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# The links between population growth and CO2 emissions and their impact on climate change

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## Abstract

In the face of increasing CO2 emissions and the need to rapidly reduce them to mitigate climate change, this master thesis takes a closer look at the population variable to understand how it affects CO2 emissions. A statistical analysis is carried out which examines the influence of the variables population, GDP per capita and energy use per capita on the variable of CO2 emissions. Based on the assumption made in this work that pure population figures and CO2 emissions draw a too simplified picture of the subject, the statistical analysis is embedded in a socio-political and historical consideration of the connections between environmental destruction and population debates. An attempt is made to understand the possible societal impact of demands for reproductive health in the context of climate change. A look is taken at the history of population control programs, but also at modern international family planning programs. At the same time, regional differences between population figures and CO2 emissions growth are examined. The statistical analysis, considered in the socio-historical framework of the reviewed literature, shows that several factors have an impact on CO2 emissions, with the population variable being the most difficult and slowest to influence and not offering a quick, human rights-friendly route to CO2 reduction.

## List of abbreviations

Association of Southeast Asian Nations (ASEAN)
Bill & Melinda Gates Foundation (BMGF)
Carbon dioxide (CO2)
Conference of Parties (COP)
Contraceptive prevalence rate (CPR)
Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)
Demographic transition (DTM)
Dichlorodiphenyltrichloroethane (DDT)
Family Planning 2020 (FP2020)
Family Planning 2030 (FP2030)
Foreign, Commonwealth & Development Office (FCDO)
Greenhouse Gas (GHG)
Gross domestic product (GDP)
Gross national income (GNI)
Intergovernmental Panel on Climate Change (IPCC)
International Conference on Population and Development (ICPD)
International Monetary Fund (IMF)
International Planned Parenthood Federation (IPPP)
Intra-uterine device (IUD)
Long-acting reversible contraception (LARC)
Marie Stopes International (MSI)
Millennium Development Goals (MDGs)
Modern Contraceptive Prevalence (MCP)
Non-governmental organization (NGO)
Sub Saharan Africa (SSA)
Sustainable Development Goals (SDG)
United States Agency for International Development (USAID)
UK National Health Service (NHS)
United Arab Emirates (UEA)
United Nations (UN)
United Nations Population Fund (UNFPA)
United States (U.S.)
World Meteorological Organization (WMO)

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# 1. Introduction

Worrying about the number of people in the world seems as old as human history itself - from the Babylonians, who predicted catastrophes caused by human overpopulation as early as the 18th century BCE in the Atra-Hasis (Cohen, 1995), to Thomas Malthus, who in the 18th century brought the growing population numbers into an economic context with agricultural resources (Malthus, 1798), the debate about the world's population always seems to find new considerations. These are most often connected with the fundamental question of how many people can fit on this earth (Cohen, 1995). Time and again, the earth is described as already overpopulated by humans (Ehrlich, 1968), especially in connection with the availability of natural resources. In the past years, the debate about the number of people has received a new impetus in the context of climate change (Ojeda et al., 2020). In 2014, the Intergovernmental Panel on Climate Change (IPCC) published in its report that global population growth is the most important factor in the increase of carbon dioxide (CO2) emissions (IPCC, 2014). Three years later, in 2017, about 15,000 scientists published a "Warning to Humanity" saying that the number of people is still the main cause of climate change (Ripple et al., 2017). Based on the premise that climate change and further environmental degradation are caused in part by inadequate family planning, in September 2021 more than 60 NGOs called for more climate spending on reproductive health in an open letter to Alok Sharma, chair of the United Nations Climate Change Conference 2021, ahead of the 26th Conference of the Parties (COP26) to the United Nations Framework Convention on Climate Change (UNFCCC) in Glasgow (Davies, 2021). Reproductive health in this context is primarily understood as improved access to modern contraceptives, as it is commonly assumed that high fertility is the result of an unmet need for contraception (Fuchs et al., 2014). The underlying argument in relation to climate change holds that adequate contraception reduces birth rates, which in turn reduces population growth and thereby greenhouse gas emissions (International Planned Parenthood Federation [IPPP], 2021). Different stakeholders have pointed to contraception as an important intervention for climate change mitigation (Proctor & Schiebinger, 2022). The letter to Alok Sharma in 2021 was co-authored by Bethan Cobley, the director of the international family planning organization Marie Stopes International Reproductive choices (MSI). This is not surprising, since other family planning programs such as the United Nations Population Fund (UNFPA) or Family Planning 2030 (FP2030) also directly bring together the issues of climate change with family planning. The focus of international family planning programs is thereby most often on the reproductive health of women in the Global South, particularly on the African continent, as many Sub-Saharan countries[1] have high birth rates and a particularly high unmet need for contraception compared to other countries in the world (United Nations, Department of Economic and Social Affairs, Population Division [UN Population Division], 2019). Partnerships, such as FP2030, specifically address women's reproductive health in low-income countries and aim to improve access to modern contraceptive methods (FP2020, 2014). To condemn these programs per se would be devastating, as they have led to large declines in maternal and child mortality (UNFPA, 2017; Agena et al., 2022; Berlin-Institut für Bevölkerung und Entwicklung, 2019) and there remains indeed an unmet need for contraception in numerous countries around the world (UN Population Division, 2019). Yet, population considerations have led to human rights abuses in the past (Pizzarossa, 2018; Follett, 2020), and there appears to be ample evidence that education of women can be much more critical to birth rates than improved access to contraception (Fuchs & Goujon, 2014; Lutz, 2013). In addition, there is a recurring criticism that the debate about reproductive health in the context of climate change distracts from the main causes of CO2 emissions (Ojeda et al., 2020). From 1990 to 2015, 52% of carbon emissions were generated by the richest 10% of the world's population, or about 630 million people (Oxfam, 2020). Regionally considered, people in the Global North have significantly higher per capita resource consumption than people in the Global South, who in turn are most significantly affected by the impacts of climate change (ibid.). The question of climate change is also a question of responsibility. Responsibility is passed back and forth between many different actors and leads to narratives that potentially distract from the real causes of climate change. One of these narratives seems to blame the number of people on the planet for CO2 emissions.

This master thesis therefore wants to take a closer look at the relationship between population growth and greenhouse gas emissions in order to better understand what contribution population growth makes to climate change?

To examine this relationship, the literature is first reviewed, with emphasis on the history of the relationship between environmental considerations and population numbers and their implementation in population control programs in the 20th century and modern family

[1] The term „Sub-Saharan Africa“ is of colonial origin, with the African continent being divided into an Arab, cultured north and a supposedly uncivilized black south (Fanon, 1961). In this work the term is used when referring to statistics using this explicit classification of the African continent.

planning programs. After a socio-political and historical overview, $CO_2$ emissions are discussed in more detail and the factors that influence them. After gaining an theoretical overview, a multiple regression analysis is performed between the independent variables of population, GDP per capita, energy use per capita, and the dependent variable of $CO_2$ emissions for the years 1990, 2000, 2010 and 2019. In addition, the data on which the statistical analysis is based on are examined more closely by means of a comparison between the $CO_2$ emissions of 195 countries and their trends between 1990 and 2020. Finally, the evaluated data are discussed with a view to the reviewed literature and the need to ensure, despite needed global emission reductions, that households in energy poverty whose $CO_2$ emissions per person are far below a global "fair" share can increase their consumption. The end goal is to determine whether calling for greater reproductive health in the context of climate change is really an appropriate way to address the causes of and adapt to climate change.

# 2. Literature Review

Answering the question about the links between climate change and population is complex. If statistical numbers could simply be considered as neutral, an answer would perhaps be easy to give. However, David Harvey (1974) writes that the relationship between resources and population involves special ethical and moral considerations. In order to place the statistical analysis used later in this work within a social and historical framework, a special look at the literature will first be taken. This will include first a review of current demographic figures on world population, followed by an examination of how the population discourse has found its way into environmental debates, and finally a closer look at the historical events of the twenty-first century, the era of population control programs, is taken. Further, this chapter looks at modern family planning programs and examines the issue of contraception, and concludes with a look at the causes and influencing factors of CO2 emissions.

## 2.1 Today's world population

The number of people living on this planet has changed significantly over the course of human history, with more people living today than ever before. Since the 1950s, population growth has been experiencing what can be perceived as a boom (Fletcher, 2014), with predictions fluctuating around the numbers of when and with how many people the world population limit will be reached. In fact, since the 1950s, the human population has increased from about 2.5 billion to 8 billion, making the world population today higher than it has ever been in human history (United Nations Department of Economic and Social Affairs, Population Division [UN Population Division], 2022). In 1800, for example, humanity is thought to have numbered only about 1 billion people (Roser et al., 2013). Toshiko Kaneda and Carl Haub estimated in 2021 that about 117 billion people have ever lived on Earth (Kaneda & Haub, 2021), implying that with a projected world population on Jan. 1, 2022 of 7.8 billion people (Moore, 2021), about 6.7% of the total number of people ever born was living in 2020 on the planet (Kaneda & Haub, 2021). China, followed by India, is today the most populous country in the world. Both China and India each count more than 1.4 billion people. China and India are followed by the USA with around 335 million people in 2022 (UN Population Division, 2022). On the African continent, Nigeria is the country with the highest population numbers, while in Europe, Germany ranks first (ibid). Global population figures are never completely accurate at 100% - the United Nation

(UN) bases its world population forecasts primarily on population surveys that are conducted only every few years. The 8 billion mark which was reached on November 15, 2022 is therefore according to the UN (2022b) rather a symbolic day. However, UN forecasts have shown to have a high hit rate (May, 2022).

The world population can be viewed in absolute numbers and in growth rates. Compared to historical data, the world population today is, as already stated, higher in absolute terms than ever before. However, the growth rate of the world population has already peaked between 1965 and 1970 at around 2.1% per year (UN Population Division, 2022). Since then, the growth rate of the global number of people has been declining. In 2020, the growth rate of 0.82% was only one-third of the 1963 population growth rate of 2.27% (ibid.). According to UN calculations, the growth rate worldwide will continue to fall in the coming years, after having already recorded falling growth rates globally for over half a century (ibid.). This also indicates that the world population is not growing exponentially, as was assumed by the influential writing of Thomas Malthus „The Principles of Population“ in the 18th century or by publications such as „The Limits of Growth“ which will be referred to later in this work. Malthus postulated that mankind increases in exponential steps (Malthus, 1789). However, constant global growth rates are required for exponential growth of the world population (Roser et al., 2013).

Despite declining growth rates and a non-exponentially growing number of people, the world's population continues to increase in absolute numbers. This is not only due to the high number of annual births, but also to the current low mortality rates in some regions, which are also included in global population growth rates. In 2020, the world population has grown by around 76 million people. However, absolute numbers also peaked as early as 1990 with 91.41 million additional people and have been declining since then (Roser et al., 2013). When we look back at the history of population growth today, it seems that the numbers exploded in the middle of the 20th century. However, Lutz (2014) describes how, as early as the 19th century, population growth in the countries of the Global North increased due to a decline in mortality rates thanks to better health care and access to better water and nutrition. IThis increase was amplified in the 20th century after World War II, when the mortality rate dropped dramatically while the birth rate was particularly high, resulting in a generation with particularly high population numbers. These developments of changing population growth rates, e.g. due to better health care like the invention of antibiotics (Lutz, 2014), have proven to be particularly true for the European continent. With regard to population growth, however, it is particularly important to note that population growth is not a homogeneous development, but differs significantly between regions and countries (UN Population Division, 2022). Today, population growth rates vary between continents and regions of the world. Since the 1980s the highest absolute population growth is found in Sub-Saharan Africa (ibid.) with a population growth rate of approximately 2.6% compared to the previous year in 2021 (The World Bank, 2022). In comparison: the growth rate of the European Union in 2021 was at about -0.1% year-on-year (ibid).

Since both growth and mortality rates vary widely around the world (UN Population Division, 2022), the point in time at which population numbers peak varies just as much in time as in magnitude across regions (Lutz et al., 2001). This makes statements about future developments difficult and uncertain (UN Population Division, 2022). In general calculations of future population figures have repeatedly failed in the past (Cohen, 1995). Future demographic development may depend on numerous events. As will be shown later, there is a wide divergence of opinion, for example, on the factors influencing fertility. "The future is unlike the past because it has not happened yet." (Cohen, 1995). According to most current UN estimations it is likely that the 11 billion human will never be born on this planet and that the worlds population is to peak at around 10.4 billion people (UN Population Division, 2022). Already in 2001, Lutz et al. (2001) projected a global demographic transition to low fertility at the end of this century, with population growth very likely to peak and then decline and with a 60 % chance that human population numbers will not pass 10 billion people (Lutz et al., 2001). An important point to note here, is that the majority of the world's population already lives in countries where fertility rates are declining significantly (Lee, 2011). The average fertility of the world's population in 2021 was at 2.3 births per woman over a lifetime. This compares with a global average of around 5 births per woman in 1950. The UN Population Division (2022) projects that in 2050 fertility will be around 2.1 births.

But as the world population continues to grow in absolute numbers, it seems logical at first to draw a direct link between climate change, environmental degradation and the number of people on the planet. The history of this relationship is therefore struck in the next chapter.

## 2.2 Considerations of human population in environmental discourses

To reflect on the number of human beings in the world seems, with regard to the Babylonian tales of the Atra-Hasis, as old as the history of humankind itself. Many historical calculations have predicted numbers over the course of time that have either greatly underperformed or exceeded (Cohen, 1995). In modern history, however, the question is no longer simply on how many people will be born in the future, but on how many people will fit on the planet in terms of available resources and whether the planet is being overpopulated already. It was Thomas Malthus who, in 1798 through his work "The Principles of Population“ translated considerations of a presumed overpopulation into an economic-demographic framework. He theorized that population growth could not exceed available agricultural resources without causing famine and disease, which in turn led to a natural restraint on population growth (Malthus, 1798). Much of Malthus' focus was on poor families as he concluded that those who could not adequately provide for their families should not start families in the first place. In addition, Malthus surmised that the institution of private property and the fear of losing one's social position led to a caution in procreation among the rich and, conversely, a lack of caution among the poor (Malthus, 1798; Bandarage, 1997). Therefore, he opposed the Poor Laws enacted by the British government of the time and called for the poor to be left to fend for themselves, i.e., to die in an emergency. Thus, from the work of Malthus emerges a notable concern for the reproduction of certain classes. This does not mean that Malthus was blind to social-structural factors leading to poverty or to possible technological progress that could advance agricultural yields. To some extent, Malthus was aware of the impact of the industrial-capitalist economy and the consumption patterns of the wealthy, and also had some awareness of the opportunities for reducing scarcity through technological innovation. Asoka Bandarage (1997) formulates that it was Malthus's class interest that probably prevented him from including these factors in his calculations. The Principles of Population identifies population growth as the cause of environmental degradation and other social problems such as poverty and social conflict, and calls for strict population control as a solution (Malthus, 1789).

Today, Malthus's ideas find their continuation in so-called Malthusianism and neo-Malthusianism, which gained popularity especially between the 1940s and 1960s, when population growth and economic development were particularly high in many countries (Park, 2007; Folett, 2020). Although there are key differences between Malthus's original piece and subsequent positions, it is the people versus natural resources perspective that continues to be focussed on (Braidotti et al. 1994), with attributing all sorts of global problems to population growth (Harvey, 1974; Hartmann; 1995). Malthusianism is fundamentally associated with the idea that population growth is potentially exponential while growth in food supply or other resources is linear, eventually lowering living standards to the point of population decline. Voices of Neo-Malthusianism advocate controlling the rate of population growth to ensure resources and environmental integrity for present and future human populations, as well as for other species (Mellos, 1988). Today's voices differ from Malthus' work, particularly with regard to opinions on contraceptive use. Whereas Malthus advocated abstinence as a morally and religiously defensible means of birth control and rejected intentional birth control, many neo-Malthusians today focus largely on contraceptive use as the most effective solution (Soloway, 1978; Schlosser, 2009; Braidotti et al. 1994; Hartmann, 1995; Harvey, 1974) and advocate a "contraceptive revolution" in countries with a so-called unmet need for contraception (Bandarage, 1997).

Malthus' original publication was then discovered by the ruling classes and policy makers, and from the late 19th century onwards statistical calculations on demographic data were increasingly incorporated into policy making (Bandarage, 1997, Agena et al., 2022). Considerations of population development in the 19th century in Europe and the United States coincided with the eugenics movement (Soloway, 1978; Collins, 2002), which became a dominant political movement in the early 20th century. The eugenic idea of preventing people who are considered unworthy of procreation lead to birth control through sterilization over many decades and reached its peak under National Socialism (ibid.), where sterilization research was carried out primarily on Jews, Sintezze and Romnja, people with disabilities, and Black and People of Color. Eugenic ideas dominated debates on population policies until the end of World War II. However, eugenic ideas did not end with Nazism. In Japan, for example, women with disabilities were sterilized until 1996 because of sterilization laws introduced in the 1940s (Tsuchiya, 1997). The links between eugenics and neo-Malthusian ideas are closely intertwined and still inform the thinking behind forced sterilizations today (Follett, 2020), however, eugenic ideas are not explicitly addressed by this work.

The population discourse is by no means a new phenomenon, as a brief look at eugenics or Thomas Malthus has shown. Long before the Second World War, population experts were already debating about the growing number of people. But it was not until after World War II that neo-Malthusian ideology came to dominate national and global discourses on population in relation to the Global South. This master thesis focuses on post-World War II neo-Malthusian discourses as the end of World War II marks both significant changes in global population growth trends and the beginnings of international development cooperation. International population numbers during the 1950s were growing in such a way that the growth was perceived as a real boom and immediate threat (Fletcher, 2014). The rapid growth of the population lead biologist and self-proclaimed Malthusian Paul Ehrlich (Bajaj & Ware, 2022) to bring together the earth's natural resources and the growing population with the biological concept of "carrying capacity“. In biology, the term carrying capacity describes the maximum number of organisms of a species that can exist in a habitat for an indefinite period of time without causing lasting damage to it (Hixon, 2008). Ehrlich, who was best known among experts as an entomologist for his studies on the common evolution of flowering plants and butterflies, published the million-selling book "The Population Bomb" in 1968. Ehrlich begins his „Population Bomb“ with a detailed description of a stay with his family in Delhi, India. He drives through Delhi in a cab, recording observations of fleas, dust in the air, people arguing, beggars, and people urinating in the street (Ehrlich, 1968). In fact, he writes that his family and himself were afraid they would not make it back to the hotel (ibid.). Reading this section, it becomes clear how Ehrlich tries to convey poverty and misery. He ends his description of Delhi by saying that now he knows what overpopulation feels like (ibid.). In 1960, Delhi recorded a population of 2,283,000 people (Population Stat, 2020). In comparison, in 1960, New York City, the largest city in the United States at the time, already counted a number of 7,781,984 people, according to the 18th Census of the United States of America conducted by the United States Census Bureau (U.S. Census Bureau, 1960).

Thanks to Paul Ehrlich, a completely new focus came to the fore politically, that of overpopulation, argued among other things by the ecological concept of the “carrying capacity” of the earth threatened by population growth. Ehrlich begins his book with the lines:

> “The battle to feed all humanity is over. In the 1970s the world will undergo famines – hundreds of millions of people are going to starve to death in spite of any crash program embarked upon.... These programs will only provide a stay of execution unless they are accompanied by determined and successful efforts at population control. The birth rate must be brought into balance with the death rate or mankind will breed itself into oblivion ... Population control is the only answer.” (Ehrlich, 1968).

In doing so, Ehrlich stirs the narrative of fears of devastating environmental catastrophes (Duden, 2009). In "The Population Bomb," he divides the world into two categories:

Developing countries, which have high birth rates, and developed countries[2], which have low birth rates (Ehrlich, 1968). Furthermore, he defines a developing country as "starving," by which Ehrlich primarily means that people cannot be fed due to an alleged failure of unprofitable agriculture (ibid.). Reading Ehrlich's work, one gets the impression that his reflections are primarily guided by concern for starving people, with his core message being that there is not enough food for everyone. Ehrlich attributes almost all of the environmental problems mentioned in „The Population Bomb“ to the need to increase food production. For example, he cites numerous examples of the poisoning of the environment by the insecticide dichlorodiphenyltrichloroethane (DDT), which led to heated debates especially in the 1960s through Rachel Carson's book Silent Spring, which is now considered a trigger of the global environmental movement (Griswold, 2021). However, Ehrlichs reflections on environmental degradation do not seem to go beyond those of agriculture. His argument, however, extends to the fact that population growth leads to garbage, litter, congested highways, misery, poorer school systems, crime, riots, and similar problems (Ehrlich, 1968). Ehrlich thus mixes all sorts of social and environmental issues with those of the population discourse. In addition, Ehrlich uses cultural identities as examples to justify his statements about hunger: For example, he reports about indigenous children in Peru chewing coca leaves because they contain cocaine and numb the feeling of hunger (ibid.), not considering that the coca leaf is an important component in the beliefs of many indigenous cultures throughout Latin America (Valdez et al., 2015).

Ehrlich recognizes in his well-known work that the USA is dependent on raw material imports from the developing countries and also writes that the prosperity of the USA can only be maintained if the USA frees itself from the import constraints. He theorizes that if people in developing countries had nothing to eat and the US did not take care of this situation, developing countries would stop supplying raw materials. Ehrlich's main proposal for solving the overpopulation problem, first noted in Delhi: the widespread sterilization of the lower class. In the process, the radical neo-Malthusian spins together the idea of temporarily adding sterilizing agents to drinking water and food, which he later discards due to low chances of realization (Ehrlich, 1968).

[2] The description of countries as developed or underdeveloped is applied conceptually here, as reference is made to the original work of Paul Ehrlich (1968). However, the terms should be fundamentally questioned and are used in this work only with reference to other sources.

While Ehrlich's Population Bomb is relatively focused on the direct effects of population growth, Ehrlich broadens his view in later works; in 1971 together with John P. Holdren, he writes:

> „Problems of population size and growth, resource utilization and depletion, and environmental deterioration must be considered jointly and on a global basis. In this context, population control is obviously not a panacea - it is necessary but not alone sufficient to see us though the crisis.“ (Ehrlich & Holdren, 1971).

In the 1970s Ehrlich together with Holdren develops his famous „IPAT“ equation. The IPAT equation relates environmental impact (I), where the maximum endurable impact equals the carrying capacity, to the population size (P), affluence (A), and technology (T). Although Ehrlich & Holdren (1974) bring factors other than population growth into the equation, they write in an earlier work from 1971 that the role of the population multiplier is underestimated since population size directly affects impact and technology (Ehrlich & Holdren, 1971). They argue that the given increase in population leads to an exactly proportional increase in consumption, but without providing a concrete empirical basis (ibid.).

"The Population Bomb" is possibly Ehrlich's most radical work, and his contemporary views have definitely expanded, but the Population Bomb also represents by far his most influential work. At the time Ehrlichs „Population Bomb“ played directly into the hands of population policy makers. Driven by Ehrlich's publication, the U.S. Department of Population and Environment, for example, determined right after the publication to invest more in contraceptive research as well as to push embryonic sex determination (Agena et al., 2022). Even today, the population bomb remains prevalent. A simple example of this is provided by the freely accessible "The Overpopulation Podcast" which aims to provide "education and solutions to the effects of human overpopulation and overconsumption on the planet, people and animals." (Bajaj, N. & Ware, A., 2022). In July 2022, Paul Ehrlich was invited for an interview. The interviewers Nandita Bajaj and Alan Ware introduce Paul Ehrlich as a true legend and talk to him about the fact that in his opinion only 3.5 billion people in the world can live sustainably and that therefore his population bomb proved to be right, since 8 billion people live on the planet today (Bajaj & Ware, 2022). The podcast illustrates quite vividly how much Ehrlich's influence is still felt today.

The environmental movement, which emerged at the same time as Ehrlich's "The Population Bomb," is also influenced by the writing. The 1972 Club of Rome-commissioned study "The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind" (Meadows et al., 1972) arguably one of the cornerstones of the environmental movement, focused even more attention on the problem of population growth and applied the concept of carrying capacity on a global scale. The Club of Rome's best-selling book, which sold about 33 million copies, popularized the idea of the world as a "system" with the human species as a new entity, shifting the focus from nature as a danger to humans to humans as a danger to nature. Thereby the survival of the system earth and the humanized world population is described as threatened, driven by the growth of the population (Duden, 2009) and by the growth of economy. Meadows et al. (1972) contrast the two exponentially growing factors of population and economy with limited factors such as non-renewable resources and food. Regarding population growth the work assumes that „population is expected to increase exponentially in the less developed regions of the world, but almost linearly in the more developed regions.“ (Meadows et al., 1972).

Meadows et al. (1972) at the time assume that all countries, as long as they develop economically, will follow the example of the U.S. and therefore wonder if there will be enough resources for seven billion people to live at a high standard of living in the year 2000. They do not blame population growth alone for increasing environmental degradation, as Paul Ehrlich did in earlier works, but rather the resulting rising consumption rates, which are growing at an even faster rate than population: „Population cannot grow without food, food production is increased be growth of capital, more capital requires more resources, discarded resources become pollution, pollution interferes with the growth of both population and food.“ (Meadows et al., 1972). Ultimately, however, growing populations and increasing industrial production are blamed for environmental degradation and other social problems, as economic output is defined as the problem, while at the same time it is claimed that increasing industrialization lowers the birth rate due to improved medical conditions. If desired birth rate is high, fertility will also be high.

> „The >>value<< of a child includes monetary considerations, such as the child’s labor contribution to the family or business and the eventual dependence on the child’s support when the partens reach old age. As a country becomes industrialized, child labor laws, compulsory education, and social security provisions all reduce the potential monetary values of a child. […] Falling birth rates due to

industrialization are not the only determinant but have in history proven to be true“ Meadows et al. (1972)

"Limits to Growth" recognizes that its simulations do not take into account factors such as the unequal distribution of resources or political processes, but subsequent updates do not take these into account either. Thus, as an example, the relationship between poverty and population growth is presented as a simple causal relationship. This oversimplification and generalization of complex relationships such as the emergence of poverty distracts from the deeper, underlying reasons (Braidotti et al. 1994). Resource consumption is not evenly distributed across the world's population (Oxfam, 2017; Chancel et al., 2021). As will be shown later in this paper, a small portion of the world's population consumes a large portion of the world’s resources and at the same time is responsible for a large portion of CO2 emissions. By generalizing population numbers, all people are held equally responsible for environmental degradation, even if there are large differences between the consumption of different individuals and groups here. Meadows et al. (1972) would have had the opportunity to address these questions of unqual distribution early on and to lay the foundation for differentiated considerations of responsibility.

Instead Meadows et al. (1972) conclude that if „the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. […] The most probable result will be a rather sudden and uncontrollable decline in both population and industrial capacity.“ (ibid.). Limits of Growth is often being attributed to Neo-Malthusianism (Park, 2007; Schoijet, 1999; Collins, 2002). Schoijet (1999) even calls Limits to Growth the most important work of neo-Malthusianism.

The publication of the Club of Rome triggered the first international environmental policy discussions and contributes significantly to the strengthening of the worldwide ecological movement. Alongside the Club of Romes report, the so-called Brundtland report from 1987 is today regarded as a milestone of the environmental movement. It is one of the most frequently cited works in environmental and development literature and is considered the beginning of the worldwide discourse on sustainability and sustainable development. Within the report, „Chapter 4“ deals exclusively with population issues. The Brundtland Report writes:

> "Current rates of population growth cannot continue. They are already threatening the ability of many governments to provide education, health care, and food security for people, let alone their ability to raise living standards. This mismatch between numbers and resources is all the more urgent because much of the population growth is concentrated in low-income countries, environmentally disadvantaged regions, and poor households.“ (United Nations World Commission and Development [UNWCED], 1987)

However, the report expresses, that population alone, is not the only factor, as „threats to the sustainable use of resources come as much from inequalities in people's access to resources and from the ways in which they use them as from the sheer numbers of people. Thus concern over the 'population problem' also calls forth concern for human progress and human equality. [...] Nor are population growth rates the challenge solely of those nations with high rates of increase. An additional person in an industrial country consume far more and places far greater pressure on natural resources than an additional person in the Third World. Consumption patterns and preferences are as important as numbers of consumers in the conservation of resources.” (UNWCED, 1987).

Additionally, well before the Cairo Conference, which will be referred to in detail later, the Brundlandt Report writes about self-determination over one's own body as a human right in connection with the discourse in the world population: „Giving people the means to choose the size of their families is not just a method of keeping population in balance with resources; it is a way of assuring – especially for women the basic human right of self-determination.“ (UNWCED, 1987). After the Universal Declaration of Human Rights in 1948, it takes until 1978 for the "Convention on the Elimination of All Forms of Discrimination against Women“ (CEDAW Convention), in which discrimination against women is adopted for the first time as a United Nations international convention on women's rights by the UN General Assembly. In this sense, the Brundtland report already years before CEDAW connects the topic of population to women’s rights and not only as a sheer environmental issue.

The narrative that environmental degradation is fundamentally caused by the growing human population has prominent public and scientific advocates also today. The popular documentary narrator and environmentalist David Attenborough in a 2013 interview with The Guardian portrayed famines in Ethiopia as an issue of too many people and publicly advocated for an increased debate on population control: “They're about too many people for too little land. That's what it's about. And we are blinding ourselves. We say, get the United Nations to send them bags of flour. That's barmy.“ (Tran, 2013).

World-renowned primate conservationist Jane Goodall attracted particular attention with her statements on population at the World Economic Forum 2020 in Davos, Switzerland:

> "What was the population in the year 1500? About 500 million. What on earth could take place that would cause a planet with 9 billion people on it to be reduced by 95% to 500 million? Hmm…I wonder if a virus could do that?“ (Climate One, 2017)

During a panel discussion at the Forum titled "Securing a Sustainable Future for the Amazon," Goodall identified four key things that activists and governments must focus on to help the Amazon forest sustainably: Poverty, less meat consumption, political corruption and population growth. She concluded the panel with the words: "Finally, we cannot hide away from human population growth, because, you know, it underlies so many of the other problems. All these things we talk about wouldn’t be a problem if there was the size of population that there was 500 years ago.“ (Climate One, 2017)

In addition to the aforementioned public figures, a growing body of scholarly work is also concerned in the past years with projecting future population trends and greenhouse gas emissions. They argue that slowing population growth through universal access to family planning interventions will result in fewer emissions and thus mitigate climate change (Gaffin & O'Neill 1997; O'Neill et al. 2010, 2012). Studies similar to those by Gaffin and O'Neill, argue that a cost-effective strategy to help the most vulnerable communities adapt to the impacts of climate change is better access to contraception (Martine, 2009). According to Ojeda et al. (2020) the projections used for greenhouse gas (GHG) emissions and population growth in some of the most recent studies mostly convey the picture of two possible opposite outcomes: high population growth with high emissions and, on the other hand, low population growth with low emissions. The creation of these population versus GHG emissions projections in terms of human lives is linked to the underlying consideration that some human lives can be averted in the service of global environmental goals (Murphy, 2017), since births are directly converted into CO2 emissions. In 2007, a spokesman for the Chinese government announced at U.N. climate change talks in Vienna that China had prevented a total of 300 million births through its one-child policy and thus made an important contribution to the fight against climate change: "Avoiding 300 million births "means we averted 1.3 billion tonnes of carbon dioxide in 2005" (Doyle, 2007).

In 2014, the Intergovernmental Panel on Climate Change (IPCC) stated in its Fifth Assessment Report that "globally, economic and population growth continue to be the main drivers of increases in CO2 emissions from fossil fuel combustion" and thus a major driver of climate change (IPCC, 2014). Likewise, in 2014, former U.S. Vice President Al Gore and philanthropist Bill Gates spoke out at the World Economic Forum in Davos in favor of providing more significant support for contraception, in part to mitigate climate change (Cox 2014). In November 2017, more than 15,000 scientists issued their "Warning to Humanity," pointing to scientific evidence of massive environmental degradation. Their public statement states that human numbers remain a major cause of the problem: “[B]y failing to recognize continued rapid population growth as a primary driver behind many ecological and even societal threats” and “to adequately limit population growth”, among other measures such as reducing greenhouse gases, “humanity is not taking the urgent steps needed to safeguard our imperiled biosphere” (Ripple et al., 2017). Their reference to "societal threats" here refers to suspected unrest to interstate wars as a foreseeable consequence of climate change (Gleditsch, 2007).

In 2022, the UN identifies population growth as a major challenge, especially in the countries of the Global South, to implement the Sustainable Development Goals (SDG), since population growth would directly increase effects such as poverty. In turn, poverty would directly reduce the ability to control one's own fertility (UN Population Division, 2022). While the UN Population Division (2022) states that population growth per se is not the direct cause of environmental degradation, it calls in its "World Population Prospects 2022" for a stronger integration of the link between population and sustainable development in the context of climate change:

> „The 46 least developed countries (LDCs) are among the world’s fastest-growing. Many are projected to double in population between 2022 and 2050, putting additional pressure on resources and posing challenges to the achievement of the Sustainable Development Goals (SDGs).“ (UN Population Division, 2022)

The discussion about population growth, CO2 emissions and climate change goes far beyond the examples given here. However, the selected examples clearly show that the dire predictions of the 1960s, when environmental mentalists such as Ehrlich (1968) and

Meadows et al. (1972), who predicted that population growth would lead to global environmental degradation, are experiencing a renaissance in the face of the looming ecological crisis of climate change.

Considerations of population numbers also resonate with feminist and activist milieus in the meantime. In 2019 British singer Blythe Pepino started the „Birth-Strike-Movement“ and announced in a BBC interview that she will no longer have children because of a collapsing world. Pepino and many other supporters of the Birth Strike movement refer primarily to a study by Seth Wynes and Kimberley Nicholas (Wynes & Nicholas, 2017), which argues that not having children is the most efficient measure that individuals can contribute to climate protection. The study compares future CO2 emissions from children extrapolated to donor generations with e.g. air travel or car trips. The figures for children are particularly high because the authors of the study also include the CO2 emissions of the children, grandchildren and great-grandchildren of the child born, i.e. of future generations up to the year 2400. The significance of these figures is therefore questionable (Franck, 2019). However, movements like the Birth Strike Movement focus on individual choices and try not to place blame and responsibility for climate change directly on to others. There are childbearing people today who are asking themselves if they even want to give birth to a child into an uncertain future. These questions, however, will not be considered in this work. However, they are mentioned to touch on the extent of consideration between issues of population and reproduction with environment and climate change.

In short: There are countless examples of the thematic linking of environmental aspects and population. These mostly go global or focus on the Global South, even if there are movements like the Birth Strike Movement in the Global North that focus on individual decisions. In this work, European voices and U.S. voices are largely considered since, as described later, these played and still play a central role in historical population control programs and current family planning campaigns, and further given the fact that US institutions such as the Bill & Melinda Gates Foundation (BMGF) are the largest donors of research on contraception today. The focus will further be primarily on those voices that concern international development cooperation and reproductive health, which in turn think in terms of nations.

## 2.3 The history of population policies

Environmental considerations have fed population discourses with supposed scientific connections between population growth and environmental degradation since Thomas Malthus. In the following section a look is taken at how these considerations have historically translated into political action. For even today, calls for greater reproductive health are primarily political decisions.

In recent decades, population policy efforts have largely been undertaken in the context of development cooperation. Today, we understand the development of countries as a linear progress (Braidotti et al., 1994) to mean the rise of poor, technologically ill-equipped countries to economically and technologically advanced countries with strong financial power (Truman, 1949). At the same time, we also associate the term with ideas of education, health, or population. The concept of development emerged immediately after World War II, with Harry S. Truman referring to the Global South for the first time as "underdeveloped areas“ (Truman, 1949) in his inauguration speech in January 1949. Truman assumed at the time that the United States would be at the top of some kind of scale of social development and that other countries would have to follow suit (Truman, 1949; Braidotti et al., 1994). Truman thus ushered in the Age of Development, which formed the basis for many years of development cooperation between countries, centered on the image of a poor Global South that could lift itself out of poverty through technological progress and assistance of the „developed“ world (Braidotti et al., 1994). The period after World War II likewise marked the collapse of the European colonial powers, when the world took on a new shape and the extent of the colonial powers' violence was felt in the colonies. Suddenly, there seemed to be nations that enjoy a high standard of living in the Global North, while people in the Global South live in great poverty in some cases, despite the new independence. To explain this gap between rich and poor, an explanation had to be found. A particularly tangible explanation seemed to be the idea that there are countries that are better off because they are better educated, more innovative and, above all, more technologically advanced. In turn, the poorer, uneducated, infrastructurally underserved global South is beaten down. The story of development is brought into being and remains deeply embedded in us today (Hickel, 2017).

An important aspect of the development debate thereby concerned population growth in the Global South (Eager, 2004; Fletcher, 2014; Braidotti et al., 1994). The main argument for the necessity of population control for a country's development held that fewer people born into poverty would ultimately promote a country's economic growth (ibid.). With the end of the World War II, the view of the population changed and globally shifted from national to more international considerations. Coinciding with the end of World War II, global population growth experienced what can properly be described as a boom (Fletcher, 2014). With the USA as the driving force behind, population control became a central tool of development policies up until the the International Conference on Population and Development in 1994 (Eager, 2004), hereafter referred to as the Cairo Conference. Before the mid-1960s, the United States categorically refused to tackle issues of birth control, let alone in the developing world. In December 1959, then-President Eisenhower publicly stated: „[Birth control is] Not Our Business. I cannot imagine anything more emphatically a subject that is not a proper political or governmental activity of function or responsibility" (TIME, 1959). Just a few years later in President Johnson's 1965 State of the Union Address, then-President Johnson addressed the topic again saying that the U.S. „will seek new ways to use our knowledge to help with the explosion in world population and the growing scarcity of world resources." (Johnson, 1965a). The U.S. underwent a complete shift in this regard in the 1960s from an absolute lack of interest to an absolute focus on population. In July 1969, US President Nixon issued a „Special Message to the Congress on Problems of Population Growth“, in which he stated that „It is (his) belief that the United Nations, its specialized agencies, and other international bodies should take the leadership in responding to world population growth." (Nixon, 1969). The instrument of population control was thus from then on promoted as the main norm for global population policy. This extreme change in U.S. policy is explained by several reasons. Hartmann (1995) understands the sudden involvement in population control as a national security concern that emerged in the post-World War II era. Agena et al. (2022) and Braidotti et al. (1994) further argue that in postwar history, population considerations and the development discourse in general became a Cold War tool because of fears that poverty would make people vulnerable to the ideas of communism. Thus, the discourse on overpopulation also served to suppress potential social revolts and anti-colonial liberation movements (ibid.). Duden (2009) explains that the shift in U.S. foreign policy was triggered in part by unusually effective private philanthropy. In 1952, for example, John D. Rockefeller founded the so-called Population Council with a large personal donation. From its inception, according to Duden (2009), the Population Council served as a lobby for „activist demographers who worked to redefine the goals of contraception in an age of explosive population growth“ (ibid.). Population Council publications at the time argued that "overpopulation" was undermining the achievement of development goals (ibid.). The private sponsors thus tied in with the discourse around development policy described earlier, arguing that explosive population growth would only plunge "underdeveloped" countries into more problems of poverty, hunger, and violence. Reducing population growth was from then on seen as a prerequisite for successful investment in economic growth and development. In 1965, at the UN's twentieth anniversary celebration, President Johnson claimed that every $5 spent on population control was worth $100 invested in economic growth (Johnson, 1965b). In 1966, the United Nations General Assembly reached a consensus on "population assistance”. With the establishment of the United Nations World Population Fund (UNFPA), the issue was elevated to the international political level in the late 1960s. The U.S. Agency for International Development (USAID), the International Monetary Fund and the World Bank became financially involved in the issue, and within just a few years a multi-million dollar sector of international politics was created.

Between 1950 and 1994, numerous so-called birth control or family planning programs were implemented in the Global South, as actions of foreign aid and development cooperation. While these were primarily enforced by the countries themselves, they were at the same time often linked by development organizations to the granting of loans such as those of the World Bank, which were coupled to the implementation of birth control programs (Hartmann, 2004). International donors such as the World Bank, USAID and the IMF supported birth control programs worldwide with millions of dollars (ibid.). Especially countries that had been trapped in the structures of the colonial powers just up until two decades earlier longed for the development of their own independent industry and economy (Hickel, 2017). In 1958, Sweden was the first country to provide international aid for population control, first in Sri Lanka and then in Pakistan, referred to as "family planning assistance" (Irwin, 2019). Shortly thereafter, as early as the early 1960s, most Asian countries and many countries in Latin America launched large-scale, tax-funded family planning programs. Thus, in the name of family planning, a huge new industry emerged with jobs, income, and all sorts of new organizations. By 1970, more than 1.7 million people worldwide were working in family planning programs (Hartmann, 2004). Overall, the United States contributed more than half of all international aid for population and family planning between 1965 and 1980, this funding numerous family planning programs in the Global South. The ideas of development, birth rates and contraception are closely linked at the time. At the 1974 World Population Conference in Bucharest, population control was argued to be the most cost-effective investment in development assistance (Hartmann, 1995).

Probably the best-known birth control program today is the family planning program launched by the Indian government in the 1970s during the so-called 21-month Emergency Rule imposed by then-Minister Indira Gandhi (Lhi, 2022; Follett, 2020; Bandarage, 1997). During the 1975 Emergency, when civil liberties were suspended, Sanjay Gandhi, the son of former Prime Minister Indira Gandhi, established a five-point program for India: adult education, family planning, tree plantation, abolition of dowry and eradication of the caste system (Tarlo, 2003). Part of this program was a large-scale campaign to sterilize poor men to limit population growth. In 1976-1977 alone, the program resulted in some 8 million sterilizations (Lhi, 2022), with numerous reports of forced sterilizations (Bandarage, 1997). Reports abound, for example, of how police cordoned off villages and practically dragged the men into surgery. The push for population control in India was financially encouraged from the 1960s onwards by tens of millions of dollars in loans from the World Bank, the Swedish International Development Agency, and the UN Population Fund. Despite critical reporting of sterilization abuses during the Emergency, the Fifth Five Year Plan of the Indian government from 1974 to 1979 increased spending on family planning with leading donors UNFPA, the World Bank and SIDA (Bandarage, 1997, Follett, 2020). According to Follett (2020), the UNFPA gave India its largest grant ever in 1974, and in 1976, the year in which 6.2 million people were sterilized alone, the Swedish Development Agency gave India $60 million for family planning. The World Bank reportedly loaned India $66 million for "population control" between 1972 and 1980 (Ibid.). Economic analyst Ashish Bose in 2014 estimated that „Sanjay Gandhi accounts for roughly 70 lakh forced sterilizations […] Sanjay Effect is a combination of coercion, cruelty, corruption and cooked figures.“[3] (Bose, 2014). After numerous protests, India's family planning program was renamed the Family Welfare Program in 1977 and refocused on the more politically acceptable strategy of sterilizing women (Braidotti et al. 1994, Bandarage, 1997). Female sterilization is still most used contraceptive method in India, with reports of forced sterilization continuing (MacAskill, 2013; Doane, 2014). According to MacAskill (2013) in a report for Bloomberg, 37% of all sterilizations worldwide in 2013 were performed in India, involving a total of 4.6 million women.

[3] Lakh is the South Asian numeral for one hundred thousand, 1 lakh = 100,000; so 70 lakh forced sterilizations equals 7 million people.

Likewise, Paul Ehrlich, in his book Population Bomb, similarly wrote about possible sterilizations in India, although prior to the Emergency, and chalked up the failure of the U.S. government to support the then Indian Health Minister's plan to carry out forced sterilizations:

> „When he suggested sterilizing all Indian males with three or more children, we should have applied pressure on the Indian government to go ahead with the plan. We should have volunteered logistic support in the form of helicopters, vehicles, and surgical instruments. […] Coercion? Perhaps, but coercion in a good cause. […] We must be relentless in pushing for population control around the world." (Ehrlich, 1968)

The population program in India in the 1970s is no exception. Another, more recent example comes from Peru: Between 1996 and 2000, during the government of Alberto Fujimori, more than 20,000 men and between 200,000 and 300,000 women were sterilized in Peru under the "National Program for Reproductive Health and Family Planning." (Ko, 2021; Agena et al. 2021; Nova Agency, 2021; McMaken, 2018) In the process, more than 8000 people report being forcibly sterilized against their will by the end of 2021 in a special register opened by the Peruvian Ministry of Justice and Human Rights (Nova Agency, 2021). The Peruvian sterilization campaign also involved numerous international donors: USAID, UNFPA and the Japanese non-profit organization the NIPPON Foundation (McMaken, 2018). According to McMaken (2018) the UNFPA alone did donate about $10 million to the forced sterilization campaign in Peru. Legal proceedings against the then president regarding the forced sterilizations are being conducted time and again. The proceedings, which involve more than 1,300 plaintiffs, began already back in 2002, but have been suspended and resumed several times (Der Spiegel, 2021). Despite the first hearing on January 11, 2021, on the subject of forced sterilizations (Ko, 2021), the proceedings are currently on hold due to formalities (France24, 2021; Der Spiegel, 2021). The former president of Peru was serving a 25-year prison sentence until early 2022 for human rights violations unrelated to the sterilization campaign (Ko, 2021). In early 2022, however, he was pardoned and released early (Taj, 2022).

The history of population control programs is long and encompasses numerous countries around the world; a comprehensive review of these programs requires a separate work. For this work, however, it is important to understand that the population control programs of the last century are known for numerous human rights violations, while having been supported by international donors such as the World Bank or the UNFPA. And although there has been an active political shift away from implementing population control programs with clear targets and numerical goals since 1994, there is evidence, as the next chapter will show, that even today's family planning programs use contraceptives still as a policy tool rather than simply providing them as a technical means of preventing pregnancies.

## 2.4 The road to reproductive health

A shift away from population control programs was achieved with the 1994 International Conference on Population and Development (ICPD) in Cairo, Egypt. Not least under the influence of feminists who sought reforms in population policy, the concept of reproductive health was for the first time enshrined in a UN international document and the 179 participating states thus recognize reproductive health as part of human rights.The 1994 Cairo Conference is today widely celebrated as the victory of women's reproductive rights over coercive population control programs and continues to be propagated as the key norm for global population policy (United Nations World Population Fund [UNFPA], 2014; Eager, 2004; Bhatia et al., 2020). Instead of viewing population policy as a means, health policy is coming into focus, as is the recognition of individual rights, which is why the Cairo conference is today traded as a paradigm shift from population control to reproductive health and rights. The Cairo Conference established internationally the right for women to control their own reproductive capacities free from coercion and violence from governments and other actors (Eager, 2004). The ICPD Conference and Programme of Action clearly seeks to move away from population control and specific demographic targets or quotas (UNFPA, 2014). Through the Cairo Conference, the concept of reproductive health is established and is still used in many international bodies today. The WHO today defines Reproductive Health as following:

> „Reproductive health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes. Reproductive health implies that people are able to have a satisfying and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to do so.“ (World Health Organization [WHO], 2022)

The Programme of Action of the ICPD, in addition to addressing the issue of reproductive health, also brings in the link to sustainable development. It recognizes that environmental degradation and social inequalities are caused by unsustainable consumption and production patterns (UNFPA, 2014), while suggesting that the inclusion of population as a determinant can accelerate sustainable development goals:

> „Explicitly integrating population into economic and development strategies will both speed up the pace of sustainable development and poverty alleviation and contribute to the achievement of population objectives and an improved quality of life of the population.“ (UNFPA, 2014).

The document repeatedly emphasizes that population-related policies can help to meet the needs of the future (UNFPA, 2014). The aim according to the Programme of Action should be to integrate population concerns into all levels of development efforts in order to ensure the needs of present and future generations with a high standard of living. Furthermore, population concerns should be integrated into development planning „in order to promote social justice and to eradicate poverty through sustained economic growth“ (UNFPA, 2014). Economic growth is presented by the Programmme of Action as a main factor for the elimination of poverty through slower population growth stimulating economic growth and thereby simultaneously reducing poverty. At the same time, the ICPD's Programme of Action blames population growth directly for poverty:

> „Poverty is also closely related to inappropriate spatial distribution of population, to unsustainable use and inequitable distribution of such natural resources as land and water, and to serious environmental degradation.“ (UNFPA, 2014).

It is remarkable that the Programme of Action of the ICPD opens its text after the Preamble and the Principles with a chapter on the „Interrelationships Between Population, Sustained Economic Growth and Sustainable Development“, i.e. that the program is introduced by the thoughts on sustainable development. The entire document opens with the words that economic growth must be sustained (UNFPA, 2014). This gives the impression that sustainable development, thoughts on poverty reduction and environmental concerns serve as a basis for the subsequent chapters on gender equality or reproductive health. Although the first chapter is followed by numerous considerations that are not further focused on environmental concerns, it smacks of reproductive rights being desirable only because of sustainable (economic) development. The ICPD's Programme of Action, as another example, shows a close interdependence of environmental concerns and population considerations. The ICPD Programme of Action further sets different priorities for the Global South and the North. While focusing on population stabilization in the Global South, the Report of the European Population Conference for the ICPD sets out very clear ideas for driving birth rates in Europe, for example through tax benefits or maternal welfare services (Hartmann, 1995). Political scientist Paige Whaley Eager, who studied the Cairo "paradigm shift“ (Eager, 2004) goes further and describes how "the language, assumptions, and norms that supported population control have been displaced by the language, assumptions, and norms that support reproductive rights and health" (Eager, 2004) by the Programme of Action of the ICPD. Scholars Susanne Schultz and Daniel Bendix (2017) do not see the Cairo conference as a break with old population policy goals, but rather as „a reform that rendered the new concepts of broader ‘reproductive health’ and ‚reproductive rights’ compatible with anti-natalist goals by infusing the former with specific norms regarding the individual’s responsibility to look after their own health, or by referring to a reduced Western concept of empowerment as equivalent to lower fertility“ (Bendix & Schultz, 2017). Neo-Malthusian ideas find their way into the framework of the language of social justice and reproductive health. While reproductive choices are recognized as a human right, they are nevertheless placed directly within the neo-Malthusian narrative between population and resources that before informed population control programs (Schultz & Benix, 2017).

The Cairo Conference is further criticized by activists and NGOs of the Global South for leaving out the „D" in the ICPD (Bandarage, 1997). In the proposed expenditures of the Programme of Action, there are no proposed expenditures on education or the integration of women into the workforce (UNFPA, 2014). There is a clear focus through the new reproductive health agenda on improved family planning as a precondition for gender equality. The focus on fertility control clearly remains at the center, with the proposed expenditures of the ICPD Programme of Action mainly focusing on family planning as the most important expenditure. Asoka Bandarage (1997) points out that if choice really wants to be taken seriously, then the new reproductive health agenda proposed must go further than just looking at family planning and address the causes of poverty and a change in the global political economy. Although the ICPD Programme of Action identifies and recognizes women's education as a key determinant for lower fertility, neither education nor labor are reflected in the proposed expenditures (ibid.).

The ICPD conference today still determines the thinking behind modern population policies. At the 20th anniversary of the ICPD Programme of Action, the UN wrote in 2014 that the reproductive health guideline until today serves as a „comprehensive guide to the progress of people-centered development." (UNFPAa, 2022). In 2015, the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development, which reaffirmed the commitments of the landmark International Conference on Population and Development, held in Cairo in 1994, by setting the goal of universal access to sexual and reproductive health and family planning (UNFPA, 2017). The Programme of Action emphasised that universal access to a full range of safe and reliable family planning methods helps couples and individuals realise their right to decide freely and responsibly the number and spacing of their children (UNFPA, 2014).

In recognition of the 25th anniversary of the ICPD, Governments at the 52nd session of the Commission on Population and Development in 2019 reaffirmed the importance of the ICPD and its further implementation to also reach the Sustainable Development Goals. The 2030 Agenda for Sustainable Development includes a target relevant for family planning and fertility under Goal 3 (UN, 2022c), that covers a range of targets to ensure healthy lives and well-being of the population. Target 3.7 aims to ensure, by 2030, „universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs" (UN, 2022c). The two measures of progress toward this target are indicator „3.7.1: Proportion of women of reproductive age (aged 15- 49 years) who have their need for family planning satisfied with modern methods" (UN, 2022c), and indicator „3.7.2; Adolescent birth rate (aged 10-14 years; aged 15-19 years) per 1,000 girls and women in that age group" (UN, 2022c.) As a look at the SDGs shows, reproductive health is understood in sustainable development primarily as access to contraception, with continued clear targets and goals - a discredited element of population control (Hendrixson, 2018).

## 2.5 Family planning programs today

Being one of the focal points of the Sustainable Development Goals (SDGs) (UN, 2022c) and their predecessors, the Millennium Development Goals (MDGs), family planning is today still considered one of the most important pillars of international development cooperation. According to the United Nations (2019), family planning is relevant to achieving most SDG targets, while Goal 3 on ensuring health and well-being for all and Goal 5 on promoting gender equality and empowering women and girls (UN, 2022d) refer specifically to family planning in many targets. In doing so, the UN (2019) clearly describes family planning as expanding access to contraceptives as well as meeting the demand for effective contraceptive methods. For the UN (2019), these are central in achieving the universal access to reproductive health services called for in the 2030 Agenda for Sustainable Development, while reaffirming the commitments made in the ICPD Programme of Action.

Providers of family planning services are mostly governments, nongovernmental organizations, and religious institutions that usually offer free or subsidized services. Perhaps the biggest global actor in the field of reproductive health today supported by the UN Secretary-General's Global Strategy for Women's, Children's and Adolescents' Health is the relatively new family planning initiative Family Planning 2030 (previously Family Planning 2020). Launched in 2012 at the London Summit on Family Planning, the initiative, a public-private partnership, brings together pharmaceutical companies with NGOs, private donors and governments. In 2012, the London Summit, designed to jumpstart the global commitment to meeting women's unmet contraceptive needs, was organized by the Bill & Melinda Gates Foundation (BMGF) and the U.K. Department for International Development (now Foreign, Commonwealth & Development Office, FCDO) in partnership with UNFPA and USAID (FP, 2030). Today, FP2030 is fundamentally supported by organizations such as the Bill & Melinda Gates Foundation, the United Nations Population Fund (UNFPA), and the International Planned Parenthood Federation (IPPF). The BMGF's involvement as a private donor is not surprising in this regard; after all, it is today the largest donor of contraceptive research and development in the world, with about $24 million in 2018 alone (Statista Research Department, 2022). From 2021 to 2030, the BMGF committed itself to provide $280 million annually to develop new and improved contraceptive technologies according to their own statements (Bill & Melinda Gates Foundation [BMGF], 2022). Meanwhile, it is involved in many international family planning programs. As noted, it is one of the key partners of the FP2030 initiative, but also of other family planning programs such as UNFPA, SEMA Reproductive Health, or MSI Reproductive Choices (Gates Foundation, 2022; UNFPA, 2022b; SEMA Reproductive Health, n.d.).

The FP2020 partnership was established as the new key international platform for cooperation on modern contraception use as part of family planning, including the concerted effort to focus on long-acting reversible contraception (LARC). From the beginning of the program on, the initiative announced a clear target: to provide contraceptives for an additional 120 million women in the global South within eight years (FP2020, 2015a; UNFPA, 2017). The FP2020 partnership expresses itself in very clear targets for contraceptive use and coverage in the worlds 69 poorest countries (FP2020, 2014), an approach that the ICPD directly opposed in 1994 as an aversion to population control (Hendrixson, 2018). The contraceptives provided through FP2020 were with one third donated by the UNFPA.

The FP2030 program is now the successor to the FP2020 program, which ran from 2012 to 2020. The initiative focuses exclusively on women and at the same time, only countries in the low-income and low-middle income classification of the World Bank 2018 are considered. Although the London Summit, according to FP2030 (2022), was designed to provide a global focus on the unmet need for contraceptives, the resulting initiative focused first exclusively on low-income countries and in the follow-up program now additionally on low-middle income countries (FP2030, 2021a). Like the previous version, FP2030 focuses mainly on access and provision of contraception. There is no longer an overarching numerical target; instead, according to the self-statement, targets are adapted individually to the participating countries. Countries must for example report on the following factors: Modern Contraceptive Prevalence (MCP), Unmet Need, Demand Satisfied, and Contraceptive Method Mix (ibid.). According to its own statement, the partnership goes beyond family planning and wants to link up with the sectors "faith, climate change, gender equality, and population-health-environment" (FP2030, 2021a), without specifying in more detail how this cooperation with other sectors is to be carried out.

One of FP2030's largest partners besides the BMGF is USAID. USAID today supports international family planning and reproductive health programs in 40 countries, with a concentrated focus on Francophone Africa (USAID, 2022). Among the benefits of family planning, USAID lists the following in its current June 2022 fact sheet:

> „Protects women's and children's health by reducing high-risk pregnancies and allowing sufficient time between pregnancies; Advances individuals' rights to decide their own family size; Improves women's opportunities for education, employment, and full participation in society.; Reduces poverty by contributing to economic growth at the family, community, and household levels.; Decreases abortion; Mitigates the impact of population dynamics on natural resources and state stability;

> Reduces HIV and AIDS through the prevention of new HIV infections and mother-to-child transmissions via increased access to voluntary family planning information, services, and commodities, including condoms.“ (USAID, 2022).

Similar projected benefits can be found, when looking at the latest report of FP2020:

> ‘Family planning is essential to health, freedom and prosperity. We know that family planning empowers women and improves health, but we also know that it has countless ripple effects across society. Family planning plays a central role in poverty reduction, sustainable development, economic growth, gender equality, social inclusion and environmental stewardship’ (FP2020, 2014).

When reading the two statements, it becomes clear that family planning as in contraception is presented as a solution to all kinds of social and environmental problems (Schultz, 2021), including poverty. In turn, inadequate family planning is blamed in part for factors such as social inequality or poverty, without placing it in a broader context. These statements clearly align with neo-Malthusian thinking (Hendrixson, 2018) that views population growth as a primary cause of global problems such as resource scarcity and has inspired many coercive methods of population control in the past. USAID also clearly brings the narrative of environmental degradation and security risk to the list of benefits of family planning, writing that it „(m)itigates the impact of population dynamics on natural resources and state stability“ (USAID, 2022). It is typical of neo-Malthusianism to propose birth reduction among the world's poor as a solution to various global crisis phenomena, thus blaming the poor and not deeper structural levels of the global economic system (Hendrixson, 2018). However, Anne Hendrixson (2018) writes in her examination of neo-Malthusian thinking in FP2020 and partner organizations and recurrent methods of population control that there are likely different attitudes about population within these organizations.

As noted earlier, FP2030 is funded with millions of dollars by the BMGF, which at the same time works directly with and funds UNFPA, another major donor of the FP2030 partnership (FP2030, 2021; UNFPA, 2017, 2022). According to its own statement, UNFPA supplies around 20 million women annually with over 40 per cent of donated contraceptives worldwide (UNFPA, 2017). The focus is solely on low-income countries, mostly on the African continent, south of the Sahara. The BMGF focuses its research on mid- and long-acting contraceptives (BMGF, 2012). In 2019 Melinda Gates explains her interest in contraception as it being „the greatest anti-poverty tool in the world“ (Gates, 2019), allowing women to come to full workforce and independence with the help of contraceptives. According to the 2012 Strategy Overview, the main goal of the BMGF in regards to contraception is to develop new innovative ideas in the field (BMGF, 2012). The focus hereby is primarily on two products: The Sino-implant (II)®, by Shanghai Dahua Pharmaceuticals, a long-acting hormone implant, and depo-subQ provera 104® by Pfizer an intramuscular hormone injection (ibid.). Both methods must be used by professional physicians. Further research is also taking place on an on-demand pill, a vaginal ring, further injection and potential non-hormonal methods and sterilization /ibid.). In general, the BMGF's main researched products appear to be designed primarily for female users, with no major research focus on male users. Melinda Gates in her TED talk „Let's put birth control back on the agenda“ from April 2012 gives as an explanation why injectables are that popular in Sub-Saharan Africa the reason that women can hide it from their husbands and also says that population numbers in SSA are high because of missing contraception (TED, 2012). She gives no empirical evidence. In contrast, Bendix and Schultz (2018) and Bendix et al. (2020) point to a massive push in family planning programs toward long-term contraceptive hormone implants. Senderowicz et al. (2022) speak of enthusiasm for LARC that has grown in the international donor and NGO community. The focus here is often on the particularly positive aspects of LARC, such as the low failure rates or the long application duration (Jacobstein, 2018; Stanbeck et al. 2015). Furthermore LARC methods are said to be more cost-effective than short-acting methods (Ssewanyana & Kasirye, 2018; Lafuma et al, 2015; Lipetz et al. 2009). Yet implants are known to have side effects. According to Lindberg (2018) Depo-Provera shows the most side effects of all contraceptive methods on the market. In general the risks of administering long-lasting hormone implants and injections are far greater in the Global South than in the Global North because of the inadequacy of the medical infrastructure that would allow for follow-up of the drugs (Bandarage, 1997). Hormone implants in regions with little medical infrastructure require adequate health services and trained health workers for insertion, follow-up, and removal (Bandarage, 1997; Bahamondes & Peloggia, 2019; Britton et al. 2021). Senderowicz et al. (2022) conducted a study of 17 focus group discussions with 146 women of reproductive age in a sub-Saharan African country that was a member of the Family Planning 2020 initiative but remains anonymous for security reasons and is therefore not named by Senderowicz et al. (2022). Senderowicz et al. (2022) note that LARC providers take a "gatekeeping" role in removal of LARC, in part by deciding which removal requests to approve and which not to approve. This includes providers not considering women's requests for removal due to side effects or simply because they no longer want to use the LARC as sufficient reason for removal (ibid.). In this regard, Senderowicz (2020) already before explicitly characterized providers' reluctance to remove LARC upon request as a form of contraceptive coercion that undercuts the self-determination rights of the requesting woman at the moment of denial. In the meantime, there is already evidence that women want to remove the implants themselves and some do so themselves (Broussard & Becker, 2021; Gbolade, 2015). Implants only represent a self-determined method if a possible removal is sufficiently ensured, otherwise they suggest a coersive method.

FP2030 is just one of many initiatives providing contraceptives in low- and middle-income countries under the heading of reproductive health. Other examples include "The Challenge Initiative" (TCI), an initiative also founded and led by the BMGF, which together with Bayer AG, one of the world's largest pharmaceutical companies, is pursuing a strategy to provide 100 million women in low- and middle-income countries living in urban poverty with access to modern family planning by 2030 (Johns Hopkins University, 2022; Bayer AG, 2022).

More than 30 years after the Cairo Conference on Population and Development, there is evidence of a renewed „discursive and financial shift toward explicitly neo-Malthusian approaches and stand-alone family planning“ (Bendix & Schultz, 2017). In international development policy, there are numerous programs today that address reproductive health exclusively through contraceptives such as FP2030 and through a concentrated focus on low- and low-middle income countries especially on the African continent. Though it seems that the term of population control has been relegated to the realm of history (Bhatia et al., 2020), family planning programs revive clear targets and goals on contraception.

## 2.6 On Contraception

Access to adequate contraception is fundamental to human health and well-being. The growing use of contraceptive methods in recent decades has resulted in improvements in health-related outcomes such as reduced unintended pregnancies, high-risk pregnancies, maternal mortality, and infant mortality (UN, 2020). Contraception can be critical to the health of women, people of childbearing potential and children themselves. At the same time, contraception gives women in particular, but also other childbearing individuals, the control to make more self-determined decisions about entering the workforce or staying in the education system. Different contraceptive methods are usually distinguished between modern and traditional. Traditional contraceptive methods include, for example, methods based on fertility awareness (rhythmic methods) or withdrawal. While modern methods include sterilization (of women and men), the pill, injections, implants, the intra-uterine device (IUD) and some other methods (Hubacher & Trussell, 2015).

However, the fact that contraception can also be harmful to health, especially if it is not used consensually, is often left out of the equation. An example of this is the birth control pill for women. The birth control pill represents a contraceptive method that can be taken and discontinued relatively self-determined and without bigger medical interventions. Today the pill is known for plenty side effects such as an increased risk of thrombosis (Trenor et al., 2011). Still, the pill is the most widely used contraceptive in Europe, North America and Oceania, followed by the male condom (UN, 2019). Worldwide, female sterilization remains the number one contraceptive method (ibid.). Female sterilization is a major surgical procedure under general anesthesia that, which can have devastating risks, while male sterilization (vasectomy) is much safer, cheaper, and more effective than female sterilization (Kjersgaard, 1989). A vasectomy can be performed purely through local anesthesia and with a central incision or on the right and left side with a total of two small incisions on the scrotum (UK National Health Service [NHS], 2021). In an international ranking, female sterilization as the most commonly chosen contraceptive method, is followed by the male condom and the copper IUD (UN, 2019).

Sub-Saharan Africa is the only region where injection of long-acting hormonal contraceptives is the most commonly used contraceptive method with a prevalence of 9.6 per cent among women of reproductive age (ibid.). At the same time, Sub-Saharan Africa is also the region with the lowest number of contraceptive users between the ages of 15 and 49, according to the UN (2019). Duvall et al. (2014) describe different factors that explain the growth in popularity of implants in SSA, including greater availability of low-cost implants and the subsequent formation of public-private partnerships that led to price-quantity guarantees for certain implants, as well as the increasing availability of implants through the donor community and development organizations, including government policymakers. Given that the BMFG is the largest donor of both major family planning organizations such as FP2030 and contraceptive research (Statista Research Department, 2022; FP2030, 2022), and that its research focuses primarily on implants and injections (BMGF, 2012), the question is to what extent consumers' contraceptive choices are influenced by this link through access and availability. Hendrixson (2018) makes an explicit connection between the focus of donor-funded family planning initiatives from the Global North on increasing LARC prevalence and the potential coercion of contraception on gendered and racialized bodies of African women. In countries that are not dependent on donations, such as many European countries, the pill and the male condom dominate as the most commonly used contraceptives. Melinda Gates herself says that such long-lasting methods are especially popular in SSA because they can be hidden from husbands (TED, 2012). This statement remains subject to speculation as does the question just formulated about the relationship between contraceptive choice and the donor-given availability of contraceptive methods.

However, regardless of whether the demand for LARC in SSA is due to supply or request, self-determined access and removal as well as adequate medical care should be guaranteed in any case. Especially in view of the dark past of the involvement of international development programs in population control programs in particular, and in view of those reports existing on coercive methods in the context of family planning programs today. In addition, family planning programs are wrongly positioned in the context of sustainable development, since, as will be shown below, contraception neither directly combats poverty nor per se leads to a decline in fertility rates. As will be shown below, access to modern energy and education can play a key role in reducing fertility, an important finding that international family planning programs should also pay attention to.

## 2.7 The demographic transition

Contraception is not only seen as a means of reproductive health and family planning, but is also thought to curb fertility and thus population growth. The growth of a population depends fundamentally on the death and birth rates. However, these cannot fully describe the development of a population, central to understanding how the development turns out is the time at which birth and death rates change. In demography, the typical course of population development of states or societies is divided into several phases, the so-called demographic transition. The demographic transition is an idealized model description of population development and can partially explain why rapid population growth is only a temporary development. The most commonly used model of demographic transition (DTM) is divided into five different steps (Roser et al., 2013): In the first phase, both birth and death rates are high and hardly deviate from each other. It is assumed that this balance existed worldwide until the end of the 18th century. In this phase, population growth is very slow, although, for example, families in Western Europe had an average of 2-6 children in the first phase. The mortality rate may temporarily exceed the birth rate due to diseases, epidemics, famines and wars (Cohen, 1995; Roser et al., 2013; World Population Review, 2022). Today no countries are classified within Stage 1 of the DTM (World Population Review, 2022). In the second phase, the birth rate remains consistently high and may even increase slightly due to improved women's health, but average mortality declines as the health of the population begins to improve. Food supply, hygiene and medical care are mast drastically improved at this stage (Cohen, 1995; Roser et al., 2013). This phase can partly be perceived as a population explosion. The birth rate in phase 3 slowly declines and the mortality rate drops to a very low level. The declining birth rate is mostly due to a change in the reproductive behavior of families: in earlier phases, people have more children because the high mortality rate causes more children to die during their lifetime. With lower infant mortality, families adjust and have fewer children than before. This can be explained in part due to economic factors, as children are a large cost, children are less economically important at this stage (Cohen, 1995; Roser et al., 2013). The third stage of the model is often brought together with the use of bio-medical elective methods (Szreter et al., 2013; Bhattacharya & Chakraborty, 2016). Neo-Malthusians associate the falling birth rates with better provision of contraception. Thus, improved access to contraception appears too emost as an simple means of addressing the problems of the Global South (Bandarage, 1997) as there are still plenty of countries being classified into the second stage of the DTM. In stage four the birth rate decreases significantly and falls to almost the same level as the hardly decreasing death rate. Rapid population growth declines, leading to a total population stability (Cohen, 1995; Roser et al., 2013). The original demographic transition model has described four stages, but there are scholars who argue for a fifth stage. Both a future with higher and lower fertility has been called a fifth stage for the future. Some scientists derive from the fourth stage a "fifth stage" in which fertility is below replacement levels (Roser et al., 2013). Others assume another "fifth stage" in which fertility increases. However, the exact developments of the fifth stage are interpreted differently.

The DTM is an idealized model that leaves much room for variation (Cohen, 1995) with the original calibration for the model being based on mostly the experience of demographic developments in Europe (Alexandersson, 1981; Bandarage, 1997), where European countries have transitioned between phases over a long period of time. For many other countries in the world, the starting conditions are different, with higher population numbers to begin with or lower mortality rates than suggested by the original model (Alexandersson, 1981). There are large differences between countries in how long the transitions between the phases can last. It is mostly assumed that socioeconomic development generally leads to a fall in mortality rates and at the same time to a fall in birth rates. Cohen (1995) calls this a pure hypothesis as the demographic transition cannot describe exactly when the decline in fertility begins or how fast the decline in mortality and fertility proceeds, so it proceeds differently in all countries.

Fertility rates worldwide have fallen significantly in recent decades. Today, half of all people live in countries with fertility rates below 2.1 births per women (UN, 2020). Combined with a low mortality rate, a fertility rate of below 2.1 births per women is roughly necessary to keep the population growth rate at zero (UN, 2020). The fertility rates are highest in SSA, meanwhile contraceptive use among women aged 15-49 is the lowest in this region, which is why the focus when talking about future population growth is often on the African continent. However, this does not mean that fertility rates can be generalized for SSA. According to the UN, 7 out of 10 countries with the highest declines in total fertility worldwide between 2010 and 2019 are located in SSA (UN, 2020). Explaining how and why a population's fertility declines is a major theoretical challenge with many uncertainties continuing. There are various conjectures that focus on partly economic partly cultural explanations, but it remains unclear whether the underlying factors are economic or cultural. Lutz (2015) writes: “We (...) live in a world of unprecedented demographic diversity. Traditional demographic groupings of countries are breaking down.”. Thus, attempts to explain declining birth rates using the classic model of demographic transition are becoming increasingly vague. Kato (2021) in their studies on birth rates in Japan summarize that it is almost impossible to look at and understand all the factors that influence fertility, as there are many different factors that also differ depending on the country and society.

However, a high contraceptive prevalence rate (CPR) is often cited as a key factor in fertility. The "proximate determinants" framework for fertility analysis (Bongaarts, 1978; Bongaarts, 2015; Stover, 1998) lists contraceptive use as the largest determinant of fertility, along with other factors such as abortion and contraceptive effectiveness. Bongaarts (2016) cites family planning as a means to a cost-effectively use of scarce resources and to a fundamental raise in living standards in poor countries. He calls for family planning to be reclassified as a „development intervetion“ so that it deserves the attention it needs. In 2020, the United Nations cites that contraceptives can have an impact on triggering or accelerating a demographic transition (UN, 2020). It is therefore surprising when Westoff and Bankole in 2001 found, analyzing data from the 1990s Demographic and Health Surveys, that the cross-sectional effect of contraceptive prevalence rates on fertility in sub-Saharan Africa was rather weak (Westoff & Bankole, 2001). In its 2020 report, the UN writes that no matter what the level of contraceptive use in 2019, sub-Saharan countries tended to have higher fertility rates compared to other regions (UN, 2020). Some low correlations between contraceptives and fertility are not only observed in countries of the SSA. In their study, Hognert et al. (2017) look at birth rates in Scandinavian countries and conclude that birth rates are high despite high contraceptive use and comparatively good access to abortion. It is difficult to make generalized statements about contraceptive use and fertility rates. In general, however, the relationship between contraceptive use and fertility appears to be influenced by factors other than mere access to contraception. Looking at the development of birth rates in Europe, they have not only coincided with contraception but rather with the development of the economy, education and medical care. The reasons why birth rates remain highon the African continent are diverse, but there is evidence that other factors influence birth rates significantly more than contraception. Often mentioned factors are the links between age at marriage, socio-economic factors, opportunity costs, the number of children born (Kato, 2021), education (Lutz & KC, 2011) and access to modern energy (Grimm et al., 2015). The last two factors mentioned - access to modern energy and education - will be shortly addressed in more detail because, as a glance at the literature shows, in addition to their influence on fertility, they can have a particular impact on women's empowerment and at the same time be central to considerations of the development debate. These are also the factors addressed by contemporary demographic studies of fertility rates, such as education and access to modern energy.

### 2.7.1 Access to modern energy and education

Access to modern energy is central to the Sustainable Development Goals, contributing to better health, lower mortality and well-being in general (Johansson et al., 2021; UN, 2022e). At the same time, it also appears to have important influences on fertility. In their study on Indonesia, Grimm et al. (2015) show how improved access to modern energy can simultaneously impact fertility and reduce poverty. How this relationship arises is difficult to break down to individual factors, but it appears that there is a strong relationship between access to energy and the use of a television. Grimm et al. (2011) attribute one-fourth of the fertility effect to television use, suggesting that television leads to a change in the number of children desired and, at the same time, to better contraceptive use. In addition, a decrease in time for sexual intimacy is assumed, although this factor remains subject of speculation. The second important factor besides television according to Grimm et al. (2011) is the decrease in infant mortality due to access to modern energy and thus also to the decrease in fertility. Also, Standal & Winther (2016) in their study on India explain the decline in fertility by modern energy through access to TV as well as mobile phones as well as improved self-efficiency through access to modern energy services that facilitate care and reproductive work. For many women, access to modern energy simultaneously means less time spent on household work and reproductive domestic tasks. Belmin et al. (2022) directly link access to modern energy to an improved aibility to reproductive choices.

Another factor that seems to deserve special attention in relation to declining birth rates is education. Lutz & KC (2011) write that it can be argued almost universally that women who have received more education also have fewer children. They create education scenarios in connection with birth rates and summarize that in 2050, depending on the education scenario, world population figures can vary widely from 8.9 billion to 10.0 billion people. Education affects all demographic characteristics, not only birth rates but also mortality rates, health, age at marriage and contraceptive use (Jejeebhoy 1995; Martín, 1995; Lutz & KC, 2011). Martín & Juárez (1993) summarize in their study on Latin America that when women are more educated they achieve a higher socioeconomic status and at the same time have less fatalistic attitudes towards reproduction compared to less educated women.

The precise links between access to modern energy and better education and fertility rates are equally complex. This work does not attempt to identify these in detail, but believes that they should be mentioned as they seem to be particularly empowering methods compared to access to contraception alone, with many more benefits than just lowering fertility.

## 3. On $CO_2$ Emissions

In 2020, about 34.81 billion tonnes of $CO_2$ from fossil fuels were emitted worldwide. This compares to 22.75 billion tonnes in 1990 and 6 billion tonnes in 1950 (Ritchie et al., 2020). In other words: between 1950 and 2020, $CO_2$ emissions increased more than fivefold. $CO_2$ emissions are probably the best known of all greenhouse gas (GHG) emissions and also the main driver of climate change (IPCC, 2021). In order to slow down climate change, there must be a drastic reduction in $CO_2$ emissions in a timely manner (ibid.) Indicators for $CO_2$ emissions usually distinguish between per capita $CO_2$, total $CO_2$, production- and consumption-based emissions.

With the question on the relationship between population and $CO_2$ emissions as a starting point, the following section takes a look at the existing literature on the subject, followed by a look at the units of measurement of $CO_2$ emissions for a better understanding of the later analysis.

### 3.1 Factors influencing $CO_2$ emissions

Since the amount of $CO_2$ emissions is increasing worldwide (IPCC, 2021) and at the same time the number of people in the world is also growing, it is certainly plausible to assume a connection between the growing world population and the increase in $CO_2$ emissions. A common argument holds that the rapid increase in $CO_2$ emissions is related to population growth because energy consumption increases as wealth increases (Shi, 2001). A handful of studies cite population as a particular influence on $CO_2$ emissions in this context. For example, Shi (2001) writes in that low-income countries are those where the influence of population on emissions is greatest as it is also where population growth is fastest. Poumanyvong et al. (2012) concludes that if the world population continues to grow at the rates of the time, total carbon emissions could increase by 76% by 2030. However, population growth is not an isolated phenomenon; according to the Independent Commission on Population and Quality of Life (1996), in the context of $CO_2$ emissions, it is related to two key factors: the prevailing patterns of production and consumption as well as the technology used and the resulting amounts of waste (Independent Commission on Population and Quality of Life, 1996). Consumption is an important buzzword in this assumption, as recognized also by those who look more closely at population growth and identify its role as a major problem factor in environmental degradation; Paul Ehrlich includes a consumption variable in his considerations, writing in 1971 together with John P. Holdren, that population growth simultaneously increases a society's consumption proportionally, since he assumes that a given population increase causes an exactly proportional increase in consumption. In doing so, Ehrlich brings in the consumption of resources as well as the consumption of energy: “Per capita consumption of energy and resources and the associated per capita impact on the environment are themselves functions of the population size.“ (Ehrlich & Holdren, 1971). Meadows et al. (1972) define resource use in terms of the world average resource consumption per capita. The consumption of resources is mainly brought into environmental debates when finite resources are at stake (see Chapter 2). The consumption of goods causes emissions of greenhouse gases in all production and trade steps, and in order to consume goods in turn, a certain amount of income must be at hand (Satterthwaite, 2009). Feng et al. (2015) look at population, consumption patterns, production structure, energy intensity and fuel mix to identify the key drivers of CO2 emissions in the US between 1997 and 2013. They find that economic growth in particular has driven emissions. Jayanthakumaran and Liu (2012) found that per capita income and trade openness are important factors that positively affect CO2 emissions in the long run in India and China. Al-Mulali & Binti Che Sab (2012) look at the drivers of CO2 emissions in 12 selected Middle Eastern countries and summarizes that the total primary energy consumption, foreign direct investment net inflows, GDP, and total trade were the important factors in increasing CO2 emissions between 1990 and 2019. Lean and Smyth (2010), found for ASEAN countries that electricity consumption and GDP growth are associated with growing the CO2 emissions. For Greece Hatzigeorgiou et al. (2011) named GDP growth the biggest driver of CO2 emissions from 1977 to 2007. For EU countries, Petrović et al. (2018) found that population, GDP per capita, and energy intensity positively affect CO2 emissions.

Some of these factors mentioned are also considered by the well-known Kaya-identity, which plays a central role in the IPCC's emissions scenarios to determine future CO2 emissions. The Kaya identity is a concrete form of Paul Ehrlich's more general I = PAT equation and relates directly to the total emission of CO2 rather than to impact on the environment. It is the product of four factors, that drive CO2 emissions, Population, GDP per capita, energy intensity (per unit of GDP), and carbon intensity (emissions per unit of energy consumed):

$$F = P*G*(E/G)*(F/E)$$

where F are the global CO2 Emissions, P global population, G stands for GDP, E/G the energy intensity of GDP and F/E the emissions intensity of energy.

Generally spoken it seems that there are several factors that fundamentally affect CO2 emissions, somewhere within the areas of consumption, production, and population. In light of this literature, the following variables will be statistically analysed in further consideration later in this work: Population, energy use per capita and GDP per capita.

## 3.2 CO2 emissions by sector

Now that a brief overview has been given of the factors that influence CO2 emissions, the next section will take a look at where CO2 emissions occur in the first place. Table 1 shows which sectors account for which share of GHG emissions. Generally speaking, different economic activities produce emissions. Industrial activities play a central role, but also trade, investment and technology. About three-quarters of all emissions are caused by the energy sector. In 2020, the energy sector accounted for 73.2% of all GHG emissions. The sector encompasses many different areas, which makes it equally complicated to break down responsibility to a single segment. On a global level, power and heat generation are the largest contributors to global emissions; however, this can vary from country to country; for example, greenhouse gas emissions in Brazil come mainly from agriculture. Looking at the percentage distribution of GHG emissions, industrial energy consumption accounted for 24.2% of all emissions, e.g. iron and steel production (around 7%). Looking only at the data for CO2 emissions, the picture is similar. Most of the emissions come from electricity and heat generation, followed by transport, and manufacturing and construction (Ritchie et al., 2020). CO2 accounts for the largest share of GHG emissions. Therefore, the focus of this work is on CO2 emissions and not on other GHG.

**Table 1.**
*Share of global greenhouse gas emissions by sector.*

| Sector | Share of global greenhouse gas emissions (%) |
|---|---|
| Energy | 73.2 |
| Agriculture, Forestry & Land Use | 18.4 |
| Industrial processes | 5.2 |
| Waste | 3.2 |

*Note. Data on the share of global greenhouse gaf emissions (%) are taken from the World in Data database which is based on $CO_2$ figures published the CAIT Climate Data Explorer via Climate Watch.*

## 3.3 CO2 per capita

The observations on total CO2 emissions described above refer to global data. However, it is common to list CO2 emissions by country and in CO2 emissions per capita emissions. The total amount of CO2 emissions is thereby divided by the number of inhabitants of a country. The countries with the highest CO2 emissions per capita in 2020 are mainly oil-producing countries, led by Qatar. Oil is one of the so-called fossil fuels and is the world's largest energy source today, serving as an energy source for the transport sector in particular (Ritchie et al. 2021). When oil is burned, CO2 emissions are released. Oil-producing countries are therefore countries with high total emissions. Some of the biggest oil-producing countries do have a relatively small population in countries, this leads to high per capita emissions as the high total CO2 emissions are divided by a small number of population. Countries such as the USA, which have significantly higher absolute CO2 emissions and at the same time are the world's largest oil producer, have a significantly higher population in comparison, which is why, conversely, despite high total CO2 emissions in tonnes, a lower CO2 emissions per capita figure is measured. The global average of CO2 emissions per capita in 2020 was 4.7 tons per person (Tiseo, 2021).

The unit of measurement of $CO_2$ emissions per capita usually refers to emissions released by a country's production. Looking at some European countries, $CO_2$ per capita emissions therefore seem comparatively low, as some European countries have no $CO_2$ intensive production such as the one of oil that takes place locally. Nevertheless, it is not possible to make a complete statement about responsibility simply looking at $CO_2$ per capita, since more factors play a role in $CO_2$ emissions than just the country's own production and number of inhabitants.

If one looks at the different $CO_2$ emissions per capita globally, it can be noticed that the numbers fluctuate. In 2020, 50% of all UN-recognized countries had $CO_2$ per capita emissions of 1.91t or lower while the average of all countries was at 3.72 tonnes per capita. The top 20% of all countries had figures of 5.35t or higher. In this sense, some countries contribute significantly more to $CO_2$ emissions and climate change than others. The question of a carbon inequality and that of a fair share of $CO_2$ emissions arises. In their 2022 report on Global Inequality, Chancel et al. (2022) define different global per capita budget to stay within the goals of the Paris Agreements. In order to stay within the +1.5°C limit, the per capita sustainable budget compatible they calculate 1.1 tonne of $CO_2$ per person. To stay within a +2°C temperature limit, they calculate a limit of 3.4 tonnes per person, both between now (2022) and 2050. Both limits are way below the current global average (Chancel et al., 2022).

At the same time, there is criticism of the concept of breaking down $CO_2$ emissions to countries alone. Especially $CO_2$ per capita emissions generalize the people of a country. As already mentioned in Chapter 2.2. when looking at the Limitis of Growth Report, an oversimplification of population figures deflects the true responsibility of $CO_2$ emissions. Many countries are characterized by significant inequalities (Chancel et al., 2022), these inequalities relate not only to income or wealth, but also directly related to $CO_2$ emissions. Even if a country's $CO_2$ per capita emissions are particularly low, that does not mean there is not an priviledged elite that emits far above a global fair share. Piketty & Chancel (2015) show that inequality within a country is responsible for about 50% of the dispersion of global $CO_2$ emissions. Allocating $CO_2$ emissions by population size smacks of neo-Malthusianism; the number of people is held generally responsible, not the underlying global economic system which is based on the unequal distribution of resources.

### 3.4 Total $CO_2$ emissions by country

The second best-known measurement for calculating CO2 emissions is the total CO2 emissions of a country. The list of the largest CO2 emitters in 2020 is headed by China with around 9.8 trillion tons of CO2, which represents 27% of total global CO2 emissions (Ritchie et al. 2021). Absolute numbers of a country's annual emissions usually only take into account production-related emissions (territorial emissions), meaning those emissions that are released during a country's production, but not the emissions that result from trade with goods produced elsewhere. Territorial or production-based emissions are most often used by authorities and international organizations to report progress on CO2 reductions and set targets and goals for such (Chancel et al. 2022). However, trade in goods as in the import of goods and services plays a central role when looking at the causes of CO2 emissions. The consumption of goods that are traded globally play a central role in the emission of CO2 emissions, since emissions are generated both in the production of goods, in transport, in sales and in many other steps of the consumption chain (Satterthwaite, 2009). Therefore, in addition to the mostly used production-based emissions, there are also calculations of so-called consumption-based emissions.

### 3.5 Consumption-based CO2 emissions

In the case of consumption-related emissions, the picture is completely different from that of CO2 emissions per capita. Many European countries, which have rather low CO2 per capita production-based emissions, become so-called net importers when looking of consumption-based emissions, i.e. they import CO2 in consumed goods. One example of this is France. In 2020, France was close to the global average of per capita CO2 emissions, with around 4.24 t per person. Energy in France is mainly produced by nuclear power and renewable energy, which is why local CO2 emissions remain relatively low. In 2019, however, France had 33.64% of share of carbon dioxide (CO2) emissions embedded in trade, which means that France imported emissions equivalent to 33.64% of its domestic emissions (Ritchie et al. 2021). High consumption-related emissions can mean, for example, that countries produce few or no goods of their own and therefore have to import a particularly large number of goods, or that countries consume a particularly large amount. The consumption of goods and thus also the consumption of CO2 depends on the income and wealth of a country and a household, since consumption expenditure usually increases as income and wealth does (Dossche et al., 2018). For a household to contribute individually to climate change in the form of CO2, goods must be consumed that cause greenhouse gas emissions in their production, transport and trade (Satterthwaite, 2009). Looking at the distribution of emissions by country income, the richest half (high and upper-middle income countries according to World Bank 2022 classification) emit around 82 % of global production-based CO2 emissions, having a share of about 53 % of world population (see Table 2). Lower and lower middle income countries emit only 18% in comparison, with a share of 47 % of world population. Many high income countries could reduce their production based emissions over the past years and externalized carbon-intensive production to the Global South. Chancel et al. (2022) call this outsourcing of production as „ecological dumping strategies to externalize their carbon-intensive industries to the rest of the world“. The lowest-income countries are responsible for only about 0.4 percent of production-based emissions and 0.2 percent of consumption-based emissions.

**Table 2.**

*Share of world population, share of production-based CO2 and consumption-based CO2 emissions according to World Bank income classifications in 2020*

| Income classification according to World Bank | Share of world population (%) | Share of production-based CO2 emissions (%) | Share of consumption-based CO2 emissions (%) |
|---|---|---|---|
| Low-income countries | 0.04 | 0.47 | 0.21 |
| Lower-middle-income countries | 47.25 | 17.28 | 16.39 |
| Upper-middle-income countries | 35.63 | 47.16 | 41.28 |
| High-income countries | 17.08 | 35.09 | 42.12 |

*Note. Income classifications are taken from the World Bank's calculations for the current fiscal year 2023 (The World Bank, 2022b). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022 (UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are taken from the World in Data database which is based on $CO_2$ figures published by Friedlingstein et al. (2022) through the Global Carbon Project.*

Looking at absolute emissions, combining both imported and exported by countries and embedded in global trade (carbon footprints), African countries in particular fall out of the equation, as some may for instance have particularly high consumption-based emissions but very few production-based emissions. For example, countries such as Botswana have hardly any industry. This results in high consumption-based $CO_2$ emissions, but hardly any production-based emissions due to the lack of its own industry.

Looking at the absolute emissions imported or exported, the list is headed by the European Union as a whole, followed by the USA, Japan and then Germany, Italy and France individually. With the exception of Botswana, no country on the African continent emerged as a net importer in 2019 (Ritchie et al. 2021).

Here, too, caution is called for: as already mentioned in connection with per capita figures, consumption-based figures should also not be generalized, since inequalities within a country play a central role. Piketty & Chancel (2015) solve this by focusing on high individual emitters rather than on high emitting countries. This work recognizes that $CO_2$ emissions need to be discussed not only in the context of countries, but also by looking at high emitting individuals. Nonetheless, policy goals currently continue to concern countries, as do goals for family planning programs. As has been shown, there is an almost exclusive focus of international family planning programs on low- and lower-middle income countries, partly justified by the Sustainable Development Goals. Therefore, this work attempts to proceed within the framework of available data on countries' $CO_2$ emissions.

## 4. Derivation of the Research Question

Within the environmental movement, calls for climate action through reproductive health are growing louder (Ojeda et al., 2019). This is mostly done in the name of empowering women, empowering the poor, and protecting the environment, while the language of social justice or human rights is used (Sasser, 2018). But calls for more reproductive health have to be seen double-edged both from a historical perspective, but also from the perspective that new family planning programs have been criticized for adopting neo-Malthusian approaches, especially when reproductive health translates into an exclusive focus on contraceptives and family planning, and factors such as increased educational opportunities fall to the back burner. There is still an unmet need for contraception (UN, 2019), especially in the Global South and family planning programs have helped to dramatically reduce maternal and child mortality (UNFPA, 2017). Nevertheless, awarding contraceptives to women in the Global South on the ground of development policies is to be viewed critically, especially after the decades-long history of population policy considerations marked by human rights abuses and when today there seems to be a focus on providing long-lasting contraceptives to low- and lower-middle income countries with sometimes major side effects. At the same time, the donor structure, especially in SSA, creates a dependency that impacts countless women*. Contraceptives, education, and health are human rights that must be guaranteed for their own sake, not to supposedly combat population growth or poverty, because as Asoka Bandarage writes: „Poverty cannot be eliminated by eliminating the poor“ (Bandarage, 1997) - or translated into the language of the hypothesis of this thesis: Climate change cannot be eliminated by providing contraception.

Given the accusations that the notion of reproductive health masks population policy goals (Sasser, 2018) that have historically led to racist methods of poverty alleviation, it seems doubly critical to question why the issue is becoming louder within the climate movement. Environmental concerns and population narratives have seemed to feed off each other for as long as humanity has existed, and environmental debates seem to have consistently provided supposed rationales and justifications for population policy considerations, particularly in the last century. Against this background, climate change also seems to provide new fodder for the population debate once again. Whereby, at the same time, there is criticism that population policy considerations only obscure the actual causes of climate change. While there seems to be plenty of awareness that environmental degradation and climate change are not caused by the sheer number of human people on the planet, there seems to be a real need to create evidence of the correlations between the both factors. Otherwise, there is a danger that population will be used as an easily influenced determinant in the climate change debate after all.

This work is therefore premised on the concern that the issue of climate change and reducing CO2 emissions is giving new impetus to the population debate, which could be misdirected and instrumentalized to advance reproductive health goals with clear targets in numbers of contraceptives to be provided in the Global South. The debate appears to be so polarized that there is an urgent need to examine more closely the links between population growth and climate change. Numerous works have examined these relationships over and over again, but because the debate between environmental degradation, poverty, and population is so entrenched, there seems to be a need to examine this relationship time and again.

Against the historical backdrop of population considerations and in light of the need to rapidly reduce CO2 emissions, this master's thesis seeks to determine the extent to which rising CO2 emissions are related to population growth and whether population reduction considerations and more spending towards reproductive health are necessary in the context of climate change or whether there are better means to mitigate CO2 emissions. Thus, the following research question arises from the above considerations: What is the contribution of population growth to the increase in CO2 emissions?

# 5. Methodology

The main goal of this research is to understand the relationship between population and CO2 emissions and its growth. As the theoretical review of Chapter 3 on CO2 emissions has shown, CO2 emissions are not solely dependent on the number of people on the planet, but on different variables. Based on a review of the literature, this thesis examines three variables that are believed to have an impact on CO2 emissions: Population, GDP per capita, and energy use per capita.

To determine the relationship of these variables to CO2 emissions, first the correlation of each variable to CO2 emissions was determined followed by a multiple regression. Four years were selected for which the data were analysed: 1990, 2000, 2010 and 2019. The selection of these years was made to identify possible changes in the comparison between years and at the same time to identify possible fluctuations. The year 2019 was chosen because, at the time of this work, complete data on per capita energy consumption for later years was not available for the variables considered. All analysis were performed using R-Studio for Windows (2022.07.2). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022 (UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are messured in tonnes (t) and taken from the World in Data database which is based on CO2 figures published by Friedlingstein et al. (2022) through the Global Carbon Project. The GDP per capita figures are derived from the World Bank database and are calculated in current US$. The data on the primary energy use per capita is  measured in kilowatt hours per person and year and was compiled by Our World in Data based on two major data sources: the BP Statistical Review of World Energy and international energy data from the U.S. Energy Information Administration (EIA). All data cleaned up in Excel for Mac (version 16.66.1).

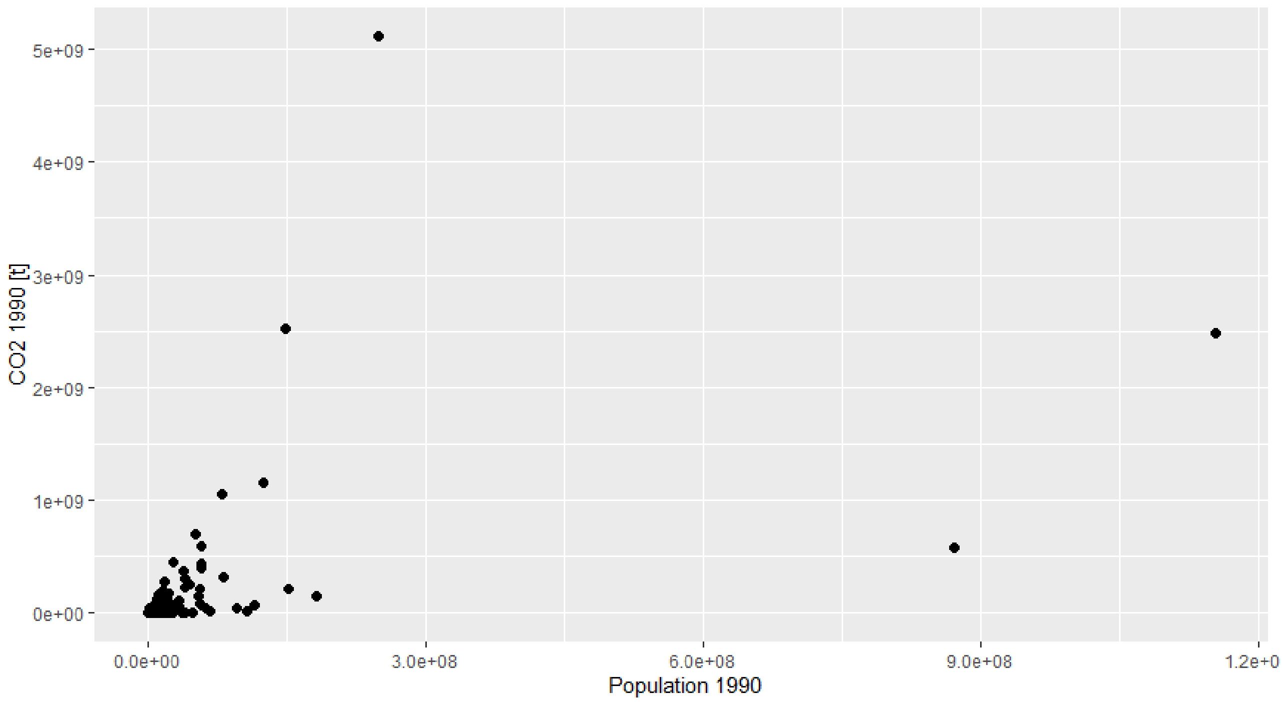
The individual methodological steps are described in detail in this following chapter.

## 5.1 Qualitative analysis

In a first step, the relationship between the individual variables on CO2 emissions was visualized for each selected year using a scatter plot. Figure 1 shows the results of the plot for the year 1990 of the variable population (x-axis) and the variable CO2 emissions (y-axis).

**Figure 1.**

*Scatter plot between CO2 Emissions [t] in 1990 and Population numbers in 1990*



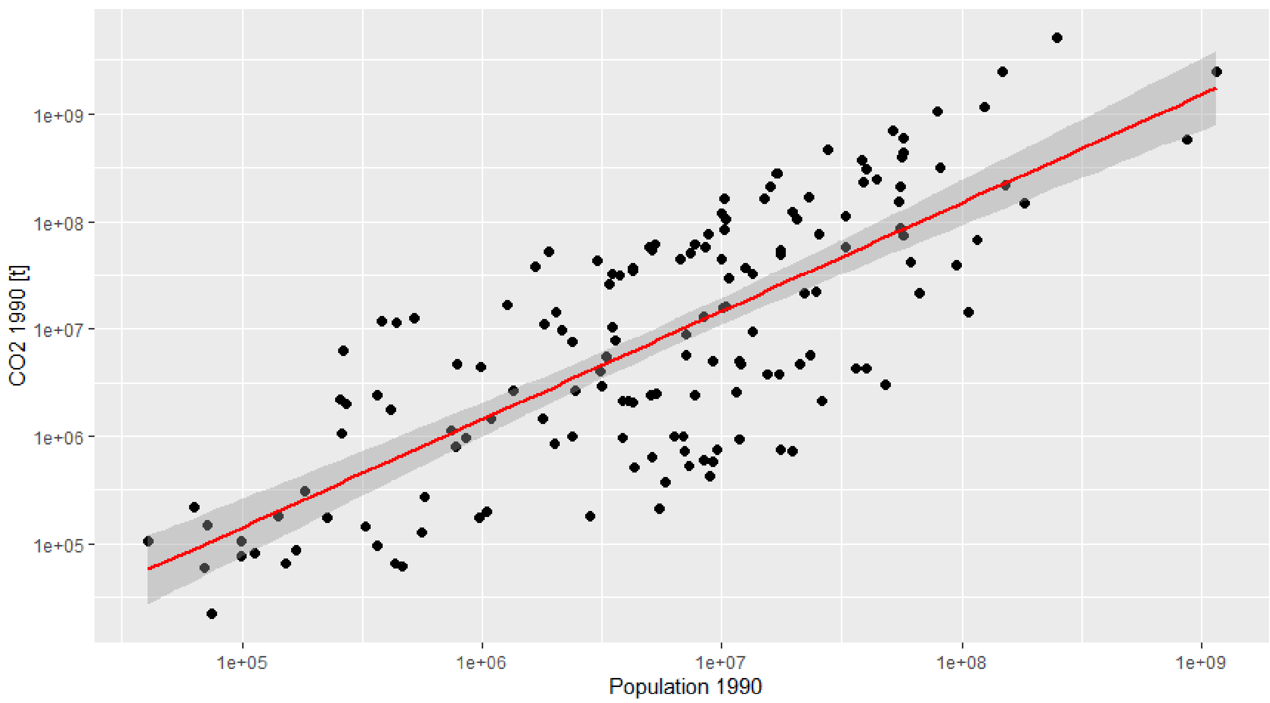

Based on this scatter plot (Figure 1) with the two variables under consideration, it can be directly deduced that there is a positive trend between the two variables. Looking at the correlation between CO2 emissions and population in 1990 (see Table 3), the Pearson Correlation Coefficient (in the following simply referred to as the correlation coefficient) r = 0.52, translates into a positive correlation. However, the calculated correlation coefficient does not say anything yet about the exact relationship between the two variables. Therefore, a regression analysis is performed to gain more insight into the specific relationship in a later step.

The distribution of population and CO2 emissions in 1990 are highly skewed. Four countries in particular stand out, which are particularly distant from the other data on the X- (Population in 1990) and Y- (CO2 emissions in 1990) axes. Comparing with the data used for this plot, the USA, Russia and India stand out with particularly high CO2 emissions. Russia and China show similar values for 1990 on the Y-axis, despite China having an X-value of about one billion people more. India stands out as the fourth country due to its high population figures, but in 1990 it was only the country with the ninth-highest CO2 emissions. For all years under consideration, there is data that is particularly widely distributed on both the X- and Y-axes, but not all of these data will be discussed in detail (see Appendix A.-D. for plots of all years). As an example, 1990 was therefore looked at above.

To control for skewness and counteract problems of heteroskedasticity, the data on population and CO2 emissions are transformed by forming their natural logarithms for the later regression. Figure 2 shows how the distribution would look like:

**Figure 2.**

*Scatter plot between CO2 Emissions [t] in 1990 and Population numbers in 1990 with logarithmized scales*



For this plot (Figure 2), both scales were logarithmized. One could also logarithmize the data before creating the plot, which this would result in an analogous plot. For reasons of visualization and better interpretability, the scatter plots are shown here with logarithmized scales. The red line shows the regression line.

Since not only the independent variable of population plays a role for the consideration of CO2 emissions in this work but also GDP per capita and energy use per capita are included, the relationships between GDP per capita and CO2 emissions as well as energy use per capita and CO2 emissions for 1990 were also considered.

**Figure 3.**

*Scatter plot between CO2 Emissions [t] in 1990 and Gdp per capita in 1990 [current US$]*

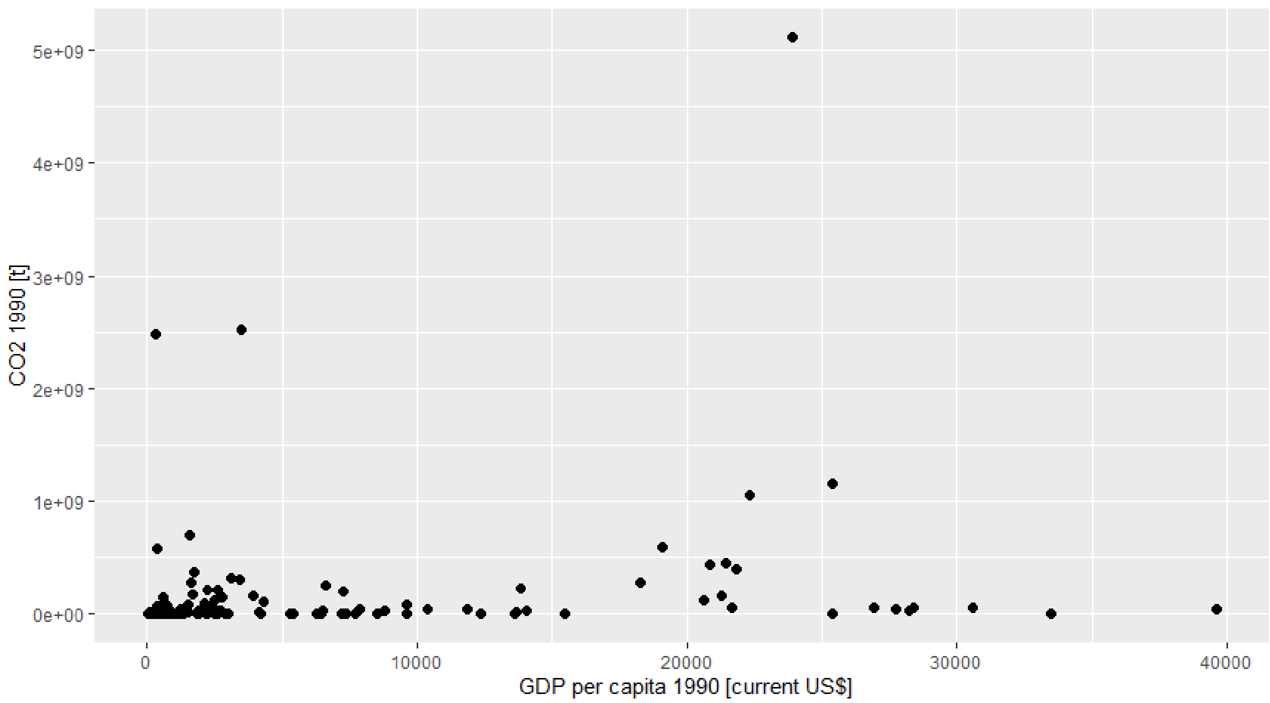



Figure 3 shows the scatter plot of the relationship between GDP per capita and CO2 emissions in 1990. The correlation coefficient r = 0.23, hence a positive correlation is also present here. As before, the scales were logarithmized for better interpretability (see Figure 4).

**Figure 4.**

*Scatter plot between CO2 Emissions [t] in 1990 and GDP per capita in 1990 [current US$] with logarithmized scales*


**Figure 5.**

*Scatter plot between CO2 Emissions [t] in 1990 and Energy use per capita in 1990 [kWh]*

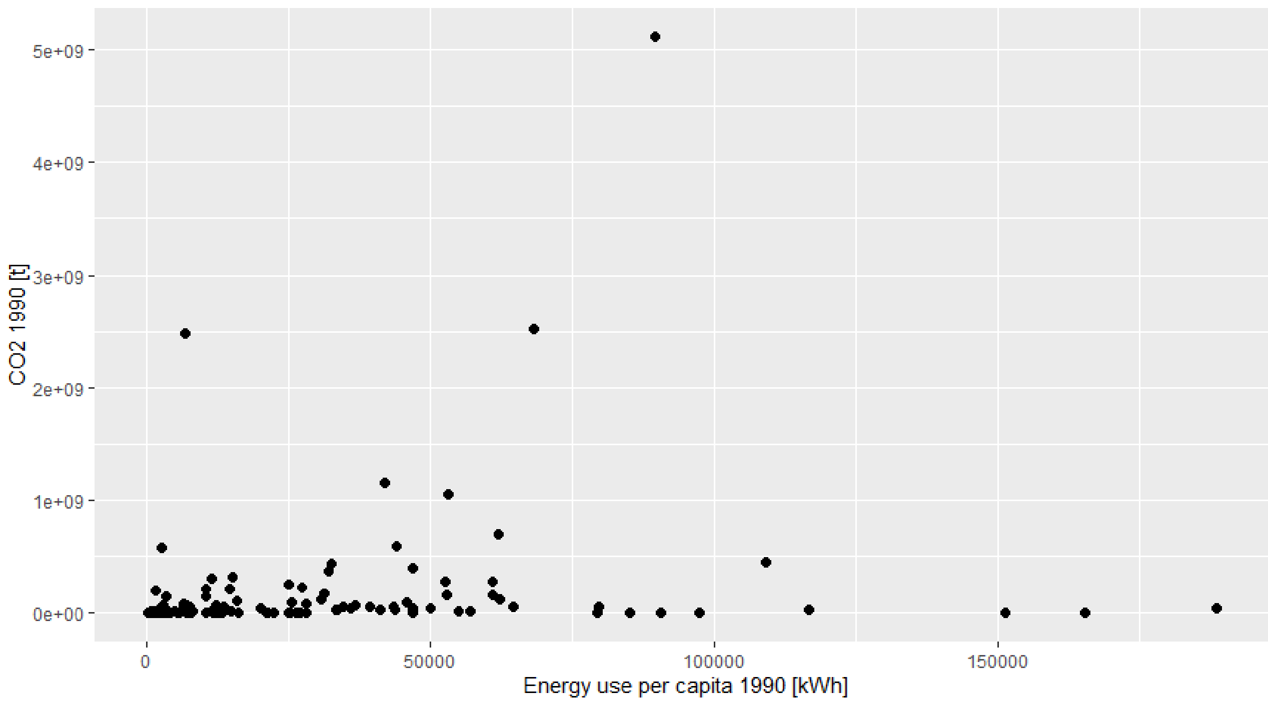


Figure 5 shows the scatter plot for $CO_2$ and energy use per capita data in 1990. The coefficient of correlation for energy use per capita in 1990 is r = 0.23 (see Table 3), indicating a positive correlation as well.

This qualitative analysis was performed between all independent variables (population, GDP per capita and energy use per capita) with the dependent variable ($CO_2$ emissions) for all selected years. The plots can be found in Appendix A.-D. Table 3 shows the calculated correlation coefficients for each year and each variable considered.

**Table 3.**
*Correlation coefficients of the independent variables population (P), GDP per capita and energy use per capita and the dependent variable CO2 emissions for the years 1990, 2000, 2010 and 2019*

| Variable | CO2 Emissions |
|---:|---:|
| Population 1990 | r = 0.52 |
| GDP per capita 1990 | r = 0.23 |
| Energy use per capita 1990 | r = 0.23 |
| Population 2000 | r = 0.59 |
| GDP per capita 2000 | r = 0.22 |
| Energy use per capita 2000 | r = 0.19 |
| Population 2010 | r = 0.77 |
| GDP per capita 2010 | r = 0.08 |
| Energy use per capita 2010 | r = 0.1 |
| Population 2019 | r = 0.82 |
| GDP per capita 2019 | r = 0.07 |
| Energy use per capita 2010 | r = 0.08 |

*Note. The data is taken from own calculations.*

In general, positive liniear trends were found for all variables (see Table 3). However, these differ considerably from year to year. Values $< 0.3$ indicate a very weak correlation or almost none, i.e., the linear relationship is weak. They indicate the possible presence of non-linearities. The highest linear correlation for each year is shown by the population variable. To perform the multiple linear regression, all data were logarithmized.

## 5.2 Simple regression analysis

To identify the simple relationship between CO2 and population, a simple regression model is first run using the natural log of CO2 emissions as the main dependent variable and the natural log of population as the primary independent variable, taking the year 1990 as an example:

$$\log(y) = \text{intercept} + \beta^*\log(x)$$

where y is the predicted value of the dependent variable; x is independent variable; β is the regression coefficient of x and intercept is the constant coefficient.

## 5.3 Multiple Regression Analysis

A qualitative analysis examines whether there is a linear relationship between two of the selected variables (see Chapter 5.1), however it does not indicate the direct influence of the variables on CO2 emissions. This influence shall be first determined in a second step with the help of a multiple regression model, by theoretically assuming a certain causal relationship between CO2 emissions, population, GDP per capita and energy use per capita. A multiple linear regression is a statistical method that attempts to explain an observed dependent variable by one or more independent variables (Nayebi, 2020). The linear regression equation predicts the dependent variable (the natural log of CO2 emissions as a function of a set of independent variables (the natural logs of CO2 emissions population size, GDP per capita and energy use per capita):

$$\log(y) = \text{intercept} + \beta\_1^*(x) + \beta\_2^*\log(x)+ \ldots$$

where y is the predicted value of the dependent variable; x is independent variable; β is the regression coefficient of x and intercept is the constant coefficient. As mentionded before all data are logarithmized.

The consideration of the influencing factors on CO2 in Chapter 3 led to the inclusion of energy use per capita and GDP per capita in this regression model. As already explained in Chapter 3, most CO2 emissions originate from the energy sector. By taking the per capita indicator and not the absolute number of energy consumption, the population share of a country is directly included. The variable energy use does include energy use from electricity, but also transport, heating and cooking, as measured in kilowatt-hours per person per year. This takes into account primary energy consumption, i.e. the consumption of fuels such as coal or natural gas. The data is sourced from Our World in Data.

As mentioned above, gross domestic product (GDP) per capita in US dollars is another variable included in the applied linear multiple regression model. GDP is considered a measure of material well-being within a country and an often used indicator for measuring consumption. It represents the gross domestic product divided by the population at mid-year (The World Bank, 2022d). GDP is the total value of the gross value added of all goods and services produced in an economy plus all taxes on products and minus all subsidies and intermediate consumption not included in the value of goods. It is measured without any deductions for the depreciation of manufactured goods or for the extraction of natural resources. Again, the per capita calculation indirectly includes a country's population size.

In the case of the model of this work, the dependent variable represents CO2 emissions, while GDP, energy use and population size present the independent variables. Excel for Mac (version 16.66.1) was used to prepare the data for later use in R-Studio (2022.07.2) for Windows, which was used to perform the multiple regression and other statistical observations. The data used for the multiple regressions are the population data of the worlds countries, the GDP per capita of each of the countries, the energy consumption per capita and the absolute CO2 emission figures. A multiple regression is performed for the years 1990, 2000, 2010 and 2019. For the year 1990, a multiple linear regression could be performed with data from 158 countries. Data for other countries were unfortunately incomplete for the year 1990. For the year 2000, the multiple regression was performed with data from 186 countries, for 2010 with 193, and for 2019, the regression could be performed for 190 countries.

On the plot showing the relation between energy use per capita and CO2 emissions in 1990, the USA, Russia and China again stand out on the Y-axis (particularly high CO2 emissions) for 1990. The same applies to the plot of CO2 emissions compared with GDP per capita in 1990. Switzerland, Luxembourg and Sweden stand out on the X axis with particularly high GDP values. After a first look at the data, the distribution of both energy use per capita and GDP per capita in 1990 are badly skewed, creating a non-linear relationship between X and Y. As done with the data of population numbers, both energy use per capita and GDP per capita are transformed by taking their natural logarithms.

After looking at the data for all years in a qualitative analysis (Chapter 5.1), it can be seen that the distribution of the data for the variables in 2000, 2010, and 2019 was also largely skewed, so the data for the multiple regression for each year were also converted to their natural logarithms (see Appendix A.-D. for plots).

### 5.3. Country analysis CO2 and population growth rates

In a third step, the relationship between CO2 emissions and population growth is explicitly examined without the other variables. For this purpose, data from the years between 1990 and 2020 on population and CO2 are taken and compared. In each case, the annual compound growth rates of both factors (CO2 emissions and population) are calculated, a geometric progression rate that provides constant growth over the period 1990 to 2020. Only data from UN-recognized states is included in the analysis. Currently, there are 193 states and 2 observer states being part of the UN. The two observer states are also included in the analysis. The data on both population numbers and CO2 emissions is derived from World in Data databases and combined with World Bank data on income classifications, calculated with the World Bank Atlas method. Of the 195 states, 59 belong to the high-income states. 28 to low-income, 54 to lower-middle income, 52 to upper-middle income. The current classifications are based on fiscal year 2023, with economies having a GNI per capita of $1,085 or less in 2021, calculated using the World Bank's Atlas method, defined as low-income countries. Lower middle-income countries are those with GNI per capita between $1,086 and $4,255; upper middle-income countries are those with GNI per capita between $4,256 and $13,205; high-income countries are those with GNI per capita of $13,205 or more. The terms economy and country are used interchangeably (World Bank, 2022b). The data on nations are used, because CO2 emissions are mostly calculated in nations and political debates on CO2 emissions most often call for national and regional targets. CO2 emissions are not calculated on individuals.

## 6. Results

To first understand the relationship between CO2 emissions and population independently of other variables, a scatter plots with a fitting line of the natural logarithm of CO2 emissions and population was created using R-Studio. The plot results show the general relationship between the two variables for the year 1990 and indicate a positive relationship as both CO2 emissions and population tend to increase. This positive relationship is also confirmed by the results of the simple regression between CO2 emissions and population in 1990. All factors were then examined in a multiple regression for the years selected; the results are listed below for all years.

### 6.1 Simple Regression Model 1990

Table 4 shows the results of the simple regression for 1990 between the dependent variable CO2 and the independent variable population (Log P) in their natural logarithm.

**Table 4.**
*Results of the Simple Regression Model between CO2 emissions and population in 1990*

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 0.25 | 1.09 | 0.23 | 0.82 |
| Log P 1990 | 1.01 | 0.07 | 14.42 | <2e-16 |

*R-squared: 0.57*

The results show that a 1 percent increase in population would lead to an increase in CO2 emissions of around 1 percent. This depecits that the more a countrys population grows, the more the CO2 emissions will grow. The R-squared value is at about 0.57 explaining about 57% of the variation in CO2 emissions. The p-value is <2e-16, indicates statistically a significant level with below 1% level.

## 6.2 Results Multiple Regression

This section lists all the results of the multiple regressions for the years 1990, 2000, 2010 and 2019.

### 6.2.1 Results Multiple Regression Analysis for the year 1990

Table x lists the results of the multiple regression analysis for 1990 between the dependent variable CO2 and the independent variables population (Log P), GDP per capita (Log GDP) and energy use per capita (Log Energy use per capita) in their natural logarithm.

**Table 5.**
*Results of the multiple regression analysis for 1990 between the dependent variable CO2 and the independent variables population (Log P), GDP per capita (Log GDP) and energy use per capita (Log Energy use per capita) in their natural logarithm*

| | *Coefficients* | *Standard Error* | *P-value* |
|---|---|---|---|
| Intercept | -9.107 | 0.52 | <2e-16 |
| Log P 1990 | 1.04 | 0.03 | <2e-16 |
| Log GDP 1990 | 0.43 | 0.06 | 3.2E-12 |
| Log Energy use per capita 1990 | 0.63 | 0.05 | <2e-16 |

*Note. R-squared: 0.94*

The equation used in this model represents the relationship between CO2 emissions, GDP per capita, population, and energy per capita in 1990. The R-squared value in the multiple regression analysis increased to 0.94, indicating that 94% of the dependent variable (the natural logarithm of CO2 emissions in 1990) can be explained by the variables of all explanatory variables of the natural logarithm of population in 1990, the natural logarithm of GDP per capita in 1990, and the natural logarithm of energy consumption per capita in 1990. The significant increase in the R-Squared value can be stressed with these additional explanatory variables. Statistical significance is given as all p-values are below 1%, which allows promising statistical conclusions.

The regression coefficients for all variables are direct (ascending) since all coefficients are positive. This means that the value of the dependent variable (CO2 emissions) is increased by increasing the value of the independent variables (population, GDP per capita and energy consumption). The linear regression coefficient of population (P-value =

2,59E-81) indicates that an increase of by 1 in the log of population will incease CO2 emissions by 1.04. Population thereby shows the highest coefficient. This indicates that CO2 emissions increase by around 1.04% for 1990 for 1% increase in human population. Further CO2 emissions increase by 0.43% with an increase of 1% in GDP per capita, with the linear regression coefficient of GDP per capita in 1990 being at 0.43 (P-value = 3.2E-12). The same is true for energy per capita, with the coefficient being at around 063 (P-value = 2.14E-25), translating into an 0,63% increase of CO2 emissions if energy per capita increases by 1%.

### 6.2.2 Results Multiple Regression Analysis for the year 2000

**Table 6.**
*Results of the multiple regression analysis for 2000 between the dependent variable CO2 and the independent variables population (Log P), GDP per capita (Log GDP) and energy use per capita (Log Energy use per capita) in their natural logarithm*

| | *Coefficients* | *Standard Error* | *P-value* |
|---|---|---|---|
| Intercept | -9.00 | 0.32 | <2e-16 |
| Log P 2000 | 1.02 | 0.02 | <2e-16 |
| Log GDP 2000 | 0.09 | 0.04 | 0.0135 |
| Log Energy use per capita 2000 | 0.93 | 0.03 | <2e-16 |

*Note. R-squared: 0.97*

The R-squared value in the multiple regression analysis for the year 2000 was at 0.97, indicating that 97% of the dependent variable (the natural logarithm of CO2 emissions in 1990) can be explained by the variables of all explanatory variables of the natural logarithm of population in 2000, the natural logarithm of GDP per capita in 2010, and the natural logarithm of energy consumption per capita in 2010. Statistical significance is given as all p-values are below 1%. Again all regression coefficients for all variables are ascending since all coefficients are positive. The linear regression coefficient of population (P-value = <2e-16) changed little compared to 1990 and indicates for 2000 that CO2 emissions increase by around 1.02 % for 1% increase in human population. CO2 emissions rise by 0.93% when energy use per capita increases by 1%, with the coefficient for the log of energy use per capita 2000 being at around 0.93 (P-value = <2e-16). Further CO2 emissions increase by 0.09% with an increase of 1% in GDP per capita, with the linear regression coefficient of GDP per capita in 2000 being at 0.09 (P-value = 0.0135).

### 6.2.3 Results Multiple Regression Analysis for the year 2010

**Table 7.**

*Results of the multiple regression analysis for 2010 between the dependent variable CO2 and the independent variables population (Log P), GDP per capita (Log GDP) and energy use per capita (Log Energy use per capita) in their natural logarithm*

| | *Coefficients* | *Standard Error* | *P-value* |
|---|---|---|---|
| Intercept | -9.00 | 0.32 | <2e-16 |
| Log P 2010 | 1.02 | 0.01 | <2e-16 |
| Log GDP 2010 | 0.14 | 0.05 | 0.00163 |
| Log Energy use per capita 2010 | 0.86 | 0.04 | <2e-16 |

*Note. R-squared: 0.97*

The R-squared value in the multiple regression analysis for the year 2010 was at 0.97, indicating that 97% of the dependent variable (the natural logarithm of CO2 emissions in 1990) can be explained by the variables of all explanatory variables of the natural logarithm of population in 2010, the natural logarithm of GDP per capita in 2010, and the natural logarithm of energy consumption per capita in 2010. Statistical significance is given as all p-values are below 1%. Again all regression coefficients for all variables are ascending since all coefficients are positive. The linear regression coefficient of population (P-value = <2e-16) did not change compared to 1990 and indicates for 2010 again that CO2 emissions increase by around 1.02 % for 1% increase in human population. CO2 emissions rise by 0.86% when energy use per capita increases by 1%, with the coefficient for the log of energy use per capita 2010 being at around 0,86 (P-value = <2e-16). Further CO2 emissions increase by 0.14% with an increase of 1% in GDP per capita, with the linear regression coefficient of GDP per capita in 2010 being at 0.14 (P-value = 0.00163).

### 6.2.4 Results Multiple Regression Analysis for the year 2019

**Table 8.**

*Results of the multiple regression analysis for 2019 between the dependent variable CO2 and the independent variables population (Log P), GDP per capita (Log GDP) and energy use per capita (Log Energy use per capita) in their natural logarithm*

| | *Coefficients* | *Standard Error* | *P-value* |
|---|---|---|---|
| Intercept | -8.29 | 0.29 | <2e-16 |
| Log P 2019 | 1.01 | 0.01 | <2e-16 |
| Log GDP 2019 | -0.10 | 0.04 | 0.02 |
| Log Energy use per capita 2019 | 1.04 | 0.04 | <2e-16 |

*Note. R-squared: 0.97*

The R-squared value in the multiple regression analysis for the year 2019 was at 0.97, indicating that 97% of the dependent variable (the natural logarithm of CO2 emissions in 1990) can be explained by the variables of all explanatory variables of the natural logarithm of population in 2019, the natural logarithm of GDP per capita in 2019, and the natural logarithm of energy consumption per capita in 2019. Statistical significance is given as all p-values are below 1%. The linear regression coefficient of population (P-value = <2e-16) changed little compared to 2010 and indicates for 2019 that CO2 emissions increase by around 1.01 % for 1% increase in human population. CO2 emissions rise most when energy use per capita increases, with the coefficient for the log of energy use per capita 2019 being at around 1.04 (P-value = <2e-16), translating into an 1.04% increase of CO2 emissions if energy per capita increases by 1%. Interestingly, when looking at the numbers for 2019, not all numbers are ascending, since the coefficient for the natural log of GDP per capita in 2019 is negative at -0.10 (P-Value = 0.02), translating at an decrease of -0.1% for 1% increase in GDP per capita 2019.

## 6.3 Population growth and growth of CO2 emissions between 1990 and 2020

The first look at the multiple regressions seems to suggest that population has the largest effect on CO2 of the three independent variables chosen for this work. However, a look at the literature review suggested other results to be expected. As mentioned already, generalizations play a major role in the consideration of population and CO2 figures. In a sense, the multiple regressions performed in this work pool all the data so that it is no longer possible to differentiate once the regression has been performed. Population growth rates vary significantly from region to region and country to country (see Chapter 2). Therefore, both CO2 emission growth rates and population growth rates for the 196 countries recognized by the United Nations between 1990 and 2020 are examined in more detail below. The data used are the same as those used for the regression.

On average, the absolute CO2 emissions of 196 countries in 2020 were at 174,280,750 t according to own calculations. The median of absolute CO2 emissions was at 11,834,052 t CO2 in 2020, which implies that 50% of the countries considered had absolute CO2 emissions of 11,834,052 t or less. Of the 39 countries with the highest CO2 emissions per capita in 2020, a total of 26 belonged to the high-income category according to the World Bank. None of the 39 countries with the highest CO2 emissions per capita fell into the low-income category.

The per capita CO2 emissions of 196 countries averaged 3.72 metric tons in 2020, according to their own calculations. However, the median was 1.91 t CO2 in 2020, implying that 50% of the countries considered had per capita CO2 emissions of 1.91 t or less. A total of 64 countries were above the average for 2020. To add to this, the emissions of the top 20% of all countries were 5.35 tons or more in 2020. At the top of the list of countries with the highest CO2 emissions per capita in 2020 are Qatar, Trinidad and Tobago, Brunei, Kuwait, Bahrain, Saudi Arabia, Kazakhstan, Australia, the United Arab Emirates and the USA. Most of the ten countries with the highest CO2 per capita emissions are known for their natural gas and oil production, while most of them are relatively small countries with low absolute population numbers.

Of the 39 countries with the highest CO2 per capita emissions, only 13 had population growth rates above 1.5% between 1990 and 2020. The growth rates of 17 other countries were below 1%, and a further five countries even had negative growth rates. The three countries with the highest population growth rates in this group are Qatar, United Arab Emirates (UAE) and Equatorial Guinea. Qatar has the highest rate of migrant workers in the world. In terms of the total population, about 88% of the inhabitants (2.2 million people) are of foreign origin (BTI, 2022). The same is true for the United Arab Emirates, where immigrants make up 88.1% of the total population (MPI, 2022). The growth rates of these countries are not discussed in detail in this work, but it is assumed, based on the mentioned UN data, that labor migration plays a central role in population growth.

Of the 39 countries with the lowest $CO_2$ per capita emissions, a total of 27 are classified as low-income economies, nine as low-middle income and three as upper-middle income. None of the countries with the lowest $CO_2$ per capita emissions is classified as high-income. Overall, 35 of the 39 countries with the lowest $CO_2$ per capita emissions have population growth rates greater than 1.5%. Thirty of the countries with the lowest per capita emissions are located on the African continent, the other nine in Asia, Oceania and Latin America. The Democratic Republic of Congo in 2020 had the lowest $CO_2$ per capita emissions with 0.03t, followed by Somalia and the Central African Republic with 0.04t each. All three countries have population growth rates of over 1.5% percent.

Of the 39 countries with the highest population growth rates, only 9 countries had $CO_2$ per capita emissions above 3t, while 29 countries had $CO_2$ per capita emissions below 1t and 12 countries even below 0.2t in 2020. Of the 29 countries with $CO_2$ per capita below 1t, 28 are classified as low-income and lower-middle class. Of the 9 countries with more than 3t $CO_2$ per capita emissions, all except one are oil producing countries, classified as high- and upper-middle income countries. In comparison of the 39 countries with the lowest population growth rates, 24 countries emitted more than 3t of $CO_2$ per person in 2020, with all of the 39 countries with the lowest population growth rates are classified as high-income or upper-middle income, 19 of them are high-income countries.

Table x compares countries with low population growth rates (below 1.5%) and annual growth in $CO_2$ emissions (annual emissions) above 3%. Of those countries with population growth rates of 1.5% and $CO_2$ growth rates of over 3% between 1990 and 2020, Nepal tops the list. Nepal has had a population growth rate of 1.35% and a $CO_2$ growth rate of 11.10% between 1990 and 2020. Nepal had a total population of 29.35 million people and total $CO_2$ emissions of 16.96 million tons in 2020, thus $CO_2$ per capita emissions were 0.58t in 2020. Of the 195 countries, Nepal ranked 89th in total emissions in 2020. Again, the fair share debate needs to be put into context. While the growth rates of these countries may be particularly high, their $CO_2$ per capita emissions are far below the 2t fair share.

**Table 8.**

*Countries with low population growth rates (less than 1.5% per year) and $CO_2$ emission growth rates of 3% or more per year, 1990-2020; 10 selected countries by highest $CO_2$ emissions.*

| Country | Income (World Bank 2022) | P 1990 | P 2020 | CAGR P | CO2 1990 (tonnes) | CO2 2020 (tonnes) | CAGR CO2 | Annual CO2 emissions (tonnes per capita) |
|---|---|---|---|---|---|---|---|---|
| Iran | Lower middle income | 55793628 | 87290192 | 1.5 % | 209943734 | 745035109 | 4.31 % | 8.87 |
| China | Upper middle income | 1153704192 | 1424929792 | 0.71 % | 2484854820 | 10667887453 | 4.98 % | 7.41 |
| Seychelles | High income | 71073 | 105545 | 1.33 % | 150224 | 491067 | 4.03 % | 4.99 |
| Turkey | Upper middle income | 54324140 | 84135432 | 1.47 % | 151508468 | 392794051 | 3.23 % | 4.66 |
| Chile | High income | 13342876 | 19300318 | 1.24 % | 32891315 | 81171490 | 3.06 % | 4.25 |
| Thailand | Upper middle income | 55228408 | 71475664 | 0.86 % | 87915996 | 257765782 | 3.65 % | 3.69 |
| Mongolia | Lower middle income | 2161440 | 3294340 | 1.41 % | 9889986 | 88441761 | 7.58 % | 2.7 |
| Grenada | Upper middle income | 99066 | 123672 | 0.74 % | 106256 | 294834 | 3.46 % | 2.62 |
| Vietnam | Lower middle income | 66912616 | 96648680 | 1.23 % | 21298647 | 254303169 | 8.62 % | 2.61 |
| Dominican Republic | Upper middle income | 7129004 | 10999668 | 1.46 % | 8936017 | 27769310 | 3.85 % | 2.56 |

*Note.* *Income classifications are taken from the World Bank's calculations for the current fiscal year 2023 (The World Bank, 2022b). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022*

*(UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are taken from the World in Data database which is based on $CO_2$ figures published by Friedlingstein et al. (2022) through the Global Carbon Project.*

Overall, none of the countries with low population growth rates and high CO2 growth rates (see Table 8) is listed as a low-income country. If we compare this with the countries with high population growth rates (above 2.5%) and low CO2 emission growth rates (below 3%) (see Table 9), almost all of them are in Africa (8 out of 11).

**Table 9.**
*Nations with high population growth rates (above 2.5% a year) and CO2 emissions growth rates that are significantly slower or negative, 1990-2019; 10 selected countries by highest population growth numbers.*

| Country | Income (World Bank 2022) | P 1990 | P 2020 | CAGR P | CO2 1990 (tonnes) | CO2 2020 (tonnes) | CAGR CO2 | Annual CO2 emissions (tonnes per capita) |
|---|---|---|---|---|---|---|---|---|
| Democratic Republic of Congo | Low income | 35987544 | 92853168 | 3.21 % | 4248965 | 2477334 | -1.78 % | 0.03 |
| Somalia | Low income | 6999098 | 16537018 | 2.91 % | 730901 | 562143 | -0.87 % | 0.04 |
| Gabon | Upper middle income | 983039 | 2292583 | 2.86 % | 4484725 | 4298177 | -0.14 % | 1.93 |
| Yemen | Low income | 13375127 | 32284044 | 2.98 % | 9520184 | 9768313 | 0.09 % | 0.33 |
| Belize | Upper middle income | 182603 | 394931 | 2.6 % | 311440 | 582795 | 2.11 % | 1.47 |
| Solomon Islands | Lower middle income | 324184 | 691198 | 2.56 % | 146560 | 298781 | 2.4 % | 0.44 |
| Cote d'Ivoire | Lower middle income | 11910540 | 26811792 | 2.74 % | 4781520 | 10070733 | 2.51 % | 0.38 |
| Liberia | Low income | 2209737 | 5087591 | 2.82 % | 467124 | 1008984 | 2.6 % | 0.2 |
| Togo | Low income | 3875958 | 8442583 | 2.63 % | 977644 | 2191571 | 2.73 % | 0.26 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Kuwait | High income | 1674942 | 4360451 | 3.24 % | 37807037 | 88935077 | 2.89 % | 20.83 |

*Note. Income classifications are taken from the World Bank's calculations for the current fiscal year 2023 (The World Bank, 2022b). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022 (UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are taken from the World in Data database which is based on* $CO_2$ *figures published by Friedlingstein et al. (2022) through the Global Carbon Project.*

Oil states lead the group of countries with high population growth rates and high CO2 growth rates (Table 10). A total of 28 countries fall into this category, led by the five high-income oil states: Qatar, Oman, Saudi Arabia, UEA and Bahrain. These five countries have CO2 per capita emissions of well over 10t in 2020 and are the high-income countries in this category. 20 other states in this group had CO2 per capita emissions of less than 1t in 2020.

Countries like Burundi fall into the list of countries with high CO2 growth rates and high population growth. Burundi, however, has a CO2 per capita emission of just 0.05t in 2020. Burundi's CO2 growth rate of 3.59% comes from the increase from 208,848 t CO2 in 1990 to 602,181 t in 2020. Burundi's 602,181 t emissions rank it 163rd on the list of annual emissions for a country. When considering the growth of CO2 emissions, the increased CO2 emissions must also be considered in the context of other countries and, as mentioned earlier, in the context of a fair share. Of the 28 countries with high population growth and high CO2 emission growth, a total of 20 countries had CO2 per capita emissions of less than 1t in 2020. All of these countries are classified as lower- and lower-middle income.

**Table 10.**

*Nations with high population growth rates (above 2.5% a year) and high CO2 emissions growth rates above 3%, 1990-2019*

| Country | Income (World Bank 2022) | P 1990 | P 2020 | CAGR P | CO2 1990 (tonnes) | CO 2020 (tonnes) | CAGR CO2 | Annual CO2 emissions (tonnes per capita) |
|---|---|---|---|---|---|---|---|---|
| Qatar | High income | 441685 | 2760390 | 6.3 % | 11411196 | 106654967 | 7.73 % | 37.02 |
| Bahrain | High income | 517429 | 1477478 | 3.56 % | 12405777 | 34960075 | 3.51 % | 20.55 |
| Saudi Arabia | High income | 16004768 | 35997108 | 2.74 % | 208496989 | 625507882 | 3.73 % | 17.97 |
| United Arab Emirates | High income | 1900160 | 9287286 | 5.43 % | 51703774 | 150268152 | 3.62 % | 15.19 |
| Oman | High income | 1804528 | 4543406 | 3.13 % | 11222441 | 62162570 | 5.87 % | 12.17 |
| Equatorial Guinea | Upper middle income | 465560 | 1596057 | 4.19 % | 62288 | 10265267 | 18.55 % | 7.32 |
| Iraq | Upper middle income | 17658384 | 42556988 | 2.98 % | 49057049 | 210829146 | 4.98 % | 5.24 |
| Maldives | Upper middle income | 224976 | 514451 | 2.8 % | 172208 | 1796469 | 8.13 % | 3.32 |
| Papua New Guinea | Lower middle income | 3864983 | 9749641 | 3.13 % | 2154432 | 6652121 | 3.83 % | 0.74 |
| Mauritania | Lower middle income | 2006035 | 4498605 | 2.73 % | 853712 | 3377180 | 4.69 % | 0.73 |

*Note.* *Income classifications are taken from the World Bank's calculations for the current fiscal year 2023 (The World Bank, 2022b). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022 (UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are taken from the World in Data database which is based on $CO_2$ figures published by Friedlingstein et al. (2022) through the Global Carbon Project.*

The $CO_2$ emission values discussed up to this point refer exclusively to so-called production-based $CO_2$ emissions. Production-based emissions are therefore significantly dependent on the economic development of a country. Therefore, it is important to look at economic changes, i.e. the extent of economic growth of a country and the sectors in which this growth has taken place, as well as changes in income and its distribution within the national population.

Of the ten countries with the highest $CO_2$ growth rates, a total of 7 are in Asia. In contrast, the countries with the highest population growth and the lowest $CO_2$ growth rates are mainly countries with low economic growth and low GDP. For example, Chad, the Democratic Republic of Congo, Yemen, and Somalia. The Democratic Republic of Congo recorded $CO_2$ rates of -1.78% between 1990 and 2020. In doing so, it is one of the countries classified as LDCs by the UN, as are 6 other of the 11 countries in this group. Although this paper fundamentally questions the concept of development, the UN classification provides an overview of a country's economic situation, as the following factors are included in determining LDC status: GDP, Human assets and Economic Vulnerability (UN, 2022a).

The relationship between $CO_2$ and population growth can also be viewed by looking at those countries that have reduced their emissions in recent years. An example of a country that reduced its emissions between 1990 and 2020 is Germany. In Germany, the emission growth rate between 1990 and 2020 was -1.62%, while the population grew very little. The same is true for Greece, Slovakia, Cuba, Sweden and other countries, for example. The population hardly grew, but territorial $CO_2$ emissions decreased. That must mean that the decline in territorial emissions is not due to the sheer number of people.

Table 11 summarizes the countries in the world regions. Here, the African continent shows the highest population growth between 1990 and 2020 with 2.56%. The world average was 1.30% in the same years. The population growth of the African continent was thus 51% greater than the global average. The absolute share of population growth was thus 28.62%. However, Asia accounted for the largest share of absolute world population growth between 1990 and 2020, at around 58%. At the same time, Asia also had the largest share of growing $CO_2$ emissions over the same period. Here, $CO_2$ emissions grew proportionately almost 2% faster than the share of population growth (see Share Quotient).

**Table 11.**
*Share of the world population growth and CO2 emissions growth between 1990 and 2020*

| Country | CAGR P | CAGR CO2 | Share P Growth (%) | Share CO2 Emission Growth (%) | Share Quotient |
|---|---|---|---|---|---|
| Africa | 2.56 % | 2.36 % | 28.62 | 5.53 | 0.19 |
| Asia | 1.25 % | 3.81 % | 57.54 | 113.55 | 1.97 |
| Europe | 0.11 % | -1.6 % | 1.0 | -25.46 | -25.53 |
| North America | 1.15 % | -0.12 % | 6.84 | -1.74 | -0.25 |
| Oceania | 1.67 % | 1.2 % | 0.68 | 1.11 | 1.63 |
| South America | 1.25 % | 1.2 % | 5.32 | 3.31 | 0.62 |
| World | 1.3 % | 1.43 % | 100 | 100,00 | 1 |

For North America and Europe, the shares of CO2 growth are negative, since here CO2 emissions were reduced from 2020 to 1990. As already described, many of the Eastern European countries have the lowest, even negative growth rates in CO2 emissions. Likewise the USA with -0.27%. However, in absolute terms, the USA still has the highest CO2 emissions after China and CO2 per capita emissions in 2020 of 14.24t. Looking at the population growth of the entire world, the world population increased by 1.30% between 1990 and 2020. In turn, CO2 emissions growth increased by 1.43% globally. This results in a growth quotient of 1.10 between global emissions growth and population growth. This means that emissions growth has risen about 10% faster than population growth. Conversely, this means that CO2 emissions are growing faster than population growth.

**Table 12.**

*Low-income, lower-middle income, upper-middle income and high-income nations' contributions to the world's population growth and to CO2 emissions growth from 1990 to 2020*

| Country | P 1990 | P 2020 | CAGR P | CO2 1990 (tonnes) | CO2 2020 (tonnes) | CAGR CO2 | Annual CO2 emissions (tonnes per |
|---|---|---|---|---|---|---|---|
| Upper-middle-income countries | 1978674629 | 2541463877 | 0.84 % | 7409711331 | 15895921988 | 2.58 % | 6.22 |
| High-income countries | 1000128696 | 1218093003 | 0.66 % | 12221516099 | 11828815872 | -0.11 % | 9.78 |
| Lower-middle-income countries | 2020653165 | 3369707355 | 1.72 % | 2238798867 | 5825886924 | 3.24 % | 1.75 |
| Low-income countries | 295113902 | 680258922 | 2.82 % | 194392983 | 156818079 | -0.71 % | 0.24 |

*Note. Income classifications are taken from the World Bank's calculations for the current fiscal year 2023 (The World Bank, 2022b). Population numbers are taken from United Nations Population Division database with data from the World Population Prospects 2022 (UN Population Division, 2022). Data on annual production-related CO2 emissions and annual onsumption-based CO2 are taken from the World in Data database which is based on $CO_2$ figures published by Friedlingstein et al. (2022) through the Global Carbon Project.*

Table 12 shows the population growth rates and the emission growth rates broken down by income classification. The lowest population growth rate is found in the low-income countries, where it is even negative at -0.71% for the years between 1990 and 2020. All other three income classifications show positive growth rates. Led by the lower-middle income countries with a growth rate of 1.72%. Interestingly, it is the high-income countries that show a negative CO2 growth rate.

Chancel et al. (2021) in their World Inequality Report point out that especially rich countries could outsource their carbon-intensive industries in the past years leading to lower territorial (production based) CO2 emissions. High-income countries such as Germany have reduced their domestic CO2 emissions in production in recent years, but are still leaders in consumption-related CO2 emissions. The data presented up to this point only consider CO2 emissions that occur in the production of a country. In their report, Chancel et al. (2021) point out that carbon inequality varies greatly by region, which is why in the following the data on consumption-related CO2 emissions associated with population growth are also considered. Not for all countries consumption-based CO2 data are available due to low data availability in some countries. Data is missing for many low-income countries on the African continent. Looking at the share of consumption-related CO2 emissions in 2019 for the African countries listed, it is striking that many African countries have a share that is vanishingly small. For example, Rwanda, whose share of consumption-based CO2 emissions was 0.0032%.

The list with the highest share of consumption-based CO2 emissions is headed by the ten countries represented in Table 13. All of them are high-income countries with significant economic power. China's share of CO2 consumption-based CO2 emissions alone is 1/4 of all emissions. However, China's population growth between 1990 and 2020 was just at 0.67%.

**Table 12.**

*List of countries with highest share of consumption-based CO2 emissions compared to their CAGR of Population and Share of consumption-based CO2 emissions in 2019*

| Country | Consumption-based CO2 emissions in 2019 (tonnes) | Absolute emissions imported or exported in 2019 | CAGR P 1990-2019 | Share of CO2 C-Emissions in 2019 |
|---|---|---|---|---|
| Saudi Arabia | 645395186.64 | 22982437.64 | 2.68 % | 1.76 |
| Indonesia | 673358180.57 | 12764195.57 | 1.3 % | 1.83 |
| South Korea | 697405484.83 | 49380926.83 | 0.53 % | 1.9 |
| Iran | 724934146.54 | -8431700.46 | 1.39 % | 1.98 |
| Germany | 824739740.12 | 113311931.12 | 0.14 % | 2.25 |
| Japan | 1288063113.89 | 182133778.89 | 0.05 % | 3.51 |
| Russia | 1432702757.36 | -246746569.65 | -0.06 % | 3.9 |
| India | 2410472685.84 | -215495462.16 | 1.54 % | 6.57 |

| | | | | |
|---|---|---|---|---|
| United States | 5625783551.99 | 369967344.99 | 0.99 % | 15.33 |
| China | 9442834851.69 | -1047153703.31 | 0.07 % | 25.73 |
| World | 36702502921.1 | 18.11 | 1.26 % | 100 |

*Note. The abbreviation CAGR P stands for Compound Annual Growth Rate of Population between 1990 and 2019.*

Looking at the population growth rates of the 10 countries with the highest consumption-based CO2 emissions, all countries except Saudi Arabia have a growth rate of less than or equal to 1.50% (compare Tab.x). Only Iran has a growth rate of 1.50%, all others are below. Russia (on place 4 of the largest share of consumption-based CO2 emissions) even has a negative growth rate of CO2 emissions. Japan has a growth rate of just 0.04% and Germany 0.16%.

All countries with the highest consumption-based CO2 emissions are high-income countries. Table 14 shows the share of consumption-based CO2 emissions by income classified groups. High-income and upper-middle income countries together have a share of 83.40% in consumption-based CO2 emissions. Lower-middle income countries have a share of 16.39% and low-income countries of just 0.21%.

**Table 14.**

*Low-income, lower-middle income, upper-middle income and high-income nations' contributions to consumption-based CO2 emissions in 2019*

| Country | Consumption-based CO2 emissions in 2019 | CAGR P 1990-2019 | Share of C-based CO2 emissions |
|---|---|---|---|
| High-income countries | 14428071122.52 | 0.65 % | 42.12 % |
| Low-income countries | 72682137.64 | 2.73 % | 0.21 % |
| Lower-middle-income countries | 5613968215.24 | 1.66 % | 16.39 % |
| Upper-middle-income countries | 14141224740.88 | 0.8 % | 41.28 % |

*Note. The abbreviation CAGR P stands for Compound Annual Growth Rate of Population between 1990 and 2019.*

The same analysis can be carried out according to the regions of the world (see Table 15). Asia has the largest share of $CO_2$ consumption-based emissions in 2019 with 52.11%, which includes China, Japan, Russia and India. Followed by North America with 18.57% and Europe with 15.93%. South America had a share of only 3.11% in 2019 and Africa 2.82%. Oceania brings up the rear with 1.13%.

**Table 15.**
*Regions contributions to consumption-based CO2 emissions in 2019*

| World Region | Consumption-based CO2 emissions in 2019 (tonnes) | Share of C-based CO2 emissions in 2019 |
|---|---|---|
| Africa | 1034752487.96 | 2.82 % |
| Asia | 1912518946.,6 | 52.11 % |
| Europe | 5846186183.96 | 15.93 % |
| North America | 6815079126.27 | 18.57 % |
| Oceania | 415546342.7 | 1.13 % |
| South America | 1139737150.48 | 3.11 % |

# 6. Discussion

The following discussion first focuses on the data analyzed in this work, both the multiple regression and the comparison of growth rates. As a critique of the generalization of population data, a look at global elites is then considered while discussing ways to address energy poverty. Last, this discussion chapter focuses on the issue of contraceptives in the context of family planning programs with the justification of climate change. In the context of this chapter, weaknesses of this thesis are identified and outlooks are given for a possible extension of the research elsewhere.

## 6.1 The influences of population, GDP per capita and energy use per capita on CO2 emissions

Looking at the results of the multiple regression model used in this paper, all the independent variables studied - population, GDP per capita, and energy consumption per capita - appear to have a generally positive impact on CO2 emissions, meaning that all variables increase CO2 emissions as they grow. It is also clear to see, through all statistical considerations, that population also has an influence on CO2 emissions. These results were already suspected through the qualitative analysis, which found a correlation, albeit weak in some cases, between each of the independent variables and CO2 emissions. However, the multiple analysis shows that the growth of CO2 emissions varies across variables and years. Particularly surprising in this regard, considering the reviewed literature, is that the natural logarithm of GDP per capita shows a negative coefficient for 2019. Ritchie et al. (2020), explaining the Kaya identity, identify the influence of GDP growth as the main influence on CO2 emissions and at the same time that it is considerably stronger than the influence of population growth on CO2 emissions. They further find a significant correlation between CO2 emissions and income, over time as well as geographically. That economic activities, which in turn lead into an increase in GDP per capita, play the central role in CO2 emissions has also been shown during the lockdowns of the COVID-10 pandemic. Le Quéré et al. (2020) show how the change in restrictions, e.g. on travel, changed both transport and consumption patterns, drastically reducing CO2 emissions in the short term, with population growth rates remaining the same for the year 2020. On November 15, 2022, the day the UN predicted the 8 billion people mark to be surpassed, the UN writes (2022b): „Even though population growth magnifies the environmental impact of economic development, rising per capita incomes are the main driver of unsustainable patterns of production and consumption. The countries with the highest per capita consumption of material resources and emissions of greenhouse gas emissions tend to be those where income per capita is higher, not those where the population is growing rapidly.“ (UN, 2022b). The UN (2022b) as well as other scholars hold per capita income and its growth responsible for environmental impact. The results of the regression performed in this paper with respect to CO2 emissions suggest otherwise to some extent. Looking at the results of other studies, the regression model therefore seems to have its weaknesses, which could be addressed by further work, since population numbers seem to have the largest influence compared to GDP per capita and energy use per capita. Although the p-values of all logarithmized data show significant values, the correlation coefficients of GDP per capita and energy consumption per capita in unlogarithmized form for all years considered indicate a non-linear relationship. Therefore, the data chosen for this work may not be optimal for looking at the relationship between CO2 and population interacting with the other variables of GDP per capita and energy consumption per capita in a multiple linear regression model such as the one used in this work.

In general, however, it can be summarized that all factors considered seem to have an influence on CO2 emissions. What is particularly interesting, is that over the years the coefficients on population of the multiple regressions performed in this work have remained persistent, for each year around 1 translating into an 1% increase in CO2 emissions if population rises by 1%. The other two factors, GDP per capita and energy consumption per capita, vary in comparison between the years considered. While the coefficients for population remained almost persistent, those for GDP per capita and energy per capita fluctuated. This may be due, on the one hand, to the fact that economic factors and energy consumption are much more susceptible than inert population figures. An example has been provided by the COVID-19 crisis (Le Quéré et al., 2020), energy use per capita and GDP per capita can fluctuate significantly while population remains stable. Changes in GDP per capita and energy use per capita could therefore provide key opportunities for faster CO2 reductions than the persistent population variable.

When looking at the data of this work, it is further interesting to note, that the coefficients of GDP per capita and energy use per capita, when added up together for each year considered, appear to result in about the same 1% increase in CO2 emissions each time, given an additional growth of about 1% in per capita GDP and per capita energy consumption. These findings of the theoretical statistical data of this work lead to the following thought: If GDP per capita and energy per capita statistically lead to about the same increase in $CO_2$ emissions as population numbers do, $CO_2$ emissions can be reduced in reverse just as well by a reduction in GDP per capita and energy use per capita together as by reducing population. This is especially important to understand when looking at the human rights violations and moral questions about population control presented in the theoretical part of this work. Population control, as history has shown, most often cuts into people's individual freedoms and deprives people of their reproductive rights, which are recognized as human rights. David Harvey (1974) describes, how there is no "ethically neutral way" in which the relationship between population and resources can be discussed. Even if population growth has important influence on $CO_2$ emissions statistically in the model used in this work, the population variable ethically offers little room for $CO_2$ reduction.

It is therefore much more important to focus on the two other variables. The variable energy use per capita shows an increasing influence on $CO_2$ emissions over the years. In 2019, the coefficient for energy use per capita is highest at 1.04. This means that for 2019, $CO_2$ emissions will statistically grow by 1.04% for 1% growth in energy use per capita. The numbers here slightly exceed the effect of the population variable. From this it could be concluded that the importance of reducing energy consumption can be of particular importance in reducing $CO_2$ emissions. Global energy consumption is growing, averaging between 1% and 2% per year. Population growth rates are already below 1% globally, with a growth rate of 0,82% in 2020 and further are expected to continue to fall in the coming years (UN Population Division, 2022). Absolute population numbers will mostly likely peak latest by the end of the century and stabilize (ibid.) Even if we make an effort to reduce population figures today, we will not stop climate change, since there is no quick way to reduce population. Bradshaw & Brook (2014), in their work edited by Paul Ehrlich, write that even a rapid transition to a global one-child policy would result in a similar population size to today by 2100 and furthermore, they predict that in the event of an extreme mass extinction of 2 billion people, there would still be about 8.5 billion people alive in 2100. Efforts to reduce $CO_2$ should therefore focus on the still growing variables of energy consumption and income, since $CO_2$ emissions must be reduced immediately (ibid.).

## 6.2 Regional and country-specific differences in population growth and CO2 emissions

Since the results of the multiple regression show that CO2 emissions are fundamentally influenced by the population variable, the relationship of the two variables was examined in more detail in a second step. For the multiple regression, the data are generalized, a detailed examination of the data is no longer possible after the regression has been performed. However, if one looks at the data individually, one will notice clear differences, already referred to as carbon inequality by studies such as Oxfam (2017) or Chancel et al. (2021).

As calculated in this work, the median absolute CO2 emissions were 11834052 t CO2 in 2020, meaning that 50% of the countries considered had absolute CO2 emissions of 11834052 t or less. However, on average, the absolute CO2 emissions of 196 countries in 2020 were at 174280750 t according to own calculations. Compared to the median, this suggests that there must be some countries that emit such high levels of CO2 emissions so that the global average is raised far above the median. Taking an anecdotal country-by-country view here, a relationship with World Bank income classifications is observed.

Looking at low-income and high-income classified countries, none of the 39 countries with the lowest CO2 per capita emissions appears to be in the high-income classification. On the contrary, none of the 39 countries with the highest per capita emissions is classified as low-income. For the countries with the highest CO2 per capita emissions in 2020, it can be clearly seen that oil and gas production play the decisive role. However, this production of gas and oil does most likely not take place for the own consumption, but is exported to a large extent. For Qatar, without questioning the data, it may seem as if CO2 emissions and population growth have a high impact on each other. With the background knowledge that Qatar is the country with the largest labour migration worldwide and at the same time produces oil and gas for export, it may remain questionable from another perspective beyond national borders with regard to the question of responsibility of CO2 emissions, whether Qatar itself is to blame or those countries that purchase oil and gas from Qatar for their own consumption?

As shown in the analysis, only 13 of the 39 countries with the highest CO2 per capita emissions have population growth rates higher than 1.5% between 1990 and 2020. At the same time, the analysis shows that the countries with the lowest CO2 per capita emissions, predominantly have high growth rates in population terms. Looking at the growth rates, it becomes clear that these must also be viewed in a differentiated manner. The analysis already mentions the example of Nepal. Nepal is placed at the top of the category of countries with low population growth rates and high $CO_2$ growth rates. The growth rates of the $CO_2$ growth may be high, but in absolute numbers Nepal placed itself in the 89th place of the countries with the highest absolute $CO_2$ emissions in 2020, being way below the average absolute $CO_2$ emissions in 2020. The growth figures may sound high, but the $CO_2$ per capita remains far below 1t and thus below a fair share.

Some countries do indeed have high population growth rates and high $CO_2$ growth rates between the years 1990 and 2020, such e.g. Burundi. Burundi belongs had both high growth rates of population as well of $CO_2$ Emissions. However, if we consider Burundi's per capita $CO_2$ emissions of less than 0.1 t in 2020, a supposed link between population and $CO_2$ emissions is put into perspective.

## 6.3 The generalization of CO2 data and the need for a differentiated view

In this work, data on $CO_2$ emissions of nations and regions were compared and used for a multiple regression model, since country-based data are both the most easily accessible data on $CO_2$ emissions and at the same time are usually used, for example, by the IPCC, which in turn informs key policy makers. This approach allows to directly compare population growth with the $CO_2$ emissions of each nation. At the same time, both $CO_2$ emissions and family planning targets are also usually linked to national considerations. However, the fundamental problem with all data on population growth and $CO_2$ emissions is that the numbers are generalized. Absolute $CO_2$ emissions are added up and broken down to the number of people in a country in per capita terms. This results in a picture where all people of a country or even globally have the same consumption and production of $CO_2$ emissions or other resources. If $CO_2$ data is inherently calculated in terms of per capita, then there is inherently a neo-Malthusian focus on numbers of population. No statements can then be made about who accounts for a particularly large or particularly small share of $CO_2$ emissions. If $CO_2$ were calculated according to individuals based on their consumption patterns, a picture would emerge in which the 1% of the richest people are responsible for 15% of all $CO_2$ emissions (from 1990 to 2015, Oxfam).

The marketing agency Yard published a study on CO2 emissions by private jets in 2022 of 21 celebrities with data via the Twitter platform „Celebrity Jets“ at the end of July 2022. At the time of the study, the selected celebrities had already emitted an average of 3376.64 tonnes of CO2 emissions through the use of their private jets (Yard Digital PR Team, 2022). Leading the list is country singer Taylor Swift, who must have emitted a total of 8293,54 calculated tonnes of CO2 through her flight at the time of the study (ibid.). In total, this is about 2229 times the average 3.72 tons of CO2 per capita in 2020 calculated in this work. Only the emissions from private jets are included in this analysis; Taylor Swift's total CO2 footprint must therefore be certainly much higher. At the same time, Taylor Swift is only one of a number of super-rich people that emits vast amounts of individual CO2 emissions. Billionaires in particular produce very high individual CO2 emissions by owning yachts and other luxury goods. In early 2021, Richard Wilk and Beatriz Barros studied the carbon footprints of 20 billionaires. The selected individuals were only those for whom publicly known information about how they live and how they get around was available. Barros et al. (2021) consider their estimates conservative because they do not include, for example, emissions from the construction of the billionaires properties or emissions for which they are responsible through their corporations. Real individual CO2 emissions could be much higher. The study found that large yachts are by far the largest emitters of greenhouse gases from the super-rich (Barros et al., 2021). The billionaire with the most CO2 emissions in 2018 was Russian oligarch Roman Abramovich, with a carbon footprint of more than 33000 tons of CO2, mainly due to the intensive use of his private yacht. Compared to the data analysed in this work, there is a total of 19 countries that had lower CO2 emissions in 2020 than Roman Abramovich alone in 2018. Among these countries are mostly small island states, but also countries such as the Central African Republic with an official population of 5343024 people in 2020 and total CO2 emissions of 187906 tons, just over half of Roman Abramovich's emissions 2018. To name the emissions of one more billionaire: Barros et al. (2021) estimate Bill Gates' CO2 emissions at about 7,493 tons of CO2 in 2018. Billionaires stand out as individuals for their extremely high CO2 emissions, but the CO2 emissions of the global elite as a whole are far above a possible fair share. Oxfam's 2020 report „Confronting Carbon Inequality“ summarizes that the richest 10 percent of the world's population accounted for over half (52%) of all CO2 emissions between 1990 and 2015. The richest 1% (about 63 million people) for 15% of all emissions, twice as much as the poorest 50% (about 3.1 billion people).

Since the majority of people are below the fair share, the necessary reduction of CO2 emissions must focus on those people who are far above the fair share. Cohen (1995), in answering the question "How many people can the Earth support?" wrote that the question needs to be phrased more precisely in many ways and in one sense more as follows: „How many [people can the earth support] at what average level of material well-being?“ (Cohen, 1995). Making a connection to population growth here: If the number of global elite and billionaires would increase due to population growth, then, there is definitely a connection that should be of particular importance in the climate change debate. But while the world's population is growing, so is global inequality. According to the latest Global Inequality Report, published at the end of 2022, the richest 10% of the world's population own around 52% of global income: „Global inequalities seem to be about as great today as they were at the peak of Western imperialism in the early 20th century. Indeed, the share of income presently captured by the poorest half of the world’s people is about half what it was in 1820, before the great divergence between Western countries and their colonies“ (Chancel et al., 2022). The share of billionaires in global wealth has increased during the COVID pandemic more than ever before, with 2020 seeing the most significant increase in the share of billionaires in global wealth since records began (ibid.)

The analysis of CO2 emissions by country allows to see a clear North-South divide, but billionaires can be found on every continent in the world (World Population Review, 2022b). Chancel and Piketty (2015) similarly show that the top 10% of emitters live on every continent. Considerations of global elites must therefore break away from national considerations. Chancel and Piketty (2015) show how within-country inequality accounts for 50% of the global dispersion of CO2e emissions and call for focusing on individual large emitters rather than high-emitting countries. They thus call for a new geography of global emitters, requiring climate action in all countries.From such a perspective, it would be possible to set completely different international political targets than just national targets. Reducing CO2 emissions of the super-rich would be an important step towards combating climate change by, for example, restricting flights by private jets or owning super yachts. Oxfam (2020) writes that public policies towards „taxing luxury carbon like SUVs, frequent business class flights and private jets, to expanding digital and public transport infrastructure – can cut emissions, reduce inequality and boost public health.“ (Oxfam, 2020). These restrictions would be one easy and timely solution to implement for an immediate reduction in CO2 emissions. A reduction here would be

conceivably simple, since the sum of billionaires in this world is limited to a few hundred individuals.
The almost exclusive focus on production-based CO2 emissions in the international debate makes it difficult to take an unmasked view of those individuals who cause particularly high CO2 emissions through their lifestyles. Focusing on global population growth in this sense serves as a perfect diversionary strategy.

This work recognizes that CO2 emissions need to be discussed not only in the context of countries. Nevertheless, policy targets currently continue to concern countries, as do targets for family planning programs. Therefore, this work has not attempted to break down current structures, but to work and discuss within the framework of them. At the same time, the focus is on population growth, which is usually reported at national levels. Furthermore, the statistical analysis carried out here shows in a way how conservative views such as that of Paul Ehrlich could come about - by taking statistical figures as a neutral source, which do not allow differentiation in population figures, CO2 emissions, GDP per capita or energy use per capita. This finding results in a need for further research, which could, for example, investigate to what extent the high emitters calculated as for example by Chancel and Piketty (2015), are distributed in population numbers and growth rates and bring together the approach discussed in this work on population numbers with the approach of Chancel and Piketty (2015).

## 6.4 Increasing energy consumption vs. poverty alleviation

As mentioned above, the coefficients for energy use per capita in the multiple regression of this work show an increasing influence on CO2 emissions, which exceeds the influence of population in the year 2019. Reducing energy use per capita could thus provide an opportunity to reduce CO2 emissions. Further, meeting the 1.5-degree targets of the Paris Agreement will require radical decarbonization of industrial societies. With large numbers of people lacking basic energy services and little room for energy growth in terms of CO2, the question arises for the most part as to whether universal access to modern energy could significantly increase energy demand and associated CO2 emissions. Rao et al. (2014) described the underlying relationship behind this question as a "climate-development conflict.“

According to Ritchie et al. (2022), 13% of the world population in 2016 did not have access to electricity, while 42% did not have access to clean fuels for cooking. These numbers are still valid and relate primarily to households in SSA. In 2019, about 590,000,000 people in SSA did not have access to electricity. According to the International Energy Agency (IEA), the numbers in SSA have even been increasing since the pandemic; in 2020, for the first time since 2013, the number of people without access to electricity had increased, from 74% before the pandemic to 77% (IEA, 2022). The lack of access to sustainable modern energy and products is referred to as energy poverty. Access to safe and accessible energy services is central to addressing many global development challenges such as poverty, climate change, food security, health and education, while at the same time, energy is also necessary for creating economic development (UN, 2022e). Different studies show that the impact on CO2 emissions that would result from alleviating energy poverty, i.e., by transitioning from the use of traditional fuels for cooking and the absence of electricity to modern energy, would be relatively small. The work of Chakravarty et al. (2013) shows that a comprehensive energy poverty eradication policy would increase global final energy consumption by about 7% (about 20 EJ) in 2030, with most of this increase occurring on the African continent, where total household final energy consumption would need to double compared to the case without poverty eradication policies. South and Southeast Asia would also see significant increases. This suggests that despite the small global impact of eliminating energy poverty, some regions would experience quite dramatic changes. However, despite the dramatic changes, Chakravarty et al. (2013) show that this policy would have little impact on mitigating climate change, estimating that the additional infrastructure would cause at most 0.13 °C of warming over the course of the 21st century. These amounts of energy could be saved if the energy consumption of individuals whose standards are above current European levels were reduced by 15% (ibid.). The study of Hubacek et al. (2017) comes to a similar result: even though emissions increase significantly with poverty eradication of everyone being lifted to a global middle class level, emissions could easily be compensated by addressing the emissions caused by high income earners that with their consumption of goods and services are accountable for a large share of emissions emitted in the production process along global supply chains. Hubacek et al. (2017) conclude that even without any new climate policies and with the use of current technologies, eradicating extreme poverty, i.e., lifting everyone above the $1.9 purchasing power parity (PPP) per day, will not jeopardize a climate target of staying under 2°. The latest IPCC report also indicates that, compared to actual investments in climate change mitigation, actions related to lack of access to energy and food and water security would be much less costly (IPCC, 2021). Rao et al. (2014) make the important distinction between poverty reduction and growing prosperity, summarizing that human development toward raising basic living standards does not have the same impact on climate change as does growing affluence.

At the centre of the studies mentioned above is the realization that the $CO_2$ emissions of those population groups that emit particularly high levels of $CO_2$ must be reduced in order to lift people out of poverty without causing an increase in $CO_2$ emissions. Once again, it becomes clear that the international debate therefore requires a shift from blaming population numbers to looking at inequality in $CO_2$ emissions, income and energy consumption not just by countries but by the global elite.

## 6.5 The role of contraception vs. donor dependency

As just discussed, access to modern energy can be achieved globally without causing excessive amounts of more $CO_2$ emissions. At the same time, as described in Chapter 2.7, access to modern energy and eduction contribute to women's empowerment and changes in fertility rates. This finding is central to the considerations of this work. There is undoubtedly some emphasis in development programs on allocating more resources to family planning and reproductive health through contraception to promote a country's development and women's empowerment (see Chapter 2.5). As explained before, fertility rates do not seem to be solely depending on contraceptives but are part of cultural and socio-economic effects (Hartmann, 1995), some of which can be better addressed through access to education and access to modern energy. In addition, a look at modern family planning programs shows that contraception does not always appear as an empowering and self-determined method. This work does not question whether contraception should be part of family planning and development cooperation. Access to contraception should be seen as part of reproductive rights as a human right. However, self-determined application and discontinuation must be possible at any time and adequate medical care must be guaranteed.

When it comes to contraception in the Global South, especially in SSA, a region that is heavily dependent on international donors and also very controversial regarding the existance of possible coercive methods, it seems important to understand that basing family planning programs on environmental justifications makes almost no sense. The highest unmet need for contraception currently exists on the African continent, particularly in SSA (UN, 2019), hence the focus of most international family planning programs in this region. After Asia, Africa has the highest annual population growth rates and the second highest share of world population. However, the share of global $CO_2$ growth from production-based emissions is less than 6% despite the high population numbers. If $CO_2$ consumption-based emissions are looked at, then Africa's share is less than 3% and thus has the second lowest share of consumption-based emissions. Demands for more spending on reproductive health and contraception to combat climate change, if implemented, would likely result in more spending on international family planning programs, which in turn focus mostly on SSA. Since the African continent does not make a major contribution to $CO_2$ growth and absolute emissions despite high population growth, such demands would probably do little to change the causes of climate change if implemented. Justifying family planning on the basis of reducing environmental degradation shifts the blame to marginalized groups in the Global South and the sheer number of people, rather than to a differentiated view of global conditions of production and consumption. That is not to say there are not individuals with high emissions on the African continent, but these would certainly not be addressed by family planning programs.

# 7. Conclusion

The world population in absolute terms is growing year by year. It therefore only makes sense to assume that the increasing $CO_2$ emissions are directly related to the growing number of world population. As this work shows, statistically speaking, $CO_2$ emissions and population growth indeed influence each other positively. However, there are other factors that have a statistical influence on $CO_2$ emissions. GDP per capita and energy consumption per capita also show a positive impact on $CO_2$ emissions and provide an important starting point for rapidly reducing $CO_2$ emissions. Population figures are inert and fertility is influenced by many different factors, some of which are unclear and vary greatly from region to region. Thus, fertility rates are predicted partly by social factors, partly by economic or political factors. No matter what factors ultimately influence fertility rates, one thing is certain: there will be no quick, human rights-friendly way to change fertility rates. $CO_2$ emissions, on the other hand, must be reduced as quickly as possible, ideally immediately. GDP per capita and energy use offer the possibility for a rapid reduction here; as the statistical data has shown, both factors fluctuate and are therefore more flexible in their influence on $CO_2$ emissions. Over the thirty years of data considered, the impact of population on $CO_2$ remained the same, while GDP per capita and energy use per capita varied from year to year.

Furthermore, fundamental care must be taken with population numbers, even if they statistically indicate a positive association with $CO_2$ emissions. Population figures are inherently generalized - all people are held equally responsible for $CO_2$ emissions to the same amount. This is also the core of the neo-Malthusian argument: all humans as in population are equally responsible for environmental degradation. However, population is not a homogeneous group of people with regard to $CO_2$ emissions, but a priviledged part of this population is responsible for significantly more $CO_2$ emissions than the rest. This connection becomes particularly clear when one looks at the individual $CO_2$ emissions of the super-rich and global elites. As noted by the Oxfam study widely cited in this work: From 1990 to 2015, 52% of carbon emissions were caused by the richest 10% of the world's population (Oxfam, 2020). In order to achieve a rapid reduction, political debates and goals must address this group of people and not the whole world population as a homogeneous group. Above all, this becomes critical when more reproductive health is demanded in political debates in the context of $CO_2$ reduction, as it is precisely then when the focus is steered away from the rich 10% by instrumentalizing women's bodies, especially those of the poor since they are said to be particularly fertile. This allocation of responsibility does not add up if, as this work shows, neither sheer population growth nor poor people generate high CO2 emissions.

However, demands for reproductive health in connection with climate change are not fundamentally wrong, but rather mismotivated if they are based on wanting to combat climate change. The issue of contraception should indeed be considered in the context of climate change, as women will be particularly affected by the impacts of climate change (United Nations Human Rights Council (UNHRC, 2019). If critical infrastructure becomes vulnerable to climate change, access to adequate contraception will also become vulnerable (ibid.), making it more difficult to guarantee reproductive rights as a human right. Especially in times of (humanitarian) crises, which can be significantly exacerbated by climate change, the risk of gender-specific and sexual violence as well as forced and child marriages increases (UNFPA, 2015). In addition, migration movements are intensified by climate change, where also refugees and climate-induced migrants must be guaranteed their reproductive rights. Further, the direct effects of climate change will affect women more, as for example extreme weather events or air pollution will have a greater impact on pregnant women (Bekkar et al., 2020). These are just a few examples of how climate change will affect women. In order to reduce vulnerability to climate change and to increase resilience and adaptation to climate change from a human rights perspective, combating all forms of marginalization and gender-based discrimination through reproductive rights is therefore of central importance (UNFCCC Conference of the Parties, 2019; UNHRC, 2019).

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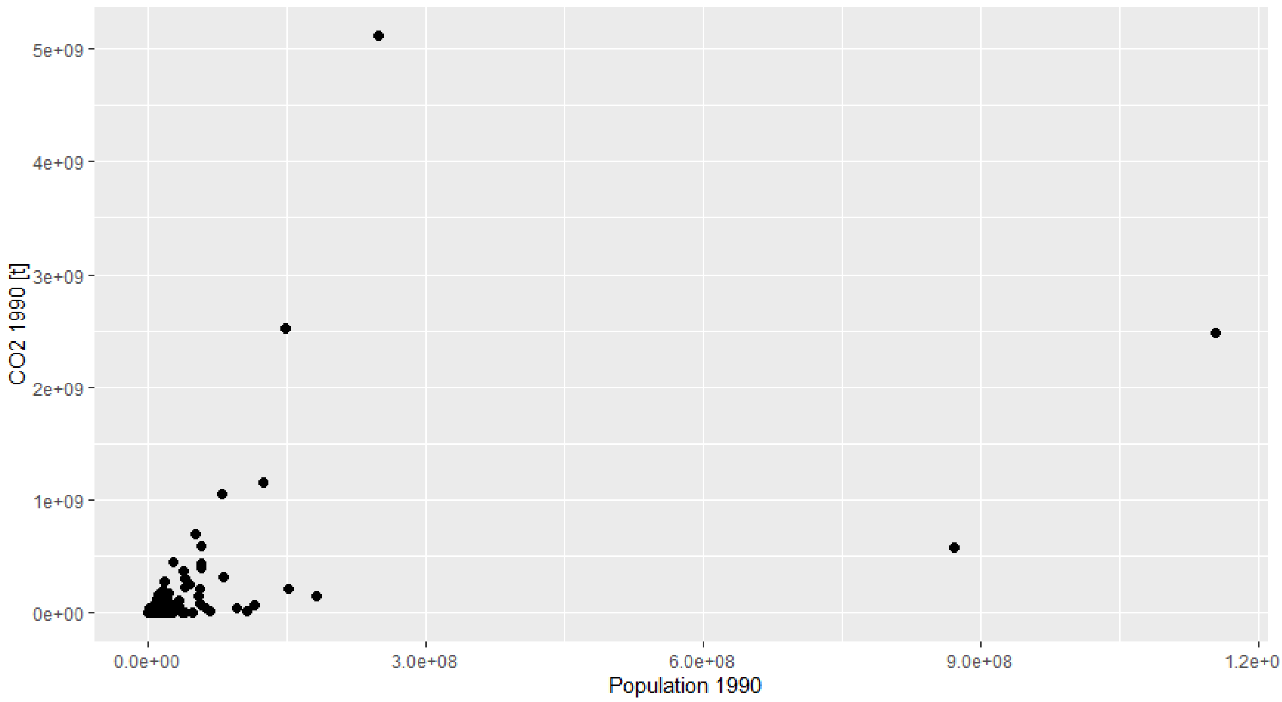
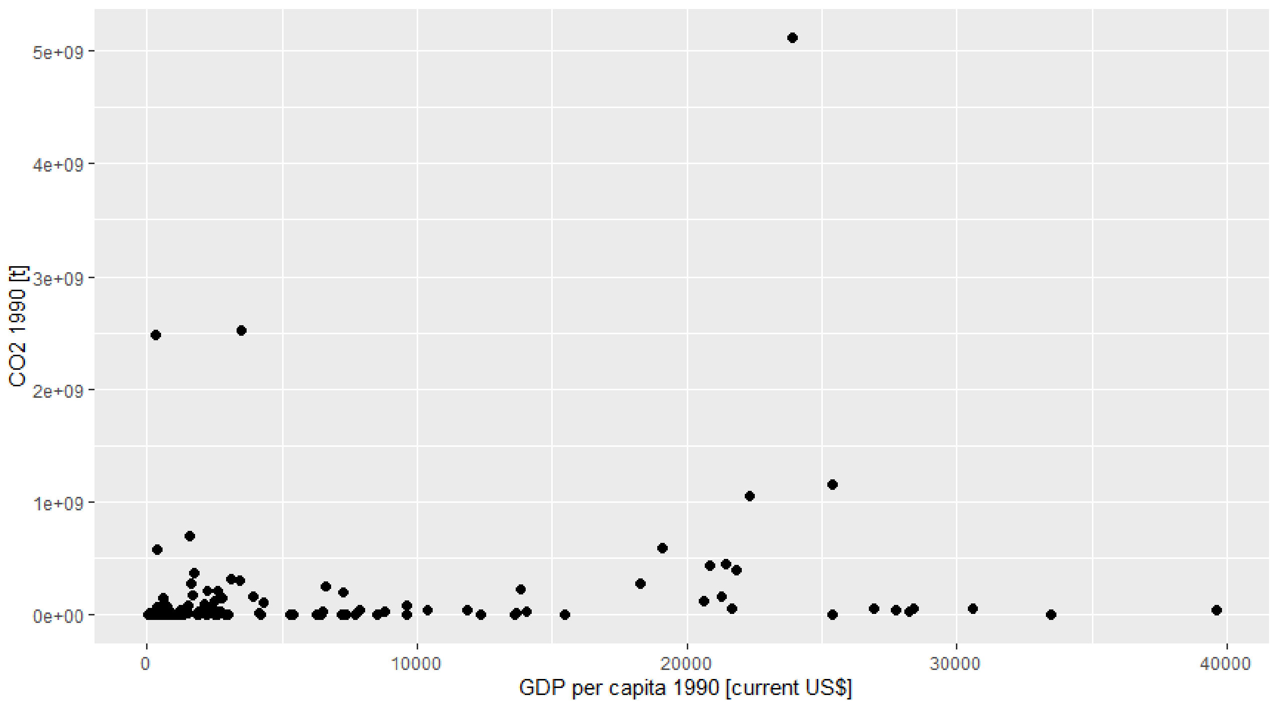
## Appendix A. Scatter plots year 1990

*Scatter plot between CO2 Emissions [t] in 1990 and Population numbers in 1990*



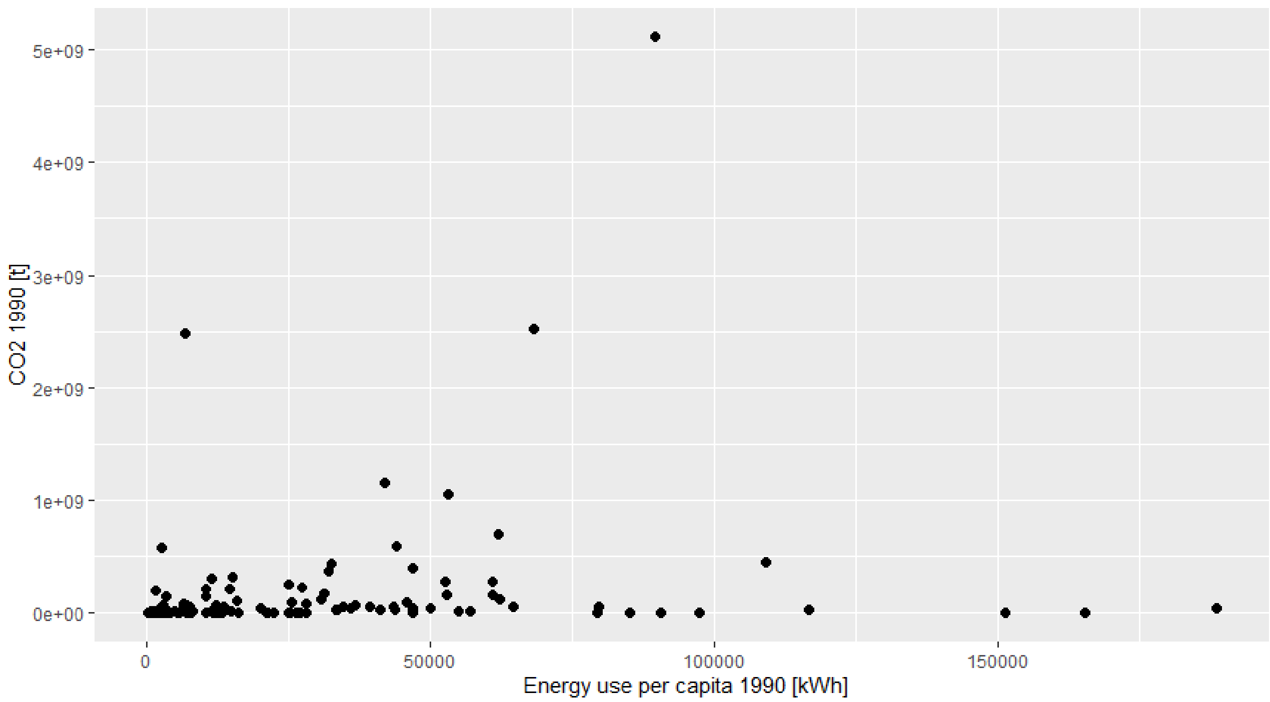

*Scatter plot between CO2 Emissions [t] in 1990 and Population numbers in 1990 with logarithmized scales*

*Scatter plot between CO2 Emissions [t] in 1990 and Gdp per capita in 1990 [current US$]*

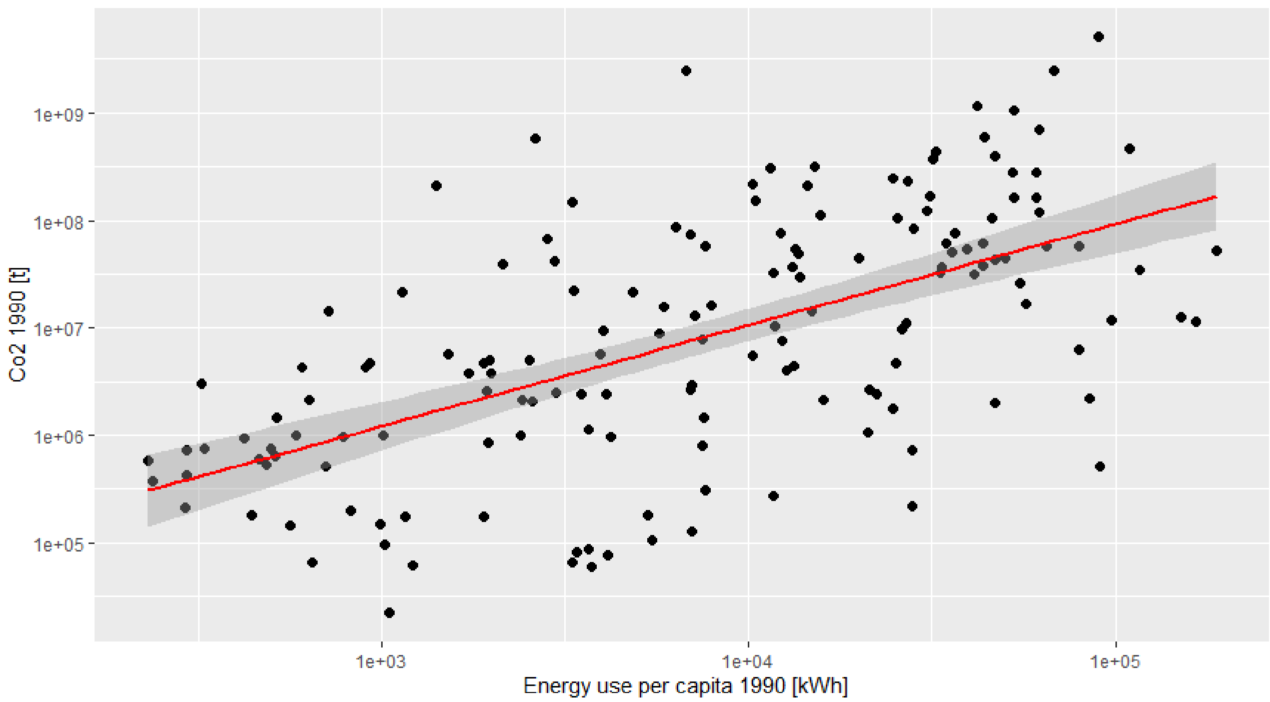



*Scatter plot between CO2 Emissions [t] in 1990 and GDP per capita in 1990 [current US$] with logarithmized scales*

*Scatter plot between CO2 Emissions [t] in 1990 and Energy use per capita in 1990 [kWh]*

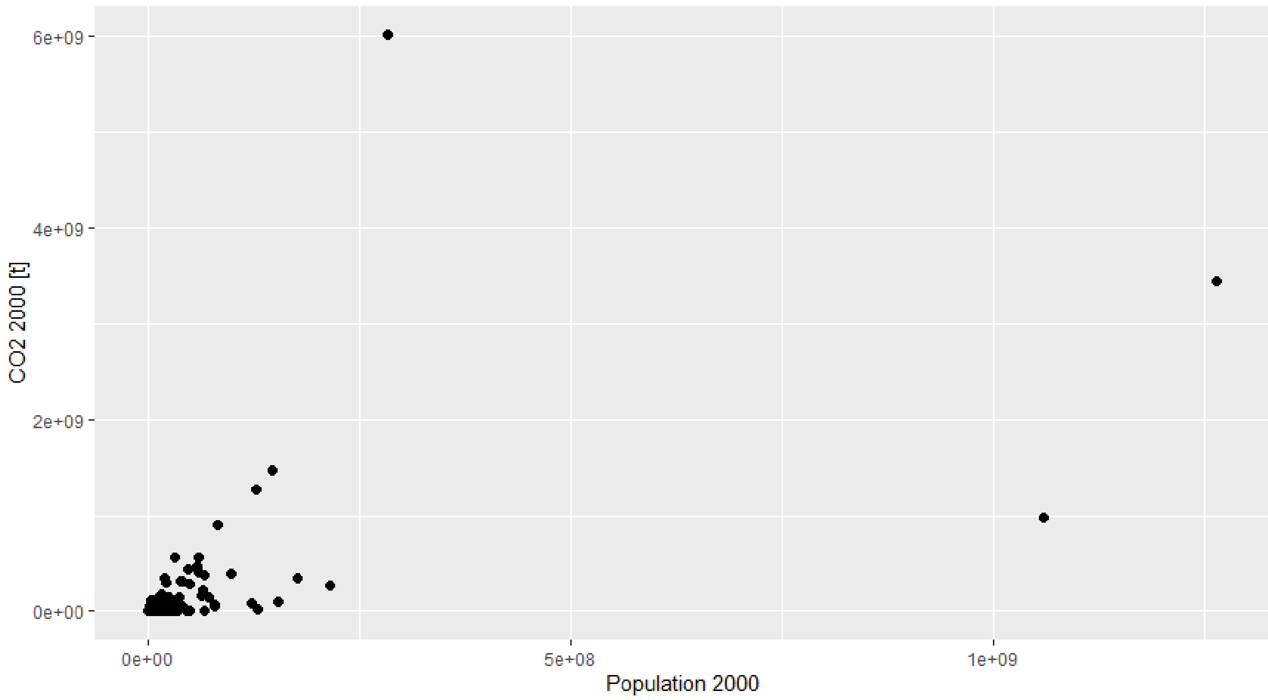



*Scatter plot between CO2 Emissions [t] in 1990 and Energy use per capita in 1990 [kWh] with logarithmized scales*

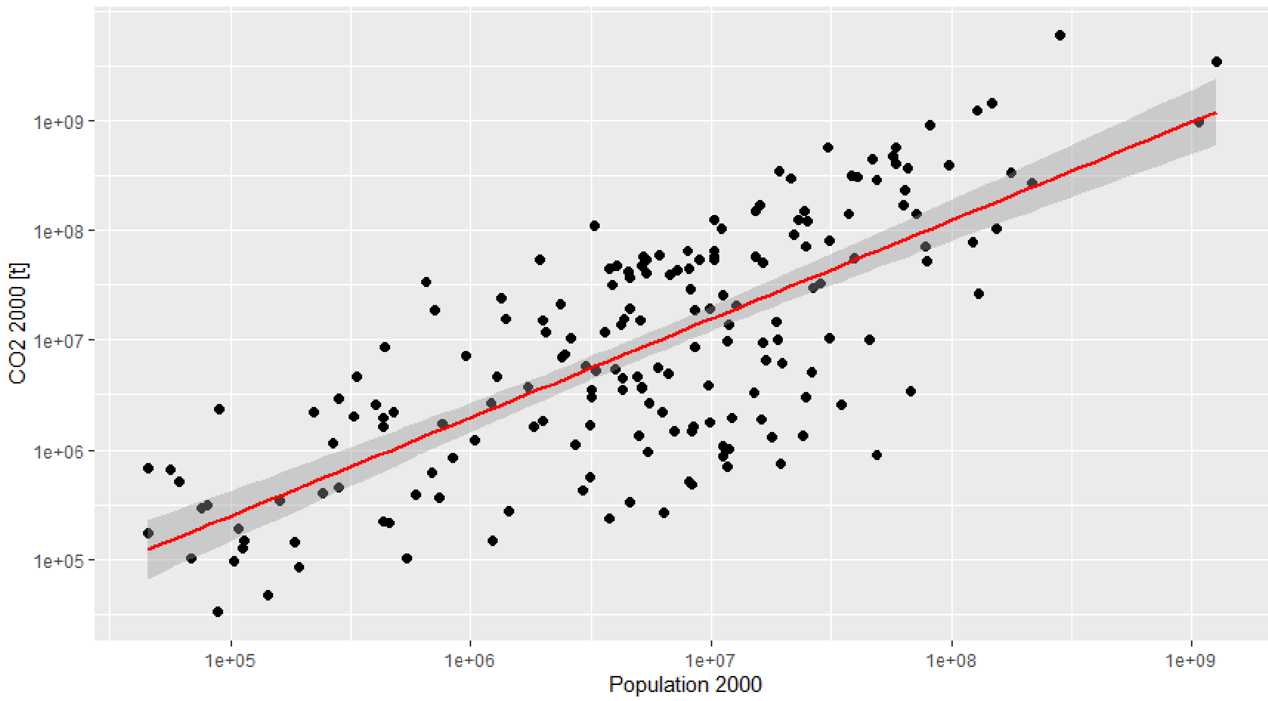


# Appendix B. Scatter plots year 2000

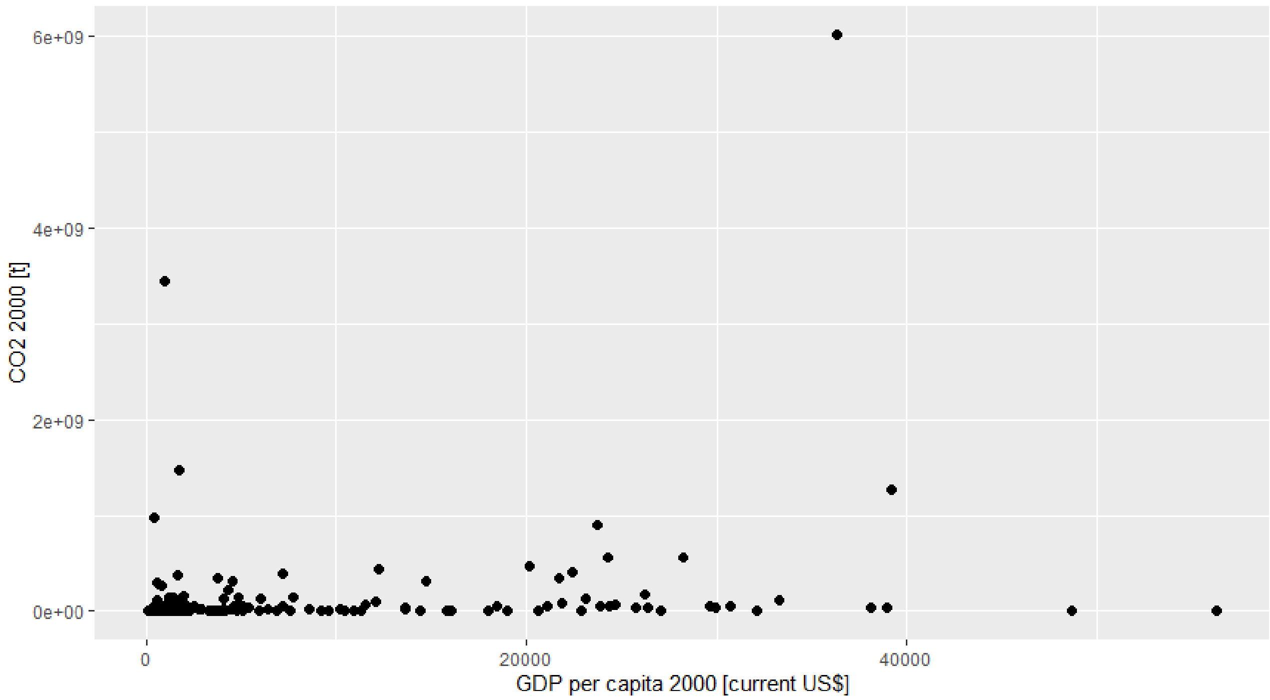
*Scatter plot between CO2 Emissions [t] in 2000 and Population numbers in 2000*



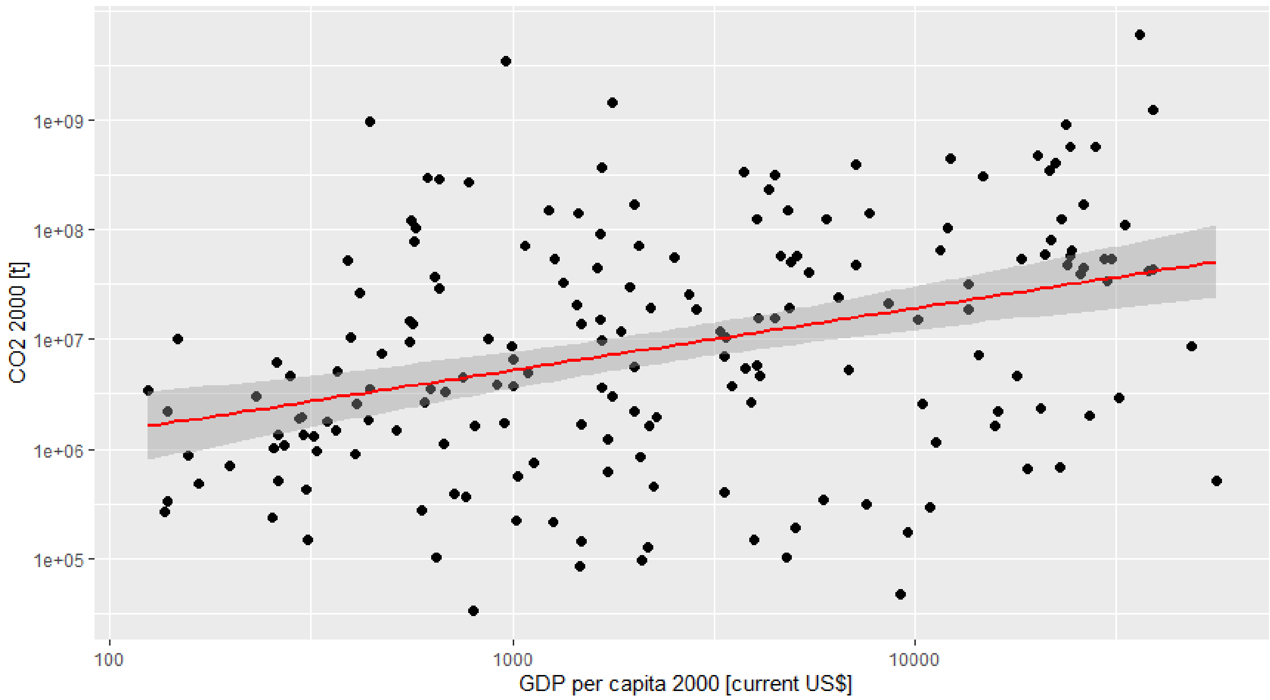

*Scatter plot between CO2 Emissions [t] in 2000 and Population numbers in 2000 with logarithmized scales*



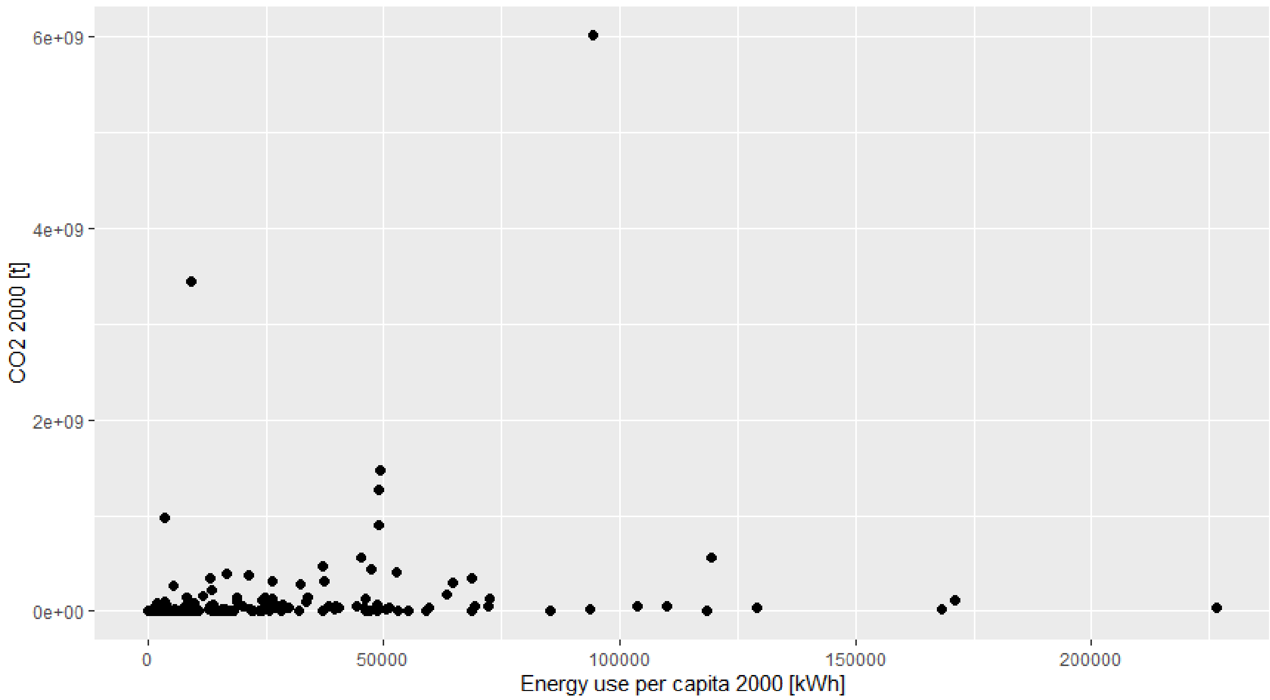
*Scatter plot between CO2 Emissions [t] in 2000 and Gdp per capita in 2000 [current US$]*



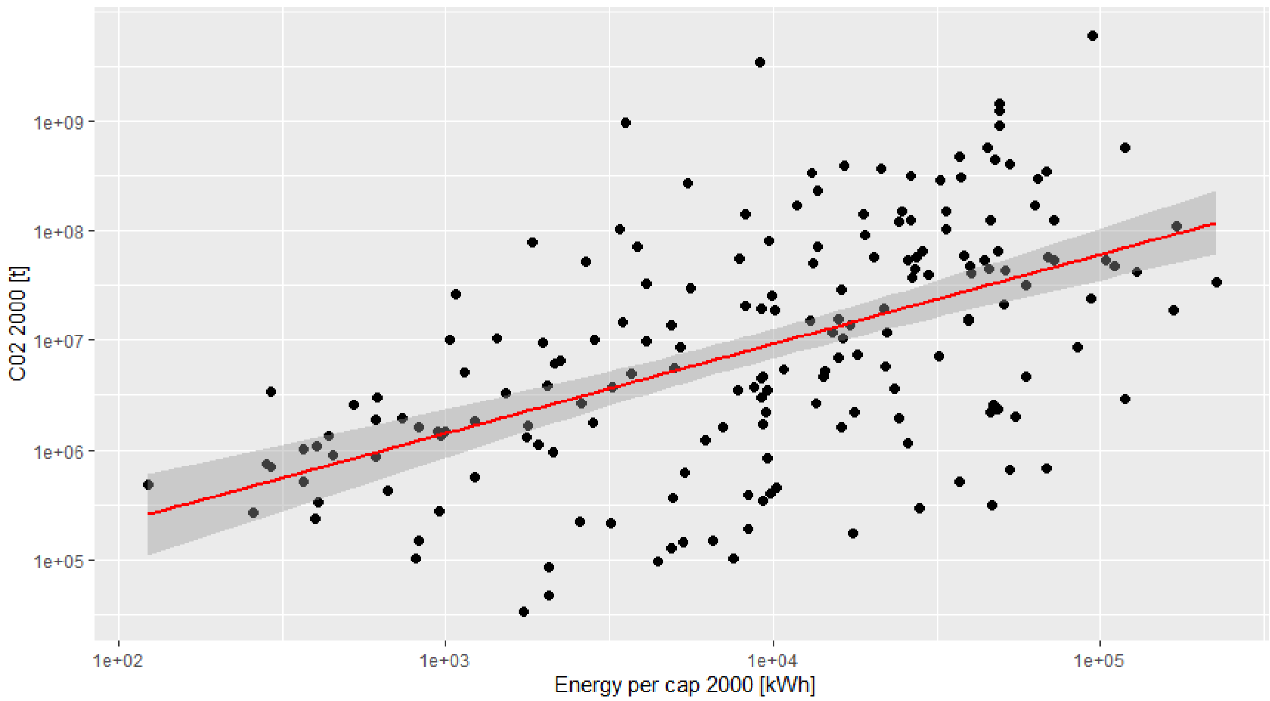

*Scatter plot between CO2 Emissions [t] in 2000 and GDP per capita in 2000 [current US$] with logarithmized scales*



*Scatter plot between CO2 Emissions [t] in 2000 and Energy use per capita in 2000 [kWh]*

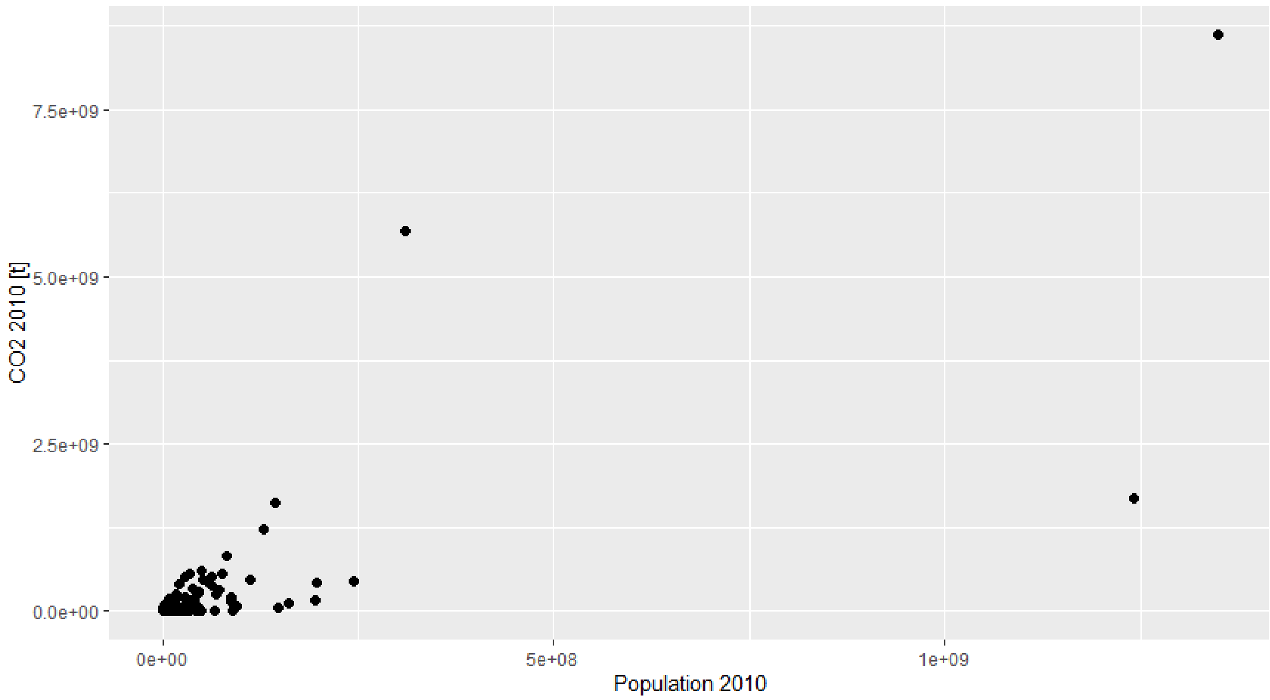



*Scatter plot between CO2 Emissions [t] in 2000 and Energy use per capita in 2000 [kWh] with logarithmized scales*

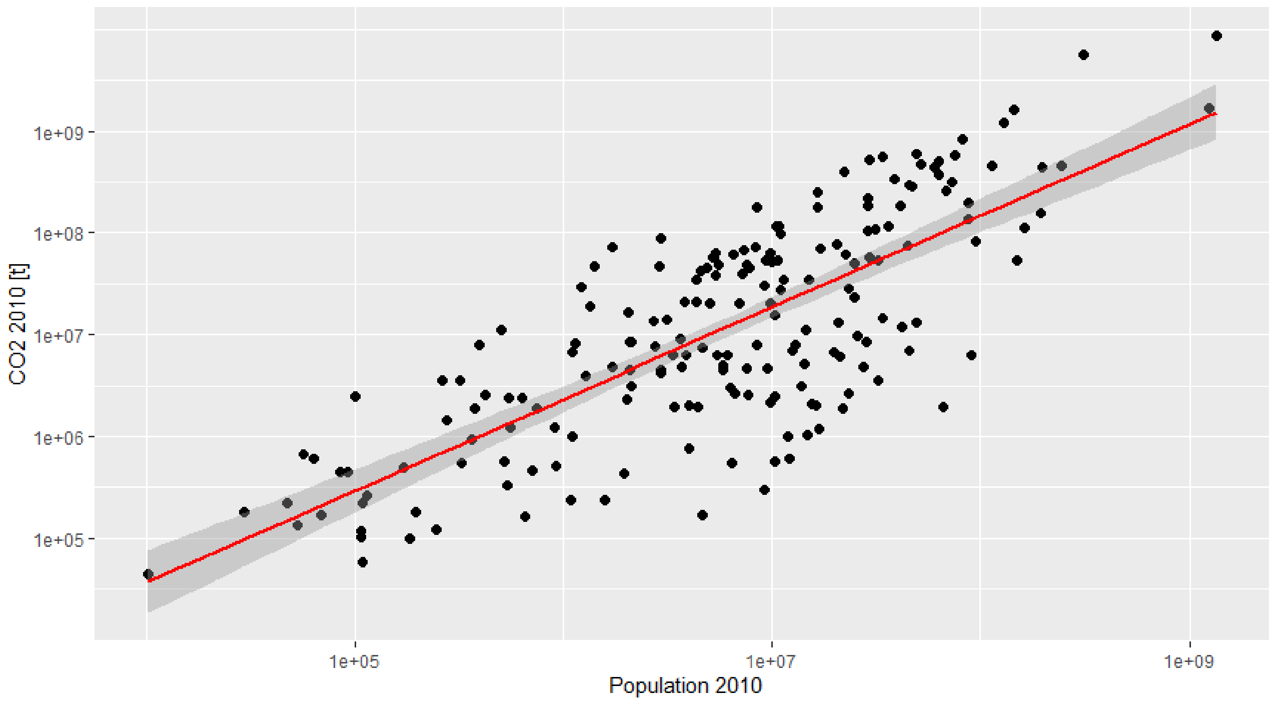


## Appendix C. Scatter plots year 2010

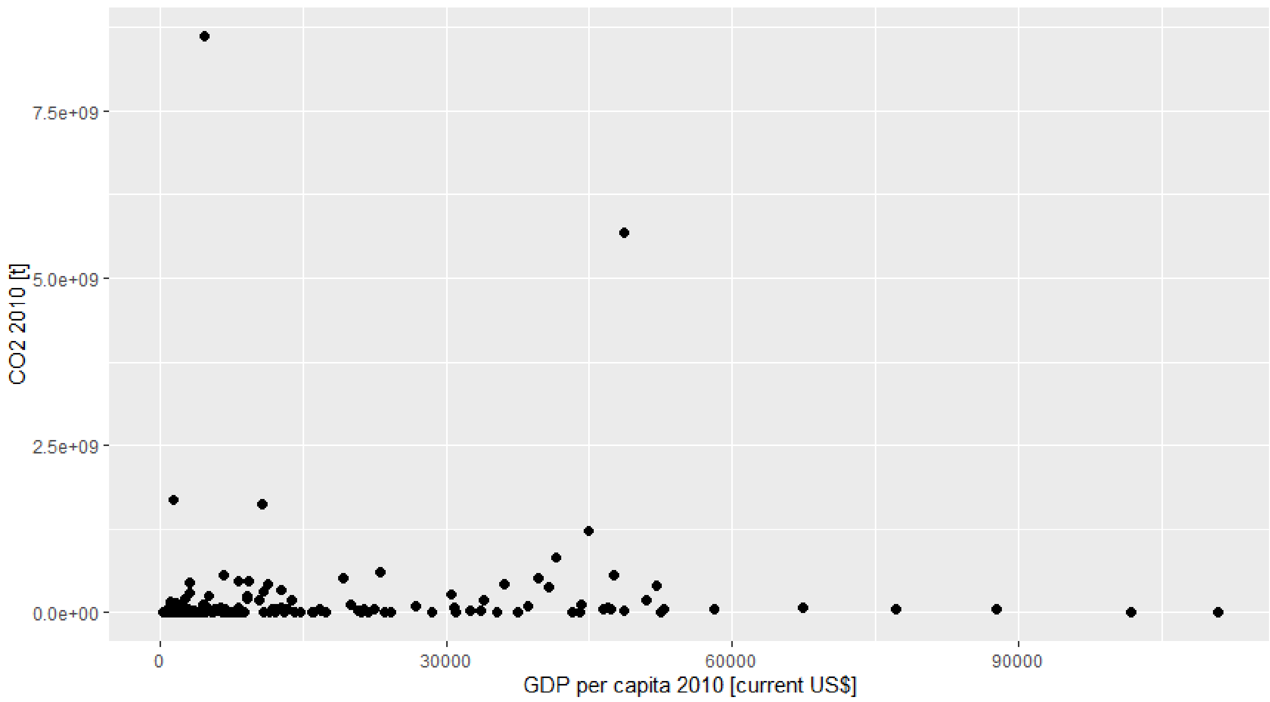
*Scatter plot between CO2 Emissions [t] in 2010 and Population numbers in 2010*



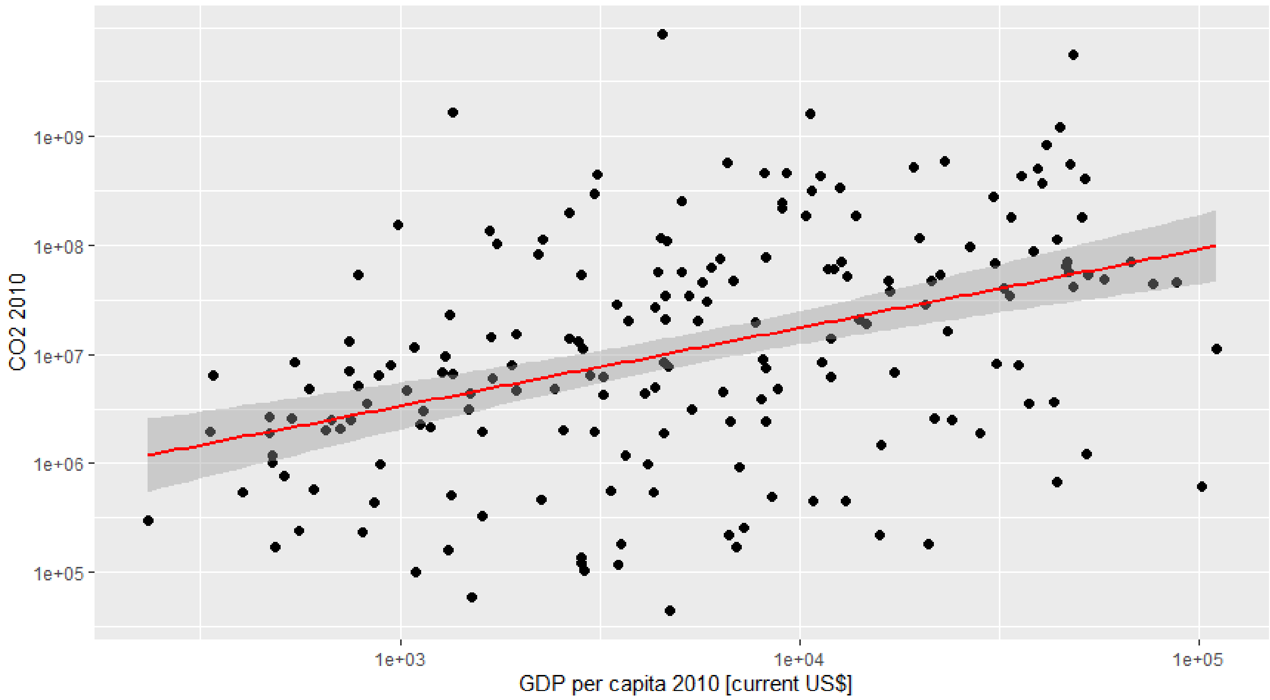

*Scatter plot between CO2 Emissions [t] in 2010 and Population numbers in 2010 with logarithmized scales*



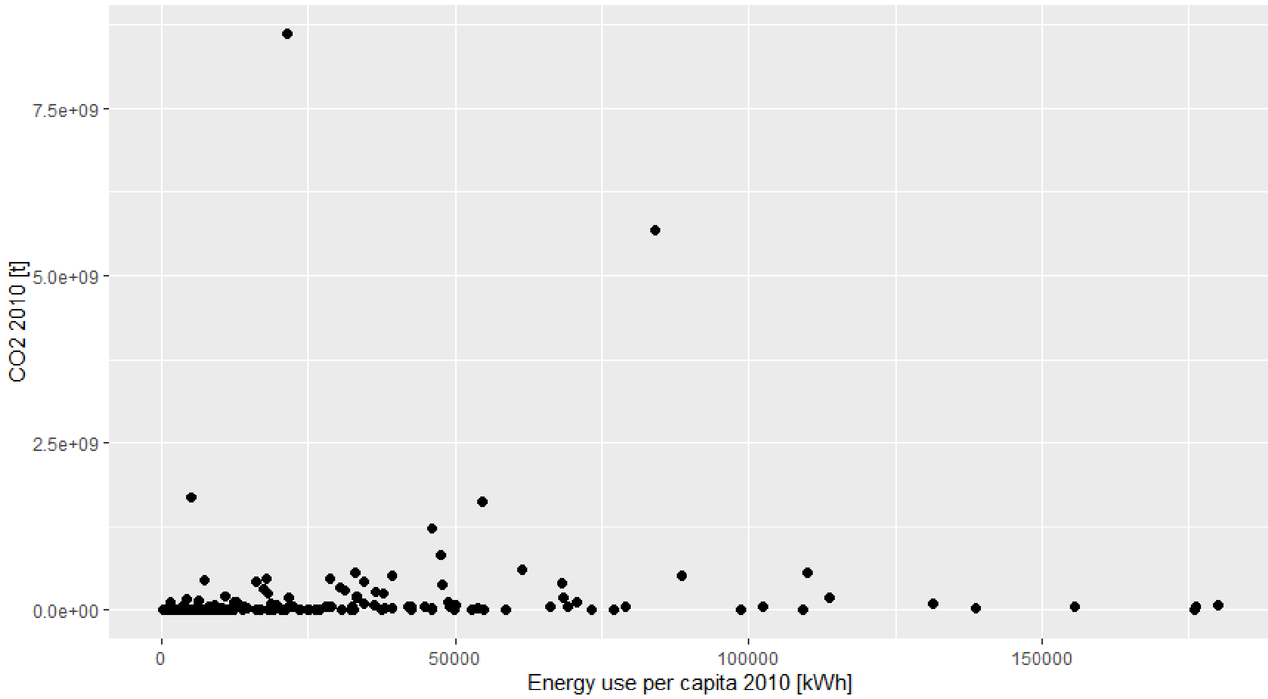
*Scatter plot between CO2 Emissions [t] in 2010 and Gdp per capita in 2010 [current US$]*



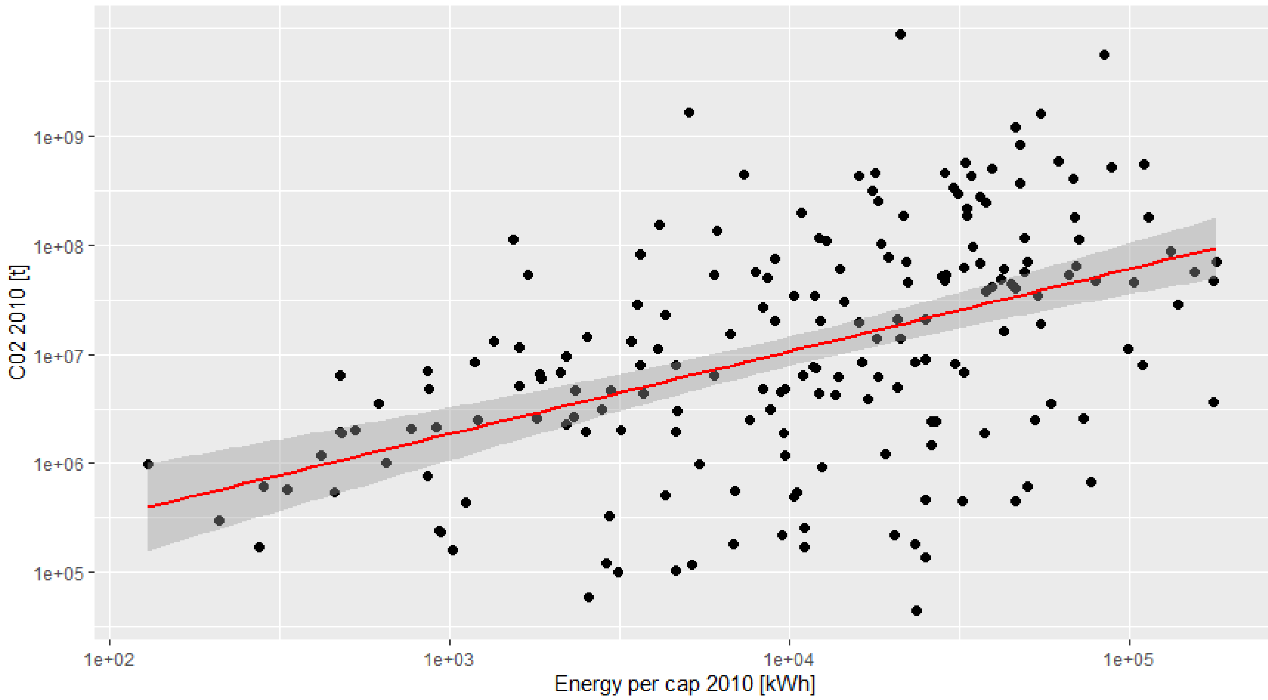

*Scatter plot between CO2 Emissions [t] in 2010 and GDP per capita in 2010 [current US$] with logarithmized scales*



*Scatter plot between CO2 Emissions [t] in 2010 and Energy use per capita in 2010 [kWh]*

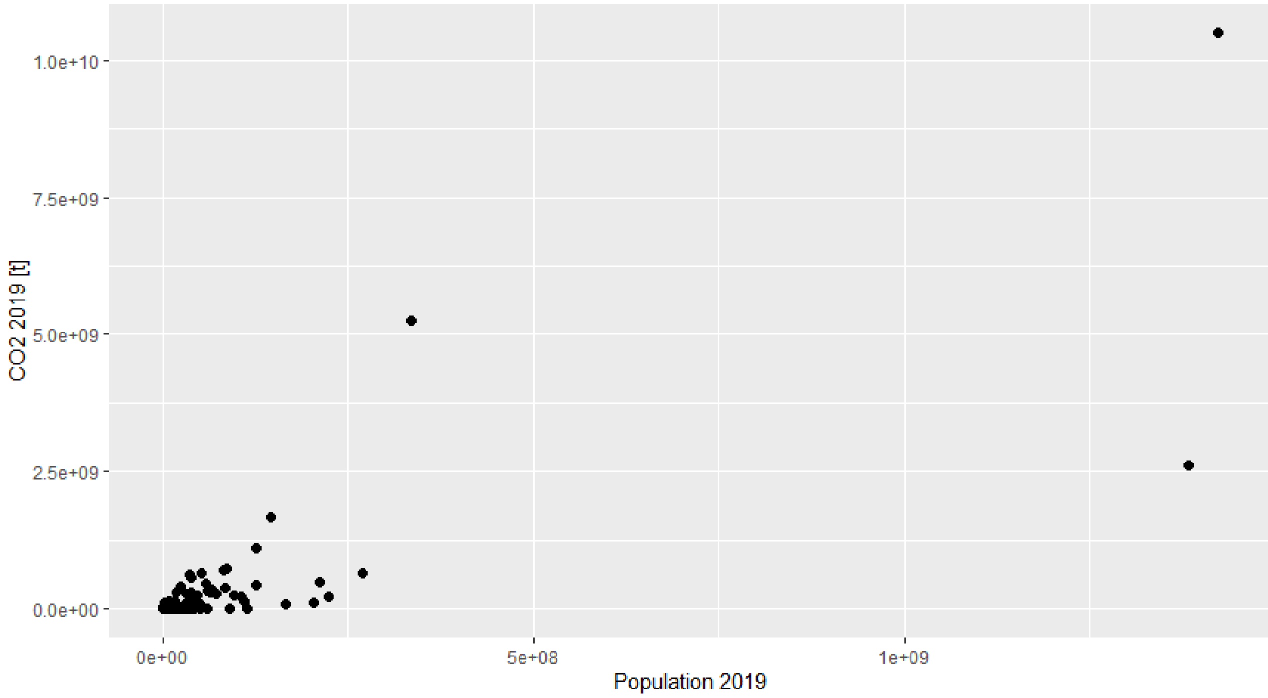



*Scatter plot between CO2 Emissions [t] in 2010 and Energy use per capita in 2010 [kWh] with logarithmized scales*

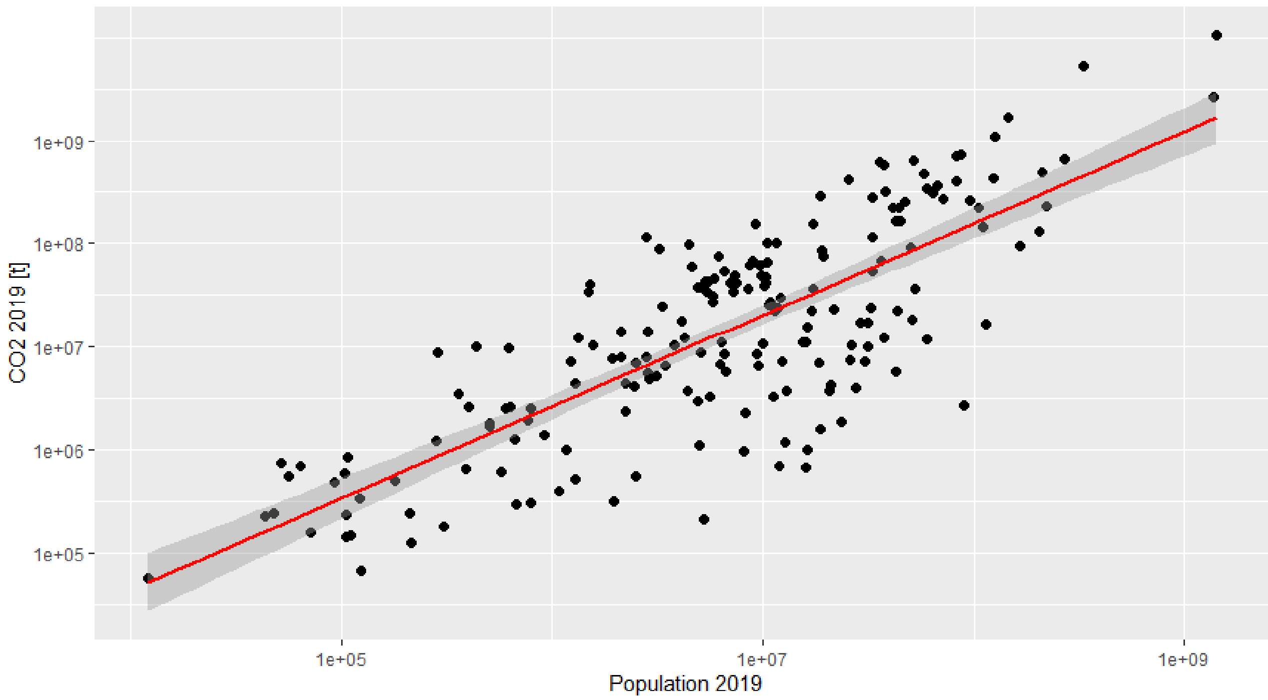


## Appendix D. Scatter plots year 2019

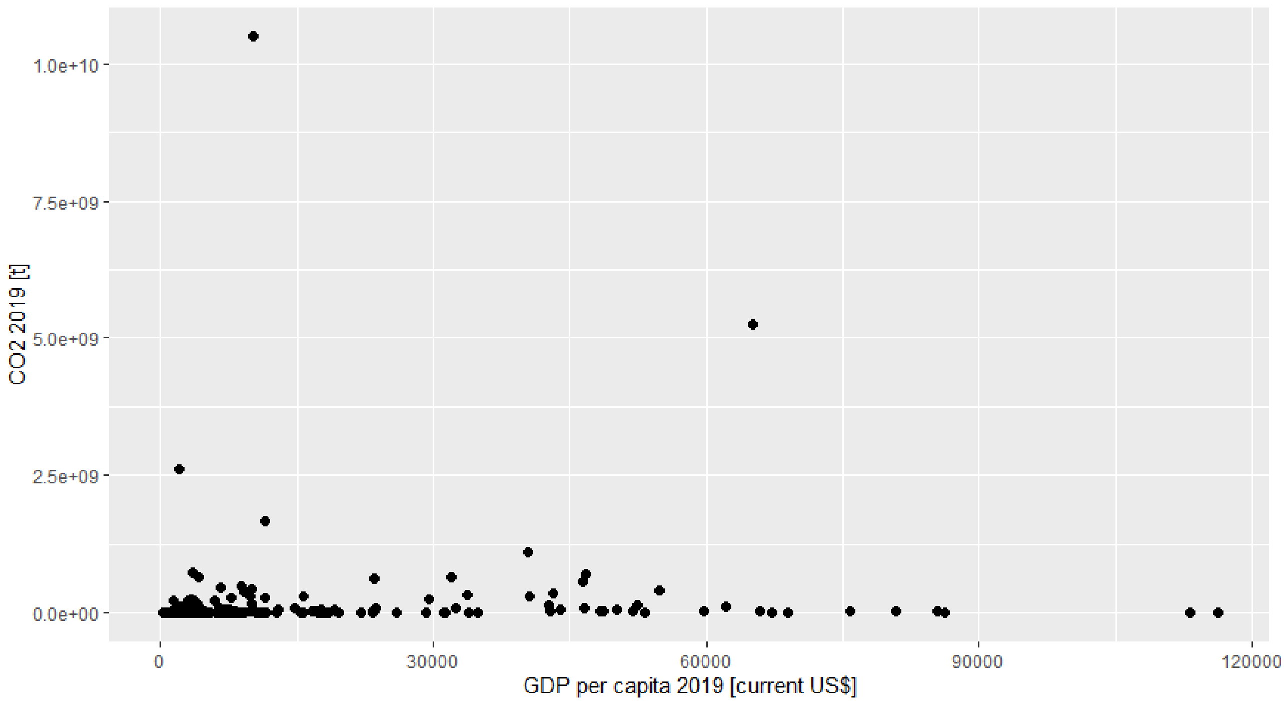
*Scatter plot between CO2 Emissions [t] in 2019 and Population numbers in 2019*



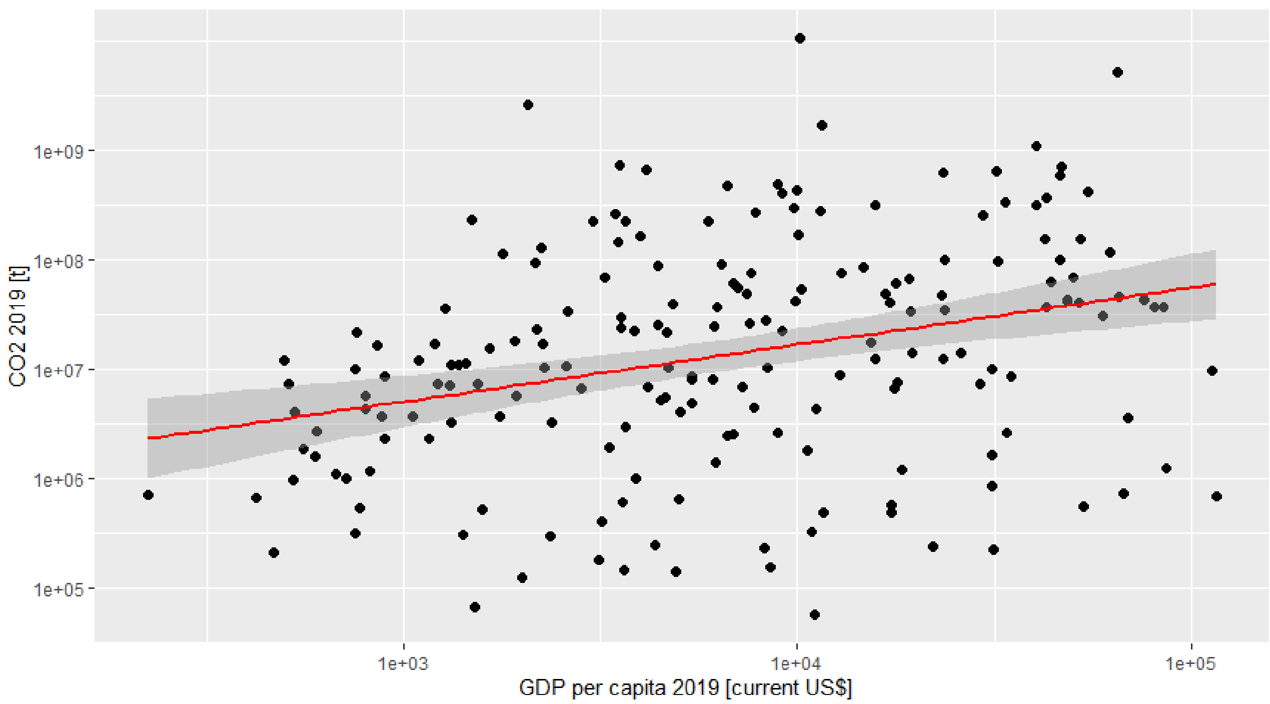

*Scatter plot between CO2 Emissions [t] in 2019 and Population numbers in 2019 with logarithmized scales*



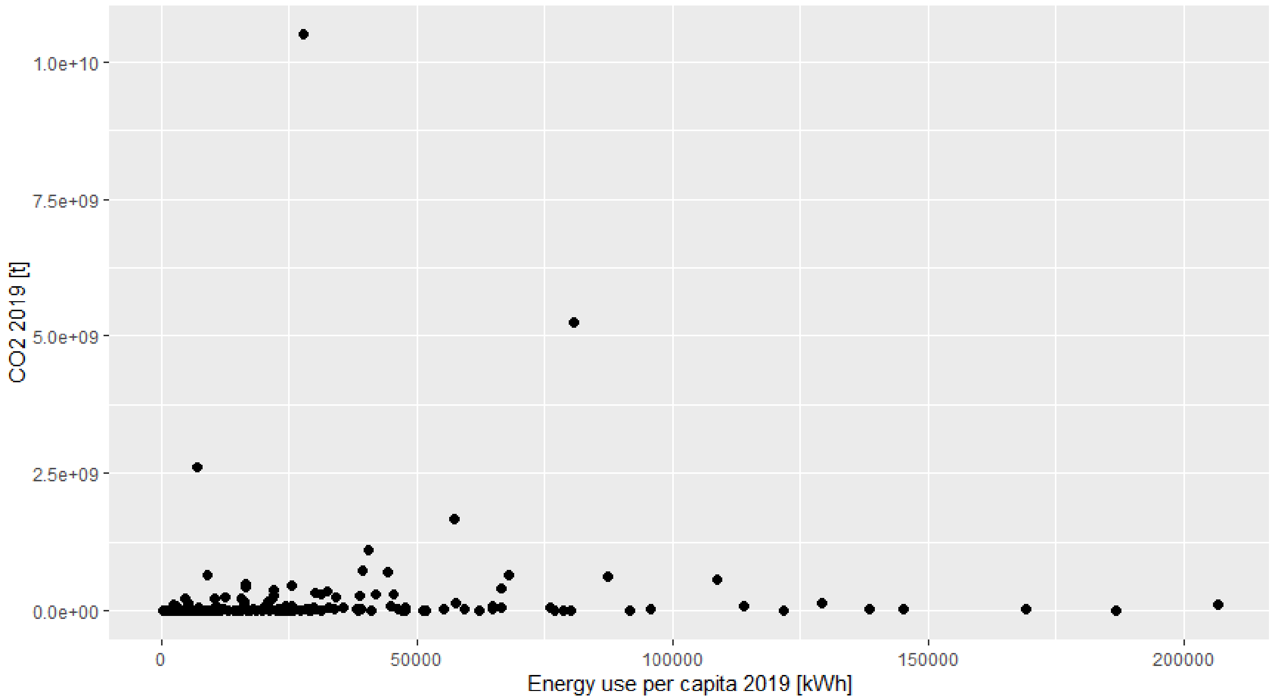
*Scatter plot between CO2 Emissions [t] in 2019 and Gdp per capita in 2019 [current US$]*




*Scatter plot between CO2 Emissions [t] in 2019 and GDP per capita in 2019 [current US$] with logarithmized scales*



*Scatter plot between CO2 Emissions [t] in 2019 and Energy use per capita in 2019 [kWh]*




*Scatter plot between CO2 Emissions [t] in 2019 and Energy use per capita in 2019 [kWh] with logarithmized scales*