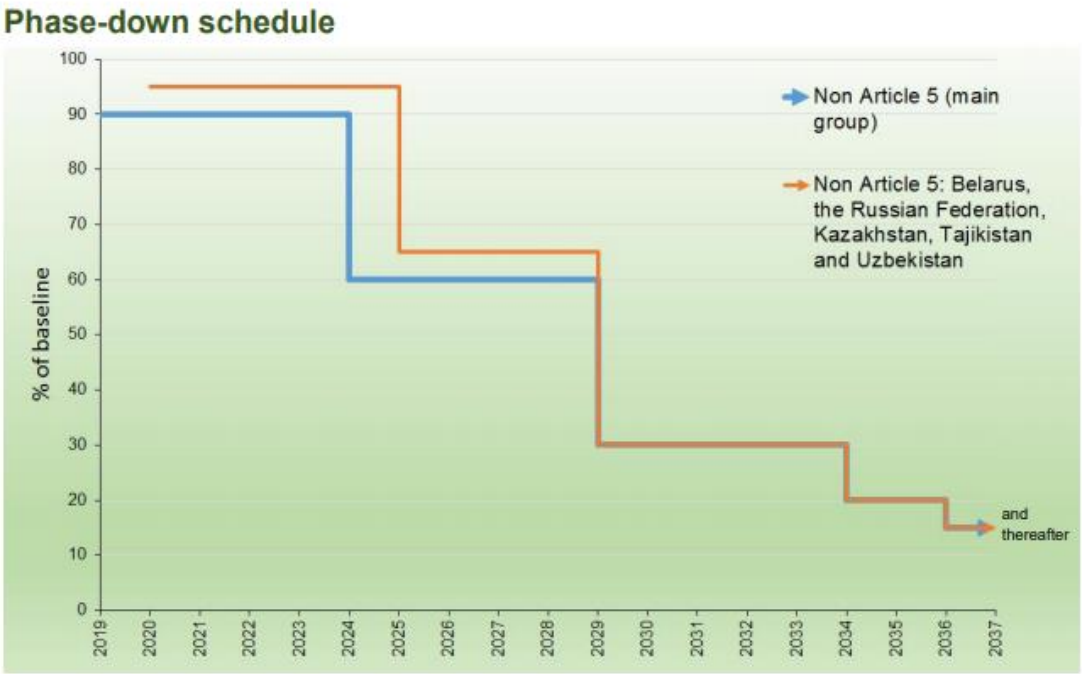

Figure 18: Phase down schedule for certain countries
Source: UNEP 2016

As pressure mounts on governments worldwide for less talk and more action to address climate change, the Kigali Amendment is indeed, a commendable move that adds momentum to a series of new global climate change agreements, including the Paris agreement.

3.22. Climate change

Climate change" and "global warming" are often used interchangeably but are of distinct significance. Global warming is the long-term heating of the Earth's climate system observed since the pre-industrial period (between 1850 and 1900) as a result of human activities, mainly the combustion of fossil fuel, which raises the heat-trapping greenhouse gas levels in the Earth's air (Figure 19). The term is often used interchangeably with the term climate change, as the latter applies to warming caused both humanly and naturally, and the impact it has on our planet. This is most generally calculated as the average increase in global surface temperature on Earth.

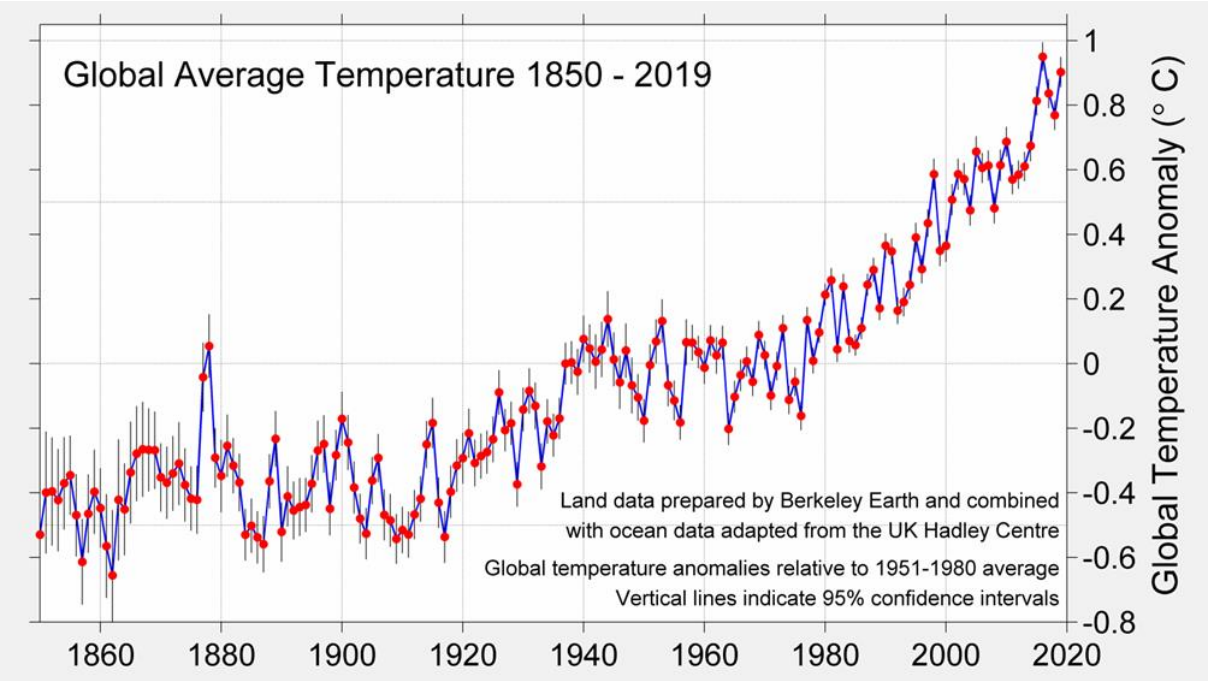

Figure 19. Change in global surface temperature
Source: berkeley.org 2020

It was concluded (RHODE 2019) that 2019 was Earth's second warmest year since 1850. In 2019 the global mean temperature was cooler than in 2016, but warmer than any other year explicitly measured. Consequently, 2016 is still the warmest year in historical observation history. Year-to-year rankings are likely to reflect natural fluctuations in the short term but the overall pattern remains consistent with a long-term global warming trend. This would be predicted from global warming caused by greenhouse gases, temperature increase across the globe is broadly spread, impacting almost all areas of land and oceans (Figure 20). In 2019, 88 percent of the Earth's atmosphere was slightly warmer than the 1951-1980 average temperature (RHODE 2019).

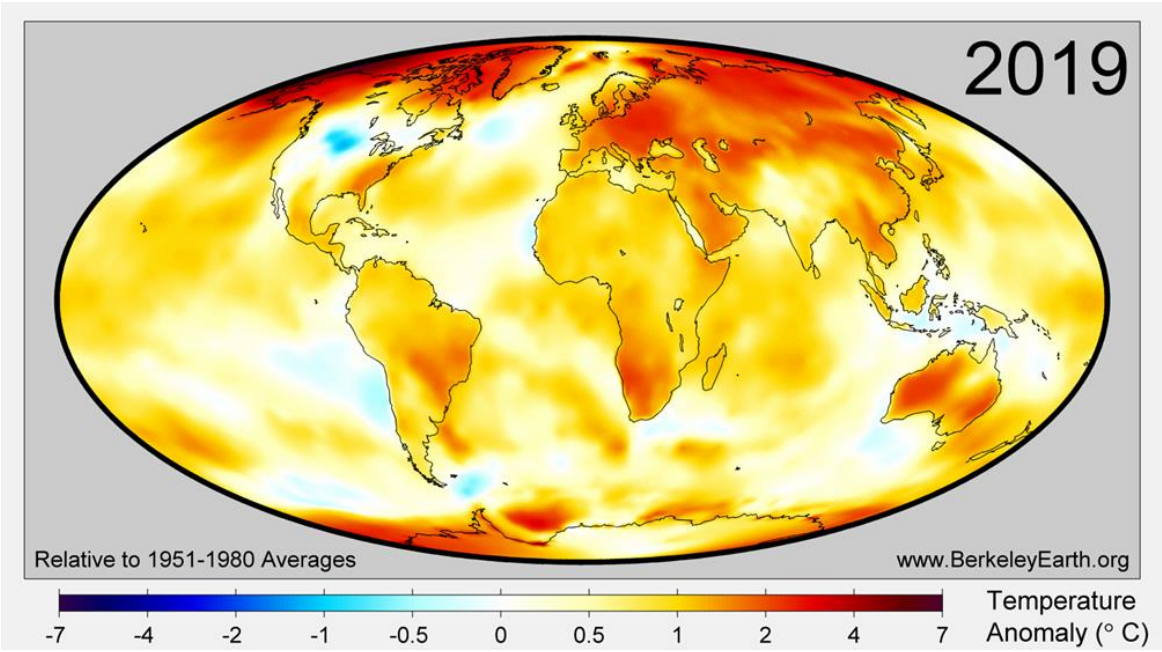

Figure 20: Local temperature rise in 2019 compared to the 1951-1980 mean temperature
Source: berkeley.org 2020

Climate change is a long-term change in the normal patterns of weather that have come to characterize the local, national and global climate of Earth. These adjustments have a broad array of observed effects associated with the term. Weather data reports include proof of important climate change measures, such as rises in global land and ocean temperature; rising sea levels; loss of ice at Earth's poles and in mountain glaciers; shifts in frequency and intensity of severe weather, such as hurricanes, heat waves, wildfires, droughts, floods and precipitation; and changes of cloud and vegetation, to name but a few. Climate change is one of the major international environmental challenges facing nations (NORDHAUS, 2018), and has the potential to cause catastrophic damages worldwide (RAMANATHAN et al., 2016). Scientific and economic consensus points to the need for a credible and cost-effective approach to address the threat of global climate change (BARRETT-STAVINS, 2003).

The ground and sea on the earth's surface would absorb the short-wave radiation from the sun and transform it into heat which, in the form of long-wave radiation, returns to the outer space. This circulation tends to regulate temperature on the planet. CO2, CH4 and other greenhouse gasses, however, are involved in reflecting long-wave radiation from the atmosphere, creating the "greenhouse effect" as the earth surface temperatures increase (FROLKING et al., 2006; KÖHLER et al., 2017). The greenhouse effect is a natural occurrence due to the accelerated industrial growth of recent years triggered by the emission of significant quantities of greenhouse gases. Under this case, the air and sea temperatures will eventually rise and the glacial crust will melt in the Polar Regions, causing the rise in sea levels and the change of climate patterns (CLOY, 2018; PERRY et al., 2012; SHAO et al., 2016).

The Earth's climate has changed throughout history. Just in the last 650,000 years there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 11,700 years ago marking the beginning of the modern climate era — and of human civilization. Most of these climate changes are attributed to very small variations in Earth’s orbit that change the amount of solar energy our planet receives. The current warming trend is of special significance as much of it is highly likely to be the result of human activity since the mid-20th century and to continue at a pace unparalleled over decades to millennia (IPCC 2014).

The current warming trend is of special significance as much of it is highly likely to be the result of human activity since the mid-20th century and to continue at a pace unparalleled over decades to millennia. In the mid-19th century, the heat-trapping nature of carbon dioxide and other gasses was demonstrated. Figure 21 based on the analysis of the atmospheric samples found in ice cores and more recent direct measurements, provides proof that after the Industrial Revolution atmospheric CO2 increased.

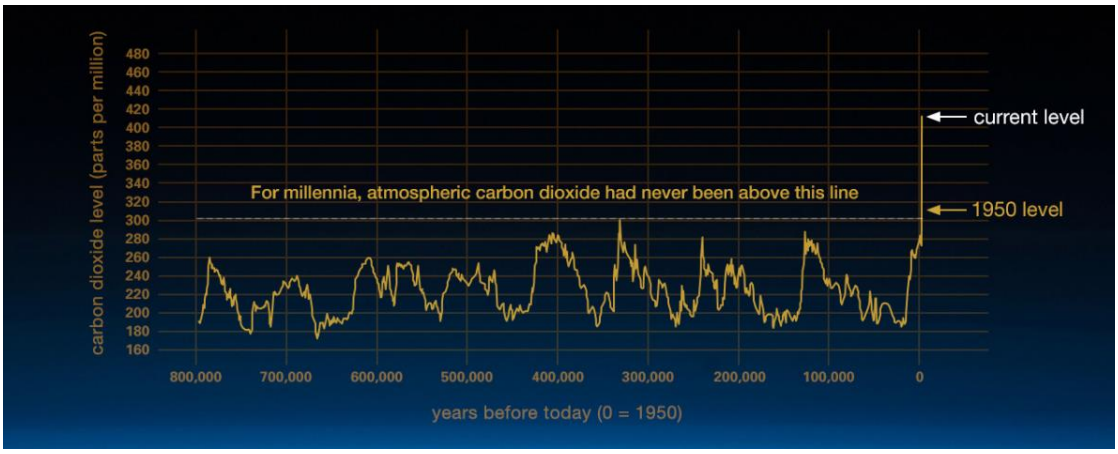

Figure 21: Timeline of CO2 level
Source: climate.nasa.gov

Ice cores taken from Greenland, Antarctica and tropical mountain glaciers indicate that the atmosphere on Earth is reacting to increases in greenhouse gas levels. Ancient evidence can be found also in tree rings, ocean sediments, coral reefs and sedimentary rock layers. This ancient data, or paleoclimate, shows that current warming occurs about ten times faster than the average ice-age recovery warming (NRC 2006).

General history of the issue of climate change (CLARK-DICKSON 2001; WEART 2003; HECHT 1995) typically starts with ARRHENIUS (1896) or earlier scientific studies. But it wasn't until the mid-1970s that a larger group of experts, including policy-makers, started to concentrate on how, when, and how to reduce warming. In the late 1980s, climate-change plans coalesced into two somewhat different strategies, one focused on environmental priorities, and the other based on political and economic viability. The feasibility strategy was inspired by the 1987 Montreal Protocol (BENEDICK 1998; AGRAWALA 1999). The problem seemed to be more alarming year by year. Nations have realised that international cooperation is a must in order to tackle the harmful impact of the toxic gas emissions.

The U.N. Climate Change Framework Convention (UNFCCC) is the first binding international instrument to address the issue of climate change directly. The Convention was adopted at the 1992 Rio Earth Summit and entered into force in 1994, when it was ratified by more than 160 nations. Its major pillars are the:

- Objective of “stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system [...] within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner”
- Principle of “common but differentiated responsibilities”, i.e. industrialised countries shall take the lead in mitigation and adaptation.
- Reporting of greenhouse gas emissions on a national level
- Setup of an institutional structure encompassing a Conference of the Parties meeting annually, two subsidiary bodies and a permanent secretariat

3.23. The Kyoto Protocol

The following milestone in climate regulation is linked to Kyoto Protocol. In1997 the Kyoto Protocol was adopted. It came into force in 2005, because of a complex ratification process. Currently the Kyoto Protocol has 192 Parties. The Kyoto Protocol operationalizes the United Nations Framework Convention on Climate (UNFCCC) Change by committing industrialized countries to limit and reduce emissions of greenhouse gases (GHGs) in line with agreed individual targets. The Convention itself only calls on those countries to adopt mitigation policies and measures and to report regularly. The Kyoto Protocol is based on the Convention's principles and rules, and maintains its annex-based structure. It only links developing countries and imposes a heavier burden on them under the " common but differentiated responsibility and respective capabilities" concept, as it acknowledges that they are primarily responsible for the current high rates of atmospheric GHG emissions. The Protocol has the following main elements

- Legally binding emission targets for a basket of six gases for the majority of OECD members and the majority of countries in transition of Eastern Europe.

- Four market mechanisms for the international transfer of emission rights: Bubbles, International Emissions Trading (IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM).

The context itself is very much dubious in nature. Developing countries never pin-point out the fallacies of their economic development or otherwise make way for the payment of economic cost which has been a menace built by the industrialization process. A quite obvious it is 0% of the emissions of greenhouse gases originated from developed countries. On the other side developed countries refuse to counter the problems as it tells the developing countries to lay a hand in hand to solve the issues. The triumvirate underlying principles in making such goals are trade, productivity and shelter against reckless severity. A nod to such type of agreement ill ring about changes, development, and cost-optimization lead to reduced capital investments in reaching emission targets for developing countries (CONVERY 2003).

As is now recognized, climate change will have major impacts on economies, culture, and human infrastructure, although those impacts are likely to be more serious in some areas of the world than in others. Examples of areas projected to be severely affected are arid regions whose people and ecological systems are at risk from expanding deserts as well as regions. Apart from the practical need to plan for and adapt to climate change, recent years 'agreements have shown that the financial and technological aspects of adaptation are gaining growing political significance. This phenomenon stems from two considerations: the concept of global justice and the long-term political strategy to engage developed countries more effectively in the UNFCCC process. Especially many less developed countries are the ones most likely to be impacted by the climate change impacts. Those countries may be expected to seek financial assistance and natural disaster compensation caused by the emissions from industrialised countries.

At the global scale, the key greenhouse gases emitted by human activities are (Figure 22):

Carbon dioxide (CO2): The main cause of CO2 is the use of fossil fuels. CO2 can also be generated by direct human-induced impacts on forests and other land use, such as deforestation, agricultural land clearing and soil depletion. Equally, land can also extract CO2 from the environment through reforestation, soil enhancement and other practices.
Methane (CH4): Agricultural activities, waste management, energy use, and biomass burning all contribute to CH4 emissions.
Nitrous oxide (N2O): Agricultural activities, such as fertilizer use, are the primary source of N2O emissions. Fossil fuel combustion also generates N2O.
Fluorinated gases (F-gases): Industrial processes, refrigeration, and the use of a variety of consumer products contribute to emissions of F-gases, which include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF6).

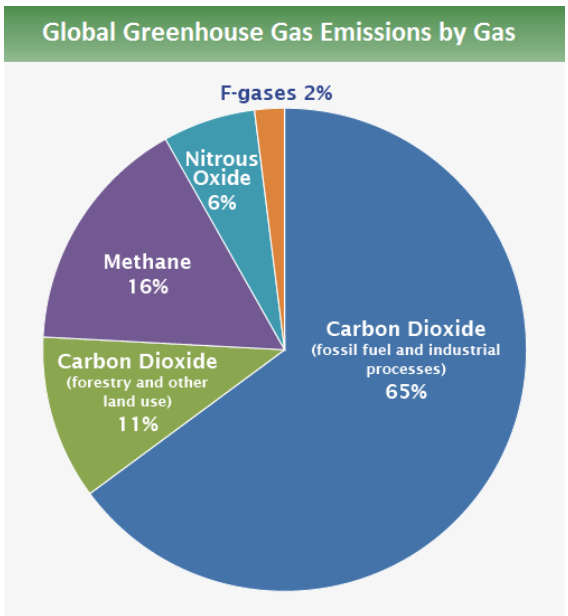

Figure 22: GHG emissions by Gas

Source: IPCC (2014)

Targets for GHG emissions can be absolute in nature or relative to a variable like GDP or population. Some analysts have suggested that GDP-related goals (commonly referred to as intensity goals) should suit countries with strong economic growth (HARGRAVE 1998, BAUMERT et al. 1999, PHILIBERT 2000). Generally speaking, the countries with strong economic growth favour relative targets whereas shrinking economies favour absolute targets which then create the so called "hot air".

The best kind of targets are mandatory targets of onerous financial penalties in the event of failure to comply. These targets are envisaged on the basis of installations in the EU carbon trading scheme and have contributed to almost 100 % compliance in U.S. SO2 trading. The Marrakech Accords, which only specify an in-kind penalty of 30 % payable in the ensuing agreement period, did not do this. Several more lenient forms of goals were suggested. The weakest type of targets are solely voluntary targets as stipulated in the UNFCCC for Annex I countries. These were not successful and were thus replaced by the Kyoto goals.

The Protocol's first commitment period started in 2008 and ended in 2012. All 36 countries that fully participated in the first commitment period complied with the Protocol. However, nine countries had to resort to the flexibility mechanisms by funding emission reductions in other countries because their national emissions were slightly greater than their targets. The greatest emission reductions were seen in the former Eastern Bloc countries (Figure 23) because the dissolution of the Soviet Union reduced their emissions in the early 1990s (SHIVLOV, 2016).

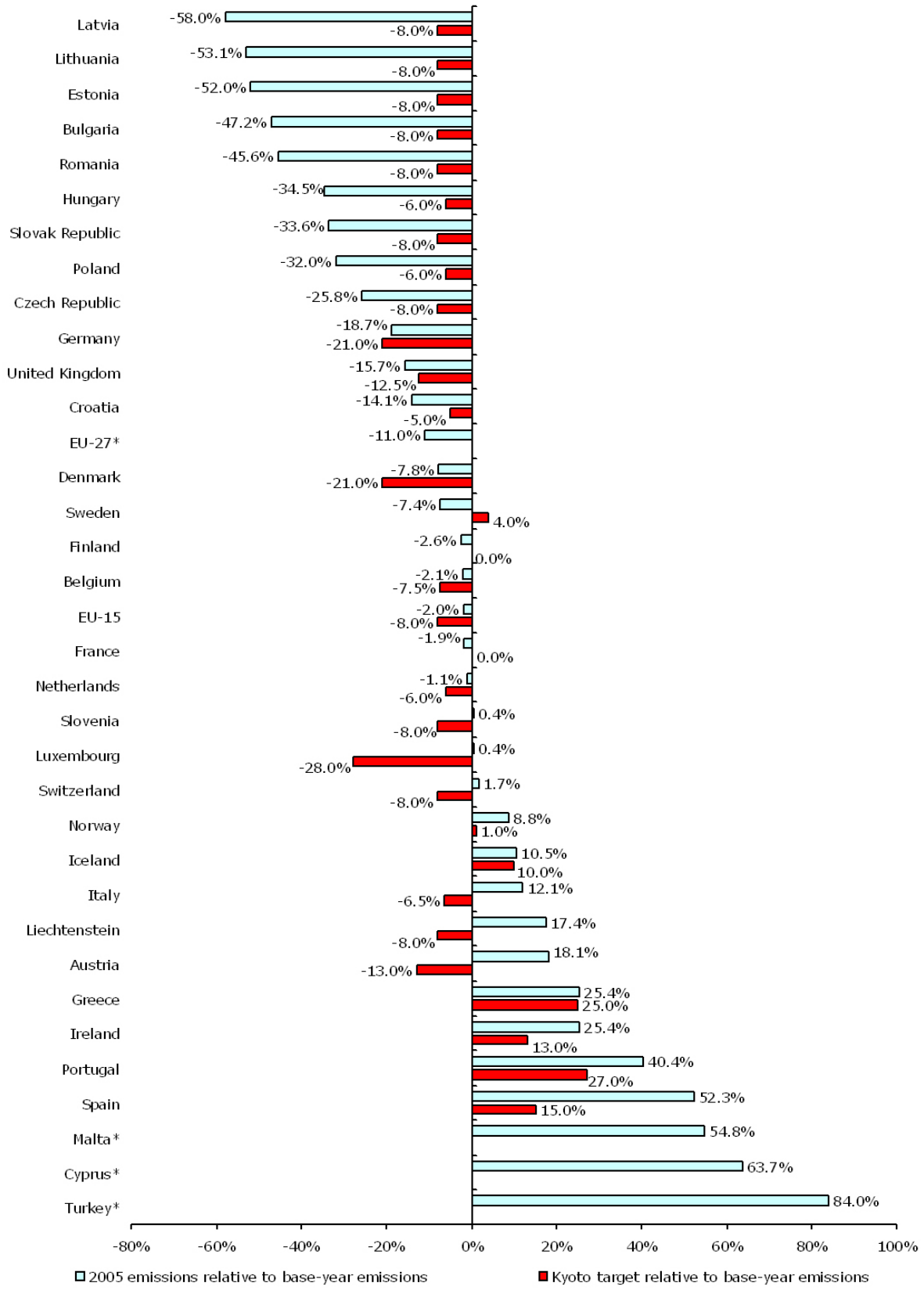

Figure 23: Change in greenhouse gas emissions in Europe between the base years and 2005, compared to Kyoto targets for 2008-2012
Source: EEA (2012)

Not all countries were obligated to reduce their greenhouse gas emissions in the same proportion on the basis of energy policies, the history of past emissions or the international agreements that

culminated in the protocol. Even though the 36 developed countries reduced their emissions, the global emissions increased by 32% from 1990 to 2010 (Figure 24).

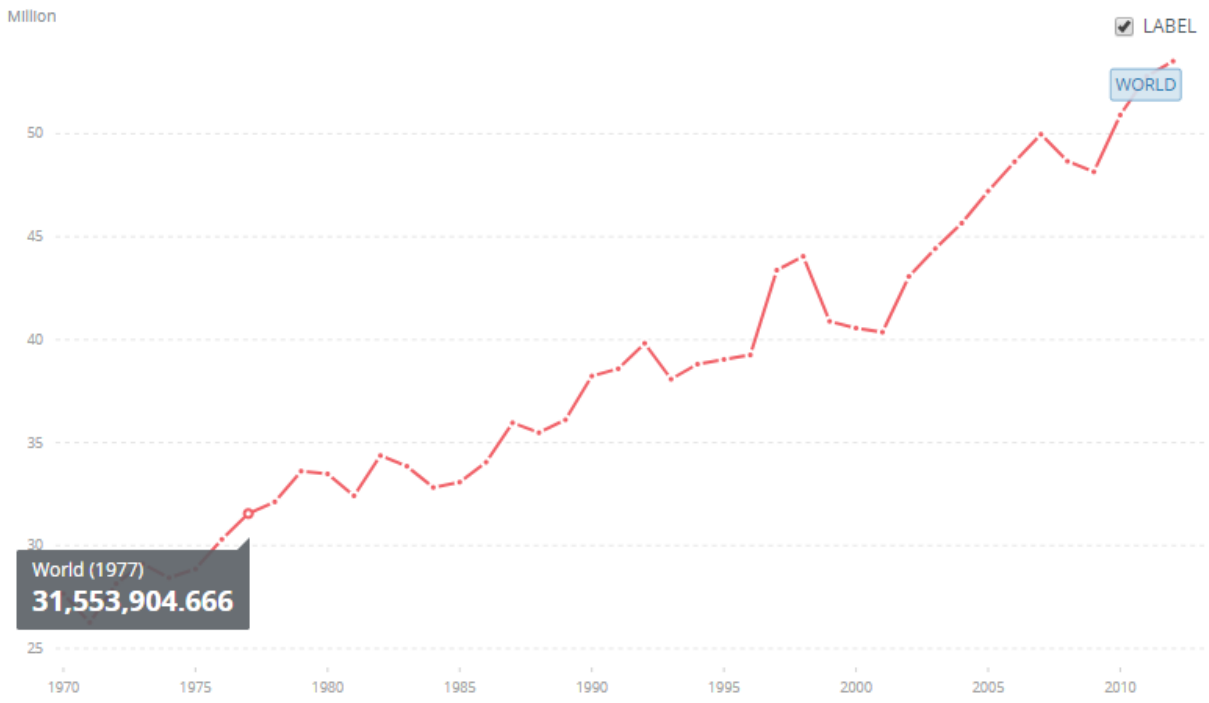

Figure 24: Total greenhouse gas emissions (kt of CO2 equivalent)
Source: European Commission (2012)

The situation differs greatly in terms of reaching expectations from one nation to another. Some countries exceeded the greenhouse gas emissions allowed under the protocol. Spain, for example, pledged to attain an emissions level only 15% higher in 2012 than in 1990, but its emissions were already up 36.8% in 2001. At the other hand, certain countries have accomplished their targets more than requested. Sweden is the prime example, with CO2 emissions dropping 28.8 % in 2001 compared to 1990, although the protocol requires it to increase its emissions by 2012.

The Doha Amendment to the Kyoto Protocol was adopted in Doha, Qatar, in 2012, for a second commitment duration, beginning in 2013 and lasting until 2020. Nonetheless, the Doha amendment has not yet entered into force; a minimum of 144 approval instruments are required for the amendment to enter into force.

According to the critics of the Kyoto Protocol, this agreement is focused on governments adopting tax and regulatory policies that allow businesses to emit lower greenhouse gas amounts. This will increase the cost of production and result in lower profits for greenhouse gas-generating activities. A "market" of emission rights generated by the Kyoto Protocol will further reduce earnings. Since buying pollution rights requires an extra expense, there will be less competitive production. Such privileges risk becoming costly as time goes on, as the protocol seeks to reduce greenhouse gas emissions Companies would find those rights more and more difficult to obtain. With the restrictions imposed by the conditions of Kyoto, some businesses would be unable to bear investment losses with no payback and the costs needed by new "clean" technology spending. The protocol currently applies to a limited group of countries, those industrialized or in transition to a market economy. As a result, with production factors costing more because of the higher price of emission rights (and tax and regulatory constraints), many firms that fall under the protocol will simply move their production to countries that are not covered by the protocol. There will be no

reduction in global greenhouse gas emissions: rather, the sources will actually be shifted to countries that do not fall under Kyoto.

Although the figures suggest that the 36 countries would have missed their targets without the financial crisis it is not certain. Without the crisis, countries might have implemented more ambitious climate policies. The main reason why the Kyoto Protocol did not have a significant impact on total GHG emission is the largest emitters (USA, China) did not participate in the agreement. The Kyoto protocol should not be judged on the basis of emissions numbers alone, it also helped lay the foundations for the Paris Climate Agreement in 2018.

3.24. The Paris Agreement

The Paris Agreement builds on the Convention and brings all nations into a common cause – for the first time – to pursue concerted measures to combat climate change and adapt to its consequences, with expanded funding to assist developing countries in this. As such, it sets a new path in the global initiative on environment. The Paris Agreement is seen as a diplomatic achievement and an important historical milestone in the history of global climate negotiations (BODANSKY 2016; BRUN 2016; DIMITROV 2016; DOELLE 2017 ;). Insiders describe the PA as "the culmination of decades of climate diplomacy" (BODANSKY 2016), and "a historic achievement in multilateral diplomacy" which is "the most optimistic outcome possible in a deeply discordant political setting" /RAJAMANI 2016).

The Paris Agreement combines a top-down approach that imposes legally binding responsibilities on countries with a bottom-up approach to formulating policy that leaves much up to the governments of the state. This leaves policymakers with full control over domestic policies, and relies on "nationally determined contributions" (NDCs) to global climate policy. At the same time, it imposes clear commitments to establish, enforce and improve these actions on a regular basis, while subjecting national policies to a comprehensive international oversight mechanism. Main provisions include a global target of keeping the temperature rise "well below 2 C" and a promise to "continue efforts to restrict temperature rise to 1.5 C". The long-term policy targets are to "as soon as possible" peak global emissions and to reach null net emissions in the second half of this century. The Paris Agreement is a treaty, although unorthodox under international law (BODLE 2017). Lawyers stress that the Paris Agreement implies comprehensive, binding legal obligations on countries (MACE-VERHEYEN 2016). This result is especially important considering that there were all legal options on the table, and that the legal essence of the agreement was not decided until the second week of Paris negotiations. Many experts also agree that the PA is not a traditional treaty that meets the top-down international law pattern. It is an instrument which is more facilitative than prescriptive. Legal experts involved in negotiations are of the opinion that the agreement has a strong potential to be successful. Recently, members of the UNFCCC concluded that the Paris Agreement is ready to attain its ambitious targets (KLEIN 2017). Although many regard the PA as a major pillar of the global climate policy system, the uncertain existence of its future effect is stressed. Many believe that telling is too early, and the outcome depends on domestic developments (WINKLER 2017).

Table 1 summarises the similarities and differences of Kyoto Protocol and Paris Agreement

Table 1: The main features of Kyoto Protocol and Paris Agreement

Feature	Kyoto protocol	Paris Agreement
Goal	Reduce greenhouse gas emissions to 5.2% below 1990 levels	Stop the global average temperature from rising more than 2 degrees Celsius above pre-industrial levels through cutting greenhouse gas emissions
Countries under obligation	Countries considered to be industrialized in 1997	All countries
Greenhouse gases targeted	Targeted gases include carbon dioxide, nitrous oxide, methane, HFCs, PFCs, and sulfur hexafluoride.	All anthropogenic greenhouse gases
Timeframe	First phase ended in 2012	Most goals to be achieved by 2025-2030

Source: differencebetween.net

4. MATERIAL AND METHODS

In this chapter I will discuss the materials and methods I applied in my research.

I have decided to use secondary research to examine the relationship between oil prices and various macroeconomic variables. I chose this type of research method because I expected to gain insights into methods and findings from previous studies, which would help me define my own research process. Secondary research also aids in identifying knowledge gaps that can be used to name my own research. Secondary research is a common method of conducting a systematic investigation in which the researcher relies solely on previously collected data during the research process. In order to reach valid research conclusions, this research design includes organising, collating, and analysing data samples.

Secondary research, also known as desk research, is the process of synthesising existing data from the internet, peer-reviewed journals, textbooks, government archives, and libraries. The secondary researcher looks at previously established patterns in previous studies and applies that knowledge to the specific research context. Secondary research entails assimilating data from multiple sources, i.e., using existing research materials rather than creating a new pool of data using primary research methods. Data collection via the internet, libraries, archives, schools, and organisational reports are all common secondary research methods. I have decided to use online data for my analysis. The term "online data" refers to information obtained through the use of the internet.

Qualitative research provides insights and understanding into a problem setting. It is an unstructured, exploratory research method that studies highly complex phenomena that quantitative research cannot explain. It does, however, generate ideas or hypotheses for future quantitative research. On the basis of observation and interpretation, qualitative research is used to gain an in-depth understanding of human behaviour, experience, attitudes, intentions, and motivations. It is a type of research in which the researcher gives more weight to the participants' opinions. Qualitative research methods include case studies, grounded theory, ethnography, history, and phenomenology.

Quantitative research is a type of research that uses natural science methods to generate numerical data and hard facts. It seeks to establish a cause-and-effect relationship between two variables through the use of mathematical, computational, and statistical methods. Because the research can be accurately and precisely measured, it is also known as empirical research.

The data gathered by the researcher can be classified or ranked, or it can be measured in terms of units of measurement. With the help of quantitative research, raw data graphs and tables can be created, making it easier for the researcher to analyse the results.

Because my research topic is entirely data-driven, I chose a quantitative secondary research method for my analysis.

In my dissertation, I primarily sought answers to my hypotheses and focused on the six hypotheses by analysing them using various statistical indicators. The data used in the study were gathered from a number of international statistical public databases. Every year, BRITISH PETROL (2019) publishes the Statistical Review of World Energy for the preceding period, and I used the 2019 issue. Another large set of data was gathered from the World Development Indicators (WDI 2019) database. This database is the WORLD BANK's premier compilation (2019). The database contains 1,600 time series indicators for 217 economies and more than 40 country groups, with data for many indicators dating back more than 50 years. It is the most widely used database because it works with a wide range of indicators. This information is available to the public and can be accessed in a variety of ways. Some sections include ready-made statistical indicators, while others collect data beginning in 1968. The database also makes use of graphical representations,

which have been used to test some hypotheses. Because both publications and sources are based on internationally accepted and secure data, I have met the research's reliability requirement. Because the WDI database is based on a conversion to the 2010 US dollar, my research also met the objectivity criteria.

With the publication of its first annual Human Development Report (HDR) and the introduction of the Human Development Index in 1990, the United Nations Development Program (UNDP) changed the landscape of development theory, measurement, and policy. HDR 1990 presented the concept of "human development" as progress toward greater human well-being.

During my research I used HDI index, the data were collected from Human Development Report 2020. The HDI was created to emphasise that people and their capabilities, rather than economic growth alone, should be the ultimate criterion for assessing a country's development. The HDI can also be used to question national policy choices, such as how two countries with the same per capita GNP can have such disparities in human development outcomes. These contrasts can spark discussion about the government's policy priorities.

The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development, such as living a long and healthy life, being knowledgeable, and having a good standard of living. The HDI is the geometric mean of the normalised indices for each dimension.

The HDI simplifies and captures only a portion of what it means to be human. It makes no mention of inequalities, poverty, human security, empowerment, or other issues. The HDRO provides the other composite indices as a broader proxy for some of the most important issues in human development, such as inequality, gender disparity, and poverty.

I started my study by selecting the groups of countries I want to study based on the Human Development Report. The selection was based on the HDR 2020 (HDR 2020) list, where the countries were ranked according to several criteria. I chose the 2020 data because the indicators that form the basis of the methodology are always the numbers that form the basis of the previous year and the 2021 data were not yet public at the beginning of my research.

The Human Development Report distinguishes 4 groups of country categories:

1. Very high human development
2. High human development
3. Medium human development
4. Low human development

As the medium and low group included a total of as many countries as the high and several underdeveloped, small or newly formed underdeveloped countries, it was very difficult to choose from them. That is why I decided to merge the medium and low categories and examine them together.

4.1. Description of the statistical methods used in the analysis

Fixed and chain base numbers

A large portion of my research hypotheses concerned what changes and correlations I could demonstrate between two time-determined factors. For example, consider the evolution of each group of countries' GDP over time. This is made easier by the analysis of chain ratios and their graphical representation. When analysing constant variables, such as determining values relative

to the 2010 dollar exchange rate, I used base ratios. Trends could be identified in relation to them as well.

Distributions

A sample of data will form a distribution. The distribution provides a parameterized mathematical function that can be used to calculate the probability for any single observation in the sample space. The first step in turning data into information is to create a distribution. Before doing the analyses I presented distribution in tables and in the form of graphs as well.

Mean

To describe the location of a distribution, I used a typical value from the distribution. There are a number of different ways to find the typical value, but by far the most used is the arithmetic mean. The arithmetic mean of a list of numbers, is the sum of all of the numbers divided by the number of numbers.

Standard deviation

I also calculated standard deviation. The standard deviation is a measure of the amount of variation or dispersion in a set of values. A low standard deviation indicates that the values of the set tend to be close to the mean, whereas a high standard deviation indicates that the values are spread out over a larger range.

The standard deviation formula weighs unevenly spread out samples more than evenly spread samples. A higher standard deviation tells that the distribution is not only more spread out, but also more unevenly spread out. This means it gives a better idea of data's variability than simpler measures, such as the mean absolute deviation.

Trend analysis

Trend analysis involves the collection of information from multiple time periods and plotting the information on a horizontal line for further review. I used linear trend estimation. Linear trend estimation is a statistical technique used to aid in data interpretation. When a series of measurements of a process is treated as, a time series, trend estimation can be used to make and justify statements about data tendencies by relating the measurements to the times at which they occurred. This model can then be used to describe the observed data's behaviour without explaining it. Linear trend estimation, in this case, expresses data as a linear function of time and can also be used to determine the significance of differences in a set of data linked by a categorical factor.

Variance

In a number of cases variance was also calculated. Variance is the expectation of the squared deviation of a random variable from its mean. It measures how far a set of numbers is spread out from their average value. The variance is the square of the standard deviation, the second central moment of a distribution, and the covariance of the random variable with itself.

Correlation

Correlation refers to any statistical relationship, whether causal or not, between two random variables or bivariate data. Correlation, in the broadest sense, refers to any statistical association, though it is most commonly used to refer to the degree to which two variables are linearly related. Correlation coefficients are used to assess the strength of a relationship between two variables. Pearson's correlation coefficient is the most common type of correlation coefficient. Pearson's correlation (also known as Pearson's R) is a correlation coefficient that is frequently used in linear

regression. I used Pearson's correlation coefficient in my analysis. For the calculation the following formula was used:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[\, n\sum x^2 - (\sum x)^2 \,]\,[\, n\sum y^2 - (\sum y)^2 \,]}}$$

Linear regression

In some cases linear regression calculations were used. By fitting a linear equation to observed data, linear regression attempts to model the relationship between two variables. One variable is regarded as an explanatory variable, while the other is regarded as a dependent variable.

The research was carried out according to the conditions of scientific research. My research met the criteria for measurement. I strived for validity, reliability and objectivity and adhered to ethical standards.

Displaying data

I used several methods to display the research data. Using the Boxplot method, I was able to display the amount of time-independent data for each country, as well as the average between the minimum and maximum data.

The Scatterplot graphs represents the examined data in a coordinate system, which in this case I used to display the regression values.

For the research and analysis of data, I primarily used IBM SPSS version 22 and converted the resulting data into Microsoft Excel 2016 version for graphical presentation

I mostly used the graphs displayed in MS Excel to display the trends and data, because the IBM SPSS diagrams are not so aesthetic and more difficult to shape.

5. RESULTS AND THEIR DISCUSSION

In this chapter I will analyse my hypotheses on order to be able to answer my research questions stated in the objectives of the dissertation.

H1: The impact of oil price changes on GDP growth is less significant in developed countries, and this impact is more significant in developing countries.

I created 3 country groups based on HDR 2020 as follows:

1. Very high human development countries

Norway
Ireland
Switzerland
Germany
Sweden
Australia
Netherland

2. High human development countries

Iran
Mexico
Thailand
Colombia
Brazil
China
Egypt

3. Medium and low human development countries

Iraq
India
Kenya
Pakistan
Uganda
Nigeria
Sudan

I defined the GDP per capita growth (annual %) of these countries because I wanted to research how changes in the price of oil affected the GDP of each country. Thus, I did not look at the annual GDP, but at its change, and since the number of countries varies, I definitely wanted to use per capita data. I used the WDI database, which contains data from 1961 to 2019.

5.1. Oil price development

For oil prices I used BP statistical Review 2020

What can be seen is that the price of oil per barrel has increased significantly over the 28 years studied, and this shows a very strong upward trend. As shown in Figure 25, the price of oil varies greatly. Basically, the curve can be divided into two parts: it was extremely low between 1990 and 2003, and then showed a steady upward trend from 2004 to almost $ 100, then declined as a result of the economic change, but then began to rise again. It is currently showing an upward trend again. I also drew the trend, in this case I defined a linear trend line and it can be seen in red that its indicator is: y = 2.5863x + 8.6414, a rather steep rise can be observed. The value of R2 gives the slope of the regression line and the degree of this in the development of the price of oil: R^2 = 0.5725, that is, we can say that there is a relationship between the year and the development of the price of oil and this relationship is theoretically considered to be moderately strong.

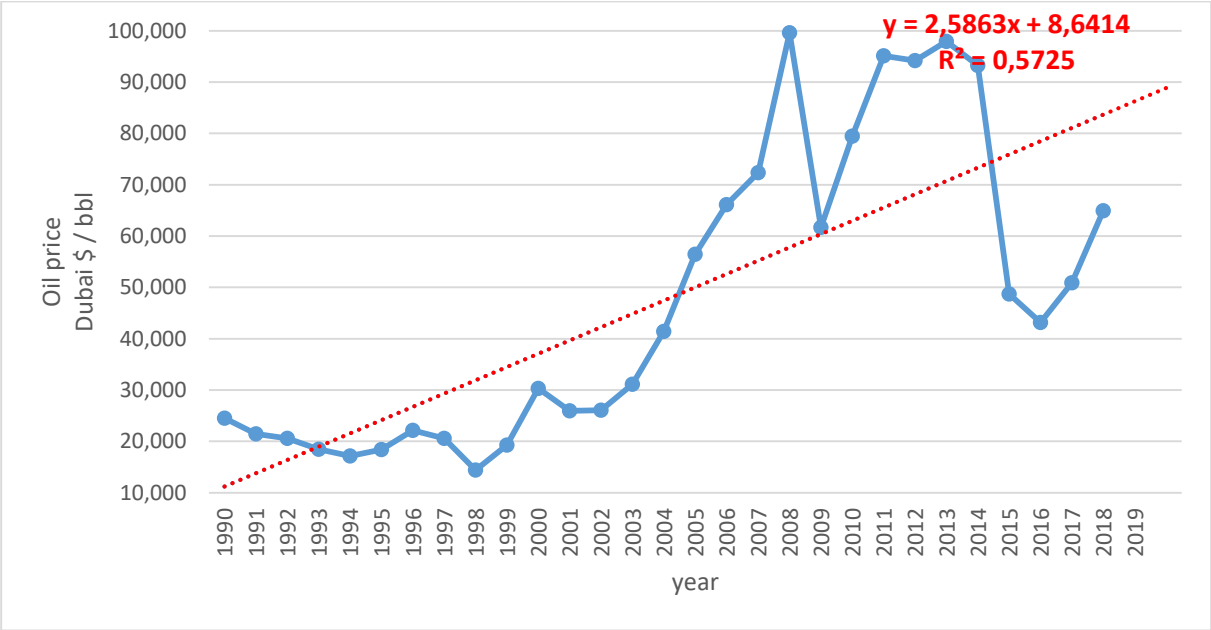

Figure25: Oil price 1990-2019
Source: BP statistical Review 2020

5.2. Analysing the relationship between oil price and GDP growth in the case of very high human development countries

As we can see in Figure 26, the GDP growth of these countries is relatively stable. Of the countries surveyed, only Ireland showed the largest difference, with the largest increase in 2015 and the lowest in 2008-209 below -6% of GDP growth.

As we can see from the time line, we have found two low points so far in the 7 countries studied: between 1991 and 1993 there was a low point, where several countries reached negative values. The next low point was during the 2008 global economic crisis, but it lasted for a relatively short time. What is striking even during the period under review is the extent to which countries achieve even GDP growth values, with their annual GDP growth ratios varying between -5 and +5. It also appears that the fluctuations in GDP growth seem to be easing over time.

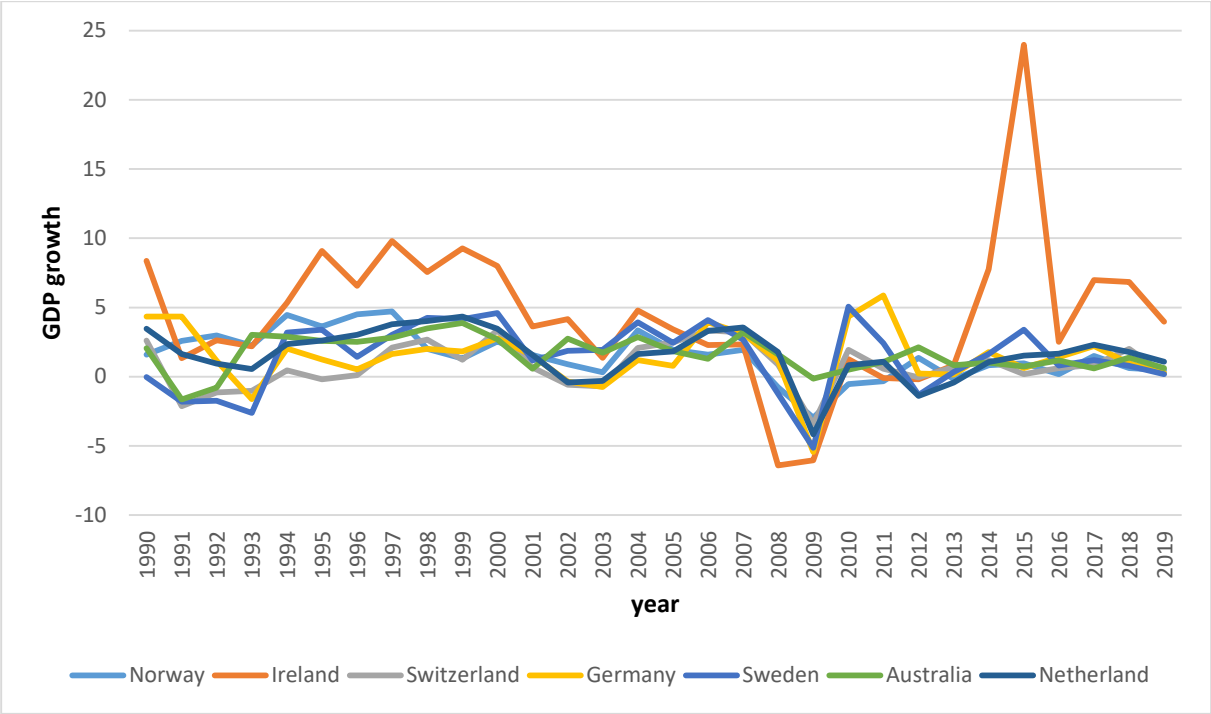

Figure 26: GDP growth change of very high human development countries
Source: Author's own editing based on WDI 2020

To further my research, I examined how the mean of GDP growth changed and what the linear trend function can be calculated from the mean GDP growth. As the evolution of GDP is outlined in Figure 26, the data in Figure 27 have been confirmed. The average was between + 4 and -4, as the large fluctuations in Ireland can be offset by the value of the other countries. The value of the linear trend line is negative, -0.0376x + 2.4288, a slightly decreasing rate. With this, I have demonstrated that very high HDI countries have stable economic indicators and there has been a slight decline in GDP growth over the last 20 years. In terms of R2, it is 0.0378, which is extremely low, ie the relationship between the annual changes and the average GDP growth is barely noticeable.

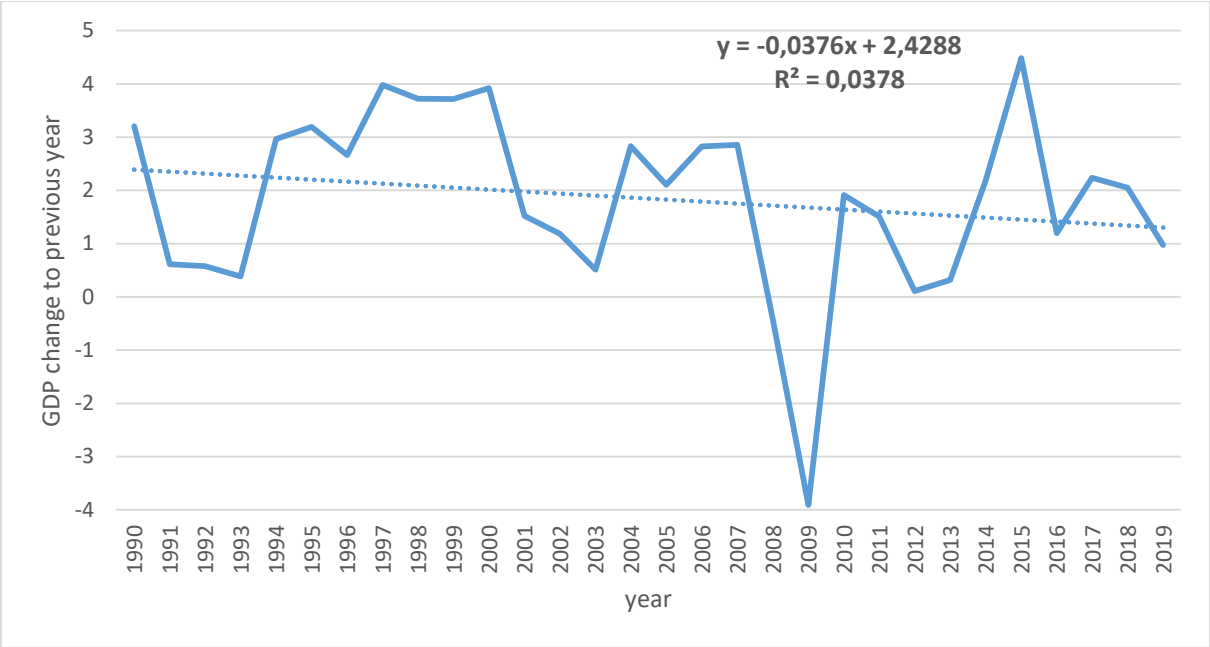

Figure 27: Mean of GDP growth and the linear trend line of very high human development countries 1990-2019
Source: Author's own editing based on WDI 2020

In the next step, I wanted to analyse the relationship between oil prices and GDP growth.

For this, I first examined the time-series figures to see what kind of relationship I can discover. As I have plotted the two data sets in parallel in Figure 28, it can be seen that until 2004, although there was a large difference between the two factors examined, they nevertheless moved in parallel. Then, oil prices soared and the mean GDP growth hit a low one year later in 2009 and then the two data under review begin to move in the opposite direction. As oil prices are rising, GDP growth is falling, and from 2016 onwards, they are moving parallel. Further statistical studies are needed to examine this relationship.

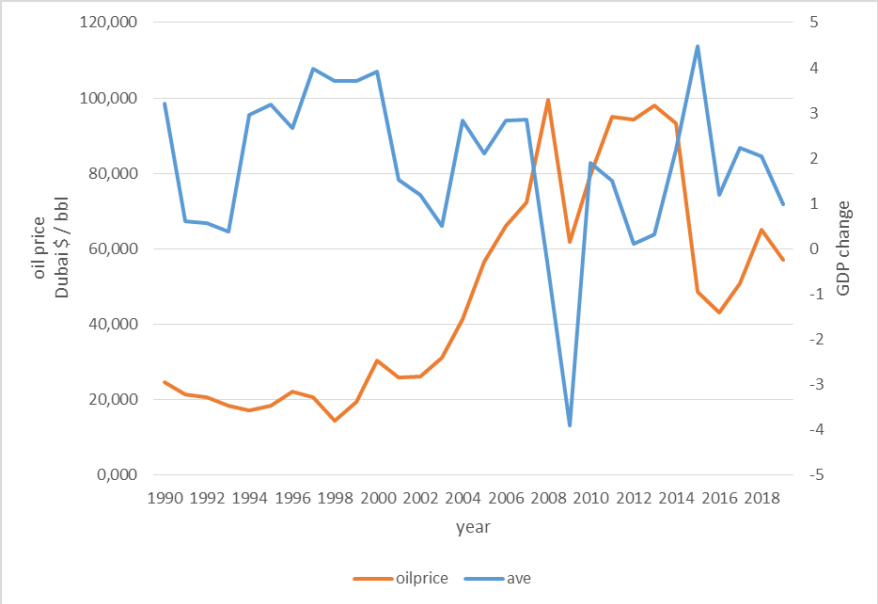

Figure 28: The relationship of oil price and mean GDP growth in very high human development countries
Source: Author's own editing based on WDI 2020

I began my statistical studies by examining the relationship between the price of oil and the mean GDP growth. Table 2 shows that the relationship is very low based on the annual changes, oil, and mean GDP growth, with a significance level of 0.237 for each factor examined, meaning that there is a very low relationship among them.

Table 2: Chi-Square Tests of very high human development countries

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	870,000[a]	841	,237
Likelihood Ratio	204,072	841	1,000
N of Valid Cases	30		

a. 900 cells (100,0%) have expected count less than 5.

The minimum expected count is 03.

Source: Author's own editing based on WDI 2020

Continuing my research, I examined the relationship between the GDP growth of each country and the price of oil. Table 3 shows the relationship between each country and oil prices. The correlation coefficient is negative everywhere except Switzerland and Germany. I found the strongest opposite relationship in the case of Norway with Pearson's correlation approaching -0.622. This is followed by Ireland, r = -0.396, and the Netherlands, where r = -0.379 (p = 0.99). I found the level of significance to be high in three countries according to Table 3, it is 0.692 for Germany and almost the same for Sweden and Switzerland.

Table3: The relationship of oil price and GDP growth of very high human development countries

Correlations

		Norway	Ireland	Switzerland	Germany	Sweden	Australia	Netherland	oilprice
Norway	Pearson Correlation	1	,438*	,241	,261	,354	,397*	,611**	-,622**
	Sig. (2-tailed)		,016	,199	,164	,055	,030	,000	,000
	N	30	30	30	30	30	30	30	30
Ireland	Pearson Correlation	,438*	1	,288	,176	,521**	,242	,496**	-,396*
	Sig. (2-tailed)	,016		,123	,351	,003	,198	,005	,030
	N	30	30	30	30	30	30	30	30
Switzerland	Pearson Correlation	,241	,288	1	,572**	,712**	,480**	,708**	,128
	Sig. (2-tailed)	,199	,123		,001	,000	,007	,000S	,500
	N	30	30	30	30	30	30	30	30
Germany	Pearson Correlation	,261	,176	,572**	1	,532**	-,022	,645**	,075
	Sig. (2-tailed)	,164	,351	,001		,002	,909	,000	,692
	N	30	30	30	30	30	30	30	30
Sweden	Pearson Correlation	,354	,521**	,712**	,532**	1	,490**	,640**	-,128
	Sig. (2-tailed)	,055	,003	,000	,002		,006	,000	,501
	N	30	30	30	30	30	30	30	30
Australia	Pearson Correlation	,397*	,242	,480**	-,022	,490**	1	,461*	-,270
	Sig. (2-tailed)	,030	,198	,007	,909	,006		,010	,150
	N	30	30	30	30	30	30	30	30
Netherland	Pearson Correlation	,611**	,496**	,708**	,645**	,640**	,461*	1	-,379*
	Sig. (2-tailed)	,000	,005	,000	,000	,000	,010		,039
	N	30	30	30	30	30	30	30	30
oilprice	Pearson Correlation	-,622**	-,396*	,128	,075	-,128	-,270	-,379*	1
	Sig. (2-tailed)	,000	,030	,500	,692	,501	,150	,039	
	N	30	30	30	30	30	30	30	30

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

Based on the Very High HDI countries that are the first subject of my study, it can be said that the effect of oil prices is not the same for each country and although most of the countries examined have a balanced economic indicator, there are differences between GDP growth and oil prices.

5.3. Analysing the relationship between oil price and GDP growth in the case of high human development countries

As shown in Figure 29, GDP growth is more diverse than in the case of several countries, such as China, which did not have a negative GDP growth in any of the 30 years studied. The lowest GDP growth value was in 1990, when it was below 5%, but in none of the following years did it reach below 5%.

All countries have achieved a negative GDP growth value at least once and, as can be seen from Figure 29, they have not achieved it at the same time. The next factor that seems interesting is that there was no negative GDP growth value in any of the countries between 2003 and 2008, all countries were in an upswing and 2007 was the peak period almost everywhere.

For high human development countries, the minimum ranged from -8.7 (Thailand) to a maximum of 13.6 (China). It can be stated that the fluctuation of GDP growth is more intense in high human development countries than in very high human development countries.

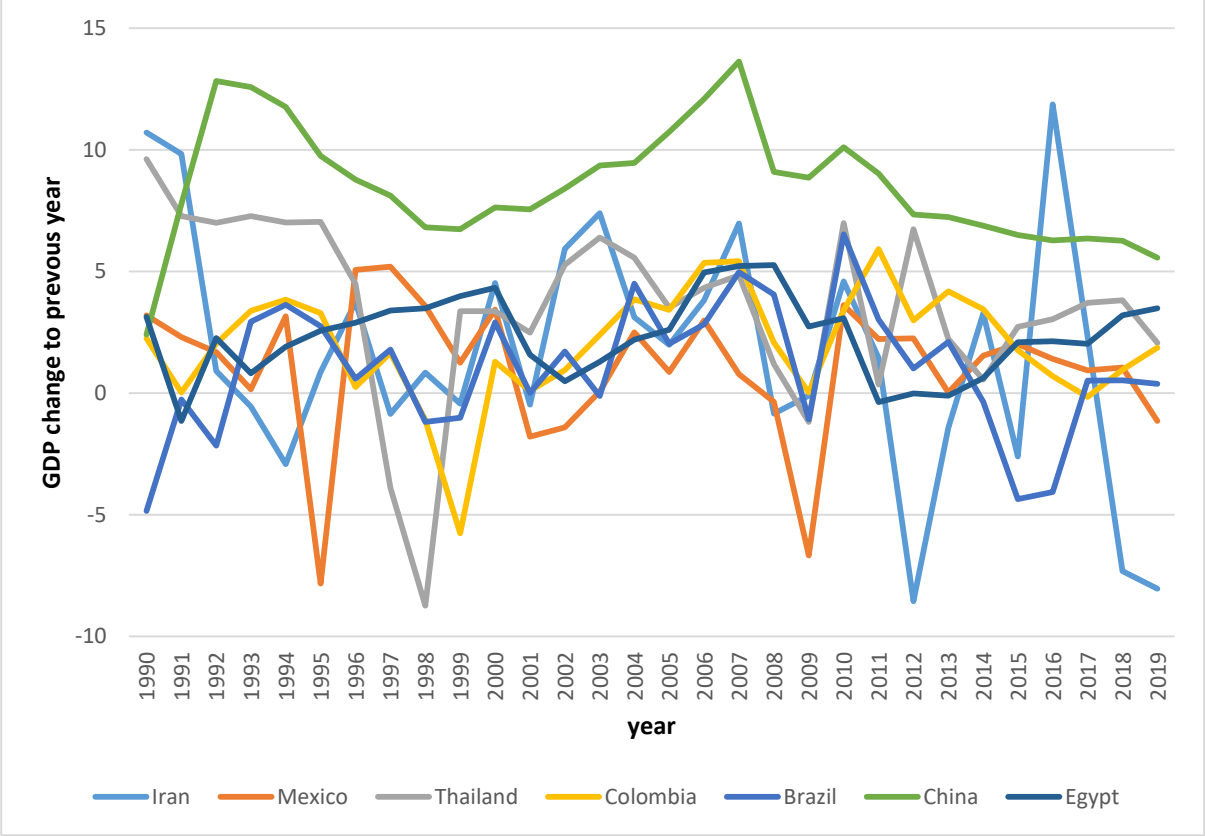

Figure 29: GDP growth change of high human development countries
Source: Author's own editing based on WDI 2020

In the next step, I examined how the mean GDP growth evolves and how the trend changes in the high human development countries.

As it can be seen in Figure 29, countries do not move in parallel, thus, it was not surprising when, as shown in Figure 30, the average did not include a negative GDP growth value, in contrast to the very high human development countries. The highest average value was 6% in 2007 and the lowest was in 2009 and 1998, with 0, 5%.

The value of the linear trend is decreasing as well, its value is -0.052x + 3.6914, the rate of GDP growth decline is much steeper than in the very high human development countries. And R2 was 0.0964, which is also higher than in very high human development countries.

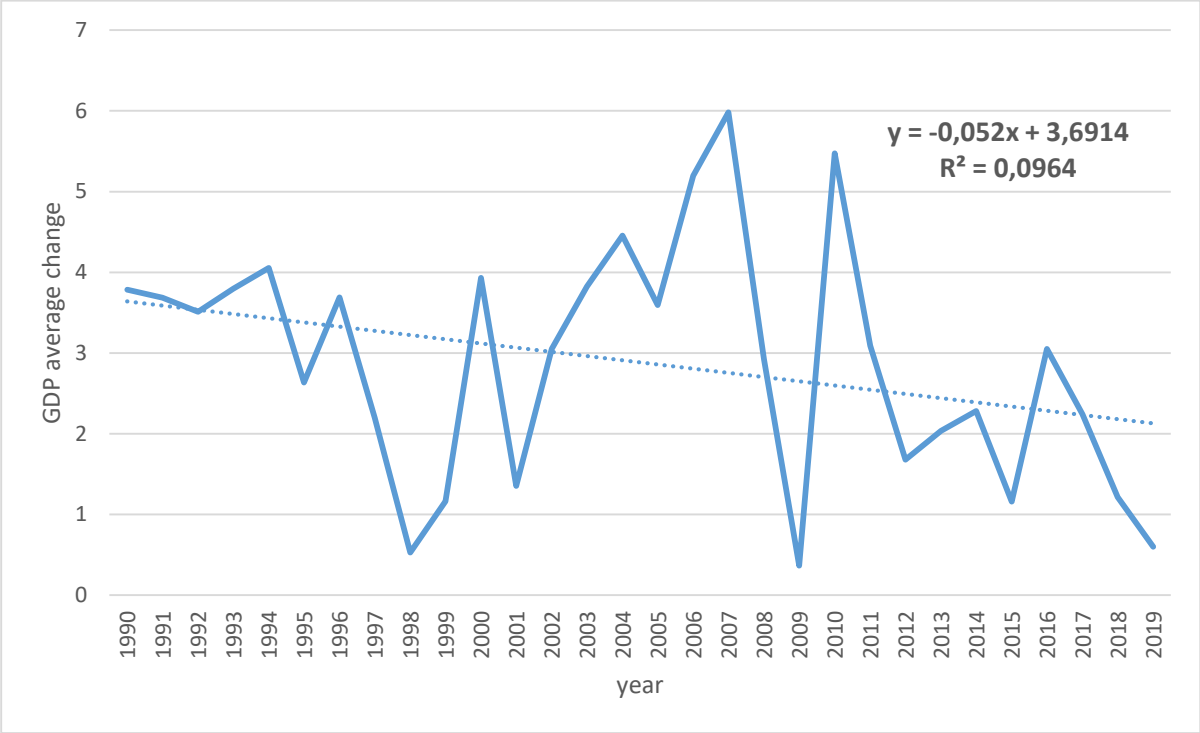

Figure 30: Mean of GDP growth and the linear trend line of high human development countries 1990-2019
Source: Author's own editing based on WDI 2020

I conducted the study by comparing the development of oil prices and the development of GDP growth.

According to the results the price of oil and GDP at several points seem to move together with a minimal time difference as shown in Figure 31. The most striking phenomenon is that from 1990 onwards a loose relationship appears, then they develop in a distinct parallel way until 2009, and then it seems that the opposite movement can be observed.

This assumes that GDP growth is more affected by oil price developments than in very high human development countries. But this, of course, needs to be further explored and further statistical indicators need to be examined.

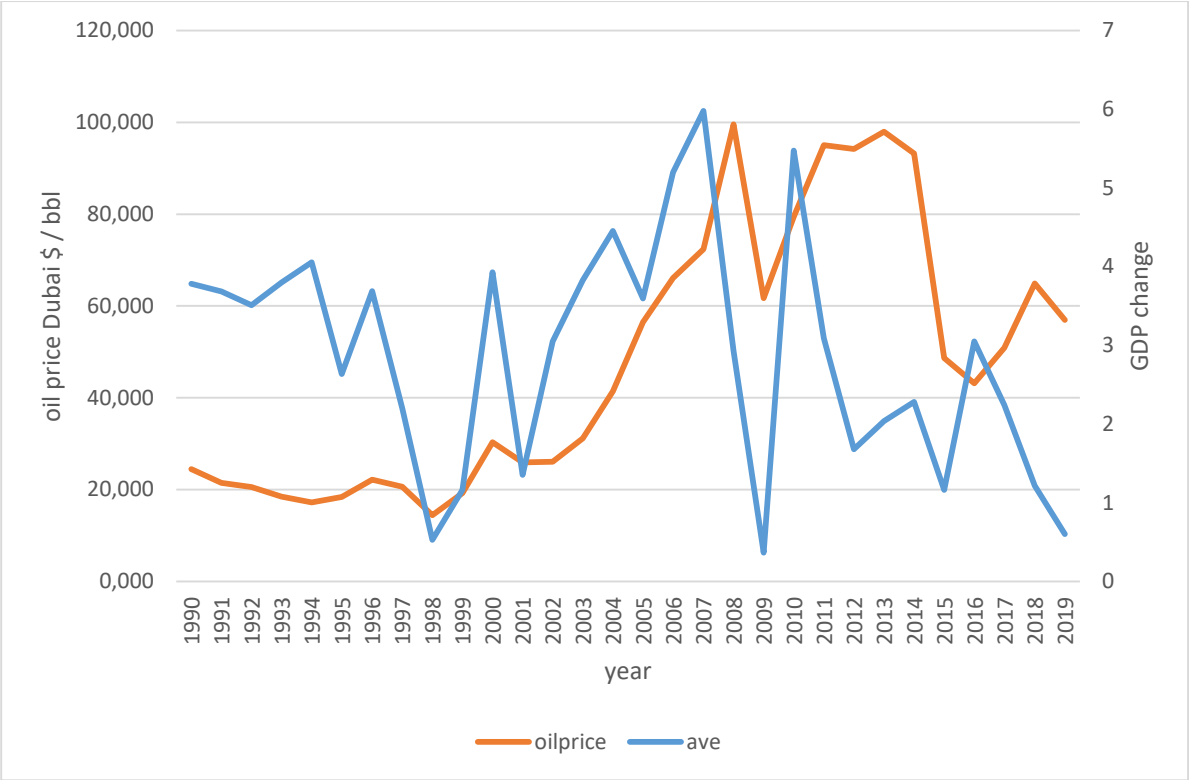

Figure 31: The relationship of oil price and mean GDP growth in high human development countries
Source: Author's own editing based on WDI 2020

As Figure 31 suggests, GDP is more affected by changes in oil prices in high countries than in very high countries.

To confirm the relationship, I first examined the value of the chi-square test as in shown in Table 4. This assumes a relationship between oil prices and GDP that is perceptible but not strong.

Table 4: Chi-Square Tests of very high human development countries

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	930,000[a]	900	,237
Likelihood Ratio	212,907	900	1,000
N of Valid Cases	31		

a. 961 cells (100,0%) have expected count less than 5.

The minimum expected count is 03.

Source: Author's own editing based on WDI 2020

In my research, I examined the correlation coefficient between the change in the GDP growth of each country and the price of oil. Since the Chi square was the same, I assumed I would get similar values here as well.

As shown in Table 5, the correlation coefficient varies widely, but only two countries show a positive relationship: Colombia is 0.477 (p = 0.01), the relationship is closer here than in any of the high human development countries. The other country is Brazil 0.307 (p = 0.05) which is weaker but still detectable.

For the other countries, this relationship is opposite and much weaker than for the very high human development countries, with the highest value -0.254 (p = 0.05) for Iran, which can be considered as a weak relationship and all the other countries can only show a weaker relationship.

My assumption that the relationship seems stronger was not justified. I found that while high human development countries appear to be more strongly associated with changes in oil prices, the strength of the correlation depends more on countries than on their HDI index.

Table 5: The relationship of oil price and GDP growth of high human development countries

Correlations

		Iran	Mexico	Thailand	Colombia	Brazil	China	Egypt	oilprice
Iran	Pearson Correlation	1	,152	,234	,021	-,136	,020	-,018	-,246
	Sig. (2-tailed)		,416	,205	,910	,466	,917	,925	,182
	N	31	31	31	31	31	31	31	31
Mexico	Pearson Correlation	,152	1	-,048	,043	,013	-,066	,071	-,048
	Sig. (2-tailed)	,416		,797	,818	,944	,723	,703	,797
	N	31	31	31	31	31	31	31	31
Thailand	Pearson Correlation	,234	-,048	1	,244	,103	,206	-,196	-,121
	Sig. (2-tailed)	,205	,797		,185	,581	,265	,291	,516
	N	31	31	31	31	31	31	31	31
Colombia	Pearson Correlation	,021	,043	,244	1	,498**	,471**	-,119	,477**
	Sig. (2-tailed)	,910	,818	,185		,004	,007	,523	,007
	N	31	31	31	31	31	31	31	31
Brazil	Pearson Correlation	-,136	,013	,103	,498**	1	,604**	,149	,307
	Sig. (2-tailed)	,466	,944	,581	,004		,000	,424	,093
	N	31	31	31	31	31	31	31	31
China	Pearson Correlation	,020	-,066	,206	,471**	,604**	1	,123	-,009
	Sig. (2-tailed)	,917	,723	,265	,007	,000		,509	,963
	N	31	31	31	31	31	31	31	31
Egypt	Pearson Correlation	-,018	,071	-,196	-,119	,149	,123	1	-,053
	Sig. (2-tailed)	,925	,703	,291	,523	,424	,509		,777
	N	31	31	31	31	31	31	31	31
oilprice	Pearson Correlation	-,246	-,048	-,121	,477**	,307	-,009	-,053	1
	Sig. (2-tailed)	,182	,797	,516	,007	,093	,963	,777	
	N	31	31	31	31	31	31	31	31

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

5.4. Analysing the relationship between oil price and GDP growth in the case of low and medium human development countries

As shown in Figure 32, here is the largest fluctuation among all the groups of countries examined. Iraq's economic indicators fluctuated as a result of the first Iraq-Iran war, and then the Arab Spring caused the great depression. As a result, the two extreme values vary between +53 and -64. In contrast, other countries show a relatively stable value. The most stable country is Kenya. The 2008 economic crisis did not affect their GDP growth as much as the very high or high human development countries.

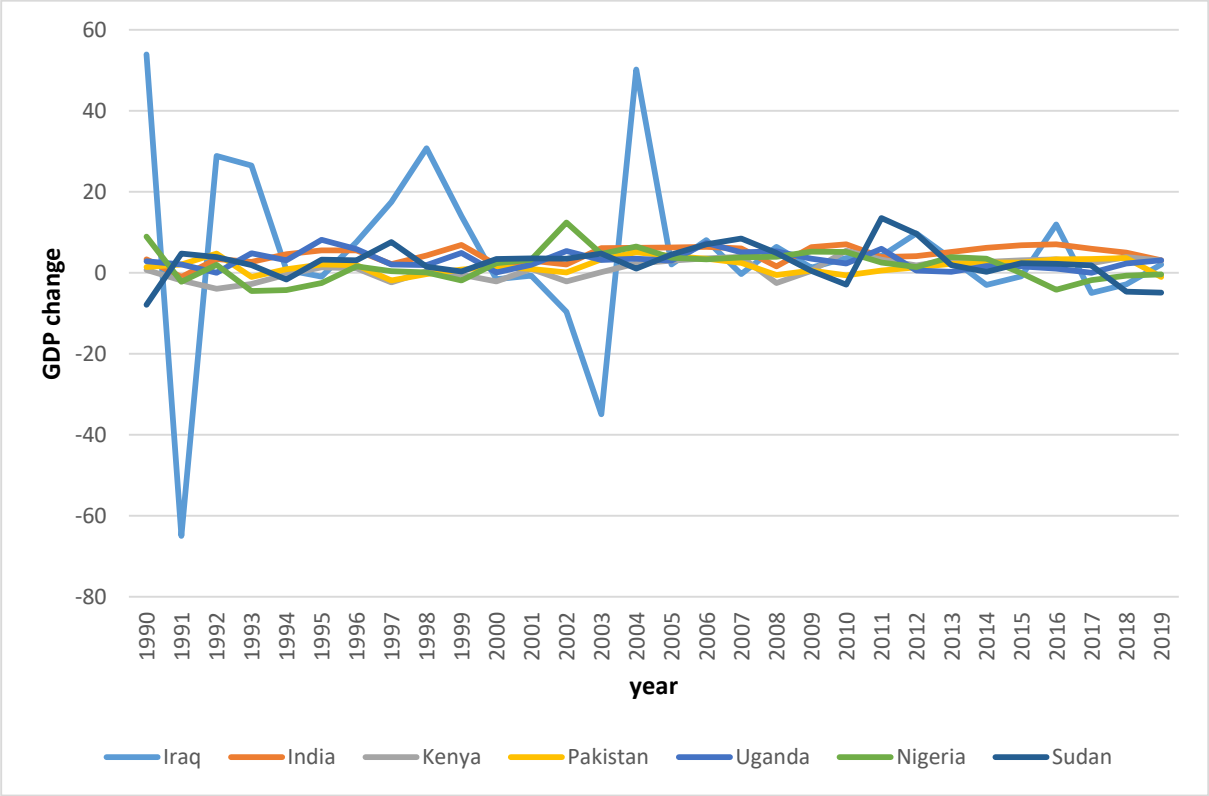

Figure 32: GDP growth change of low and medium human development countries
Source: Author's own editing based on WDI 2020

Representing the mean GDP growth in Figure 33, my statement above was confirmed, as the trend line is the least variable here, with a value of −0.0114x + 3.0579. That is, the average is 3, 0579 and the value of GDP is declining so slightly that its decline is almost barely noticeable. The value of R2 supports this because it is 0.0009. That is, its extent can hardly be detected. If I add the magnitude of the fluctuations and the extreme values that Iraq has taken up as a percentage of GDP, it can be assumed that there is even a slight increase in their GDP growth.

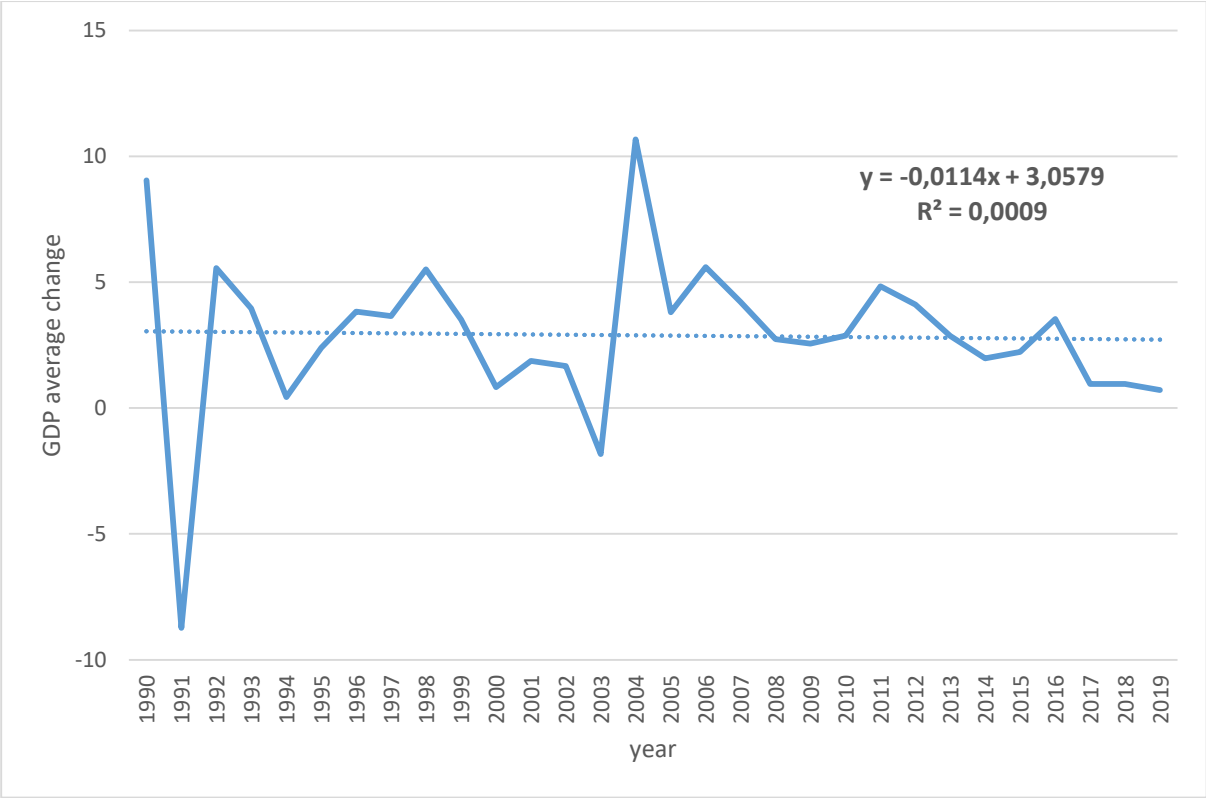

Figure 33: Mean of GDP growth and the linear trend line of low and medium human development countries 1990-2019
Source: Author's own editing based on WDI 2020

Continuing my research, I examined how the annual oil price and mean GDP growth in the low and medium human development countries developed. In contrast to the other types of countries studied, a large difference can be observed here and until 2008 no correlation or relationship can be seen at all on the basis of Figure 34. The crisis of 2008 occurred in 2009 and caused major decline. However, no significant relationship can be seen after that, the impact of the events of 2016 can still be seen in the decline in GDP growth. Based on this, I confirm the assumption that I will not find any link between GDP and oil prices.

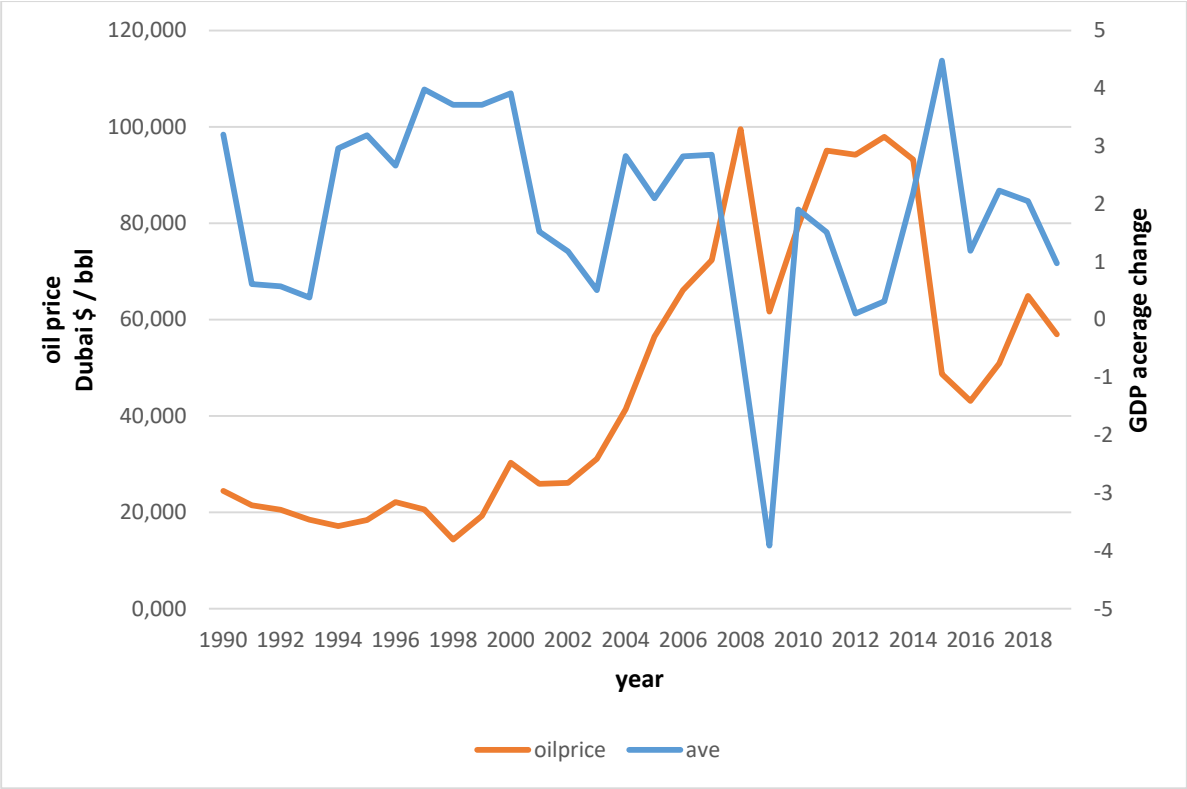

Figure 34: The relationship of oil price and mean GDP growth in low and medium human development countries
Source: Author's own editing based on WDI 2020

To examine my above assumption, I turned to statistical indicators. I first examined what the chi square test showed. As shown in Table 6, we obtained the normal value here as well, i.e. we can expect some relationship between the change in the price of oil and the mean GDP growth, similar to the types of the countries studied.

Table 6: Chi-Square Tests of low and medium human development countries

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	870,000[a]	841	,237
Likelihood Ratio	204,072	841	1,000
N of Valid Cases	30		

a. 900 cells (100,0%) have expected count less than 5. The minimum expected count is 03.

Source: Author's own editing based on WDI 2020

Examining the correlations (Table 7), I obtained opposite results as in the previous analyses. I found that 5 countries had positive relationship and the two negative relationships. Iraq (-0.082, p = 0.05) and Uganda (0.053, p = 0.05) were very weak, almost imperceptible. In contrast, the rate of positive relationships is the highest in Kenya (0.550, p = 0.01). For the other countries, I no

longer found a close relationship, I was given a weak positive value around 0.2 or they approach zero.

Table 7: The relationship of oil price and GDP growth of low and medium human development countries

Correlations

		Iraq	India	Kenya	Pakistan	Uganda	Nigeria	Sudan	oilprice
Iraq	Pearson Correlation	1	,215	,002	-,034	,017	,151	-,246	-,082
	Sig. (2-tailed)		,254	,991	,857	,927	,425	,190	,667
	N	30	30	30	30	30	30	30	30
India	Pearson Correlation	,215	1	,683**	,424*	,081	-,020	-,136	,233
	Sig. (2-tailed)	,254		,000	,019	,672	,917	,475	,215
	N	30	30	30	30	30	30	30	30
Kenya	Pearson Correlation	,002	,683**	1	,283	,027	,045	-,110	,551**
	Sig. (2-tailed)	,991	,000		,130	,888	,814	,564	,002
	N	30	30	30	30	30	30	30	30
Pakistan	Pearson Correlation	-,034	,424*	,283	1	-,177	,042	,039	,040
	Sig. (2-tailed)	,857	,019	,130		,350	,825	,838	,833
	N	30	30	30	30	30	30	30	30
Uganda	Pearson Correlation	,017	,081	,027	-,177	1	,101	,207	-,053
	Sig. (2-tailed)	,927	,672	,888	,350		,596	,272	,781
	N	30	30	30	30	30	30	30	30
Nigeria	Pearson Correlation	,151	-,020	,045	,042	,101	1	-,001	,247
	Sig. (2-tailed)	,425	,917	,814	,825	,596		,996	,188
	N	30	30	30	30	30	30	30	30
Sudan	Pearson Correlation	-,246	-,136	-,110	,039	,207	-,001	1	,226
	Sig. (2-tailed)	,190	,475	,564	,838	,272	,996		,229
	N	30	30	30	30	30	30	30	30
oilprice	Pearson Correlation	-,082	,233	,551**	,040	-,053	,247	,226	1
	Sig. (2-tailed)	,667	,215	,002	,833	,781	,188	,229	
	N	30	30	30	30	30	30	30	30

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Author's own editing based on WDI 2020

By factor analysis I tried to determine what relationship I find for the countries studied and in relation to the factors I found that the value of eigenvalue in Table 8 is valid up to the 8th degree, i.e. this is required to find a relationship with the factors.

Table 8: Factor analysis of examined countries

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4,555	21,688	21,688	4,555	21,688	21,688	3,864	18,401	18,401
2	2,902	13,817	35,506	2,902	13,817	35,506	2,645	12,594	30,995
3	2,359	11,231	46,737	2,359	11,231	46,737	2,224	10,592	41,587
4	2,148	10,231	56,968	2,148	10,231	56,968	2,134	10,163	51,750
5	1,563	7,445	64,412	1,563	7,445	64,412	1,732	8,245	59,995
6	1,426	6,792	71,204	1,426	6,792	71,204	1,719	8,185	68,180
7	1,194	5,683	76,888	1,194	5,683	76,888	1,534	7,306	75,487
8	1,002	4,770	81,657	1,002	4,770	81,657	1,296	6,171	81,657
9	,896	4,266	85,923						
10	,660	3,142	89,065						
11	,569	2,707	91,772						
12	,413	1,969	93,741						
13	,364	1,731	95,472						
14	,286	1,364	96,836						
15	,265	1,260	98,096						
16	,150	,713	98,810						
17	,085	,405	99,214						
18	,082	,390	99,605						
19	,042	,202	99,807						
20	,029	,138	99,945						
21	,012	,055	100,000						

Extraction Method: Principal Component Analysis.

Source: Author's own editing based on WDI 2020

This is confirmed by the scree plot in Figure 35 where the value of eigenvalue also decreases below one at 8, but the curve is also broken at component 4.

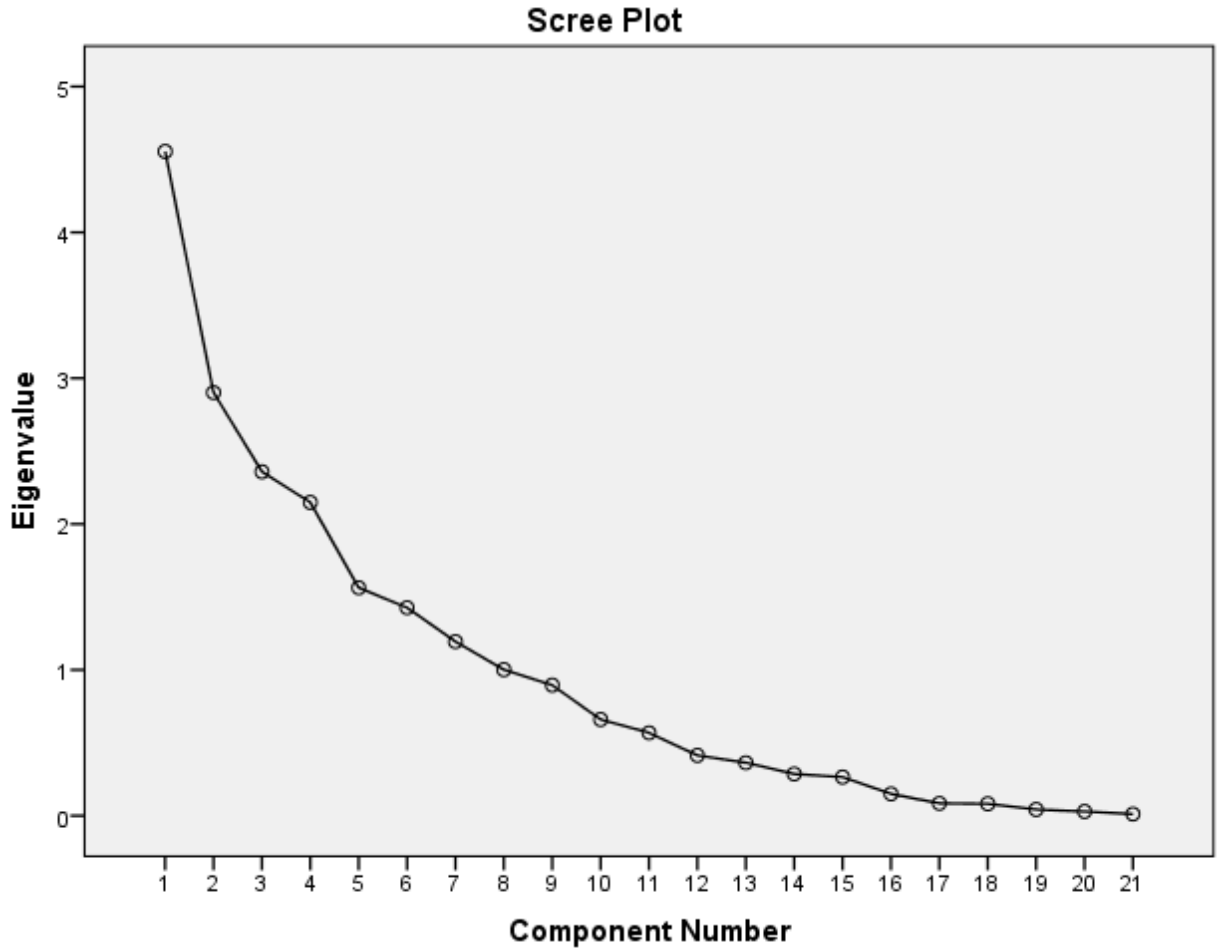

Figure 35: Factor analysis of screen plot
Source: Author's own editing based on WDI 2020

As shown in Table 9 the very high human development countries are all in factor 1, low and medium human development countries are in the last factor. I could not classify the high human development countries in any of the factors, as there are only 6 countries in the 2, 4 and 6 component at a time.

My hypothesis that the impact of oil price changes on GDP growth is less significant in developed countries, and this impact is more significant in developing countries.

Based on my analysis, I conclude that in the case of very high human development countries, the change in the price of oil has the opposite and stronger effect on the development of the GDP growth.. In the case of high-human development countries, this relationship is weaker and opposite. The relationship between the price of oil and GDP growth in low and medium human development countries is significantly weak and can be considered positive. Based on the above H1 hypothesis was not confirmed.

Table 9: The component matrix of the examined countries

Component Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
Netherland	,883	-,177	-,252				-,198	
Switzerland	,878		,207		-,277		,113	
Sweden	,841		,153			-,171	-,204	
Germany	,627	,102		,534	-,346		-,135	-,227
Australia	,600		-,254	-,490	,161	,150		
Mexico	,591	-,157	-,122	,386	-,270	-,111	,337	,132
Norway	,548		-,512	,279	,441		,200	
Egypt	,524			-,513		,221	-,143	
Brazil	,222	,798	-,130	-,151	-,103	-,171		-,252
China		,792	-,182		,345			,193
Colombia		,715	,254	,189			,373	-,106
Uganda	,158	,548	-,135	-,332	,175	,230	-,458	-,164
Ireland	,510	-,543			,350	-,125		
Kenya	,214	,111	,837			-,335		-,200
India	,211		,769	-,273	,378			,185
Pakistan			,531	,453	,434	,153		,329
Iran	,151		,116	,478	-,178	,549	-,405	,247
Nigeria		,241	,287		-,515	,521		,162
Thailand		,253	,104	,460	,386	,478	,128	-,441
Iraq	,383	-,130		-,418		,343	,562	,136
Sudan		,538	-,255	,198		-,366	-,142	,546

Extraction Method: Principal Component Analysis.

a. 8 components extracted.

Source: Author's own editing based on WDI 2020

Finally, I outlined the scatter plot matrix of the countries based on 3 factors:

- on the vertical y-axis I plotted the mean GDP growth of each country based on the amounts achieved during the 30 years under review

- on the x-axis I plotted the values of r2 for the examined countries

- on the z-axis I showed, which HDI classification they belong to (1 = very high, 2 = high, 3 = low and medium)

As Figure 36 shows, China is very different from other countries in all respects and, it is followed by Ireland, where fluctuations in GDP values were also relatively high initially. Iraq differs in mean GDP growth and r2 values because it still had high r2 values. Based on the factors, I can say that the countries in group 1 are more likely to be found together, while the countries in groups 2 and 3 are more diverse.

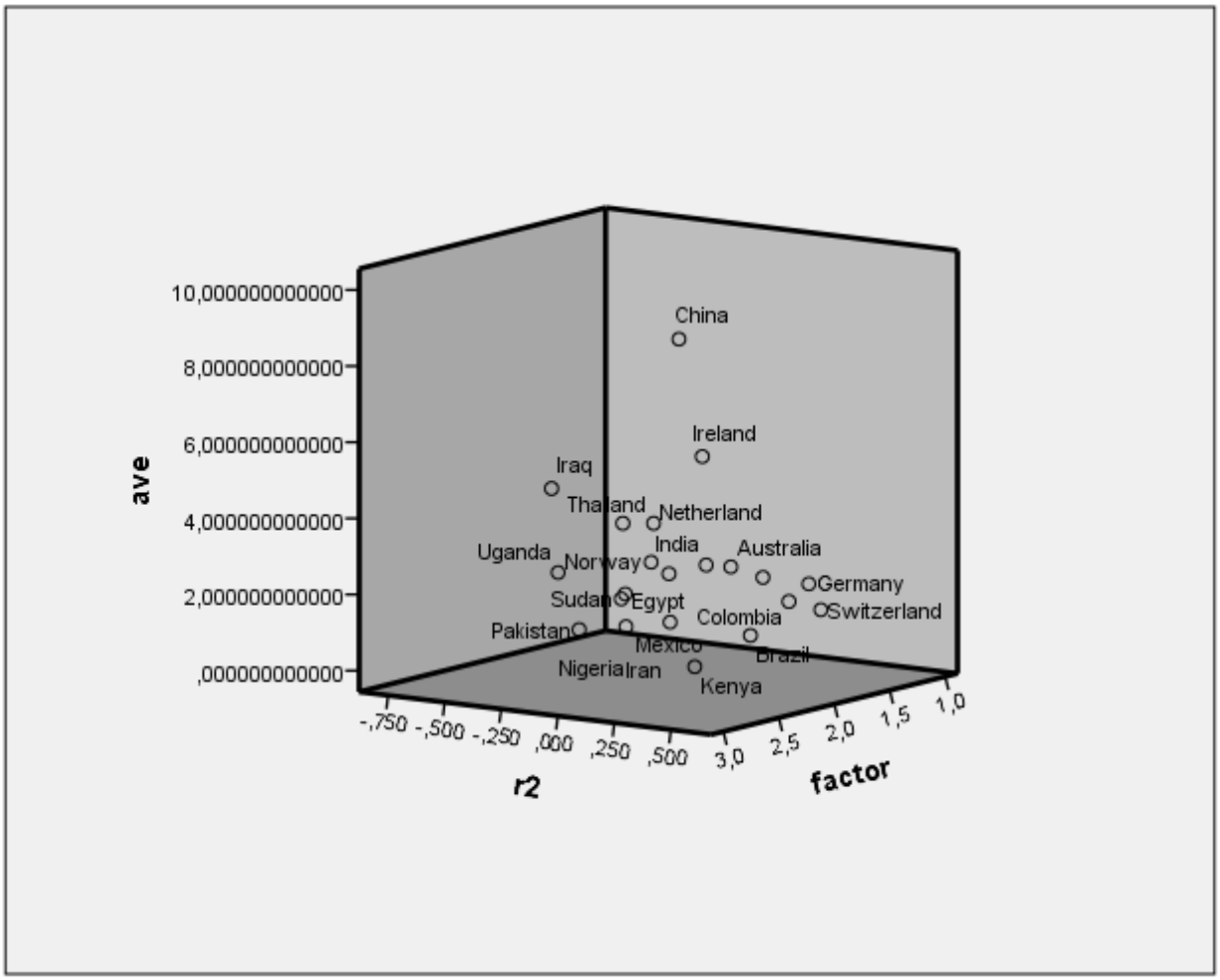

Figure 36: Scatter plot of examined countries
Source: Author's own editing based on WDI 2020

H2: Applying carbon abatement policies will reduce GDP growth in developed countries, but it will rise GDP growth in developing countries

In my research, I examine the relationship I can show between the regulation of carbon emissions and the GDP / capita between developed and developing countries. I assumed applying carbon abatement policies will reduce economic growth and GDP in developed countries, but it will rise economic growth and GDP in developing countries.

I used data from countries ranked by GDP from the CIA database (CIA Factbook 2017), as the database is also used to distinguish between developed and developing countries. The 2017 data were the baseline data, I listed them in Table 10.

Table10: Developed countries analysed

GDP-PPP rank	Country	GDP-PPP in USD (2017 est.)
1	China	$25,360,000,000,000
2	United States	$19,490,000,000,000
3	India	$9,474,000,000,000
4	Japan	$5,443,000,000,000
5	Germany	$4,199,000,000,000
6	Russia	$4,016,000,000,000
7	Indonesia	$3,250,000,000,000
8	Brazil	$3,248,000,000,000
9	United Kingdom	$2,925,000,000,000
10	France	$2,856,000,000,000

Source: CIA 2017

The ranking of the least developed countries has been more difficult to establish because it includes several countries that have recently been recognized or have unreliable data. Thus, in the research, I selected 80-90 rankings from the CIA database in Table 11

Table 11: developing countries analysed

GDP-PPP Rank	Country	GDP-PPP in USD (2017 est.)
80	Ghana	$134,000,000,000
81	Puerto Rico	$130,000,000,000
82	Serbia	$105,700,000,000
83	Panama	$104,100,000,000
84	Turkmenistan	$103,700,000,000
85	Croatia	$102,100,000,000
86	Cote d'Ivoire	$97,160,000,000
87	Lithuania	$91,470,000,000
88	Cameroon	$89,540,000,000
89	Uganda	$89,190,000,000
90	Jordan	$89,000,000,000

Source: CIA 2017

5.5. Analysing GDP growth in developed and developing countries

I first examined the overall performance for the world based on the WDI database from 1995-2019, which I present in Figure 37. A steady and rapid development can be observed in the period under review, with a decline in the period of 2008-2010.

Figure 37: World GDP growth 1995-2019
Source: WDI 2020

In Figure 38 it is immediately apparent that the best-performing countries are divided into two groups, between which I have plotted the average with a solid blue line. The economic crisis of 2008 had an impact on every country, perhaps India is the only country where there is no drop back. Another stand out is China, which has been developing since 2004 and will continue to do so dynamically from the following years.

Comparing Figures 37 and Figure 38, it can be seen that while the decline at the global level was the largest in 2010, it is shorter and less steep in developed countries.

The middle of the figure shows the mean, which almost coincides with the linear trend indicated by the blue dotted colour, which is $y = 323.56x + 19710$ and the degree of linear regression is almost one $R^2 = 0.9769$.

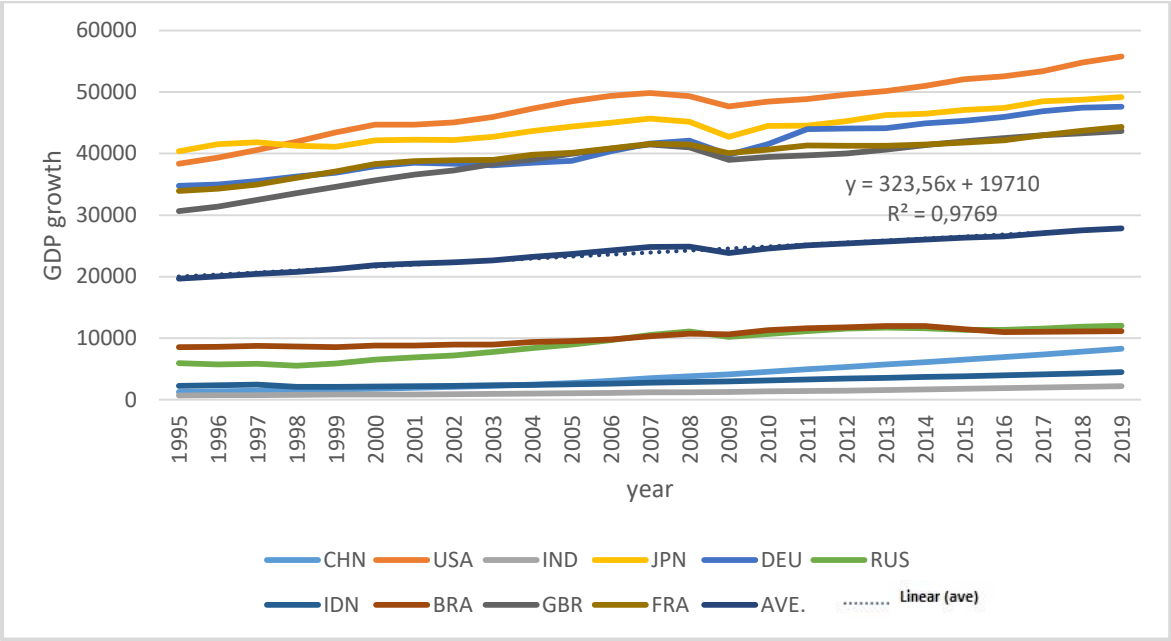

Figure 38: GDP growth in developed countries
Source: Author's own editing based on WDI 2020

Continuing my study with developing countries, I found in Figure 39 that Turkmenistan is the only country whose GPD has risen higher than the other countries, but developing countries have a much more homogeneous characteristic than developed countries.

The value of the trend is y = 169.39x + 2701.8, which is half that of developed countries, but the value of r2, which gives the slope of development, is greater than that of developed countries: R^2 = 0.9862. From this, I concluded that although their GDP growth is lower, their rate of development is somewhat higher than that of developed countries.

This is also confirmed by the appearance of the economic crisis in 2008 in these countries, in the case of Lithuania and Croatia we can see a decline, and Turkmenistan has produced continuous development. And some countries, like Jordan, are showing declining or stagnant progress.

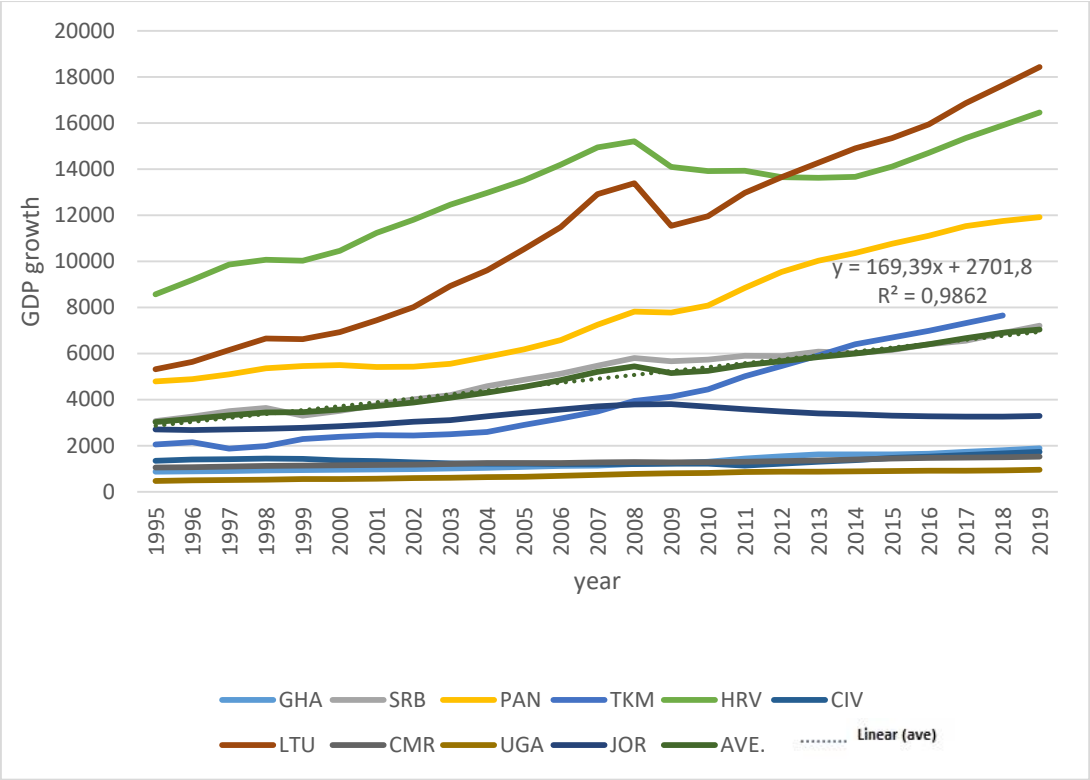

Figure39: GDP growth in developing countries
Source: Author's own editing based on WDI 2020

5.6. Analysing CO2 emissions in developed and developing countries

In the next step, I analysed carbon emissions among developed and developing countries. The amount of total CO2 emissions is given in kilotons I used WDI database (Figure 40).

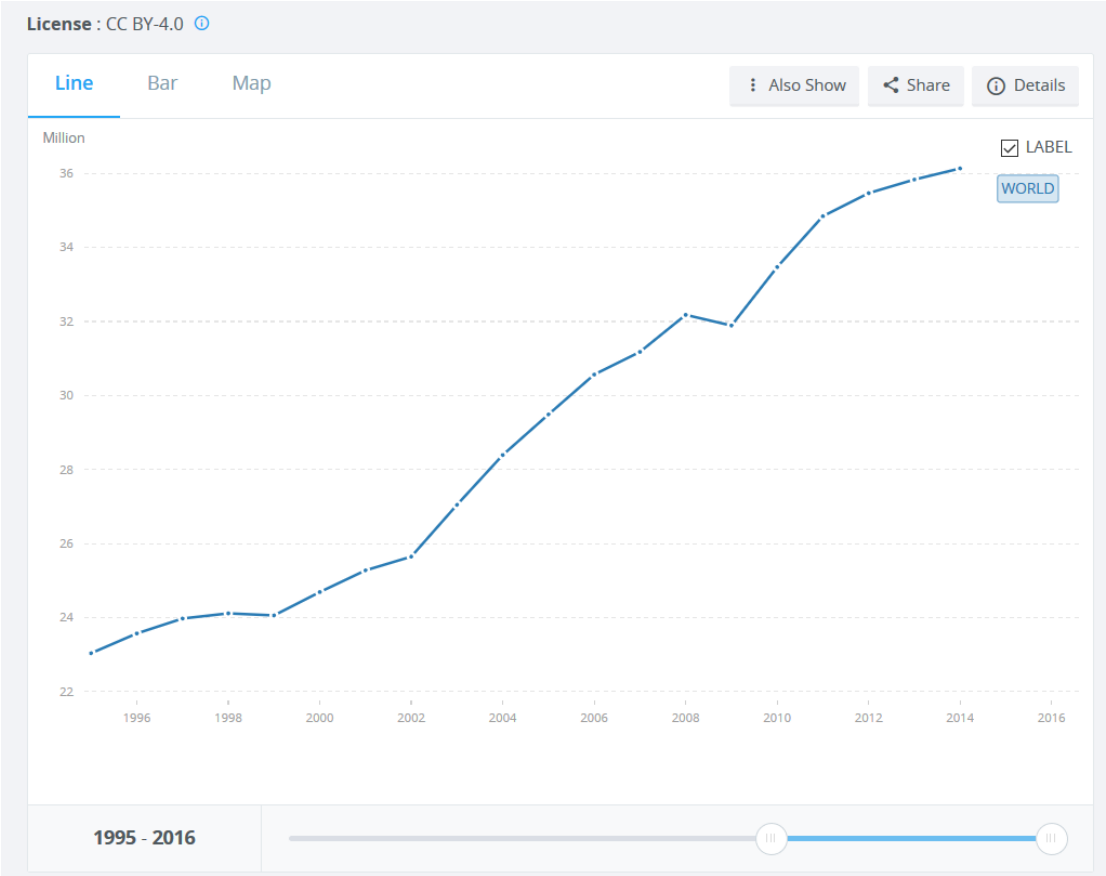

Figure 40: World CO2 emissions 1995-2019
Source: WDI 2020

In the next figure I plotted C02 emissions (kg per 2017 PPP $ of GDP) Although the decrease shown in Figure 41 does not appear to be significant at first because it barely reaches the decrease of 0.1, it can be seen that the decrease is not continuous, but there are fractures in it. A smaller decline is seen in 1998, followed by a relative stagnation, which is broken by a visible decline after 2007, marked by a more significant decline after 2012.

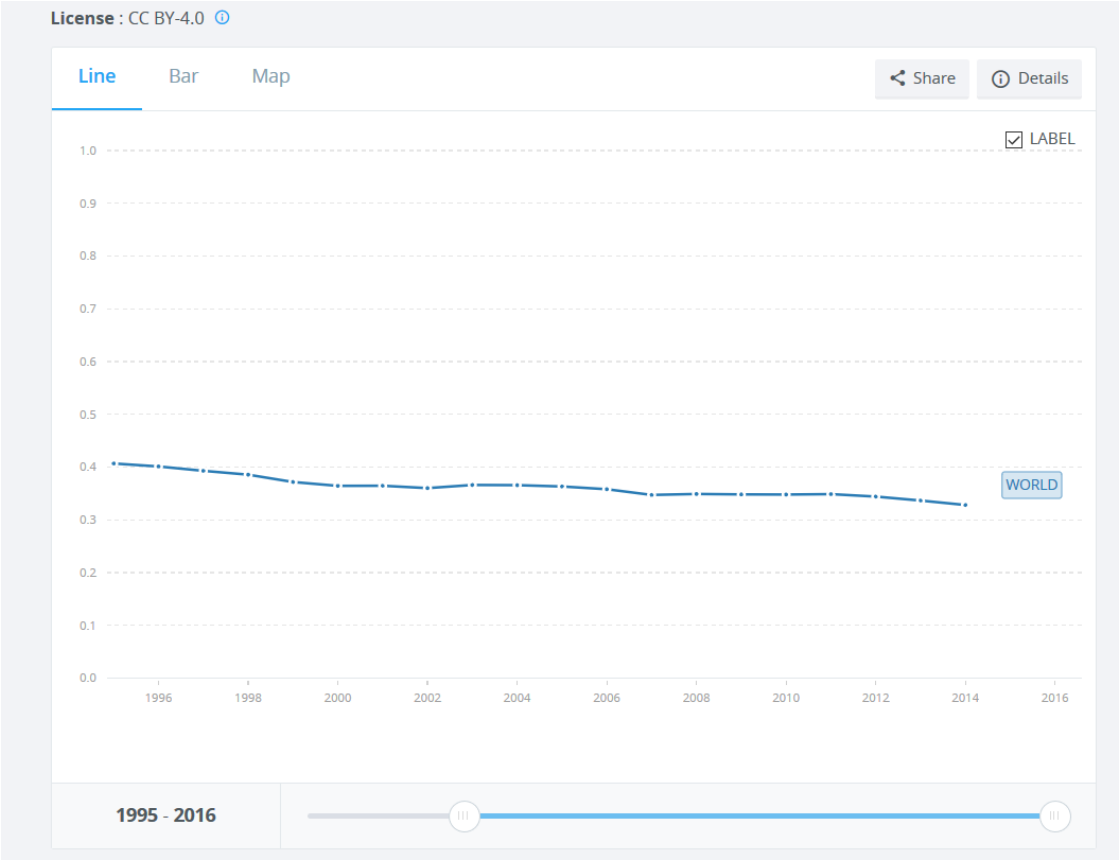

Figure 41: World CO2 emissions (kg per 2017 PPP $ of GDP)
Source WDI 2020

I first examined the CO2 emissions of developed countries between 1995 and 2016 based on the WDI data available to me. The diagram in Figure 42 shows a decreasing trend, which is also supported by the linear trend line, in the trend formula the value of y has a negative sign and r2 does not reach a whole, $y = -0.0066x + 0.4065$, $R^2 = 0\ .9501$. In other words, the environmental burden on developing countries is steadily declining.

The country with the highest environmental impact, as shown in Figure 42, is China, but they are also the ones with the largest reductions over the period, reducing their emissions from nearly 1.2 kg to 0.53 kg. The figure also shows that there were several stagnations between 2002 and 2006. Russia, the second largest CO2, successfully halved its CO2 emissions from 0.84 to 0.46. For France, no data were available for 2015-2016. India and Indonesia are the two countries that have achieved only minimal reductions, also to varying degrees over time.

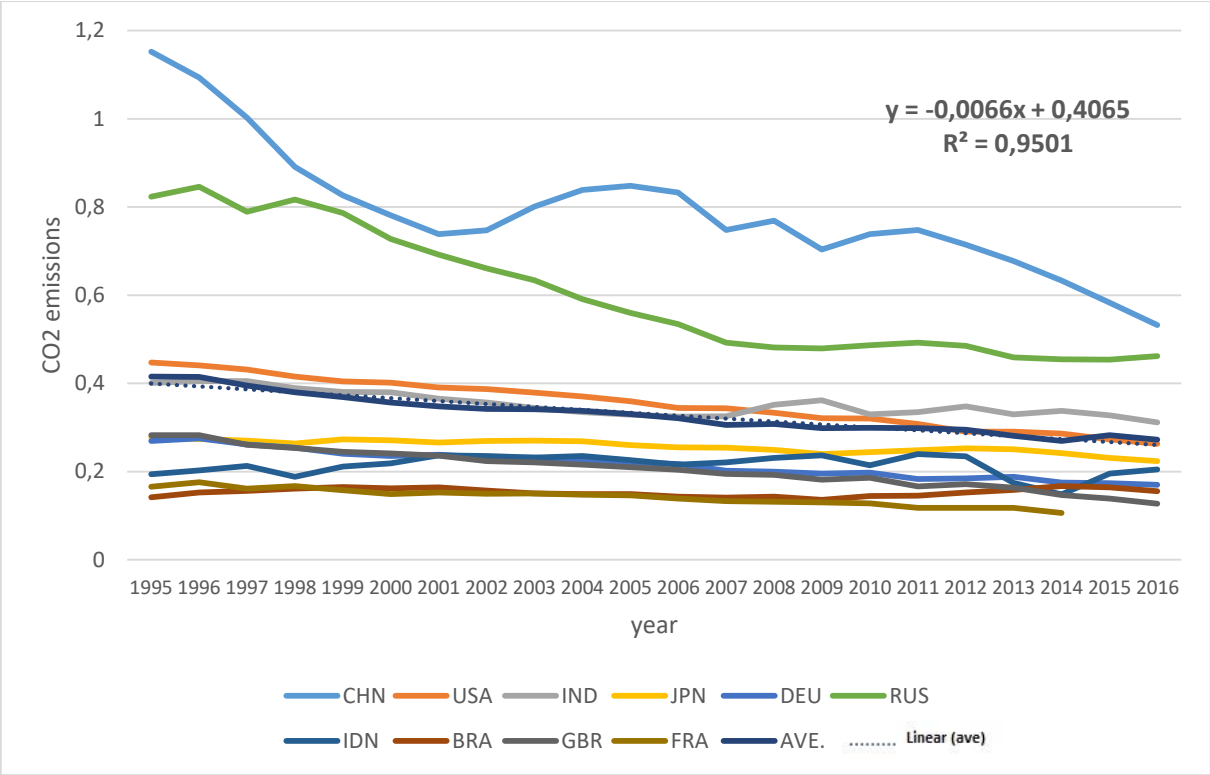

Figure 42: CO2 emissions of developed countries 1995-2016 (kg per 2017 PPP $ of GDP)
Source: Author's own editing based on WDI 2020

As far as developing countries are concerned, we get a better distribution picture based on Figure 43, CO2 emissions are declining, y is also negative and r2 is lower than in developed countries, y = -0.0071x + 0.4034R^2 = 0.881. In the case of Serbia, data were only available from 2006 onwards.

The highest environmental load, was achieved by Turkmenistan, which reached more than 2 kg / PPP in 1995, and by 2016 it had fallen back to 0.91, significantly from 2004 onwards.

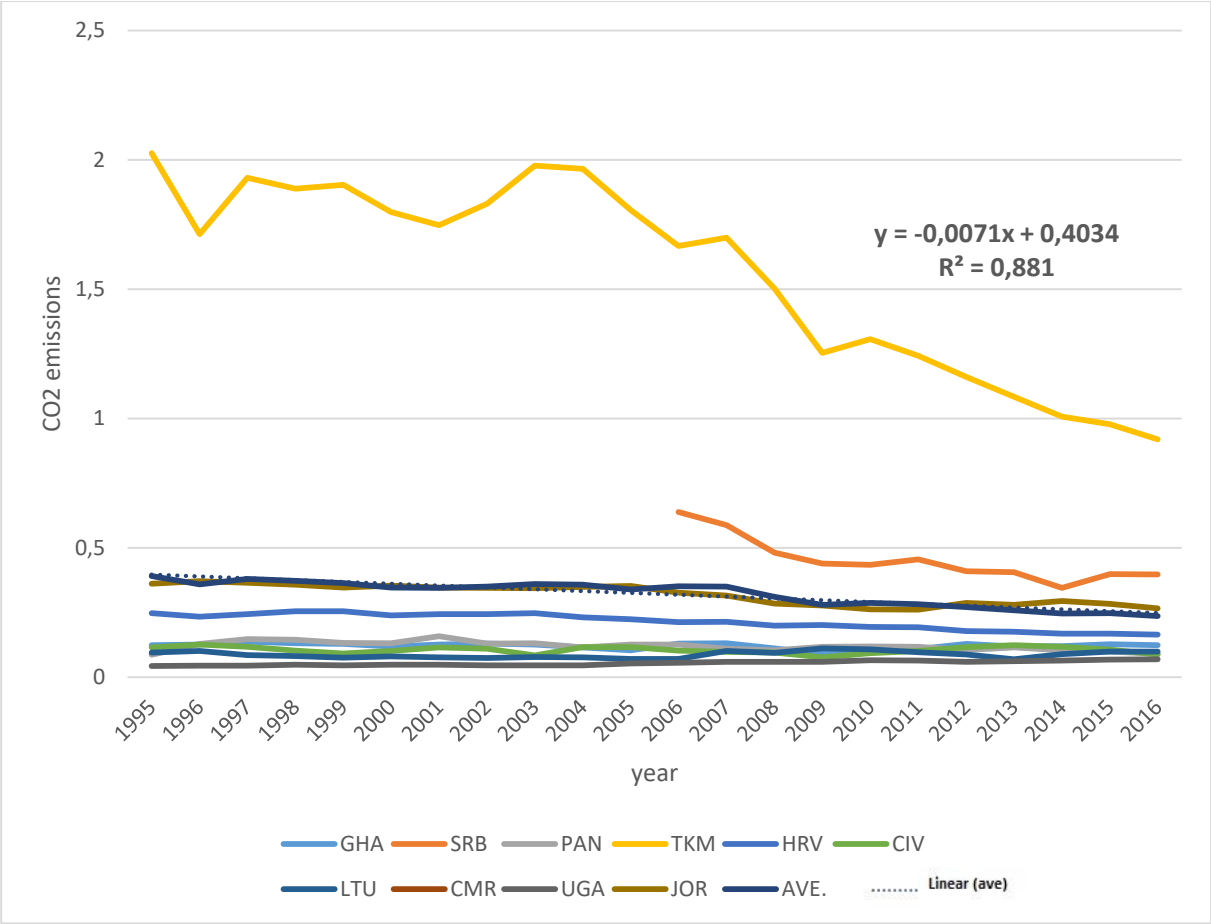

Figure 43: CO2 emissions of developing countries 1995-2016 (kg per 2017 PPP $ of GDP)
Source: Author's own editing based on WDI 2020

We can observe that both high and low GDP countries are experiencing a declining trend in CO2 emissions, despite the fact that global emissions continue to rise sharply.

After examining the data based on GDP, I turn to the hypothesis that developed and developing countries react differently to the environmental agreements and that this will have a demonstrable effect on the extent of GPD.

5.7. Analysing the relationship between GDP growth and CO2 emissions in developed and developing countries

In Table 12, I examined the extent to which average GDP and CO2 varied between countries with different levels of development in each year. We see that while GDP grew steadily in all two types of countries, it stalled in developed countries until 2009 and in developing countries until 2009 and 2010. In contrast, CO2 emissions have fallen steadily, by 65% in developed countries and by 60% in developing countries. Declining emissions were more even than in developed countries, while in 2010 developing countries stalled.

Table 12: GDP and CO2 emission in developed and developing countries

	Developed		Developing	
	AVEGDP	AVECO2	AVEGDP	AVECO2
1995	19670,72	0,416	3024,84	0,391
1996	20018,61	0,415	3166,85	0,359
1997	20460,71	0,395	3311,18	0,380
1998	20764,77	0,380	3442,65	0,372
1999	21212,75	0,369	3451,54	0,363
2000	21884,18	0,357	3562,32	0,347
2001	22145,63	0,348	3727,03	0,346
2002	22322,49	0,342	3877,41	0,350
2003	22633,84	0,341	4079,62	0,360
2004	23188,11	0,338	4306,46	0,357
2005	23662,71	0,331	4559,41	0,339
2006	24270,83	0,321	4841,66	0,352
2007	24845,48	0,305	5211,45	0,350
2008	24874,26	0,308	5443,06	0,311
2009	23841,84	0,298	5154,11	0,280
2010	24557,29	0,299	5244,23	0,287
2011	25083,00	0,298	5497,62	0,282
2012	25376,40	0,295	5664,59	0,271
2013	25700,92	0,281	5847,67	0,258
2014	26030,09	0,270	5999,01	0,246
2015	26321,40	0,282	6181,46	0,247
2016	26563,21	0,272	6396,25	0,236

Source: Author's own editing based on WDI 2020

As Figure 44 shows, the average GPD of developed countries is six times that of developing countries, which by 2016 decreased 4 times.

Based on the chart, I found that GDP grew at a slower rate in developed countries than in developing countries, despite the fact that CO2 emissions changed at almost the same rate.

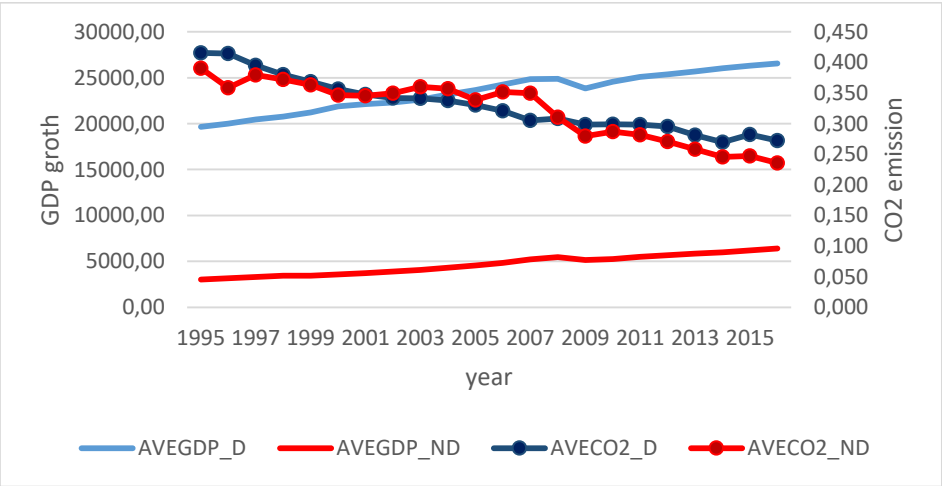

Figure 44: GDP and CO2 emission in developed and developing countries

Source: Author's own editing based on WDI 2020

As I assumed based on Figure 44, the results of the significance test for developed countries in terms of GDP and CO2 emissions according to Table 13 are r = -0.980 (p = 0.01), and among developing countries according to Table 14. based on the table it is lower r = -0.915 (p = 0.01). Based on this, there is a strong negative relationship between GDP and CO2 for both developed and developing countries, but it is stronger for developed countries than for developing ones.

Table 13: significance between the GDP of developed countries and CO2 emissions

Correlations

		AVE.DD	AVE.DDC
AVE.DD	Pearson Correlation	1	-,980**
	Sig. (2-tailed)		,000
	N	22	22
AVE.DDC	Pearson Correlation	-,980**	1
	Sig. (2-tailed)	,000	
	N	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

Table 14: significance between the GDP of developing countries and CO2 emissions

Correlations

		AVE.Developing GDP	AVE.Developing CO2
AVE.Developing GDP	Pearson Correlation	1	-,915**
	Sig. (2-tailed)		,000
	N	22	22
AVE.Developing CO2	Pearson Correlation	-,915**	1
	Sig. (2-tailed)	,000	
	N	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

If we examine the relationship between the GDP of developed and developing countries, we get the result that the relationship between the GDP of developed and developing countries is also significantly strong, but in this case we find a positive relationship r = 0.985 (p = 0.01) as can be read from Table 15. However, in the case of carbon dioxide emissions, this relationship is also strong according to Table 16, but lower r = 0.879 (p = 0.01) and also positive.

Table 15: significance between the GDP of developing and developed countries

Correlations

		AVE.Developed GDP	AVE.Developing GDP
AVE.Developed GDP	Pearson Correlation	1	,985**
	Sig. (2-tailed)		,000
	N	22	22
AVE.Developing GDP	Pearson Correlation	,985**	1
	Sig. (2-tailed)	,000	
	N	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

Table 16: significance between the CO2 emissions of developing and developed countries

Correlations

		AVE.DevelopedCO2	AVE.Develpoing CO2
AVE.DevelopedCO2	Pearson Correlation	1	,879**
	Sig. (2-tailed)		,000
	N	22	22
AVE.Develpoing CO2	Pearson Correlation	,879**	1
	Sig. (2-tailed)	,000	
	N	22	22

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

Based on this, I can conclude that developed and developing countries show a strong opposite relationship between GDP and CO2 emissions, i.e. the higher their GDP, the lower their CO2 levels will be. If GDP increases, so does CO2. In the case of developing countries, the relationship is also similar, but it is weaker, meaning that it is less related to the evolution of GPD.

Our hypothesis was that carbon regulations affect the GDP of developed countries in a way that their GDP is decreasing. This part of my hypothesis was confirmed, however in the case of developing countries, my assumption that the decrease of CO2 emission will increase GDP was not justified. Based on this H2 hypothesis was partially confirmed.

H3: By applying carbon abatement policies total petroleum and coal use will drop and natural gas and renewable energy use will intensify in both developed and developing countries.

I examined the data over a time line to see how they change between 1991 and 2019. For the countries included in the study, the data were not always clear, as some countries, such as Germany, were only established in their current form after 1990, while other countries had such minimal incontinence that they did not have substantive data to include in the research. Although the database has been available to me since 1965, some of the energy sources studied only got a role later, such as renewable energy sources.

The 4 consumption factors I examined were as follows:

- coal and coke consumption, in this case pure coal was examined, lignite and other impure substances such as anthracite were excluded from the data used in the research. In this case, the rate is mst / year.

- Petroleum consumption, in which I also examined the total consumption. Its unit is Mb / d

- the natural gas in which the dry natural gases are viewed for each country and is measured in bcf

- renewable energy sources, which in this case I was able to use our world in Data data, as only indirect or inherited data tables were available to me. Renewable energy sources consist of several components, such as hydropower, solar or wind. its unit of measurement can be measured by the electricity it produces: twh (terawatt / hour)

In the research I included the countries I present in table 17.

Table 17: Countries and their HDI index

country	HDI
Australia	very High
Switzerland	very High
Germany	very High
Ireland	very High
Netherlands	very High
Norway	very High
Sweden	very High
Brazil	High
China	High
Colombia	High
Egypt	High
Iran	High
Mexico	High
Thailand	High
India	Low
Iraq	Low
Kenya	Low
Nigeria	Low
Pakistan	Low
Sudan	Low
Uganda	Low

Source: HDR 2020

5.8. Analysing natural gas consumption in developed and developing countries

In Figure 45 I have shown how the natural gas consumption of the studied countries changed and the bar chart shows how much their total natural gas consumption is. I found that in almost all countries, 2004 was a year of stagnation. In the case of China, the consumption of natural gases

increased dynamically the most after 2009 throughout the period under review. The other country that has steadily increased its reliance on natural gas is India, where looking closely at the period 2009 and 2003, I have seen a sharp increase in their consumption in the years that followed. For some countries with very high human development index, such as Germany, I have seen a marked decline. Overall, I found a steady increase in natural gas consumption, with $R^2 = 0.966$ and $p = 0.05$.

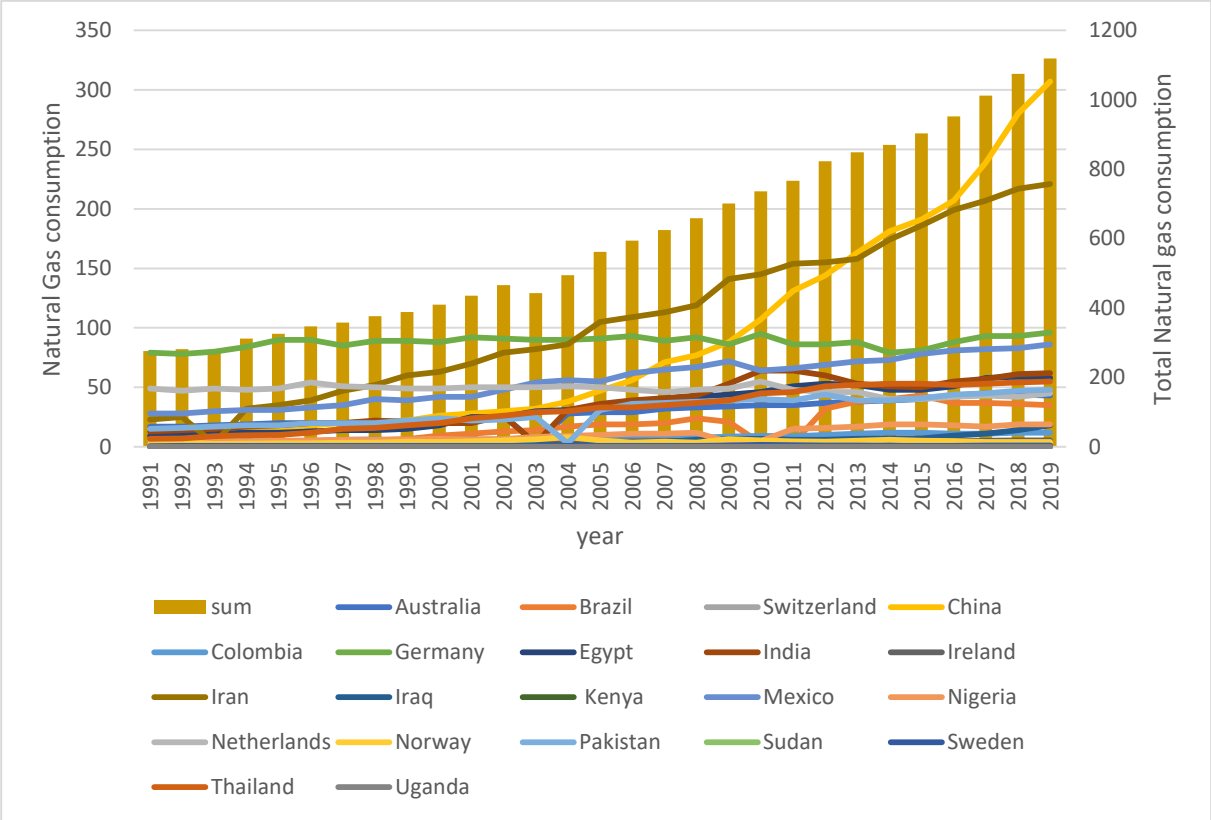

Figure 45: Natural gas consumption between1991-2019
Source: Author's own editing based on WDI 2020

5.9. Analysing renewable energy consumption in developed and developing countries

It can be clearly seen from Figure 46 1 that the consumption of renewable energy sources is not increasing to the extent I expect and seems to stagnate in all cases. Norway is the world's largest user of renewable energy, much higher than any other country. The figure also shows how much its consumption is higher than that of any developed country.

The analysis of the data also shows that consumption fluctuates greatly in most countries, which is particularly interesting in Switzerland and Sweden. Switzerland barely reached 3.69 in 2010, before rising almost tenfold in the years that followed. But I also found the same fluctuation in the sum column containing all the data, which clearly shows a cyclicality of 5 years, except for the period after 2015.

Examining all the data, the degree of the correlation coefficient inferred from the trend line was $R^2 = 0.5015$, $p = 0.05$, i.e. we can see an increase, but this is not so significant.

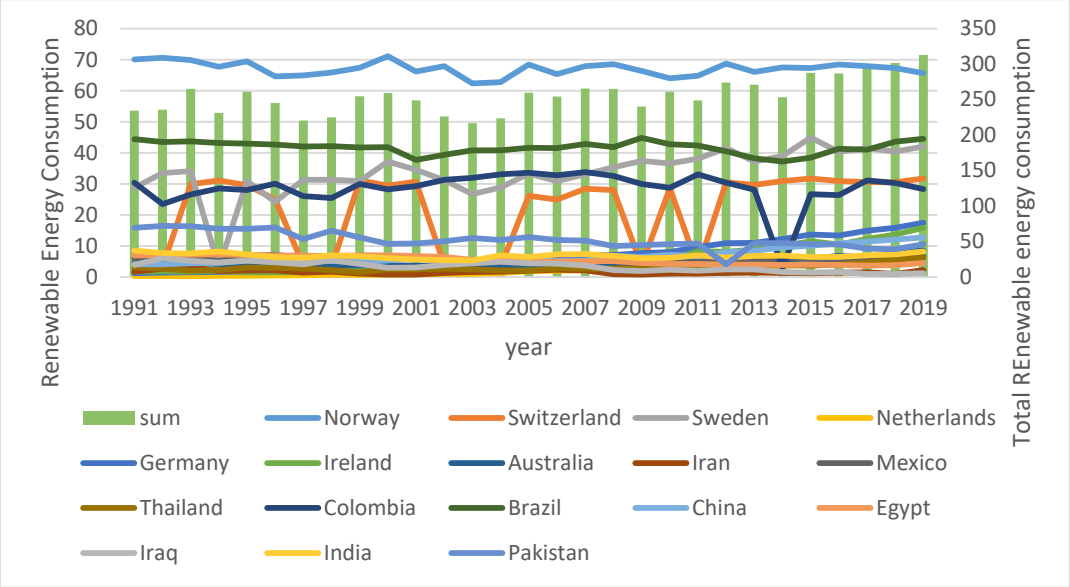

Figure 46: Renewable energy consumption 1991-2019
Source: Author's own editing based on WDI 2020

5.10. Analyzing petroleum consumption in developed and developing countries

Figure 47 shows petroleum consumption for the analyzing period.

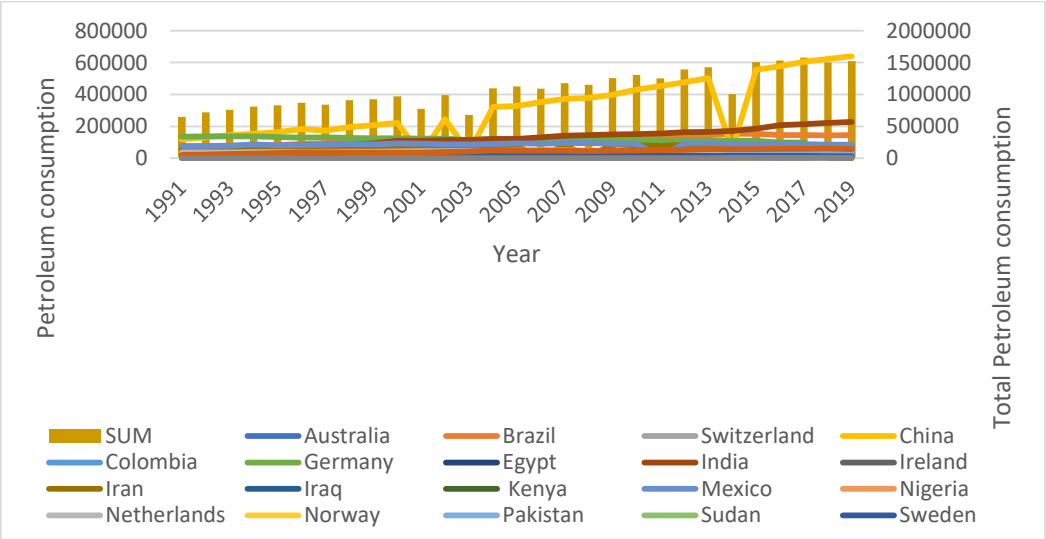

Figure 47: Petroleum consumption 1991-2019
Source: Author's own editing based on WDI 2020

As shown in the figure, world consumption of petroleum was significantly affected by Chinese consumption, after 2001, China's entry into the world market, its impact on liquid fuel increased sharply. As China's consumption demand grew, so did total consumption, and it can be seen from the bar chart that a stagnation was observed in 2018 and 2019 nonetheless, the use of petroleum has steadily increased.

The significance level in this case is $R^2 = 0.842$, $p = 0.05$, which shows a strong co-effect when examining the total consumption.

Examining the chart, I would like to highlight my next observations.

- India, like China, has steadily increased its consumption of petroleum.

- Petroleum consumption in high HDI countries is relatively low.

- The less developed a country is, the more vulnerable it is to petroleum.

5.11. Analyzing coal and coke consumption in developed and developing countries

Consumption of coal and coke (Figure 48) shows a very similar movement to petroleum consumption. I examined the value of r2 and found a value of $R^2 = 0.816$, $p = 0.05$, i.e. it almost coincides with the consumption of petroleum.

Based on this, I concluded that the consumption of petroleum and coal is strongly influenced by Chinese consumption.

A sharp fall was observed in 2006, which was not followed by a consumption shock caused by the post-2008 global economic crisis. In 2018, it was significantly affected by India in terms of total consumption, which is not compensated by China because a slower pace of consumption was also observed there.

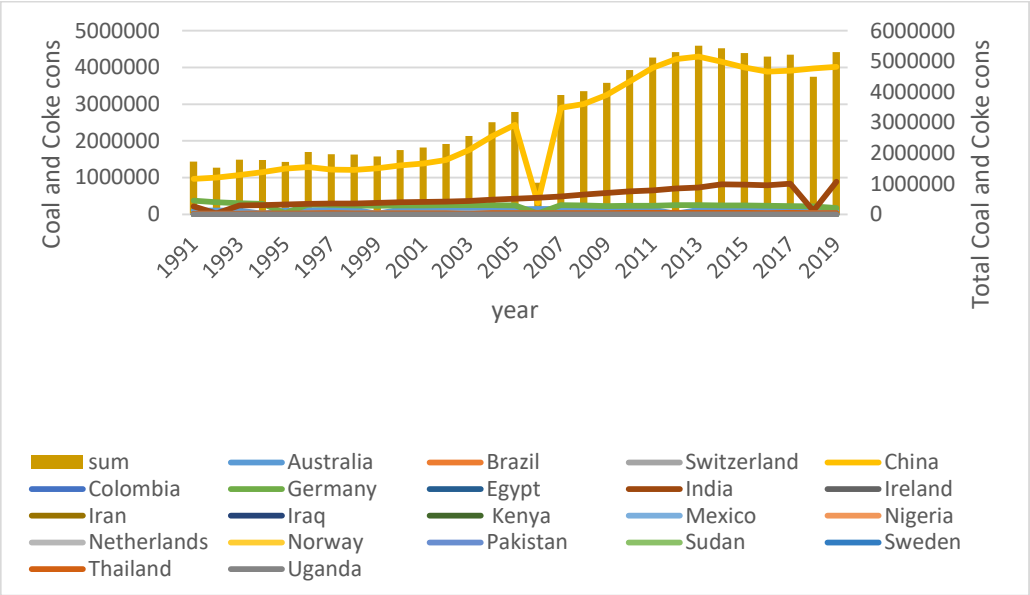

Figure 48: Coal and coke consumption 1991-2019
Source: Author's own editing based on WDI 2020

Returning to my research question, I examined the extent to which the decline in non-renewable energy sources and the increase in renewable energy sources can be demonstrated using the above figures and comparing the data.

I took into account the value of r2 presented in each description.

It can be clearly seen from Table 18 that the value of r2 is quite variable and shows a strong correlation between the consumption of each factor and the progress over time. Based on this, I

was able to show the strongest correlation when examining natural gases, as the relationship between them is very strong there. But in the case of coal, coke and petroleum can also be considered as a significant relationship.

Table 18:R2 value of examined elements

element	***r2 value (p=0,05)***
coal and coke	$R^2 = 0,816$
petroleum	$R^2 = 0,842$
renewable energy	$R^2 = 0,501$
natural gas	$\mathbf{R^2 = 0,966}$

Source: Author's own editing based on WDI 2020

Renewable energy sources showed less significant relationship during the period under review. Based on the above H3 Hypothesis was not confirmed.

H4: The Montreal Protocol and its extensions on Substances that Deplete the Ozone Layer has reduced ozone depleting substances in the atmosphere and has produced significant environmental benefits to protect the earth's ozone layer

In my research, I examined the relationship I can find between countries with different human development index and the change in CFC emissions. Which type of country has reduced its CFC gases the most in the period available to us and how this has reduced the size of the ozone hole in the northern hemisphere.

For the research, I used the data of the UN environmental program Ozone secretariat.

I examined country groups according to HDR classification as it was used in Hypothesis 1. I could not find specific data for the EU Member States, as the UN only examined EU countries together so I had to replace a significant part of the EU countries.

5.12. Analysing CFC emissions in very high human development countries

The following countries were examined in this group:

Norway

Japan

Switzerland

Singapore

New Zealand

Australia

Canada

As Figure 49 shows, there are very large differences between countries over the period under review and a significant decrease has been observed since 1996. I will use this as the base year later on.

Figure 49 shows the significant amount of CFC consumption of Japan. In 1989, it approached 150,000 in ODP tonnes or in CO2-eq tonnes. With this, it was the 3rd most emitting country in the period under review, ahead of only the US and the EU combined.

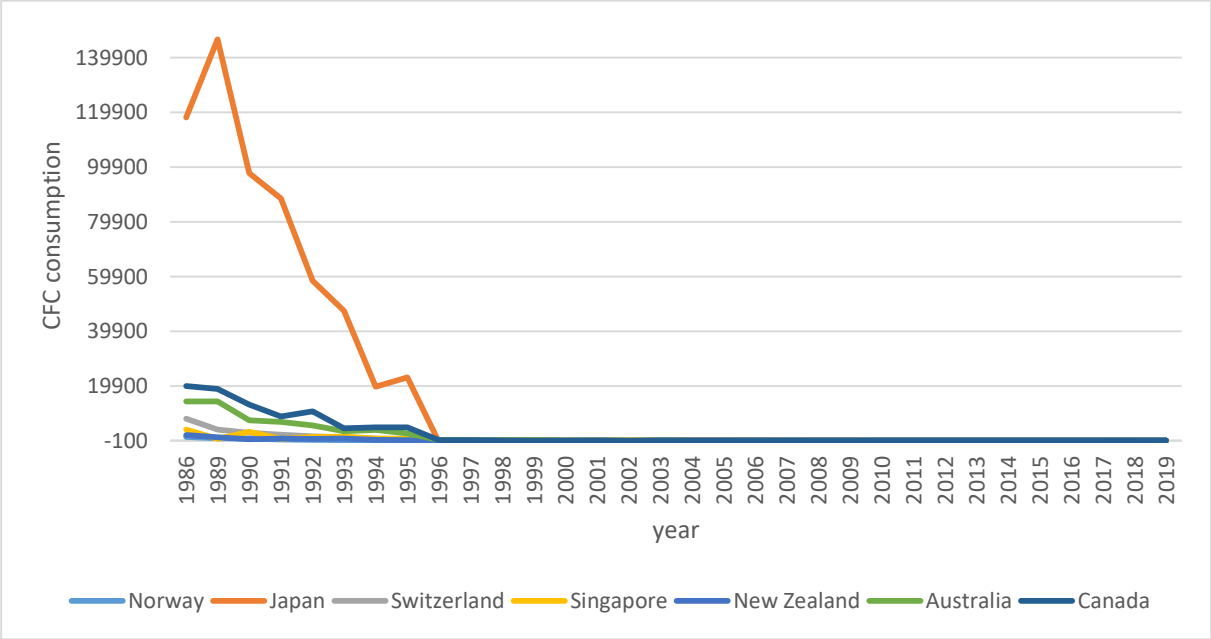

Figure 49: CFC emission of very high human development countries 1986-2019
Source: Author's own editing based on WDI 2020

As the data table would be difficult to analyse due to the large number of data, I first examined the period from 1986 to 1996. Figure 50 shows that the most significant decline was achieved by Japan, which continued to reduce its emission after its peak in 1989 until 1996, when it appears to have reached the level reached by others.

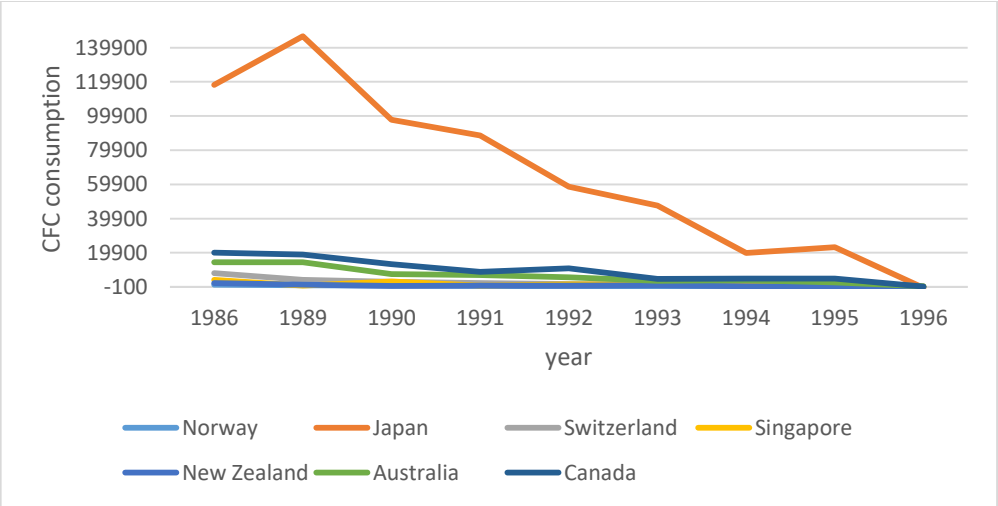

Figure 50: CFC emission of very high human development countries 1986-1996
Source: Author's own editing based on WDI 2020

As the data are significantly influenced by the measure given by Japan, I have already plotted the values in Figure 51 without Japan, also showing the trend line, which includes the average along with Japan, and this was taken into account in my research.

In order to better present the data in Figure 3, so the data has already visibly shifted to a negative value, it will be Japan that first reduced its CFC emissions to -614 in 1996, and Switzerland in Figure 3. will be the other country.

Therefore, the trend line is characterized by a strong negative decrease, its value is: y = -3276.2x + 28885, which is supported by the value of R2, i.e. I found a strong relationship between how the emission of CFCs decreased over the years, its value: $R^2 = 0.9538$

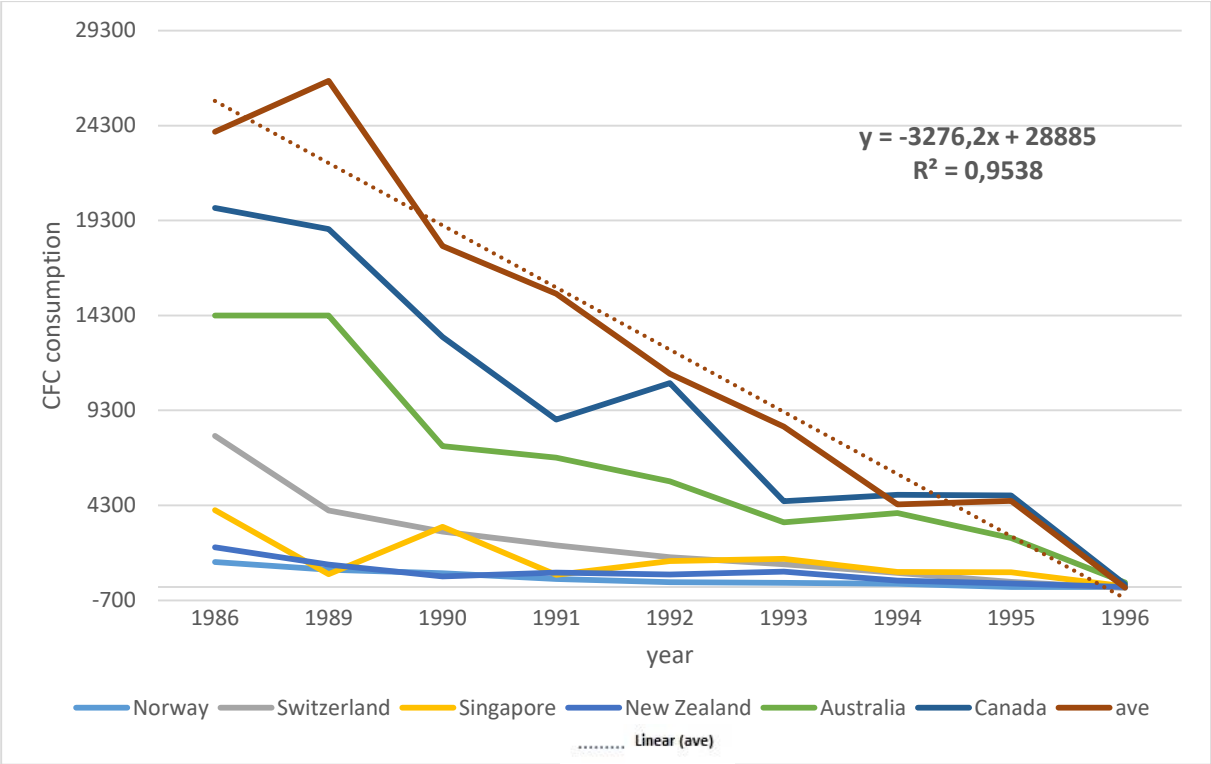

Figure 51: CFC emission of very high human development countries without Japan 1986-1996
Source: Author's own editing based on WDI 2020

As the period under study covers the period up to 1996, I have continued to look at the evolution of the data and, as shown in Figure 52, the data are more balanced here and the values allowed me to represent all 7 countries together.

Initially, Australia also showed much higher-than-average values, but after 1999, it also drastically reduced its CFC emission, and then shifted it significantly. The other extreme country is Japan, it reached a negative peak, although not as much as in 1996, but only fell to -271.

The trend seemed to slow down during the period under review and its value was halved on the x-axis y = -1.472x + 2.8877, which is also reflected in the value of r2, because it was also more than halved: $R^2 = 0.4006$

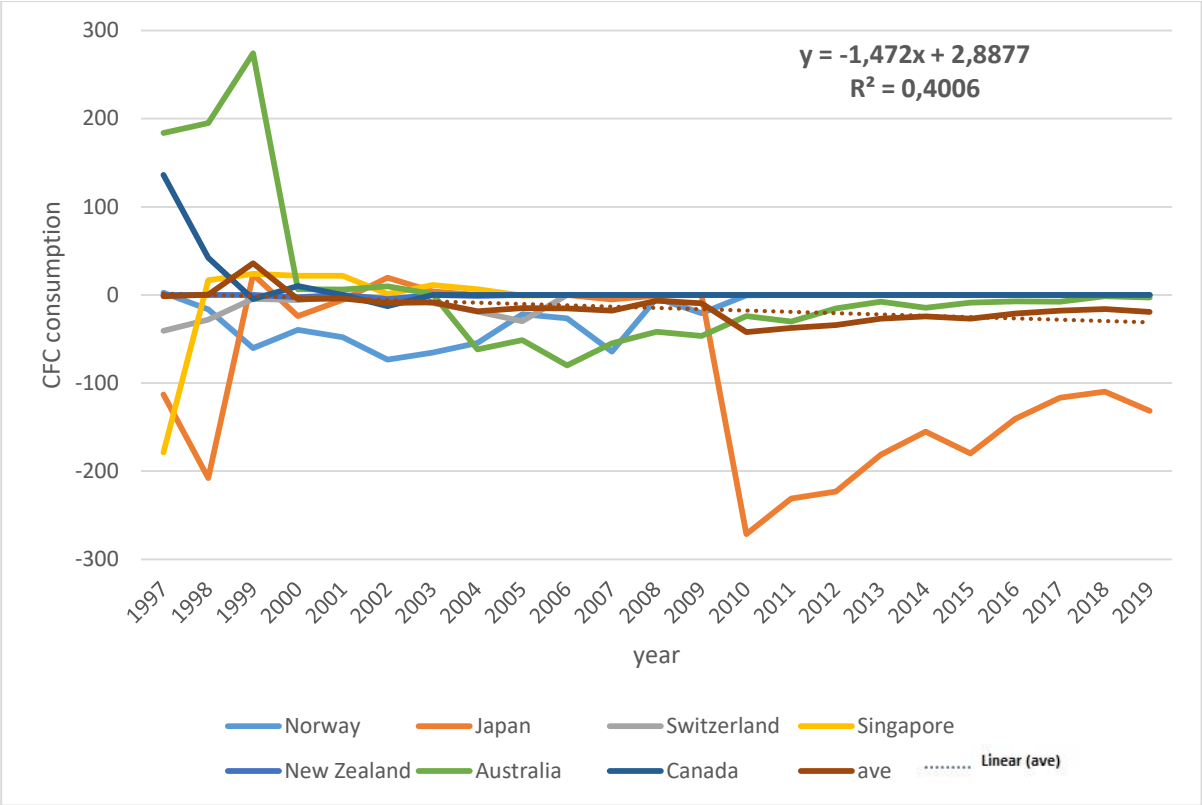

Figure 52: CFC emission of very high human development countries 1997-2019
Source: Author's own editing based on WDI 2020

5.13. Analysing CFC emission in high human development countries

The following countries were examined in this group:

Iran

Mexico

Thailand

Colombia

Brazil

China

Egypt

As it can be seen in Figure 53, there are some outstanding values but they are not as high as in the case of Japan.

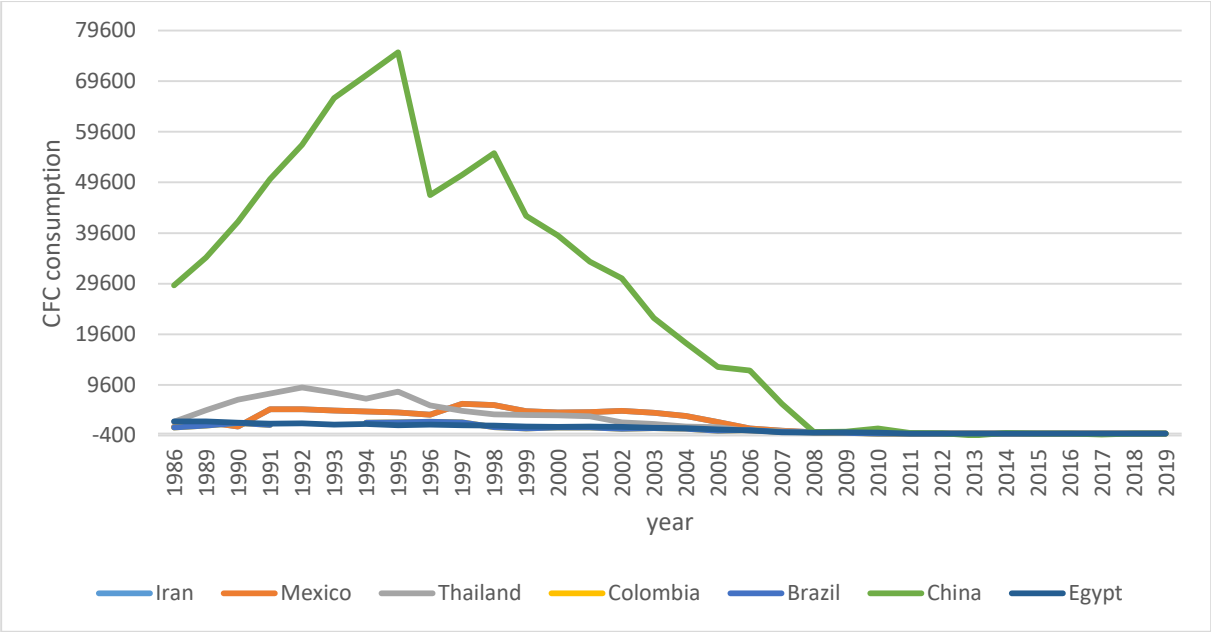

Figure 53: CFC emission of high human development countries 1986-2019
Source: Author's own editing based on WDI 2020

I split the time line and, for the sake of comparability, into the same period between 1986-1996 and 1997-2019.

Figure 54 shows that the trend of emission increased slightly between 1986 and 1996, compared with the very high HDI countries, as this period was the most significant decrease. China is the dominant largest consumer during the period, there is no significant decrease in Thailand either. The average is relatively high, rising towards the values of the other countries studied, and peaked in 1993. The value of the trend is: y = 884.95x + 6730.9, ie the degree of slight increase on the x-axis shows a stronger displacement along the y-axis. The value of r2 is also relatively low but positive: $R^2 = 0.3731$, i.e. the values of the examined are less in line with the trend line.

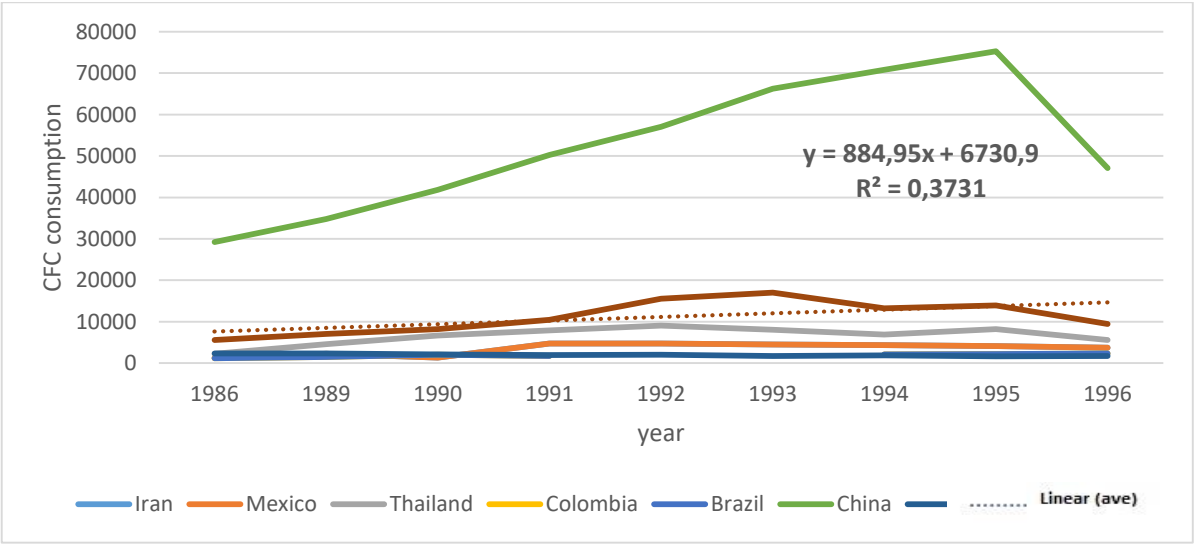

Figure 54: CFC emission of high human development countries 1986-1996
Source: Author's own editing based on WDI 2020

Based on the data shown in Figure 55, China reached a second peak in 1998 and has continuously reduced its consumption of CFCs since then. China has clearly taken the issue of CFC emisssion seriously after 2008 and even though it has been high for a while compared to other countries, we can see lower values than its previous figures. Examining the other countries, we can see that after 2010 the value dropped to zero everywhere, before that even Iran, Mexico and Egypt had a positive emission balance. The trend here is already reversing and turning negative, but it is considered low because it is almost halved in the negative direction as in the period closing 1996 and its value is y = -498.11x + 8891.4. However, the value of r2 became higher, more than double: $R^2 = 0.8139$

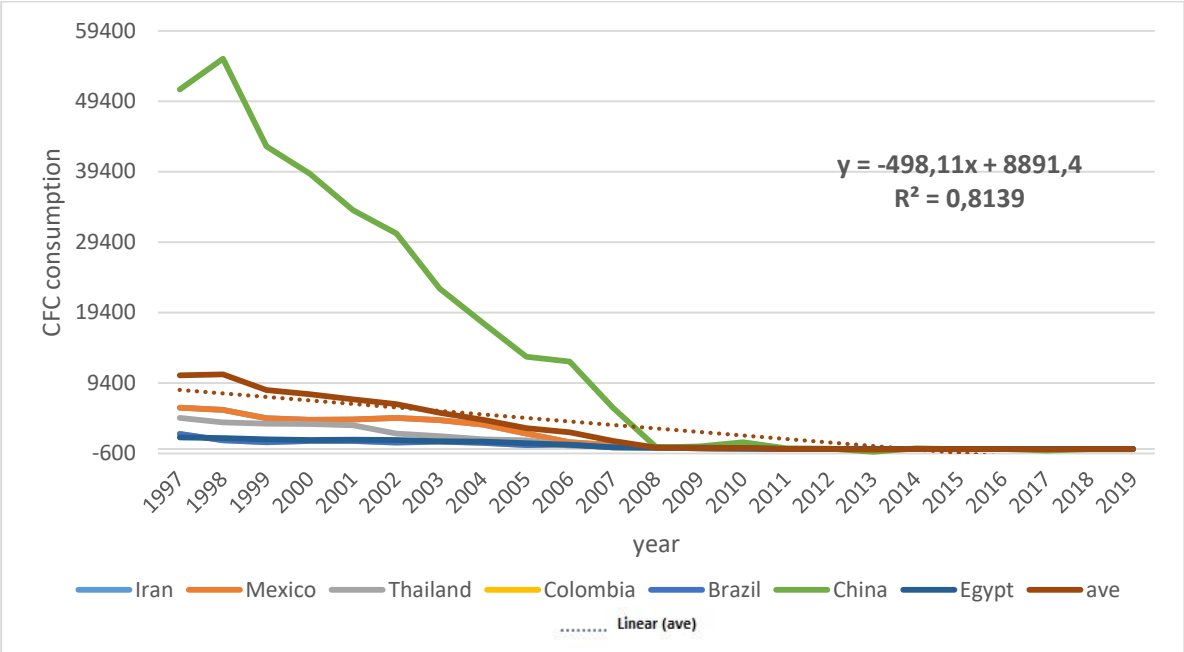

Figure 55: CFC Emission of high human development countries 1996-2019
Source: Author's own editing based on WDI 2020

We can state that the highly developed countries did not emit CFC gases to such an extent, but they also started to reduce them more slowly.

5.14. Analysing CFC emissions in low and medium human development countries

The following countries were examined in this group:

Morocco

India

Kenya

Pakistan

Uganda

Nigeria

Sudan

Figure 56 shows that even the highest value in India is significantly lower, barely reaching 7,000 units. The second highest consumption takes place in Nigeria. The values are well shifted over time compared to either very high or high countries. The value of Sudan and Uganda is lower than in many other countries.

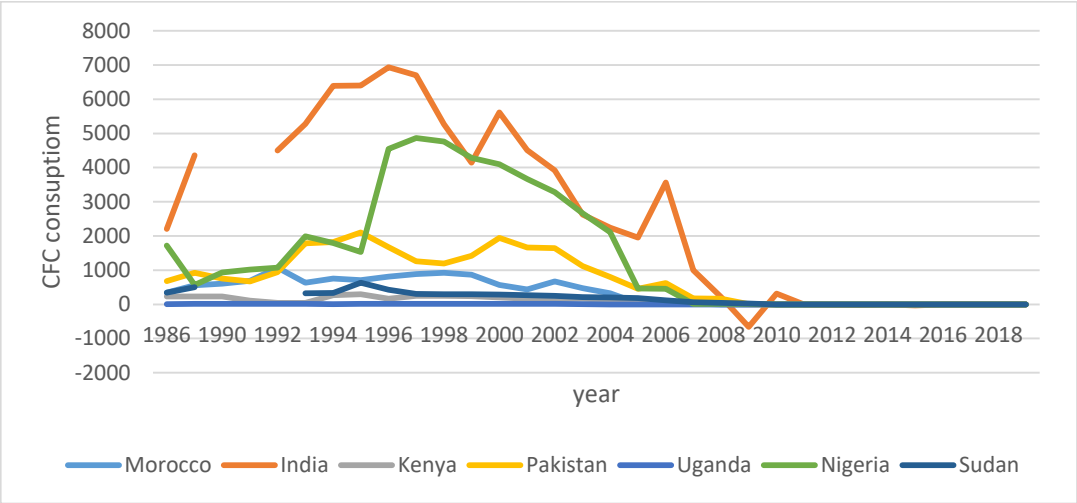

Figure 56: CFC emission of low and medium human development countries 1996-2019
Source: Author's own editing based on WDI based on WDI 2020

I split the time line of the research into two parts, keeping the previous 1996 time, and although it can be seen from Figure 57 that there are empty data, it can be seen that the trend shows a slightly rising line. The value of y is less high: y = 171.35x + 357.41. In contrast, the value of r2 is high because it predicts that the values of the selected countries are 73% in line with the trend: R^2 = 0.7371

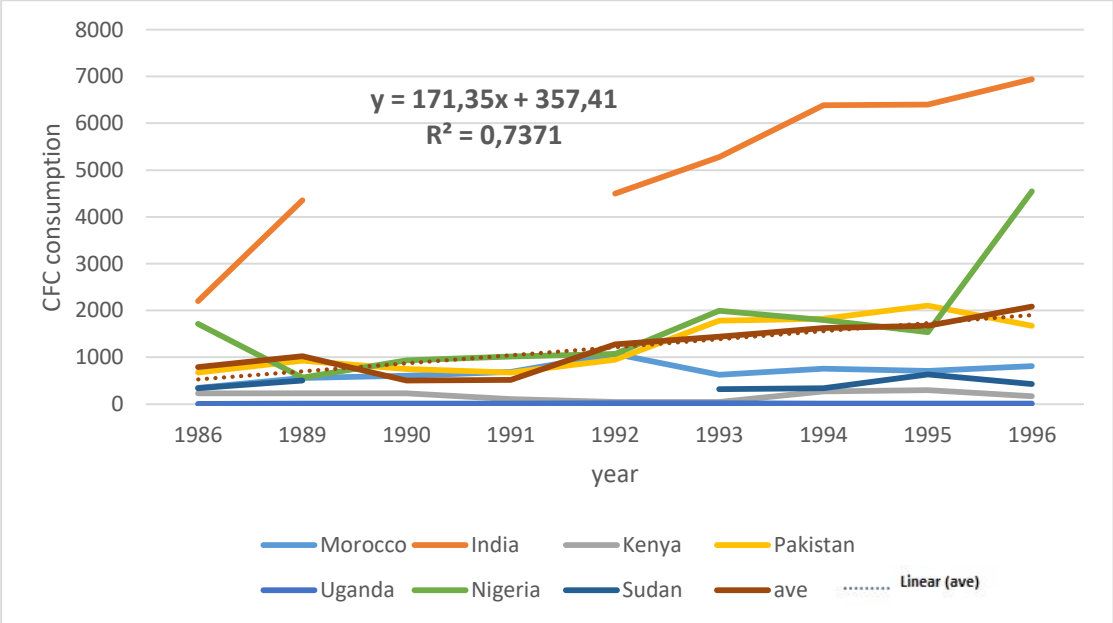

Figure 57: CFC emission of low and medium human development countries 1986-1996
Source: Author's own editing based on WDI 2020

Figure 58 for the next 22 years is already showing a clear negative trend, with CFC consumption declining in all countries, even though there are peaks in several countries in some years. In

addition to plotting the average, I also examined the trend line and saw that the value of y became negative, y = -99.242x + 1776.3, ie the trend was decreasing here as well, but the value of r2 showed a very close relationship: $R^2 = 0$, 8065

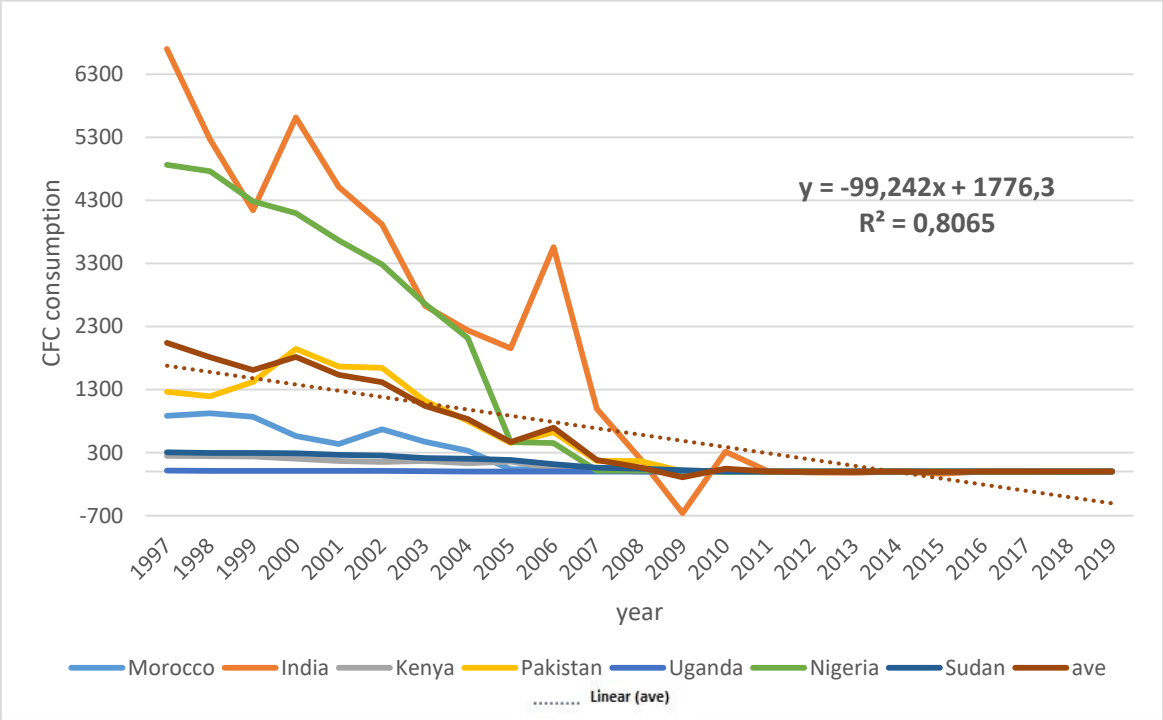

Figure 58: The trend line of CFC emission of low and medium human development countries 1997-2019
Source: Author's own editing based on WDI 2020

5.15. Analysing the aggregated data

Examining the aggregate data, I examined CFC emission level for each HDI country.

I first analysed the trend values, and Table 19 shows that CFC emission decreased in all three country types, most notably in the very high HDI countries, and this declining trend was observed throughout each study period.

In comparison, in both high and medium / low countries, this showed an increase between 1986 and 1996, and after 1997 the trend became negative. That is, very high HDI countries reacted sooner to agreements to reduce CFC consumption than other countries.

Table 19: Trend change in CFC emission by country type

trend value	Very high HDI	High HDI	medium and Low HDI
between 1986-2019	**y = -547,56x + 12541**	**y = -478,01x + 13119**	**y = -56,903x + 1701,1**
between 1986-1996	**y = -3276,2x + 28885**	**y = 884,95x + 6730,9**	**y = 171,35x + 357,41**
between 1997-2019	**y = -1,472x + 2,8877**	**y = -498,11x + 8891,4**	**y = -99,242x + 1776,3**

Source: Author's own editing based on WDI 2020

Table 20 provides an answer to the assumption of trend-setting and the lowest overall values for the very high HDI countries with the highest 71% and slightly higher than the 50% for the low and medium human development countries.

The breakdown by sub-period shows that the very high HDI countries almost completely reduced their CFC consumption in the first period, the high, medium and low HDI countries decreased CFC consumption after 1997.

Table 20: Analysis of r2

r2 value	Very high HDI	High HDI	medium and low HDI
between 1986-2019	**R^2 = 0,4843**	**R^2 = 0,7133**	**R^2 = 0,5104**
between 1986-1996	**R^2 = 0,9538**	**R^2 = 0,3731**	**R^2 = 0,7371**
between 1997-2019	**R^2 = 0,4006**	**R^2 = 0,8139**	**R^2 = 0,8065**

Source: Author's own editing based on WDI 2020

Based on the above H4 hypothesis was confirmed.

H5: The Kyoto Protocol and its extensions to the United Nations Framework Convention on Climate Change has reduced greenhouse gas substances in the atmosphere and has produced significant environmental benefits to protect global warming. The Protocol has played a significant role in the reshaping the economy of developed and developing economies.

In the study, I examined GHG gases, how well they managed to comply with the Kyoto Treaty, and how GHG emissions changed in each country.

I analysed the data in three time periods. The goal of the Kyoto Treaty itself was to reduce greenhouse gas emissions by 5.2% between 1990 and 2008-2012, and to 8% in EU countries.

The treaty allowed the former socialist countries not to take the year after the change of regime as the base year, but another year, but no data were included in any of the groups of countries in our study. What might lead to a distortion of data is in the case of Germany, where the merger of the two parties could have been a problem.

I filtered out the downloaded data and started basic analysis. The indicators used here for GHG gases are expressed in kilotons of CO2 equivalent and Co2 is also expressed in kilotons / year throughout the hypothesis test.

5.16. Analysing CO2 emissions in very high human development countries

I started my study with CO2 emissions, examining how their CO2 emissions changed between 1990-2008 and 2012 for countries with very high HDI. We can see that the largest amount was provided by Germany in 1990, which includes the unification of the two German territories. It can then be seen that this was reduced to 81% by 2008 and then to 77%. That is to say, they have complied with the Kyoto Protocol.

I was able to show a similarly significant reduction in the case of Sweden, which reduced CO2 levels to 89 and then 82%. But all other countries increased their CO2 levels between 1990 and 2008, and by 2012, if not by 5 5, overall, all high HDI countries were able to achieve significant reductions. The best example of this is Ireland, which increased its CO2 levels by more than 140%

between 1990 and 2008, as did Australia, and by 2012 this level was the highest in Ireland, falling to 81%, while the highest in Australia is 98%. These data are presented in Table 21 and based on this I came to the conclusion that I would get similar results for both total and per capita GHG, as CO2 is one of the most important parts of GHG.

Table 21: CO2 emissions of very high HDI countries

country	co2_1990	co2_2008	co2_2012	**1990 basis year to 2008**	**basis year to 2012**	**basis 2008 to 2012**
Australia	279,365	409,653	402,666	147%	144%	98%
Sweden	57,378	50,887	46,774	89%	82%	92%
Norway	35,098	44,837	44,342	128%	126%	99%
Ireland	32,944	47,367	38,242	144%	116%	81%
Switzerland	44,153	44,714	42,255	101%	96%	95%
Germany	1052,477	854,927	813,985	81%	77%	95%
Netherlands	161,807	174,862	164,7	108%	102%	94%

Source: Author's own editing based on WDI 2020

I examined two indicators GHG per capita and total GHG. In both cases I looked at how emissions changed between 1990, 2008 and 2012.

The total GHG emission is shown in Table 22, which does not take into account per capita data, further demonstrates the failure of the Kyoto targets, as I was able to show a significant increase over 1990-2008, with GHG emission rising above 100% in all three countries during the period under review. In contrast, Sweden was able to show a particularly high 33% decline, which it could nearly double by 2012, reducing GHG emissions by 56%. None of the HDI countries was able to show a larger decline than this.

Germany and the Netherlands were also able to comply with the Kyoto Protocol and reached the 5% reduction. Compared to this, Norway reduced its GHG emissions to 82% by 2008, but by 2012 this figure had risen by 119%, meaning that overall GHG emissions had fallen by 3%, but had risen significantly since 2008. By 2012, the GHG rate. Australia is the other country to show an increase compared to 2008-2012, but they have steadily increased their GHG emissions and have not been able to produce a decrease in any of the periods studied.

All of the High HDI countries surveyed were among the signatories to the Kyoto Protocol, which undertook to reduce GHG emissions. Sweden, Germany and the Netherlands were able to comply with the Kyoto Protocol in terms of total GHG emissions.

Table 22: Total GHG emission of very high human development countries 1990-2012

country	**total ghg 1990**	**total ghg 2008**	**total ghg 2012**	**basis year 1990 to 2008**	**basis year 1990 to 2012**	**basis year 2008 to 2012**
Australia	558,21	617,09	643,12	111%	115%	104%
Sweden	70,26	47,38	30,98	67%	44%	65%
Norway	30,91	25,29	30,03	82%	97%	119%
Ireland	54,11	69,64	60,06	129%	111%	86%
Switzerland	51,19	51,65	49,04	101%	96%	95%
Germany	1109,28	889,47	837,46	80%	75%	94%
Netherlands	205,44	197,69	188,48	96%	92%	95%

Source: Author's own editing based on WDI 2020

Looking at the per capita results, (Table 23) we can see a different scenario. I have noticed that while emissions fell in all areas except Ireland between 1990 and 2008 (102% in Ireland), the decline in GHG emissions was much higher in all countries between 1990 and 2008. With the exception of Ireland, there is no country that would go above 90% and this change could be continued until 2012, but the rate of decline slowed down during this period. All in all, I can say that all countries have reduced their GHG emissions by at least 15% in terms of per capita figures, and the highest value belongs to Sweden, which has fallen below 60%.

In terms of this result, it could be stated that all countries have met their commitments under the Kyoto protocol.

Table 23: GHG per capita emission of very high human development countries 1990-2012

country	**ghg pc 1990**	**ghg pc 2008**	**ghg pc 2012**	**basis year 1990 to 2008**	**basis year 1990 to 2012**	**basis year 2008 to 2012**
Australia	32,912	28,928	28,079	88%	85%	97%
Sweden	8,201	5,13	3,246	63%	40%	63%
Norway	7,278	5,301	5,99	73%	82%	113%
Ireland	15,412	15,77	13,033	102%	85%	83%
Switzerland	7,694	6,776	6,124	88%	80%	90%
Germany	14,032	10,972	10,343	78%	74%	94%
Netherlands	13,728	11,932	11,224	87%	82%	94%

Source: Author's own editing based on WDI 2020

Compare the per capita consumption of GHG to the total emission, we can see the contradiction, per capita values were decreasing but total values were increasing.

5.17. Analysing CO2 emission in high human development countries

I continue my research with the High HDI countries, in which I first analysed the CO2 results for the first time. All the countries involved in the research have committed to and signed the Kyoto Treaty.

We see in Table 24 all countries surveyed have steadily increased their CO2 emissions since 1990, with Iran, Thailand and Egypt more than doubling their CO2 emissions by 2008. Thailand has finally tripled this to 2012. All of the countries further raised their CO2 emissions to 2012, the lowest of which is Colombia, which is "only" 140.

Table 24: Total CO2 emission of high human development countries 1990-2012

country	year	1990	2008	2012	1990 basis year to 2008	1990 basis year to 2012	2008 basis to 2012
Iran	1990	209,944	534,644	602,738	255%	287%	113%
Mexico	1990	317,042	492,98	496,3	155%	157%	101%
Thailand	1990	87,916	226,873	270,268	258%	307%	119%
Colombia	1990	56,898	66,65	79,727	117%	140%	120%
Brazil	1990	218,658	412,638	498,309	189%	228%	121%
Chile	1990	32,891	70,795	79,684	215%	242%	113%
Egypt	1990	75,218	194,764	208,718	259%	277%	107%

Source: Author's own editing based on WDI 2020

The indicators show (Table 25) even more that most of these countries did not even strive to achieve any reduction in GHG emissions between 1990 and 2008, with Iran increasing it to 278%, which it eventually raised to 316% in 2012. But similar to the CO2 results, total GHG emissions also increased in Mexico, Thailand, and Egypt. Colombia showed just 9% and 2% growth. In contrast, Brazil and Chile took a completely different path. Both countries significantly reduced GHG by 2012 compared to 1990 and banned the ban on these gases to a particularly high level. Chile reduced it by 62% overall and Brazil by 45%.

Table 25: Total GHG emission of high human development countries 1990-2012

country	total ghg1990	total ghg 2008	total ghg 2012	basis year 1990 to 2008	basis year 1990 to 2012	basis year 2008 to 2012
Iran	240,54	669,06	761,05	278%	316%	114%
Mexico	417,45	595,78	674,16	143%	161%	113%
Thailand	174,02	310,02	386,03	178%	222%	125%
Colombia	217,08	236,44	221,94	109%	102%	94%
Brazil	1642,29	2030,84	1311,58	124%	80%	65%
Chile	30,34	55,06	20,68	181%	68%	38%
Egypt	129,43	268,73	294,89	208%	228%	110%

Source: Author's own editing based on WDI 2020

I examined in the Table 26 the amount of GHG emissions per capita could or could not be reduced. Colombia, Brazil and Chile met Kyoto expectations to a significant extent, between 27-40%.

In contrast, all other High HDI countries also saw an increase in GHG emissions per capita overall, a country that stands out from Thailand, which almost doubled its rise above 180% between 1990 and 2008, and between 2012 and 2008 was able to further increase GHG per capita by 22%.

Table 26: GHG per capita emission of high human development countries 1990-2012

country	ghg pc 1990	ghg pc 2008	ghg pc 2012	basis year 1990 to 2008	basis year 1990 to 2012	basis year 2008 to 2012
Iran	4,267	9,277	10,075	217%	236%	109%
Mexico	4,973	5,376	5,749	108%	116%	107%
Thailand	3,077	4,66	5,691	151%	185%	122%
Colombia	6,558	5,343	4,817	81%	73%	90%
Brazil	11,022	10,576	6,581	96%	60%	62%
Chile	2,286	3,295	1,188	144%	52%	36%
Egypt	2,306	3,374	3,412	146%	148%	101%

Source: Author's own editing based on WDI 2020

Based on these, I was able to conclude that the high human development countries did not comply with, even significantly increase, their GHG emissions overall, thus failing to meet their commitments under the Kyoto Protocol.

5.18. Analysing CO2 emission in low and medium human development countries

At a minimum, Iraq and Kenya increased their CO2 emissions by 174 and 187%, but this rose further. Iraq has increased so much between 2008 and 2012 that the rate of co2 has risen to 166% in just these 4 years. Pakistan is the only country to have reduced its CO2 emissions by 1% from 2008 to 2012 (Table 27).

Overall, between 1990 and 2012, Uganda almost doubled its CO2 level and the minimum level for Kenya was doubled during the period under review.

Table 27 CO2 emissions of low and medium human development countries

country	co2 1990	co2 2008	co2 2012	1990 basis year to 2008	1990 basis year to 2012	basis 2008 to 2012
Iraq	49,057	91,803	152,815	187%	312%	166%
India	578,518	1462,815	1963,586	253%	339%	134%
Kenya	5,687	9,911	11,988	174%	211%	121%
Pakistan	67,827	155,356	153,876	229%	227%	99%
Uganda	0,761	2,78	3,627	365%	477%	130%
Sudan	4,769	13,634	14,539	286%	305%	107%
Nigeria	38,857	94,772	116,331	244%	299%	123%

Source: Author's own editing based on WDI 2020

5.19. Analysing GHG emissions in high and low human development countries

After the CO2 results, I examined the level of total GHG and examined that in the case of the low and medium HDI countries that signed the Kyoto treaty, the level of GHG increased in all cases according to Table 28. Kenya was the only country to be able to show a 4% reduction between 2008 and 2012 in only one case during the period under review, so they were not able to meet the Kyoto Protocol.

Table 28: Total GHG emission of low and medium human development countries 1990-2012

country	total ghg1990	total ghg 2008	total ghg 2012	1990 basis year to 2008	1990 basis year to 2012	basis 2008 to 2012
Iraq	78,65	104,97	175,68	133%	223%	167%
India	1009,44	2317,48	2758,53	230%	273%	119%
Kenya	34,15	77,78	74,73	228%	219%	96%
Pakistan	166,5	316,9	332,43	190%	200%	105%
Uganda	34	54,95	61,57	162%	181%	112%
Sudan	73,23	116,38	120,84	159%	165%	104%
Nigeria	249,87	277,1	303,64	111%	122%	110%

Source: Author's own editing based on WDI 2020

It is expected that the level of GHG emissions per capita will also exceed the level agreed in the Agreement.

As Table 29 shows Uganda, Sudan and Nigeria equally reduced their per capita GHG rates between 1990 and 2008 and then further reduced them by 2012. So even though previous indicators show an increase in the proportion of GHG, I was able to show a significant decrease in the proportion of the population per capita.

But this is not the case for Iraq, India, Kenya and Pakistan, which have increased their GHG rates throughout 1990-2012. Iraq can show compliance by 2008, with an 18% reduction but a one-and-a-half-fold increase in GHG consumption over the next 4 years. In the case of Kenya and Pakistan, there is a demonstrable decline between 2008 and 2012, with Kenya reducing its consumption of GHG by 14% and Pakistan by 4%.

Table 29: GHG per capita emission of high human development countries 1990-2012

country	ghg pc 1990	ghg pc 2008	ghg pc 2012	1990 basis year to 2008	1990 basis year to 2012	basis 2008 to 2012
Iraq	4,515	3,698	5,509	82%	122%	149%
India	1,156	1,93	2,179	167%	188%	113%
Kenya	1,439	1,955	1,685	136%	117%	86%
Pakistan	1,547	1,846	1,775	119%	115%	96%
Uganda	1,959	1,806	1,782	92%	91%	99%
Sudan	3,635	3,52	3,339	97%	92%	95%
Nigeria	2,624	1,844	1,816	70%	69%	98%

Source: Author's own editing based on WDI 2020

Although the data show a slight decrease in the emission of GHG per capita, total emission has increased significantly in line with population growth.

To examine my research question, I need to look at whether there is a demonstrable relationship between the development of each country and GHG emissions and per capita emissions.

For each country, total GHG emissions according to Table 30 were higher than those of the very High HDI countries marked with code 1 and the lowest of the low HDI countries marked with code 3, but this ratio was reversed by 2012.

Table 30: Mean and standard deviation of total GHG emission

Report

code		total ghg1990	total ghg 2008	total ghg 2012
1	Mean	297,0571	271,1729	262,7386
	N	7	7	7
	Std. Deviation	403,74202	343,19507	335,44003
2	Mean	407,3071	595,1329	524,3329
	N	7	7	7
	Std. Deviation	557,22916	667,69355	431,10722
3	Mean	235,1200	466,5086	546,7743
	N	7	7	7
	Std. Deviation	350,24448	822,40948	981,01148
Total	Mean	313,1614	444,2714	444,6152
	N	21	21	21
	Std. Deviation	429,16148	624,98987	629,03240

Source: Author's own editing based on WDI 2020

I examined the relationship between the development of countries and total GHG emissions with Pearson's significance test. The strongest connection could be detected in 1990, where the significance rate was 0.768 and the value of the degree of freedom F was 0.268 (Table 31).

By 2008, the significance level decreased to 0.644, which is the lowest but still considered high and this number has increased to 0.666 by 2012.

In other words, it can be said that the level of total GHG emissions depends on the period examined in each country, the highest in 1990, but the data for 2008 and 2012 show that regardless of the fact that all countries have signed the Kyoto Protocol a common improvement can be seen, but it also depends on the HDI index of each country.

Table 31: ANOVA test total GHG emission

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
total ghg1990 * code	Between Groups	(Combined)	106492,597	2	53246,298	,268	,768
	Within Groups		3577098,860	18	198727,714		
	Total		3683591,457	20			
total ghg 2008 * code	Between Groups	(Combined)	372517,436	2	186258,718	,451	,644
	Within Groups		7439729,297	18	413318,294		
	Total		7812246,733	20			
total ghg 2012 * code	Between Groups	(Combined)	349093,442	2	174546,721	,415	,666
	Within Groups		7564541,757	18	420252,320		
	Total		7913635,199	20			

Source: Author's own editing based on WDI 2020

Examining the mean and standard deviation values (Table 32), I observed that the per capita mean of each country type is highest in the very high HDI countries and lowest in the low and medium HDI countries. So the higher a country's development rate, the more GHG its population consumes, and this is supported by the standard deviation rate. Time has shown in this case that 2008 is the lowest in the low and medium HDI country and they fail to meet the 5% Kyoto threshold.

Table 32: Total GHG per capita

Report

code		ghg pc 1990	ghg pc 2008	ghg pc 2012
1	Mean	14,17957	12,11557	11,14843
	N	7	7	7
	Std. Deviation	8,926422	8,377566	8,217389
2	Mean	4,92700	5,98586	5,35900
	N	7	7	7
	Std. Deviation	3,096071	2,843315	2,753122
3	Mean	2,41071	2,37129	2,58357
	N	7	7	7
	Std. Deviation	1,254390	,848650	1,413352
Total	Mean	7,17243	6,82424	6,36367
	N	21	21	21
	Std. Deviation	7,357827	6,378239	6,041371

Source: Author's own editing based on WDI 2020

To the question of whether there is a correlation between total GHG per capita and output, I used the significance test.

Table 33 shows that although the degree of freedom is quite high (F = 8,879, 6,451 and 5,201), there is no demonstrable relationship between them in which country the GHG per capita changed between 1990 and 2012.

Table 33: ANOVA test total GHG per capita

ANOVA Table

		Sum of Squares	df	Mean Square	F	Sig.
ghg pc 1990 * code	Between Groups (Combined)	537,711	2	268,856	8,879	,002
	Within Groups	545,041	18	30,280		
	Total	1082,752	20			
ghg pc 2008 * code	Between Groups (Combined)	339,709	2	169,855	6,451	,008
	Within Groups	473,930	18	26,329		
	Total	813,639	20			
ghg pc 2012 * code	Between Groups (Combined)	267,347	2	133,673	5,201	,016
	Within Groups	462,616	18	25,701		
	Total	729,963	20			

Source: Author's own editing based on WDI 2020

Examining the data obtained in total GHG per capita, I was able to create a scatter plot figure (Figure 59) that shows that the countries with the highest GHG per capita emissions are Australia, Ireland, Germany, the Netherlands and Brazil. Very high human development countries have the highest GHG rates per capita in all three periods studied.

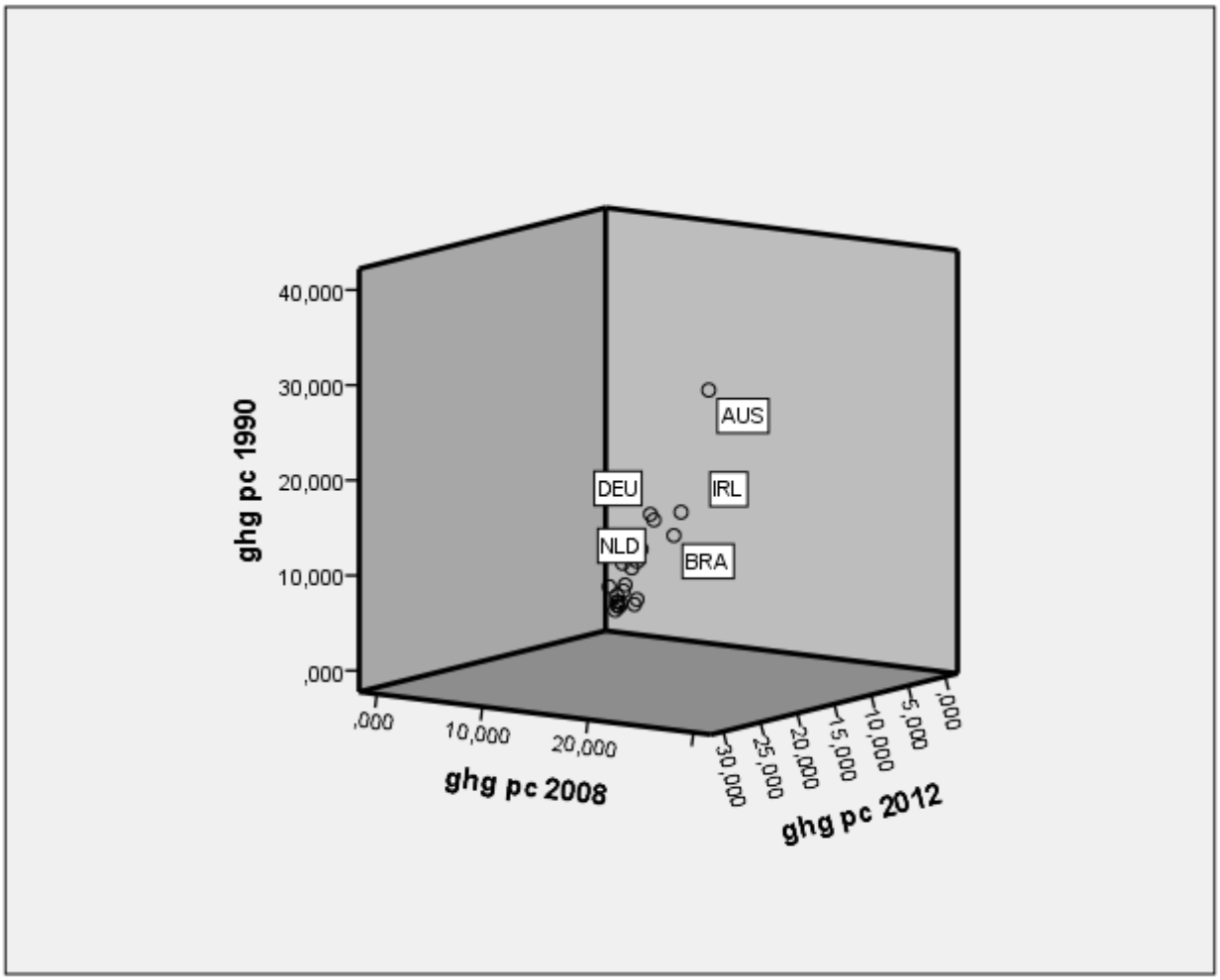

Figure 59: Scatter plot of GHG per capita 1990-3012
Source: Author's own editing based on WDI 2020

Comparing the commitments made in the Kyoto Protocol with the very high, high low and medium human development countries I concluded that from very high group, most countries were able to meet the 5% reduction in the Kyoto agreement, but the reduction was less as in their original commitment.

This was even more the case in the high development countries, they were able to reach the reduction commitment only if we look at total GHG per capita data.

The already low-consumption low-HDI countries did the opposite, increased their total emissions.

We do not consider the Kyoto Treaty to be the most successful, which has been proven in terms of CO2 and total GHG emissions, but in terms of per capita GHG emissions, there has always been an effort to comply with it.

H6A: Developed countries are more involved in international environmental agreements than developing countries.

H6B: Participation in international environmental agreements is related to the rule of law in a country. Countries with higher rule of law index are involved in larger amount of international agreements.

In the first step, I examined how many international agreements have been ratified by the countries ranked by the Human Development Index. I wanted to examine if there is a correlation between the country's level of development and the number of international agreements. For this, I used the World Justice Project Rule of Law Index 2021(WJP 2021), which included the 2020 data.

I analysed the countries as follows:

1. Very high human development

Norway

Netherlands

Ireland

Denmark

Germany

Sweden

Australia

2. High human development

India

Mexico

Thailand

Colombia

Brazil

China

Egypt, Arab Rep.

3. Low and medium human development

Honduras

India

Kenya

Pakistan

Nigeria

Uganda

Sudan

In the next step, I examined the level of rule of law index: RLI and their rank number. For this, I took into account the data from 2021, which refer to 2020. To analyse the data, I examined the last data released by WGI in 2021.

The Worldwide Governance Indicators (WGI 2021) are a research dataset summarizing the views on the quality of governance provided by a large number of enterprise, citizen and expert survey respondents in industrial and developing countries. These data are gathered from a number of survey institutes, think tanks, non-governmental organizations, international organizations, and private sector firms.

In the third step, in addition to the level of the rule of law, I also examined how many international conventions they participate in and thus how many have been ratified. I collected the necessary data from (IEA 2020) database.

5.20. Analysing rule of law in very high human development countries

The ranking of each country can be seen in Table 34.

Ratification means how many international agreements have been ratified by the country.

Table 34: Rule of law in very high human development countries

	ratification	RLI 2021	RLI rank 2021
Norway	227	0,90	2
Ireland	126	0,81	10
Denmark	227	0,90	1
Germany	236	0,84	5
Sweden	226	0,86	4
Australia	128	0,79	13
Netherlands	235	0,83	6

Source: Author's own editing based on WGI 2020

It can be seen that Denmark is the highest in the ranking followed by Norway. But all the European countries listed here are also in the top ten, and Australia is the 13th in 2021 ranking. As far as international agreements are concerned, there is a more significant variation, with Ireland ratifying only 126 environmental conventions and Australia having 128 in total.

Further analysing the countries (Figure 60) after 2000, I observed that Ireland was the lowest with the rule of law Index (percentile rank), with 88, 94 in both 2017 and 2019. But if you look at that a. It can be seen that Norway and Denmark have successfully obtained the highest 100 value for several times. In other words, the rule of law has been fully respected in these countries for several years.

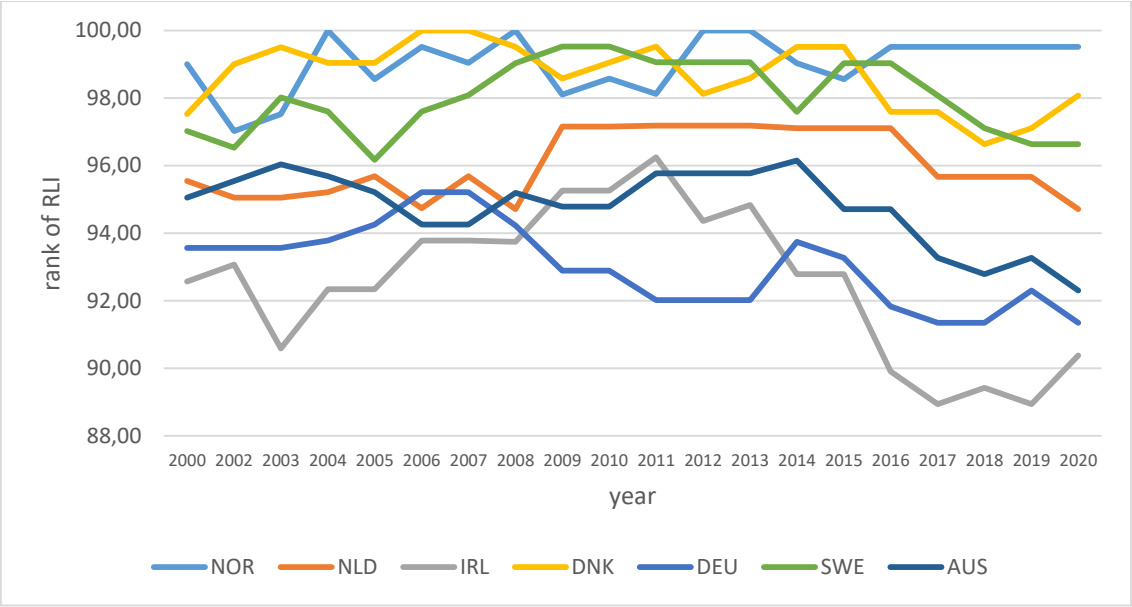

Figure 60: Very high HDI countries with rank of rule of law
Source: Author's own editing based on WDI 2020

5.21. Analysing rule of law in high human development countries

As Table 35 shows the 2021 Rule of Law Index classifies these countries as 77-136, but these figures show very few differences numerically. Thailand and Brazil have the same values, but there is still a difference of 3 places between them. Colombia is only one percent behind and this is already 6th place in the ranking. That is, we can see that we get very close results in this group.

In terms of the number of ratifications of international conventions, Mexico stands out from the group, it they adopted 117 conventions. Iran ratified only 69. Meanwhile, the RLI ratios of the two are slightly different at 113 and 119, respectively.

Table 35: Rule of law in high human development countries

	ratification	RLI 2021	RLI rank 2021
Iran, Islamic Rep.	69	0,42	119
Mexico	117	0,43	113
Thailand	72	0,50	80
Colombia	95	0,49	86
Brazil	96	0,50	77
China	96	0,47	98
Egypt, Arab Rep.	95	0,35	136

Source: Author's own editing based on WDI 2020

Further examining the data, I examined how the rule of law index developed in 2000 based on Figure 61.

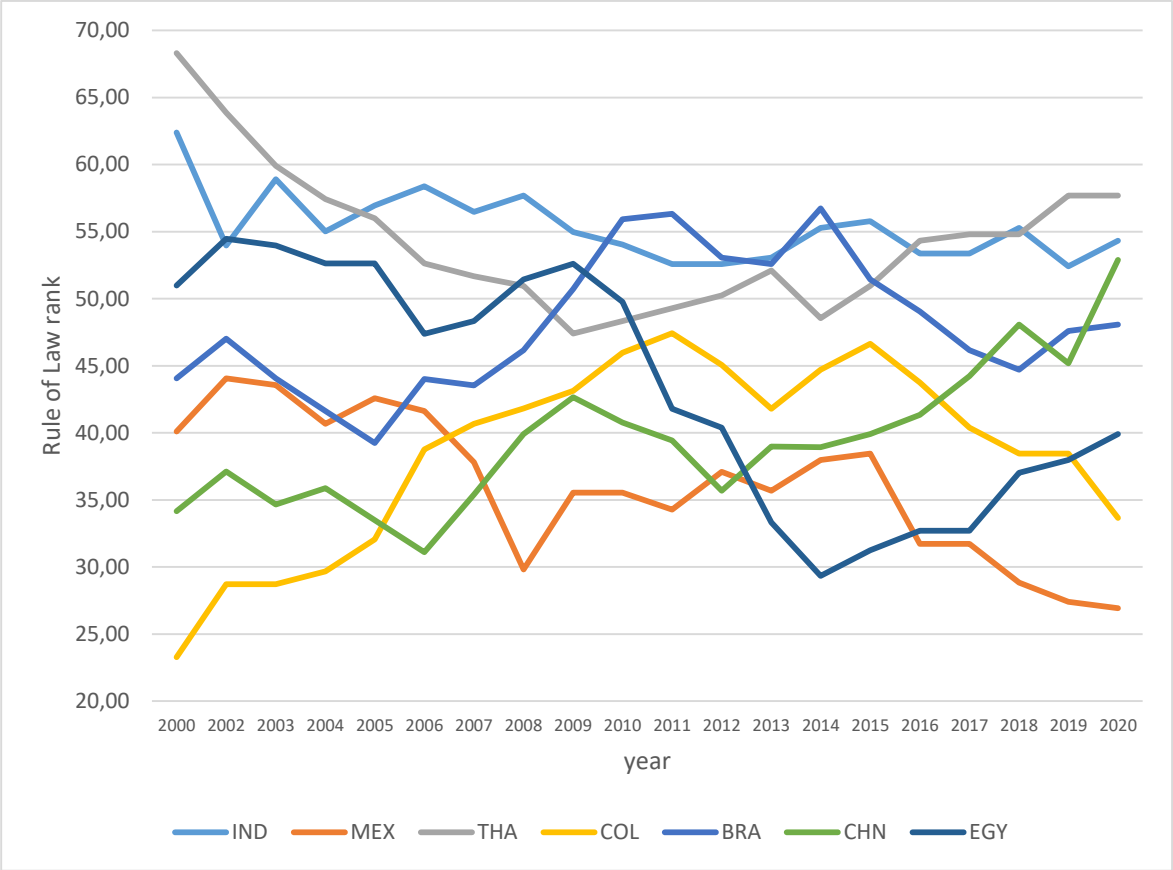

Figure 61: High HDI countries with rank of rule of law
Source: Author's own editing based on WDI 2020

5.22. Analysing rule of law in low and medium human development countries

Honduras ranked 132nd in the HDI rankings and as described in Table 36 it shows a similar result in the RLI rankings as it is ranked 126th. India reached the highest RLI ranking and has 88 international treaties ratified.

Table 36: Rule of law in low and medium human development countries

	ratification	RLI 2021	RLI rank 2021
Honduras	81	0,39	126
India	88	0,5	79
Kenya	82	0,44	106
Pakistan	73	0,39	130
Uganda	59	0,39	125
Nigeria	84	0,41	121
Sudan	51	0,42	116

Source: Author's own editing based on WDI 2020

The change in the order of the low HDI countries also shows that their performance is low during the period under review. It is the highest in India, which also coincides with the characteristics of the rule of law and is followed by Uganda, which has been performing relatively steadily since 2006. Sudan, Nigeria and Honduras were also particularly low, below 20%. The latter country has seen a marked decline over the last 10 years from 2011, which is not the case for any other country. Kenya significantly increased its regulatory performance between 2011 and 2014, although this 30-40% result is also low for High HDI countries.

The rule of law index development can be seen in Figure 62.

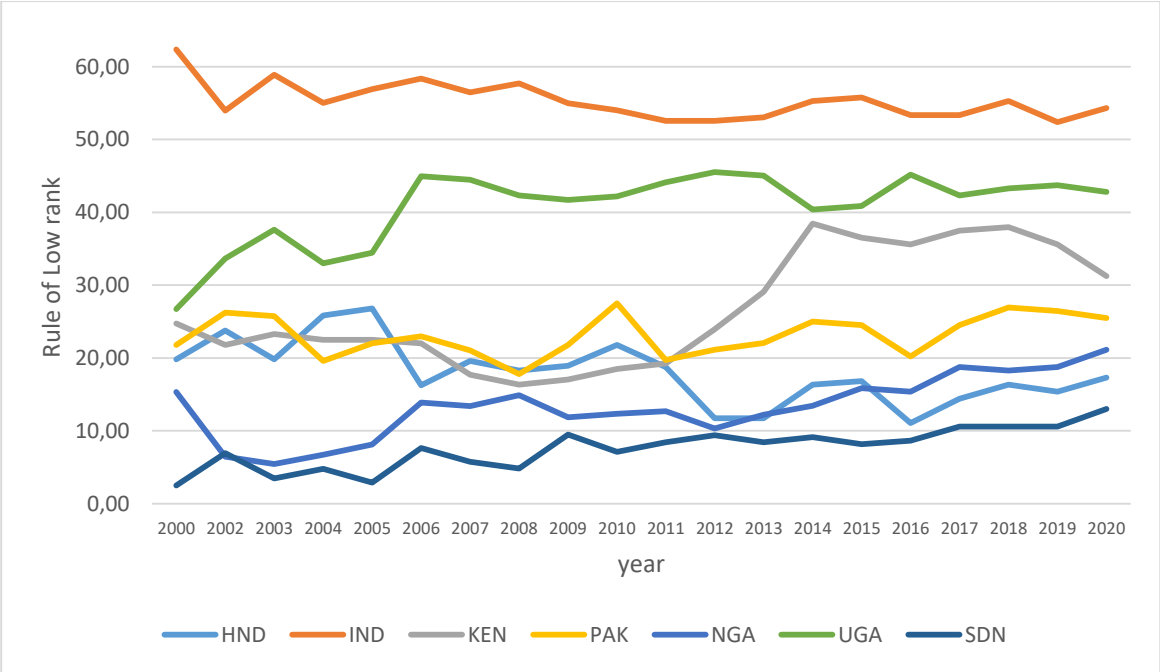

Figure 62: Low and medium countries with rank of rule of law
Source: Author's own editing based on WDI 2020

5.23. Comparison of the rule of law, HDI, and rule of law rank averages

In what follows, I have examined the relationship I can make between the number of international treaties and the demonstrable links between each country in the HDI rankings.

First, I examined the simple descriptive statistical analysis as described in Table 37 shows the number of ratifications of international conventions, then the average number of international treaties is 122, the standard deviation is 65, and the value of RLI 2021 is 73. The Rule of Law: Percentile Rank is 56 and the standard deviation is 32.

Table 37: Descriptive Statistics

	Mean	Std. Deviation	N
ratification	122,0476	64,85328	21
RLIrank2021	73,9524	52,07348	21
averank	55,8258	31,80609	21

Source: Author's own editing based on WDI 2020

For this purpose, I examined the previously obtained results with the SPSS program. Since I was looking for a relationship between two values, I first conducted a bivariate study between ratification and the HDI code of the countries. Very high HDI countries received code 1, high HDI countries code 2 and low and medium countries code 3.

Based on this, I assumed that the higher the code in the HDI index for countries, the lower the number of international treaties ratified. I expected an opposite correlation based on this. As Table 38 shows that my assumption was confirmed, as I found a very strong correlation level r2 = -0.817 (p = 0.01). Based on this, I justified the first half of my hypothesis, according to which HDI is significantly related to the number of international conventions.

Table 38: Correlations between the number of international contracts and the HDI classification

		ratification	code
ratification	Pearson Correlation	1	-,817**
	Sig. (2-tailed)		,000
	N	21	21
code	Pearson Correlation	-,817**	1
	Sig. (2-tailed)	,000	
	N	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI2020

I continued my research and examined the relationship between the HDI index and the rule of Law 2021.

I used the same coding system as before. I expected the result that if the code for the HDI of the country is low, the 2021 rank of the rule of law index will also be low. That is, I expected a positive correlation relationship here.

My research verified my expectations and I experience a very strong significance here, as shown in Table 39. In this case, the value of the correlation is r2 = 0.874 (p = 0.01) and this also means that the more developed countries had a higher level of rule of law in 2021.

Table 39: Correlations between the rule of law ranking and the HDI classification

		code	RLIrank2021
code	Pearson Correlation	1	,874**
	Sig. (2-tailed)		,000
	N	21	21
RLIrank2021	Pearson Correlation	,874**	1
	Sig. (2-tailed)	,000	
	N	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

In the third step, I examined the average rule of law: percentile rank between 2000 and 2020 and expected a negative correlation here as well, as the relationship between the two values is opposite. Based on the previous results, I expected that the relationship between the two factors will be strong here as well, as the previous two results predicted the result.

The result obtained in this way exceeded my expectations, as the level of significance r2 = -0.916 (p = 0.01) is very strong, as shown in Table 40. The lower a country's HDI, the lower its value in the average percentile rank.

Table 40: Correlations between the rule of law percentile ranking and HDI classification

		code	averank
code	Pearson Correlation	1	-,916**
	Sig. (2-tailed)		,000
	N	21	21
averank	Pearson Correlation	-,916**	1
	Sig. (2-tailed)	,000	
	N	21	21

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's own editing based on WDI 2020

In my research, I also examined whether there is any other relationship between the three factors based on the fact that the HDI code of countries is the control factor. Based on this, I explored further correlations. As can be seen, there is a negative significant relationship between the number

of international treaties and the RLI 2021 rank. That is, the number of international contracts determines their ranking in the RLI rankings. The lower the rank level, the more ratified international treaties belong to the countries. The significance level of the relationship is r2 = -0.545 (p = 0.01) and there is a positive relationship between their average level because the two numbers are equally considered high. This relationship is no longer so significant, the level of significance is r2 = 0.389 (p = 0.01) (Table 41).

Table 41: Correlations of rule of law, percentile rank and ratification

Control Variables			ratification	RLIrank2021	averank
code	ratification	Correlation	1,000	-,545	,389
		Significance (2-tailed)	.	,013	,090
		df	0	18	18
	RLIrank2021	Correlation	-,545	1,000	-,689
		Significance (2-tailed)	,013	.	,001
		df	18	0	18
	averank	Correlation	,389	-,689	1,000
		Significance (2-tailed)	,090	,001	.
		df	18	18	0

Source: Author's own editing based on WDI 2020

Finally I plotted the average of international treaties and the rule of law: percentile rank.

For the graphical representation, I chose the scatter plot (Figure 63) and showed the two factors side by side to show that the high HDI countries with a code of 1 coincided with the countries that had both ratification and the average rule of law: They also achieved high results in terms of percentile rank. I separated 4 groups, while the very high HDI countries would clearly form two smaller groups, while justifying the partial correlation, the high and low groups in groups 2 and 3 are less separated.

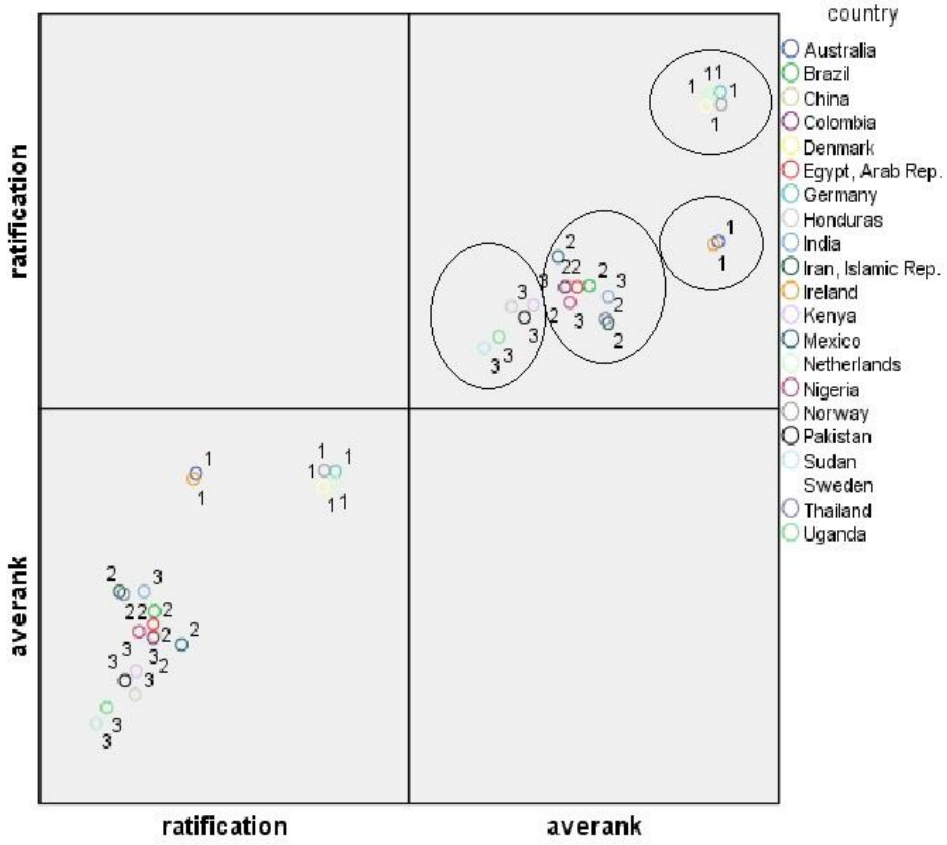

Figure 63: Ratification and rule of law index
Source: Author's own editing based on WDI 2020

We get almost the same figure when I compare the number of ratifications and the 2021 RLI rank, with as many differences as it is depicted in Figure 64. It can also be seen that I did not separate the high and low HDI countries in groups 2 and 3. This also shows how strongly the rule of law and the number of international conventions determine a country's HD Index.

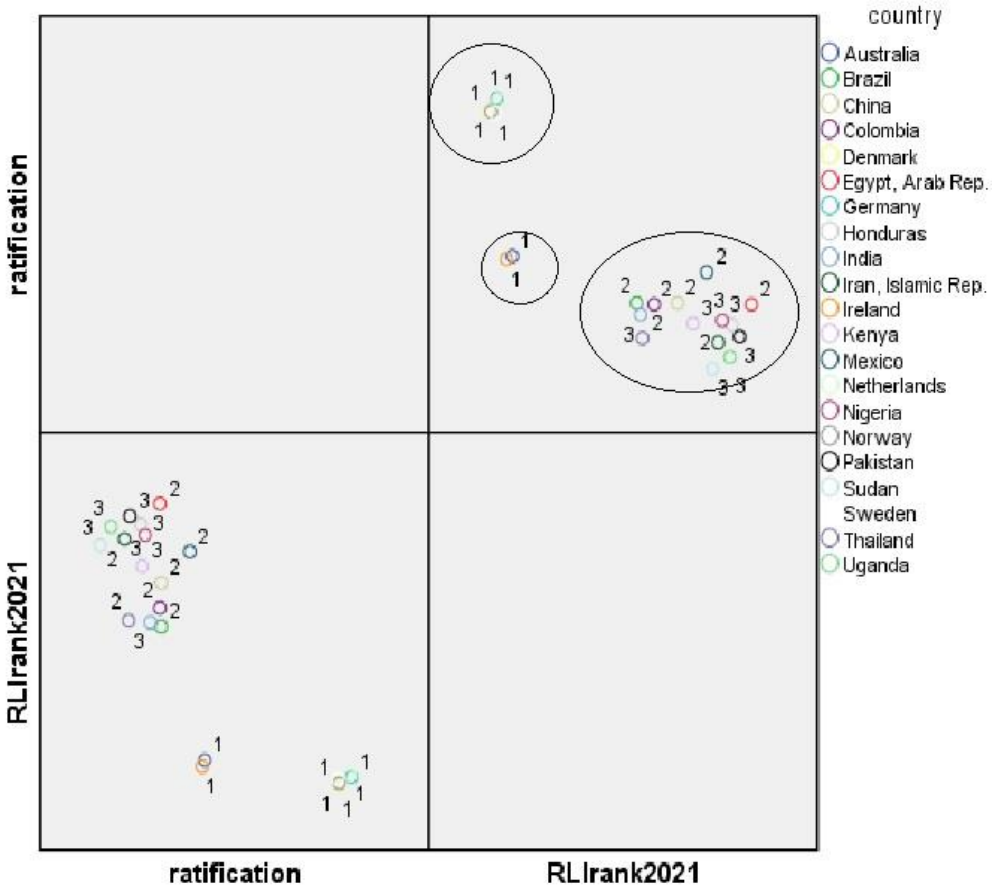

Figure 64: Ratification and 2021 RLI rank number
Source: Author's own editing based on WDI 2020

In the last step I analysed how factors affect each other. I set up a dendogram based on cluster analysis. As Figure 65 shows the 2021 RLI and the average rule of law are closest to each other, then the percentile rank and finally the ratification.

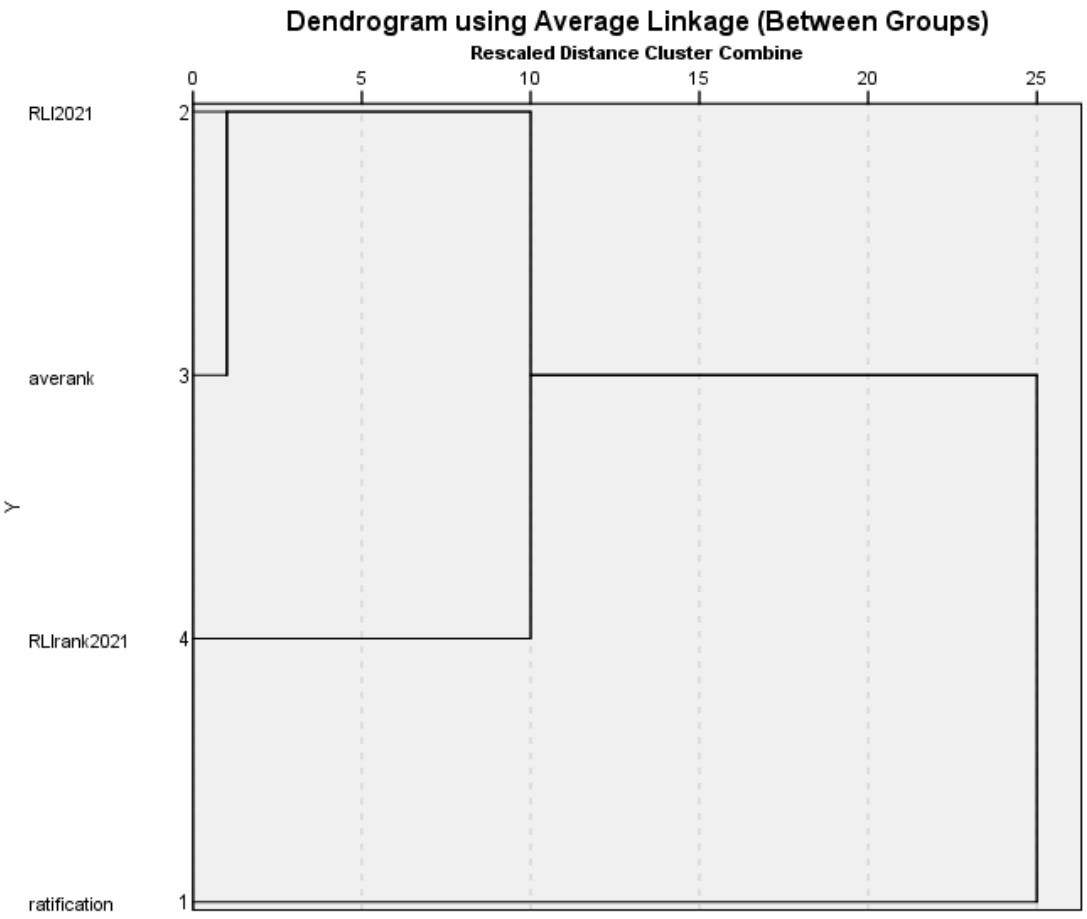

Figure 65: Cluster analysis of examined factors
Source: Author's own editing based on WDI 2020

Based on these, I confirmed my H6 hypothesis. Countries with a high HDI Index enter into more international agreements and have a higher rule of law index with higher ranking. The relationship between the examined factors is considered to be particularly strong and significant.

6. CONCLUSIONS AND RECOMMENDATIONS

In this chapter based on my findings I will draw my conclusions and make recommendations to different actors.

6.1. Conclusions

In this chapter, I summarise my ideas based on my research, answer my research questions, and present the results of my hypotheses testing. I also discuss the research's future directions. I draw conclusions that may be useful in the future based on their practical applicability.

Research Question 1 and the connecting hypothesis were as follows:

What is the relationship between oil price and economic growth of countries with different development level?

The relationship between oil price and economic growth in developed countries is linear and negative. The relationship between oil price and economic growth in developing countries is linear and positive.

H1: The impact of oil price changes on GDP growth is less significant in developed countries, and this impact is more significant in developing countries.

In the case of very high human development countries, the change in the price of oil has opposite and more significant effect on the development of the GDP growth (Pearson correlation from -128 to -622). In the case of high-human development countries, this relationship is weaker and opposite (Pearson correlation from -0.009 to -246). The relationship between the price of oil and GDP growth in low and medium human development countries is significantly weak and can be considered positive (Pearson correlation from (040 to551). Based on the above H1 hypothesis was not confirmed.

Research Question 2 and the connecting hypothesis were as follows:

Do carbon abatement policies have impact on GDP growth?

Carbon abatement policies have an impact on GDP growth

H2: Applying carbon abatement policies will reduce GDP growth in developed countries, but it will rise GDP growth in developing countries.

Developed and developing countries show a strong opposite relationship between GDP growth and CO2 emissions ($r = -0.980$ ($p = 0.01$) . The higher their GDP growth is, the lower their CO2 levels will be. If GDP increases, so does CO2. in the case of developing countries, the relationship is also similar, but it is weaker $r = -0.915$ ($p = 0.01$)., meaning that it is less related to the evolution of GPD. Based on the above H2 hypothesis was not confirmed.

Research Question 3 and the connecting hypothesis were as follows:

Do carbon abatement policies have impact on petroleum, natural gas, coal and renewable energy use?

Carbon abatement policies do not have impact on petroleum, natural gas, coal and renewable energy use.

H3: By applying carbon abatement policies total petroleum and coal use will drop and natural gas and renewable energy use will intensify in both developed and developing countries.

According to my findings total petroleum, coal and natural gas use is rising. Renewable energy consumption is fluctuating in both country types. Based on the above H3 hypothesis was not confirmed.

Research Question 4 and the connecting hypothesis were as follows:

Did the ratification of Montreal Protocol have impact on the atmosphere?

Montreal Protocol has had impact on the atmosphere.

H4: The Montreal Protocol and its extensions on Substances that Deplete the Ozone Layer have reduced ozone depleting substances in the atmosphere and have produced significant environmental benefits to protect the earth's ozone layer.

Countries with very high human development almost completely reduced their CFC consumption by 1997. High, medium and low HDI countries decreased CFC consumption after 1997. The Montreal Protocol has reduced ozone depleting substances in the atmosphere. Based on the above H4 hypothesis was confirmed.

Research Question 5 and the connecting hypothesis were as follows:

Did the ratification of Kyoto Protocol have impact on the atmosphere?

The ratification of Kyoto Protocol has not had impact on the atmosphere?

H5: The Kyoto Protocol and its extensions to the United Nations Framework Convention on Climate Change has reduced greenhouse gas substances in the atmosphere and have produced significant environmental benefits to protect global warming. The Protocol have played a significant role in the reshaping of the economy of developed and developing economies.

Comparing the commitments made in the Kyoto Protocol with the very high, high, low and medium human development countries, I concluded that from very high human development group, most countries were able to meet the 5% reduction in the Kyoto agreement, but the reduction was less as in their original commitment.

This was even more the case in the high human development countries, they were able to reach the reduction commitment only if we consider total GHG per capita data. The low and medium human development countries increased their total emissions. The low and medium human development countries increased their total emissions. Based on the above H5 hypothesis was not confirmed.

Research Questions 6 and 7 and the connecting hypothesis were as follows:

Is there a relationship between the development level of a country and the number of international agreements the country ratified?

Yes, there is. The relationship between the development level of a country and the number of international agreements the country ratified is linear and positive.

What is the relationship between the rule of law status of a country and the number of international agreements the country ratified?

The relationship between the rule of law status of a country and the number of international agreements the country ratified is linear and positive.

H6A: Developed countries are more involved in international environmental agreements than developing countries.

Countries with a high HDI Index enter into larger amount of international agreements.

H6B: Participation in international environmental agreements is related to the rule of law in a country. Countries with higher rule of law index are involved in larger amount of international agreements.

Countries with a high HDI Index enter into more international agreements and have a higher rule of law index with higher ranking. The relationship between the examined factors is considered to be particularly strong and significant. Based on the above H6B hypothesis was confirmed.

6.2. Recommendations

Some argue that fluctuations in oil prices increase output, thereby driving growth; others argue that price fluctuations reduce output, thereby impeding growth. Oil price increases are widely thought to increase inflation and slow economic growth. Oil prices have a direct impact on the prices of goods manufactured with petroleum products in terms of inflation. Oil prices have an indirect effect on costs such as transportation, manufacturing, and heating. Increases in these costs can affect the prices of a wide range of goods and services, as producers may pass on production costs to consumers. The extent to which increases in oil prices lead to increases in consumption prices is determined by the importance of oil in the production of a particular good or service.

Changing oil prices can have different impacts on a country depending on the development of the country. Governments should implement different policies to stop the pass-through indirect effect. In countries with deregulated prices governments can suspend pricing policy so as not to pass higher world prices fully to consumers. Governments can lower taxes or fees levied on petroleum products. It is also possible to subside fuel prices directly from the budget. Oil product price stabilisation funds can be established. There are other ways to attempt to lower end-user prices: threatening to withdraw licenses, boycotting firms that raise prices, requiring that justification be provided for price increases, forcing oil companies to absorb losses from under-pricing fuels. Prices can be set lower for certain consumers, for example fishermen, farmers, power producers. Energy efficiency measures can be made. Cash transfers or other compensations mechanism can be introduced. Switching to alternative sources of energy can also be an effective policy.

Given the circumstances in which developing countries find themselves—different income levels, budgetary situation, amounts spent on price subsidies, availability of indigenous petroleum

resources, fuels used for electricity production, and the impact of weather on hydropower, to mention a few—there is no simple or universal strategy for dealing with higher oil prices.

The influence of low-carbon energy on economic development is a vital issue. It is a dilemma we were dealing with. On the one hand, we are aware of the negative consequences of greenhouse gas emissions induced by fossil fuel combustion on ecosystem activity. Energy, on the other hand, is a vital component of economic development that has a direct impact on our basic well-being. The new coronavirus epidemic has had a significant impact on the world economy, with demand for nearly all energy products plummeting. However, in the short term, these negative impacts are likely to fade, and global energy demand is expected to climb.

Governments can use a variety of policy instruments to reduce carbon emissions Emission-pricing mechanisms are the initial part of a comprehensive policy mix GHG taxes and emission trading schemes, such as the EU Emissions Trading System, are included in this component, as are other incentive-based instruments like polluting products taxes. A national uniform carbon price is a cornerstone of mitigation plans since it is extremely successful in lowering emissions in the short term.

Standards and subsidies to accelerate the implementation of low-carbon technologies are the second component of a comprehensive policy mix. Emission quotas, green certifications, and technology regulations are only some of the constraints that these instruments might impose. They can be especially useful in situations where high-emitting activities or technology must be restricted or phased out by a given date. Although standards and regulations do not set explicit emission prices, the costs they imply can be considered implicit emission prices (contrary to emission-pricing schemes, which set explicit emission prices). The third component of a comprehensive policy mix is complementary and framework policies. All measures that do not directly try to reduce emissions but instead lessen the economic and social costs of policies that do so are included in this category. Complementary policies attempt to hasten the development and implementation of novel pollution-reduction technology. These policies include R&D and innovation incentives, measures supporting business dynamism, promoting data consistency and comparability of environmental, social and governance rating methodologies to crowd-in private capital, higher investment to upgrade electricity and transport networks.

To date, the Montreal Protocol to safeguard the Earth's ozone layer is the only UN environmental pact that has been ratified by every country on the planet. It's also one of the most recognized. The Protocol's parties have phased out 98 percent of their ozone-depleting compounds, saving an estimated two million people each year from skin cancer. It is expected that the ozone layer will return to pre-1980s levels by the middle of the century and the Antarctic ozone hole by around 2060s. The Montreal Protocol is one of the world's most successful environmental treaties, encouraging governments to pledge to phase out the production and consumption of ozone-depleting compounds since its inception. The Protocol's parties agreed to address this after learning that the alternatives, known as hydrofluorocarbons, are significant greenhouse gases that contribute to global warming. The Kigali Amendment was enacted in 2016 after lengthy negotiations. The success of the ozone protection regime was due to the global partnership, stakeholder involvement, and overall commitment of the governments. A effective hydrofluorocarbon phasedown might prevent a 0.4°C rise in global temperature by 2100 while also protecting the ozone layer.

Montreal and Kyoto Protocols addressed different environmental problems. The Montreal protocols put limits on chloroflourocarbons, which were harming the ozone layer. The Kyoto accords sought to limit carbon emissions, which lead to enhanced greenhouse warming.

Fundamentally, both were global agreements to address climate change. Kyoto put the burden on developed nations, and gave a “pass” to developing nations. For this reason it was never ratified by the US Senate, because it was recognized that for it to be at all effective, it must include all nations. Indeed, most growth in GHG emissions are coming from developing nations. We could eliminate developed world emissions and still not address the problem.

This was the fundamental difference, and the difference which made Paris Agreement even more widely adopted. The United States withdrew from the Agreement in 2020, but re-joined in 2021.The US agreed to Paris Agreement because all nations must do their part, with no exception for developing nations. What made this possible was redefining “do their part” to mean voluntary goals set by each participant, so a developing nation could simply set an easier goal, but still be on board with a collective effort. The idea was to gradually increase the goals in future commitments, with peer pressure, once developing nations realize that participation is not hard and goals are achievable.

The Montreal Protocol worked very well - the hole in the ozone layer has already stopped expanding. The Kyoto Agreement was only a beginning toward solving the warming problem.

The rule of law is a governance principle in which all public and private individuals, institutions, and entities, including the state, are held accountable to laws that are publicly promulgated, equally enforced, and independently adjudicated, and are consistent with international human rights norms and standards. It necessitates measures to ensure that the supremacy of the law, equality before the law, accountability to the law, fairness in the application of the law, separation of powers, participation in decision-making, legal certainty, avoidance of arbitrariness, and procedural and legal transparency are all adhered to. The rule of law is essential for international peace and security, as well as economic and social progress and development, as well as the protection of people's rights and fundamental freedoms. It is essential for people's access to public services, the fight against corruption, the restraint of power abuse, and the establishment of the social contract between people and the government. The rule of law and development are inextricably intertwined, and a stronger rule of law-based society should be a goal of the 2030 Agenda and Sustainable Development Goals (SDGs).

6.3. Research limitations and future research directions

The research methodologies I utilised are not appropriate for describing causality. Causality is defined as the influence of one event, process, or state (a cause) on the creation of another event, process, or state (an effect), where the cause is partially accountable for the effect and the effect is partially dependent on the cause. It could be interesting to look into the causality of the variables I looked at in the future. A Granger causality test could be used for this. A statistical model called a vector autoregression (VAR) could be used to describe the relationship between several quantities as they change over time.

In the future, I believe it is critical that the countries involved in research be more diversified, and that more economic indicators be considered. The other modification is that I think it would be beneficial to broaden the scope of existing data over time. The study has now extended a decade,

but if I had the chance, I would look at countries from 1990 onwards, which would allow me to add more groupings, such as Eastern European countries.

In connection with the rule of law research, one of my specific goals is to further examine relationships with other indicators.

7. NEW SCIENTIFIC RESULTS

1. I have statistically proven that the relationship between oil price and economic growth in developed countries is linear and negative. The relationship between oil price and economic growth in developing countries is linear and positive. In the case of very high human development countries, the change in the price of oil has opposite and more significant effect on the development of the GDP growth. In the case of high-human development countries, this relationship is weaker and opposite. The relationship between the price of oil and GDP growth in low and medium human development countries is significantly weak and can be considered positive.

2. I have statistically proven that developed and developing countries show a strong opposite relationship between GDP growth and CO2 emissions. The higher their GDP growth is, the lower their CO2 levels will be. If GDP increases, so does CO2. In the case of developing countries, the relationship is also similar, but it is weaker, meaning that it is less related to the evolution of GPD.

3. I have statistically proven that by applying carbon abatement policies total petroleum and coal use is not dropped, natural gas use intensified and renewable energy use fluctuated in developed and developing countries during the analysed period.

4. I have statistically proven that countries with very high human development almost completely reduced their CFC consumption by 1997. High, medium and low HDI countries decreased CFC consumption after 1997. As a result of this the Montreal Protocol has reduced ozone depleting substances in the atmosphere.

5. I have statistically proven that from the very high group of human development countries most countries were able to meet the 5% reduction defined in the Kyoto agreement, but the reduction was less as in their original commitment. This was even more the case in the high human development countries, they were able to reach the reduction commitment only if we consider total GHG per capita data. The low and medium human development countries increased their total emissions.

6. I have statistically proven that developed countries are more involved in entering into international environmental agreements than developing countries. The relationship between the development level of a country and the number of international agreements the country ratified is linear and positive.

7. I have statistically proven that the relationship between the rule of law status of a country and the number of international agreements the country ratified is linear and positive.

The results of my research is summarized in Table 42 as follows:

Table 42: The results of the research

HYPOTHESIS	RESULT OF TEST	CONCLUSIONS
The impact of oil price changes on GDP growth is less significant in developed countries, and this impact is more significant in developing countries.	This hypothesis has not been confirmed.	In the case of very high human development countries, the change in the price of oil has opposite and more significant effect on the development of the GDP growth. In the case of high-human development countries, this relationship is weaker and opposite. The relationship between the price of oil and GDP growth in low and medium human development countries is significantly weak and can be considered positive.
H2: Applying carbon abatement policies will reduce GDP growth in developed countries, but it will rise GDP growth in developing countries.	This hypothesis has not been confirmed.	Developed and developing countries show a strong opposite relationship between GDP growth and CO2 emissions. The higher their GDP growth is, the lower their CO2 levels will be. If GDP increases, so does CO2. In the case of developing countries, the relationship is also similar, but it is weaker, meaning that it is less related to the evolution of GPD.
H3: By applying carbon abatement policies total petroleum and coal use will drop and natural gas and renewable energy use will intensify in both developed and developing countries.	This hypothesis has not been confirmed.	According to my findings total petroleum, coal and natural gas use is rising. Renewable energy consumption is fluctuating in both county types.

H4: The Montreal Protocol and its extensions on Substances that Deplete the Ozone Layer have reduced ozone depleting substances in the atmosphere and have produced significant environmental benefits to protect the earth's ozone layer.	This hypothesis has been confirmed.	Countries with very high human development almost completely reduced their CFC consumption by 1997. High, medium and low HDI countries decreased CFC consumption after 1997. The Montreal Protocol has reduced ozone depleting substances in the atmosphere
H5: The Kyoto Protocol and its extensions to the United Nations Framework Convention on Climate Change have reduced greenhouse gas substances in the atmosphere and have produced significant environmental benefits to protect global warming. The Protocol has played a significant role in the reshaping the economy of developed and developing economies.	This hypothesis has not been confirmed.	Comparing the commitments made in the Kyoto Protocol with the very high, high, low and medium human development countries, I concluded that from very high human development group, most countries were able to meet the 5% reduction in the Kyoto agreement, but the reduction was less as in their original commitment.
H6A: Developed countries are more involved in international environmental agreements than developing countries.	This hypothesis has been confirmed.	Countries with a high HDI Index enter into larger amount of international agreements.
H6B: Participation in international environmental agreements is related to the rule of law in a country. Countries with higher rule of law index are involved in larger amount of international agreements.	This hypothesis has been confirmed	Countries with higher rule of law index have more international agreements. The relationship between the examined factors is considered to be particularly strong and significant.

Source: Author's own editing

8. SUMMARY

The objective of the dissertation is to deal with the economic impact of international environmental agreements. In the first segment I explore the development, function, characteristics and the problems of international agreements. I put special emphasis on the environment-related agreements. In the following section I will focus on the economic effects of these agreements by analysing different macroeconomic indicators. The dissertation covers two specific environmental problems. The first one is ozone depletion, the second is greenhouse gas emission. Both environmental problems were caused by human activities. The impact of these phenomena can be disastrous for our planet.

The mechanism, process, institution, practise, or norm that supports the equality of all citizens before the law, secures a nonarbitrary form of government, and, more broadly, prevents the arbitrary use of power is known as the rule of law. I dissertation analyses the possible relationship between the concept of rule of law and human development. I formulated 6 hypotheses. In the research, I primarily tested my hypotheses by analysing them with different statistical methods.

Firstly I analysed the relationship between oil price and economic growth of countries with different development level. I concluded that the relationship between oil price and economic growth in developed countries is linear and negative. The relationship between oil price and economic growth in developing countries is linear and positive.

Examining my second hypothesis I have found that Developed and developing countries show a strong opposite relationship between GDP growth and CO2 emissions. The higher their GDP growth is, the lower their CO2 levels will be. If GDP increases, so does CO2. In the case of developing countries, the relationship is also similar, but it is weaker, meaning that it is less related to the evolution of GPD.

In my third hypothesis I have shown that Carbon abatement policies do not have impact on petroleum, natural gas, coal and renewable energy use. According to my findings total petroleum, coal and natural gas use is rising. Renewable energy consumption is fluctuating.

In my fourth hypothesis I have found that Countries with very high human development almost completely reduced their CFC consumption by 1997. High, medium and low HDI countries decreased CFC consumption after 1997. The Montreal Protocol has reduced ozone depleting substances in the atmosphere. Based on the above H4 hypothesis was confirmed.

In my fifth hypothesis I have concluded that Comparing the commitments made in the Kyoto Protocol with the very high, high, low and medium human development countries, I concluded that from very high human development group, most countries were able to meet the 5% reduction in the Kyoto agreement, but the reduction was less as in their original commitment. This was even more the case in the high human development countries, they were able to reach the reduction commitment only if we consider total GHG per capita data. The low and medium human development countries increased their total emissions. The low and medium human development countries increased their total emissions. Based on the above H5 hypothesis was not confirmed.

In my last hypothesis I have found that countries with a high HDI Index enter into more international agreements and have a higher rule of law index with higher ranking. The relationship between the examined factors is considered to be particularly strong and significant.

9. APPENDICES

9.1. Appendix 1. Bibliography

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