Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Energy and Process Engineering

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Understanding the consequences eradicating poverty and reducing world inequalities will have on the carbon-, material use- and land use footprints

An Environmentally Extended Multi-Regional Input-Output Analysis

Master's thesis in Energy and Environmental Engineering
Supervisor: Richard Wood
June 2019

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Problem description

The following is copied from the Master Thesis Agreement.

"If we are to reach the sustainable development goals of reducing world inequality, eradicating poverty and ensuring sustainable consumption, a larger focus on the interconnectivity of the three should take place to understand how they affect one another. This master thesis aims to do a scenario analysis where the consumption-level of the 1st quintile (bottom 20%) changes to the consumption-level of the 2nd quintile and the consumption level of the 5th quintile (top 20%) changes to the 4th quintile-level. The impact from having these changes will then be assessed with regard to different environmental consequences (e.g. material use, land use, carbon emissions) in order to see if reducing the inequality and eradicating poverty will lead to a higher or lesser impact on the environment.

The objective of this master thesis is to assess the impacts of reducing inequality by moving the consumption level of the poorest to a higher level, and at the same time reducing the richest consumption level. Additionally, it is aimed to get a better understanding of what level of environmental consequences we can expect when reaching the SDG of reducing inequality and eradicating poverty with focus on e.g. material use footprint, land use footprint and carbon footprint."

Preface

This master thesis concludes my master studies in Environmental Engineering at the Norwegian University of Science and Technology (NTNU) and was written within the field of Industrial Ecology at the Department of Energy and Process Engineering (EPT).

I have been lucky enough to be able to study within a field I have a genuine interest in, and during my years here at NTNU I have experienced a high academic growth. My interest in climate change studies and the current levels of inequalities and unfairness in the world have continued to grow ever since my first day as a student, and in the later years, I found that doing my master thesis on a subject I felt connected to was important. Consequently, to conduct an in-depth study of the environmental consequences of eradicating poverty and reducing world inequalities was an opportunity I could not miss.

I want to thank my two supervisors, Richard Wood and Kirsten Svenja Wiebe for their excellent guidance and helpful inputs throughout the year. I would like to thank Richard for allowing me to follow the visions I had for my thesis and letting me work independently on a subject I am interested in. Also, a special thanks is needed to Kirsten for consistently challenging me to do independent thinking and being available for weekly meetings. An additional thanks to Eivind Lekve Bjelle who got involved in a later stage, but nevertheless gave valuable help in the last weeks of my writing.

Further, I want to thank my family for encouraging me all the way, Jakob for doing the same in addition to showing me magic in Excel, and last, but not least, my closest classmates who have made the past six years unforgettable.

Heidi Snemyr

Trondheim, June 5th 2019

Abstract

The anthropogenic greenhouse gas emissions over the last decades have made irreversible impacts on the Earth's climate system, which will affect both current inhabitants and future generations. The average global temperature has already seen a one-degree Celsius increase since the pre-industrial times and will continue to rise if no radical changes are made on the current exploitation of the Earth's resources and capacity. As a global response to the environmental challenges, The Sustainable Development Goals (SDGs) were developed by the United Nations and agreed upon by the member states in 2016. The Goals are meant as a guideline for all countries to ensure a sustainable development, where social, economic and environmental issues are addressed. Nevertheless, the interactions of the Goals and whether these would potentially nullify each other is a field of study where there currently are substantial knowledge gaps.

In thesis, the potential interactions between three of the SDGs will be investigated; eradicating poverty (goal 1), reducing inequalities (goal 10), and mitigating climate change (goal 13). The aim of this thesis is to better understand how eradicating poverty and reducing inter- and intra-country inequalities will affect the environment, and what policy measures that are needed to reduce the possible consequences. Accordingly, three main what-if scenarios are set up: where poverty is eradicated, inter-country inequalities are reduced, and intra-country inequalities are reduced. For each scenario the changes in carbon-, material use- and land use footprint are calculated. The scenarios are run by using an environmentally extended MRIO analysis, and further, regression analyses are conducted to analyze the correlation between the footprints and GDP, followed by a discussion of the possible policy impacts these scenarios may entail.

The results show that reducing inequalities by redistributing the current footprints equally amongst all, and thus also eradicating poverty, will still make the per capita footprint levels unsustainable. This implies that it is impossible to meet the three SDGs simultaneously with the current global consumption level. Nevertheless, it is concluded that reaching the three SDGs simultaneously might be possible with a large reduction in the consumption level of the richest. Thus, implying that the richest carry the main responsibility in reducing the global footprints to a sustainable level by minimizing their own consumption. However, finding ways to realize a reduction in over-consumption may prove problematic as it will require both policy measures and consumption regulation specifically targeting the rich, which may be met with resistance by the targeted.

Sammendrag

Menneskeskapte klimagassutslipp har de siste tiårene resultert i permanente skader på klimaet, noe som både vil påvirke denne og fremtidige generasjoner. Jordens gjennomsnittstemperatur har allerede steget med én grad siden preindustrielle tider - og stigningen vil fortsette dersom det ikke iverksettes radikale tiltak for å redusere dagens nivåer av klimagassutslipp. Som et globalt svar på klimautfordringene, ble bærekraftsmålene i 2016 signert av De Forente Nasjoners medlemsland. Ambisjonen er at målene skal bidra til å sikre en bærekraftig utvikling hvor både sosiale, økonomiske og miljømessige problemer blir adressert gjennom et sett med retningslinjer. Til tross for et stort, globalt fokus på bærekraftsmålene, er det gjort lite forskning på samspillet mellom disse målene, og om det vil finnes tilfeller hvor arbeid for å nå et mål kan ha negative effekter på andre mål.

Denne oppgaven kartlegger samspillet mellom tre av bærekraftsmålene; å utrydde fattigdom (mål 1), å redusere ulikheter (mål 10) og å motvirke klimaendringer (mål 13). Målet med denne oppgaven er å få en bedre forståelse av miljøkonsekvensene fattigdomsbekjempelse og reduksjon av ulikheter kan gi, i tillegg til hvilke tiltak som må iverksettes for å redusere disse konsekvensene. Følgelig blir tre ulike hovedscenarier utforsket: ett hvor fattigdom er utryddet, ett hvor ulikheter innad i land er redusert, og ett siste hvor ulikheter mellom land er redusert. Det blir brukt en flerregional kryssløpsanalyse (MRIO) for å studere konsekvensene scenariene vil ha på tre klimaavtrykk; karbonavtrykk, arealbruk og materielt bruk. Det blir i tillegg utført regresjonsanalyser for å kartlegge korrelasjonene mellom de tre forskjellige klimapåvirkningene og BNP.

Resultatene tilsier at å redusere ulikheter ved å fordele det nåværende globale fotavtrykket likt mellom alle, og dermed også utrydde fattigdom, vil føre til et fortsatt lite bærekraftig forbruk, noe som gjør det vanskelig å samtidig oppfylle de tre bærekraftsmålene per dags dato. Det er videre konkludert at å oppfylle de tre målene kan være mulig dersom de rikeste reduserer sitt forbruk i stor grad. Dette impliserer at de rikeste forbrukerne har det største ansvaret for å redusere de globale fotavtrykkene ved å redusere sitt eget overforbruk. Å finne måter å realisere en reduksjon i overforbruk kan være problematisk da dette vil kreve forbedrede politiske tiltak og endringer i forbrukeratferd spesielt rettet mot de rikeste, noe som potensielt kan bli møtt med stor motstand fra de rike.

"Earth provides enough to satisfy every man's needs, but not every man's greed."

- Mahatma Gandhi

"The concept of global warming was created by and for the Chinese […]"

- Donald Trump

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Abbreviations

CES	Consumer Expenditure Surveys
CF	Carbon Footprint
COICOP	Classification Of Individual COnsumption by Purpose
EE-IO	Environmentally Extended Input-Output
EE-MRIO	Environmentally Extended Multi-Regional Input-Output
EU	European Union
EUA	Eurostat, USA and Australia
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	GreenHouse Gas emissions
LCU	Local Currency Unit
LU	Land Use footprint
MF	Material use Footprints

OECD	Organization for European Economic Co-operation
RoW	Rest of the World
SDG	Sustainable Development Goals
SNA	System of National Accounts
UN	United Nations
UNESCO	The United Nations, Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank

1 Introduction

1.1 Motivation

This thesis will analyze and discuss the environmental consequences of reducing world income inequality and eradicating poverty where the main focus will lie on the global carbon, material use, and land use footprints. Additionally, it will assess which policy measures are needed to deal with the environmental consequences of eradicating poverty and reducing world inequalities.

The anthropogenic greenhouse gas (GHG) emissions over the last few decades have made irreversible impacts on the Earth's climate system (Hubacek et al., 2017a, Di Giulio and Fuchs, 2014, van Vuuren et al., 2013, UN, 2015). In 2015, the United Nations Framework Convention on Climate Change (UNFCCC) signed the Paris-agreement as a response to the increasing emissions and set a goal of keeping the overall global temperature increase below 2 degrees Celsius compared to pre-industrial levels, with efforts to keep it below 1.5 degrees (UN, 2015). However, in 2017 the global average temperature was measured being 1.1 degree Celsius above the pre-industrial average temperature (IPCC, 2018, UN DESA, 2018), thus making it easy to conclude that there is quite an amount of work needed to meet the goal.

Parallel to the Paris Agreement, the United Nations (UN) developed the Sustainable Development Goals (SDG) in 2015 as a plan to ensure that the future development of the world's societies will evolve sustainably. It was introduced as a plan to balance the three main aspects of sustainable development; economy, social factors and the environment, to make sure that no one is left behind in the development process (United Nations, 2015). In contrast to the Paris Agreement, the SDGs have a large focus on societies as a whole, thus making it inevitable that some of the goals will affect one another in some way. The interactions of the goals could potentially lead to cancellations, where achieving one goal would make another goal impossible, but also in terms of indivisibility where to achieve one goal is dependent on achieving another goal (Scherer et al., 2018), and everywhere in-between.

Increased amounts of GHG emissions will lead to gradual climatic changes, such as changes in precipitation, temperature increase, and oceanic flows, which in turn leads to more natural disasters, higher sea-levels and changes in biosystems (IPCC, 2018, Easterling et al., 2000, UN DESA, 2018, Webster et al., 2005, Malik et al., 2016). Those hardest affected are the ones in exposed areas with low infrastructure security and income, where high levels of climate change can possibly lead to more poverty and higher levels of inequalities, both within and between countries (Beg et al., 2002). It is therefore important to fully understand the environmental impacts eradicating poverty and reducing inequalities may have on the environment; will they potentially enhance the climate changes, and consequently contribute to an even higher level of poverty?

Extreme poverty is according to the United Nations one of the largest challenges humans face today (United Nations, 2015). It is essential to eradicate poverty in order to obtain future sustainable development and is the first goal addressed in the SDGs (United Nations, 2015). In 2013, it was said that around 770 million people lived on less than $1.90/day and that around half the population had less than $2.97/day (Hubacek et al., 2017b). And, even though the amount of people living in extreme poverty has been largely reduced in the past decade (in 2013 it was only a third of the 1990 value (UN DESA, 2018)) the problem is still great and must be reduced. Nevertheless, lifting 770 million people out of poverty will lead to a higher global consumption level and thus also possibly contribute to an even higher pressure on the Earth's resources (Hubacek et al., 2017b, Di Giulio and Fuchs, 2014, Schandl et al., 2016).

There are large inequalities in the world which can be found in access to many different resources (Afonso et al., 2015, Alsamawi et al., 2014, Hubacek et al., 2017a, Keeley, 2015). From 2000 to 2017 the material footprint of persons living in developing countries grew from 5 to 9 metric tons, however the developed countries have in average double the material footprint per capita than the developing countries, where the largest difference is found in fossil fuel use (UN DESA, 2018). Also, it is said that only 59% of the world population have access to clean cooking options, leaving around 2,8 billion people using polluting fuels (UN DESA, 2018). There are currently negative trends in income inequalities, where the intra-country income inequalities have generally seen a rise in the last two decades for most of the world (Alvaredo et al., 2018, OECD, 2019, Niño-Zarazúa et al., 2017), while the inter-country income inequality has been reduced, however, largely influenced only by a few, large developing countries (Niño-Zarazúa et al., 2017).

"*Achieving the SDGs will create a world that is more sustainable, equitable, and prosperous.*" (SDG Impact, 2018). Even though there may be consensus amongst the UN member states that reaching the SDGs by 2030 will give a more sustainable world than what we have today, there is no guarantee that the goals won't impact each other negatively and diminish each other's effects. Consequently, it is a crucial task to assess the consequences and interconnectivity of the goals, yet the literature body on this is currently limited (Nilsson et al., 2016, McCollum et al., 2018, Scherer et al., 2018) as most studies have focused on specific goals alone. There are not, to my knowledge, any research papers addressing the possible environmental consequences of reducing world income inequality and eradicating poverty at the same time by alternating the consumption levels of the different income groups within a country on a global scale, and this is where this thesis aims to contribute.

1.2 Objective and structure of thesis

The objective of this master thesis is to answer the following research questions:

- How will eradicating poverty (SDG 1) affect the global land use, material use and carbon footprint?
- How will reducing world inequalities (SDG 10), both inter- and intra-country, affect the global land use, material use and carbon footprint?
- What policy responses are needed to deal with the possible environmental consequences of eradicating poverty and reducing world inequalities?

The rest of this thesis is structured as follows. Chapter 2 will cover the background and existing literature relevant to the objective of this thesis. The chapter aims to give a full understanding of the current state of art, in addition to further understand why this kind of research is relevant for today's many challenges. It will introduce the concepts of poverty and income inequality with their current levels and main drivers. Thereafter, an introduction to the concept of environmental footprints will be introduced, followed by a section discussing the possible interconnectivity between poverty, inequality and environmental footprints. Closing this chapter is a short overview of the general methodologies used in relevant research papers. Chapter 3 presents the methods used to approach the objective of this thesis. This mainly includes an introduction to environmentally extended MRIO analysis and consumer expenditure surveys. It further introduces methods and adjustments made to make the data available utilizable for this study. Lastly, the main scenario analyses conducted in this thesis are established and explained. Following the methods-chapter, the results of the scenario analyses will be presented along with commentary of the results in chapter 4, before they are further discussed in chapter 5 in line with the literature given. Chapter 5 also includes a discussion of weaknesses and limitations that were experienced and taken during this study, along with some comments on what future studies should focus on to contribute further to this field of study. Lastly, chapter 6 will provide a conclusion of the research questions based on the literature review, results and discussion.

2 Background

In this chapter, the background and relevant literature for this thesis will be presented. Sections 2.1, 2.2 and 2.3 briefly introduces the theory and current state of art of the main three pillars of this thesis; income inequality, poverty and environmental consequences. Sections 2.1 and 2.2 are meant to give the reader a perspective on the current levels, drivers and consequences of poverty and inequality, while section 2.3 defines the concept of an environmental footprint and introduces the environmental focus areas of this thesis. Section 2.4 investigates how these three pillars are interconnected and how their connection is and should be handled. In the last section, a summary of the literature review's main findings is given.

2.1 World inequalities

2.1.1 Introduction

Inequality is a concept that can be found in many aspects, such as in income, electricity access, health care, and even human rights, and can be found both within and between countries (Bourguignon, 2015). The concept of not having equal opportunities or not have equal access to e.g. a resource can be driven by forced and involuntary factors, such as gender or location (Afonso et al., 2015), which can make it a state beyond someone's own hard work and wishes. One common way of using the term "inequality" is through looking at monetary inequalities, often as income inequality or wealth inequality. Income inequality can shortly be defined as the difference in household income either between co-citizens or between countries (Balestra et al., 2018, Keeley, 2015) and is closely connected to many of the other inequalities in some way as one's options in life are enhanced by a good economic base. Environmental inequality is not a widely used term but has generally been used to map how uneven an environmental footprint, e.g. a nation's carbon footprint, is distributed amongst its inhabitants (Wiedenhofer et al., 2016, Hubacek et al., 2017a).

Inequality in general is a complex term, and how to define and measure it may be challenging. It has over time been introduced several ways to measure inequality based on sources of data and metrics used, however all are used to measure the same concept; how something is distributed within a group of people (Alvaredo et al., 2018). Nevertheless, summarizing distribution and to state which level of distribution is a fair one, may be subjective to whoever conducts the inequality analysis and to what kind of perspective the analysis has.

The possible consequences of high inequalities can be grave within in a country; politically, economically, and socially, thus making raising income of the poorest and eradicating poverty a great concern for many countries but also for the world. It is argued that high inequality within a country could lead to dangerous situations and excessive violence through being socially destructive (Wilkinson and Pickett, 2006), and sociopolitical unrest can be incited by high inequality of wealth and where one can find large differences of social groups (Barro, 2000, Alesina and Perotti, 1996). In addition, several studies over the years have found a close link between rising inequality and declining economic growth (Afonso et al., 2015, Alesina and Perotti, 1996). Another study finds a strong correlation between the average income of the bottom quintile of a population and the average income of a nation, where the fall or increase in average income will happen at the same rate as the fall or increase in the average income of the bottom quintile (Dollar and Kraay, 2002a). These findings thus stress the importance of finding ways to reduce the world inequalities, both within and between countries.

2.1.2 *Inequality today*

There have always been inequalities in the world and the trend points to it not being eradicated any time soon (Alvaredo et al., 2018, OECD, 2019, Keeley, 2015). In any scenario where the concept of hierarchy-based income and privately regulated income levels are existing, there will be some form of income inequalities, and is therefore in some way inevitable (Alvaredo et al., 2018). Unfortunately, this have been the case for many generations, even in the previous world without any enterprises and large businesses there were high forms of inequalities e.g. between kings and peasants. Even Socrates was concerned of the effects indiscriminate distribution of wealth could have on a society, and Plato manifested in his work that to ensure peace and prosperity, one needed social equality (Niño-Zarazúa et al., 2017). Nevertheless, income inequality is not set or described by a fixed level; it is adaptive to change and is therefore a parameter worth figuring out how to reduce.

The intra-country income inequalities have generally seen a rise in the last two decades for most of the world (Alvaredo et al., 2018, OECD, 2019, Niño-Zarazúa et al., 2017), while the inter-country income inequality has been reduced (Niño-Zarazúa et al., 2017). It is estimated that in 2011, the 10% richest in the developed countries had an average of around nine times that of the bottom 10% of the population (Gurría, 2011). In OECD (Organization for European Economic Co-operation) countries, which consists mostly of developed countries, the intra income inequality has generally risen since the 1980s and has today a Gini[1]-coefficient average of around 0.315 (Keeley, 2015, OECD, 2019).

[1] The Gini-coefficient is a common way of measuring income inequality and ranges from 0 to 1 where countries having a Gini-coefficient of 0 has a distribution of equal wealth, i.e. perfect equality. For more information, see Keely (2015).

Keely (2015) continues to explain that in 2010, the top 10% in rich OECD countries had 9.5 times the income of the bottom 10% in the same country. The Nordic countries, who generally have unusually high income levels, are found to have remarkably low levels of intra-country inequalities with a Gini-coefficient of around 0.25 (OECD, 2019), even though it has been observed a slight increase in inequality also here (Alvaredo et al., 2018). It is estimated that income inequality is generally a larger issue in the developing countries than in the developed, yet not all developing countries have seen a rise in income inequality (Balestra et al., 2018, Alvaredo et al., 2018). Several countries in Latin-America; Bolivia, Brazil, and Peru to mention some, has actually seen a reduction in income inequality the last decade (Balestra et al., 2018), however, the level of inequalities is still extremely high (Alvaredo et al., 2018, OECD, 2019). It is estimated that Brazil, Colombia, Costa Rica, India and China have a Gini-coefficient of around 0.50 and South Africa 0.62, while the least unequal countries in OECD have a Gini-coefficient of around 0.25 (Balestra et al., 2018). China and India had a rise in income inequality from around 1990 to the mid-2000s but have stabilized the last couple of years, while the even lesser developed seems to still be on an increasing path (Balestra et al., 2018).

As mentioned, inter-country income inequality has been reduced over the last decade. Table 1 below shows the current level of income inequality between the different continents. When assessing the ratio between the share of the world total income and the share of population, it is clear that Europe and America have got an unfair piece of the fortune, while Africa and Asia come out worst.

Table 1: Population share versus percent of world total income, 1980-2016

Region	Share of world population		Share of world total income		Ratio	
	1980	**2016**	**1980**	**2016**	**1980**	**2016**
Europe	15%	10%	37%	20%	2,46	2
America	14%	13%	30%	25%	2,14	1,92
Africa	11%	16%	5%	5%	0,45	0,31
Asia	60%	60%	27%	49%	0,45	0,81
Oceania	1%	1%	1%	1%	1	1

Source: (Alvaredo et al., 2018). Percent of world total income is based on national income given in 2016 EUR-PPP, with a world total of 78 trillion EUR-PPP and a population total of 7 372 million in 2016, and 25 trillion EUR-PPP (2016) and population of 4 389 million in 1980. The ratio is the share of income divided by the population share, which in an ideal scenario should be 1. Take note that the share of world population in 1980 adds up to 101% which is a mistake observed in Alvaredo et al. (2018)'s study.

However, as it is generally stated that world inequality becomes lesser. Table 1 shows that this only seems to be the case for some. The main point being that when considering world inequality reductions, one need to take into consideration which countries that have contributed to the reduction. In the last decade, India and China has seen a massive increase in income levels (Alvaredo et al., 2018), and with their total world population share of around 40% this will have a considerable effect on the global inequality levels. Over the last twenty years, countries included in the bottom fifteen poorest countries in the world have shifted from being a group of mostly Asian and African countries, to mainly consisting of African countries due to Asia's economic growth and Africa's many recessions (Bourguignon, 2015). The influence these growing Asian countries have on the average global income inequality raises the question if the trend of inter-country income inequality is in fact a fair representation of the world economy or not.

2.1.3 *Drivers of income inequality*

Income inequality is a much-discussed topic, and the conclusions of how, when and to what degree it can affect a country are many and often different (Berumen, 2016, Alesina and Perotti, 1996, Balestra et al., 2018, Gurría, 2011, Mills, 2009, Wilkinson and Pickett, 2006). Several drivers of income inequality has been found in the extensive literature body on global inequality, with most classifying as economic, social or state-driven (Balestra et al., 2018). Previously it was thought that income inequality was mainly driven by globalization and changes in technology, however it is argued that a large part may be played by the labor markets and its policies (OECD, 2011) and that one of the largest drivers is inequality in wages and salaries (Gurría, 2011). However, the gap between high wages and low wages differ between countries and would therefore not be a main driver for some (Balestra et al., 2018). Robinson and Acemoglu (2002) argue that the decrease of inequality in the West in the nineteenth century was not necessarily a consequence of economic development, but rather a result of political changes. Bourguignon (2015) on the other hand, argues that the trend of global inequality is reflected by the growth of the global economy and how it grew geographically, which can be exemplified through looking at the Industrial Revolution and how it was centralized mainly around Western European countries and the United States. In terms of globalization, some conclude that it leads to more equality (Dollar and Kraay, 2002b), while others claim that increased globalization has increased inequality by not equally sharing its benefits and driving down incomes by outsourcing jobs and businesses (Balestra et al., 2018). Some claim that one can never conclude with one or the other, as each country has its own inequality response when opening the trade borders due to political regulations (Wade, 2004). There seems to be no definite conclusion on how globalization and economic growth has affected a country's inequality by itself, however, opening borders for trade will indeed affect a country economically. There are several cases where two countries that have experienced high economic growth have different growth in inequality. E.g. China and Korea have both been successful in raising the average national income level, however, China's inequality has risen quite much (39%) while Korea's income inequality level have decreased (-14%) between 1990-2010 (Niño-Zarazúa et al., 2017).

One well-known theory to predict income inequalities within countries is the Kuznets curve theory, which claims that high income inequality is a temporary phenomenon in an economically growing country, and as the country grows, the income inequality will fall due to natural market forces. Graphically that would look like an inverted U-shape where the x-axis would be economic status of the country and the y-axis the income inequality (Robinson and Acemoglu, 2002). Kuznets argued in his theory that developing countries would experience an increase in inequality as they moved from agricultural practices to non-agricultural industries, but as the persons move from the rural areas to urban areas, they will over time adapt and obtain more secure income and power, leading to a decrease in inequality (Kuznets, 1955). In some countries, e.g. China and India, there is a large difference in the rural and urban areas, where the urban areas experience much growth in income and other opportunities (i.e. health care, education) while the rural areas stay relatively stable (Balestra et al., 2018).

On the other side, there are some skeptics to the validity of Kuznets's theory. Robinson and Acemoglu (2002) explains that the Kuznets curve-like trends of the West in the nineteenth century is most likely due to a rising democratization rather than to natural market effects. Additionally, the income inequality has risen also in highly developed countries. Numbers presented in Keely's (2015) report shows that some countries that belong in the "most developed"-category, and has been for a while, has had a large increase in inequality in the timeframe 1980-2013. For example, Sweden and Finland has had an increase in Gini-coefficient of around 0.08 (40%) and 0.06 (30%), respectively, something implying that high economic growth over a long period of time may not naturally give lower intra-country inequality. Nevertheless, one should note that on a global level, the inequalities of the highly developed countries are indeed significantly lower than lesser developed countries but also rising in most cases. Keely (2015) points out that based on the inequality trends in the twentieth century, the inequality growth can be graphically explained as a U – thus the inverse of the Kuznets theory. He further explains that in the 1920-30's there was a decline in inequality in much of Europe and North America, where in the start, the rich didn't become much richer while the poorer slowly earned more. However, in the 1970's and onwards, the same areas experienced a high growth in inequality. These two contradictions, the U-shape and the inverted U-shape, gives economic growth the role of both worsening inequality and at the same time lowering inequality, and it seems that the role economic growth plays in the different countries is formed of parameters other than simply the market-related ones.

2.1.4 *Measures for reducing inequality*

Inequality can be assessed with regard to two different perspectives; inequality of opportunities and inequality of outcomes (Afonso et al., 2015). The first can be understood as the ability to have life choices of those beyond income regardless of any involuntary disabilities. That could be access to education, living condition, political power, health care, and human rights, and represents a people's basic needs not controlled by how much they earn or own, but what is equal to all. Inequality of outcomes however, represents the monetary inequalities, and are those extra means obtained by higher income or wealth, much affected by factors beyond one's control, but also by someone's talent or extra efforts. As inequality of opportunities has a direct connection with a nation's general welfare and what each government can offer to each inhabitant in terms of education, health, and legal rights, the main responsibility of reducing this kind of inequality principally lies within the government. However, this part is not as relevant for this thesis and is too complex to dive into as it would include how to define which rights a person should have.

To reduce inequalities of outcomes, one need to look at monetary regulations. As mentioned in 2.1.3, the drivers of inequality within a country can be many. Two important factors are gaps in wages and how the political powers choose to regulate income inequality through e.g. taxes (Alvaredo et al., 2018). In countries with low inequality, such as in the Nordic countries and Switzerland, the state has set high income taxes making the richest pay a much larger tax than those who earn less. In addition, there are low unemployment rates and the difference on the average top and bottom income (before taxes) are less than seen in other countries with higher inequality, such as Mexico, United States or Chile (Keeley, 2015). In the report presented by Alvaredo et al. (2018) it is claimed that income tax progressivity is one of the most important tools when wanting to combat rising inequalities due to rising income, in addition to taxation of wealth and inheritances. This seems to be highly agreed upon in other empirical studies on income inequalities (Bourguignon, 2015, Alsamawi et al., 2014, OECD, 2011). Bourguignon (2015) points out the fall in intra-country inequalities after the Second World War as a result of progressive income taxes, cash benefits, and access to public healthcare.

2.2 Poverty

2.2.1 Introduction and definition

One of the world's most important inequalities is probably the extreme variant of poverty. Poverty has been defined in various ways in different dictionaries, but bears similar meanings; "*the state of one who lacks a usual or socially acceptable amount of money or material possessions*" (Merriam-Webster, 2018), "*Poverty is a state or a condition in which a person or community lacks the financial resources and essentials for the minimum standard of living.*" (Investopedia, 2018). The United Nations Educational, Scientific and Cultural Organization (UNESCO) adds that one can disaggregate the poverty-term into two; relative and absolute poverty. Absolute poverty represents the lack of means to obtain basic needs such as food, shelter and clothes, and relative poverty *"… defines poverty in relation to economic status of other members of society: …*", meaning that someone is relatively poor if they live below what is the living standard of a country (UNESCO, 2017). Extreme poverty is the worst form of poverty and is by the World Bank defined to be a person living on less than $1.9 per day where the line of $1.9 is set based on the average of basic needs of the world's fifteen poorest countries (Frykholm, 2016). The value is based on a person's consumption (Roser and Ortiz-Ospina, 2019) and is collected mainly through national household surveys conducted by different parties, e.g. statistical offices or the government, within a nation (The World Bank, 2019b). However, finding a proper way to measure poverty can be challenging. All countries have different definitions of what kind of living standards that falls under the poverty-category (Frykholm, 2016), and the richer the country, the higher the level of living-standards are. It is therefore unlikely that one will find many living below the international extreme poverty line in highly developed countries, thus giving an even stronger indication of the effect extreme poverty has on world inequalities. Nevertheless, it does not mean that the only important level of poverty is those living below the extreme poverty line, and this is where the relative poverty enters. Someone can live in poverty within a country even though they have a consumption well over $1.9 per day (Roser and Ortiz-Ospina, 2019), and despite the fact that those under the extreme poverty line is those urgently in need, one also should have some focus on those living in relative poverty as this also contributes to a crooked and unequal society.

2.2.2 Poverty today

It is claimed that in the year of 1820 83.4% of the world lived in what we define as extreme poverty[2] and 94.4% in poverty (Bourguignon and Morrisson, 2002). In 2015,

[2] At the time the article was written (2002), the extreme poverty line was set at $1.0 per person per day. It was increased to $1.9 in 2015.

10% of the world's population was below the extreme poverty line (The World Bank, 2019c) and in 2013 it was estimated that 783 million were extremely poor, with the majority living in Africa and Asia (UN DESA, 2018). Yet, Bourguignon and Morrisson (2002) calculated that in line with a falling level of extreme poverty from 1820 to 1992, the Gini-coefficient was estimated to have increased from 0.50 to 0.66. This still seems to be the case, as half of the world's poor in 2015 were residents in only five different countries; India, Nigeria, Democratic Republic of Congo, Ethiopia, and Bangladesh (World Bank, 2018). A large contribution as to why the number of people living below the extreme poverty line has been so drastically reduced over the years is that economic growth has been more rapid than population growth (Bourguignon, 2015), especially in China where millions have been lifted out of poverty. It is estimated that in the timeframe 1990 to 2015, the percent share of extremely poor in China decreased from 62% to less than 3% (World Bank, 2018). This massive impact on the global amount of people living below the extreme poverty line has out-shadowed the fact that there still exist countries where the amount of people living below this line is actually increasing. Sub-Saharan Africa has the largest amount of poor people and the level of extremely poor has seen an increase from 278 million in 1990 to 413 million in 2015 (World Bank, 2018), making around 42% of the inhabitants in Sub-Saharan Africa extremely poor. In comparison, the total amount of extremely poor in Sub-Saharan Africa is now equivalent to 79 times the population of Norway.

2.2.3 Dealing with poverty

A citation found in Balestra et al. (2018)'s paper states "*[...] the biggest causes of poverty are not lack of development in the country as a whole, but political, economic and social marginalisation of particular groups in countries that are otherwise doing well.*". The same is concluded by the UN who state that eradicating poverty is a multifaceted problem requiring most of all to address political, social, economic and institutional dimensions (The United Nations, 2018). The high levels of extreme poverty found in South-Asia and Sub-Saharan Africa is according to the World Bank mainly due to three factors; slow rate of growth, conflicts and weak institutions, and not successfully using economic growth for poverty reductions (World Bank, 2018). As mentioned in the introduction, poverty is a form of inequality, and will thus be reduced if one is able to reduce intra- and inter-country inequalities (UN DESA, 2018, Alvaredo et al., 2018). Alvaredo et al. (2018) stresses the importance of inequality reduction and how it can increase the average income of the world's bottom 50% by three times if the countries are able to follow the same inequality trend EU has had the last two decades, however, this would imply that those countries affected need to both experience high economic growth and adapt the governmental structures found in the EU. From here, one can easily draw the line to corruption and the importance of having trustworthy governments. High levels of corruption within a government is found to have exacerbating effects on inequality and poverty (Chetwynd et al., 2003, Gupta et al., 2002). Gupta et al. (2002) found that an increase of one standard deviation in corruption will on average lead to a 0.11 increase in the Gini-coefficient and a five percentage point increase in number of poor within a country, however the exact effects of corruption have been found to vary from region to region (Dimant and Tosato, 2018, Gyimah-Brempong and de Gyimah-Brempong, 2006).

2.3 Environmental footprints

2.3.1 The concept of a footprint[3]

A common way of defining an environmental footprint is as an indicator or describer of the pressures humanity exerts on the environment in different footprint categories, or in other words a measurement of how humans appropriate Earth's natural resources to meet their demands and the possible environmental changes this pressure can lead to (Čuček et al., 2012, Fang et al., 2015, Figge et al., 2017, Hoekstra and Wiedmann, 2014). The concept of footprints is much used and can be found in many different research papers (Wannebo et al., 2002, Moran et al., 2013, Sommer and Kratena, 2017, Hertwich and Peters, 2009, Figge et al., 2017, Hoekstra and Wiedmann, 2014), and is used when addressing challenges e.g. with increasing population, food availability, biodiversity losses, but also to estimate the environmental impacts from products or technologies in different footprint categories. Common footprint indicators are water use, material use, energy use, carbon, and land use, which all can be used when assessing e.g. a person's, a nation's, or a company's overall impact on the environment (Peters et al., 2016).

In this thesis, three footprints will be considered; carbon footprint, material use footprint and land use footprint. These three footprints are relevant for this kind of study for several reasons. Firstly, all three footprints are thought to be closely connected to economic growth (Scherer et al., 2018). As a country or a person obtains more wealth, the carbon footprint may increase because of higher accessibility to more carbon-emitting technologies, e.g. cars, flying, and fossil-based electricity (Hubacek et al., 2017a, Fernández-Amador et al., 2017). Additionally, lifting the extremely poor to a higher income level may lead to more food production, more residential buildings, higher product consumption, etc., which requires additional material use and land use.

[3] Parts of this section is based on previous work: SNEMYR, H. 2018. Inequality and Environmental Consequences NTNU. Some of this section's structure and content is based on and extracted from own previous work: ibid. The work was my project thesis which is meant as an introduction to my master thesis, thus having some of the same theoretic base. Footnotes that are found later in this thesis and are marked: *Parts of this section is based on previous work* are under the same definition as this footnote.

Secondly, they are all assumed to be relevant and interconnected world-wide. For example, to measure the carbon footprint of a country is interesting for all as it per today is not possible to live completely carbon neutral if one has any level of wealth, as somewhere in the production chain of products, there has been emitted greenhouse gases. The carbon that is emitted due to human activity will affect the whole world as it directly worsens air quality and is relatively permanently stored in the atmosphere. However other footprints, as e.g. freshwater footprint, may not have the same range of current global impacts (Steffen et al., 2015) and will in some countries not have exceeded its maximum sustainable level, while in others being a large and stressing issue. Land use is also a local challenge, but is a globally stressing factor (Steffen et al., 2015) since it is needed to produce enough food, be available for e.g. biofuel production, solar panels, higher ocean levels, increasing housing demand, but also due to forest feedbacks, albedo change, biodiversity, and so forth.

There are however several aspects that need to be taken into consideration when using these footprints in a comparative study. Firstly, if a country does well in one footprint category, it does not necessarily mean that the country has an overall positive environmental profile, and it might happen that doing well in e.g. water use might lead to doing worse in land use. Secondly, to compute the environmental footprints of a country or a product, certain databases must be used to extract relevant data to assess the whole supply chain of the product or footprint. This data may contain uncertainties and give some inaccuracies due to lack of data in e.g. some time periods or that some newly developing regions/countries have less accurate data than more developed countries. Thirdly, the accuracy or consistency of both the intra- and inter-country levels may deviate as there are several ways of defining what a footprint is, how it should be measured, and where the allocation of different impacts a long a supply chain should lie.

2.3.2 *Carbon footprint*[4]

A carbon footprint (CF) of a country is the total CO_2 emission-level caused by the inhabitants' consumption and investments, in addition to the country's emissions caused by production (Aichele and Felbermayr, 2012, Liobikienė and Dagiliūtė, 2016, Hertwich and Peters, 2009). The carbon footprint is to the author's experience one of the most known and discussed footprints as of today and can be found in most literature addressing footprints, where it most often is used to quantify the amount of GHGs emitted in the full lifetime of a process or product and its environmental impact (Čuček et al., 2012).

[4] Parts of this section is based on previous work: ibid.

The CF of a country is said to be closely connected to its general income level or GDP (Hubacek et al., 2017a), and naturally one reason for this may be that higher income levels leads to the possibility of higher consumption, and higher consumption in turn leads to higher environmental deterioration. A study done by (Fernández-Amador et al., 2017) shows that the emissions intensity of a country per unit of output may decline with the per capita income after reaching a certain level, but that the overall net emissions will be higher than the reduction in CO_2-emissions achieved when earning a higher income. In other words, they argue that raising income will most likely lead to an increase in the CF of a country (Fernández-Amador et al., 2017, Liobikienė and Dagiliūtė, 2016). Over the last decade, the amount of anthropogenic CO_2-emissions have steadily increased and in 2017 it grew by 1.6% (Jackson et al., 2018). It is well known and agreed upon that the increasing emissions become a larger threat to the human population and the surrounding natural systems as every day passes (UN DESA, 2018, Beg et al., 2002, Jackson et al., 2018), and even with the many global agreements on climate change mitigation, i.e. Paris Agreement, Kyoto Protocol and The Sustainable Development Goals, the world has not been able to deal with the continuous growth of emissions. Part of the recent CO_2-increase may be due to fossil fuels meeting 70% of the 1.7% increase in global energy demand in 2017, which was double the increase experienced in 2016 and additionally made the energy-related CO_2-emissions increase with 460 million tonnes (1.4% increase) from the previous year (International Energy Agency, 2017). Due to both an increase in energy and transport, one of the largest sources of CO_2-emissions is currently from burning fossil fuels (World Bank, 2017, Jackson et al., 2018), and it is not believed that the emissions will decrease in 2019, as there is continuous growth in both oil and natural gas consumption (Jackson et al., 2018). In the energy sector, fossil fuels have been the main source of energy in the last three decades, even with the higher implementation of renewable energy (International Energy Agency, 2017). One of the main reasons for the high growth of world energy consumption is the increase found in Asian countries, mainly China and India, which accounted for two-thirds of the energy use increase in 2017. Developing countries in general accounted for 80% of the energy consumption increase in 2017 (BP, 2017, International Energy Agency, 2017), thus stressing the fact that it is crucial to find new, less carbon-intensive energy-sources as the developing countries further evolve economically.

2.3.3 Material use footprint[5]

A material use footprint (MF) represents a chosen reference's raw material consumption and the amount of environmental problems the reference exerts on nature through the material use (Giljum et al., 2015, Wiedmann et al., 2015, Tukker et al., 2016).

[5] Parts of this section is based on previous work: ibid.

Steinberger et al. (2010) claims that the environmental issues connected to material use occurs when the materials are extracted, when they are processed, and at the end-life when they become waste and returns to nature. The MF of an economy is said to be the allocation of total raw materials extracted globally over the whole supply chain to meet the economy's consumption demand (Wiedmann et al., 2015, UN DESA, 2018). To sum up into a proper definition of MF for this thesis, a broad, but specific, definition defined by Giljum et.al (2015) is used: MF is a "*… consumption-based indicator, which allocates all globally extracted and used raw materials to domestic final demand*". Raw materials can in this case consist of e.g. biomasses, fossil fuels, metals, mineral products, and so forth.

Material use is one of the most effective drivers of environmental change and it is estimated that that the annual global material extraction rate is somewhere between 47-59 billion ton, with an still increasing rate (Steinberger et al., 2010). From 1995 to 2008 the extraction of biomass, fossil fuels and minerals grew by 44%, from 48 to 69 billion metric tons, where 18 billion tons were extracted in China alone (Pothen, 2017). The main drivers of the increasing extraction rate has been argued to be international trade and economic growth, and lately the largest growing share stems from developing countries (Giljum et al., 2015, Wiedmann and Lenzen, 2018, Plank et al., 2018). Agreeing on this, a study conducted by Wiedmann et.al (2015), shows that the overall material use increases as wealth increases, but the countries' domestic use of materials decreases due to increasing international trade. Also, UN DESA (2018) claim that the developing world is dependent on an increase in material use to better the living standards of their populations, however, it is not to fill their personal consumption. There is data showing that much of their material extraction is due to developed countries' consumption, either through raw materials or finished products containing raw materials (UN DESA, 2018, Pothen, 2017, Bruckner et al., 2012). International trade, in connection with globalization, connects the developing countries to the rest of the world, giving them the opportunity to use their access to natural resources to grow their country's wealth (Teixidó-Figueras et al., 2015), thus making the final, non—domestic consumers actual enhancers of the country's material extraction growth. However, it is important to reflect on how the extraction of raw materials often leads to environmental consequences not directly affecting the actual consumers, but the one exporting the goods (Bruckner et al., 2012).

As beforementioned, the annual natural resource use has increased rapidly over the last decades. In the timeframe 1970-2010 the global annual material use grew from 24.8 to 79.4 billion tonnes (Schandl et al., 2016). In the European Union (EU), there has been a MF increase over the time-period 1995-2011 of 3.8 billion tonnes (Giljum et al., 2016). Biomass has become one of the most important sources of energy and currently accounts for around 11.5% of the world's primary energy supply, where residential utilization of biomass for energy have grown by 14% in the last decade (Nejat et al., 2015), thus largely contributed to an increase in total material use. However, the extraction of fossil fuels and construction materials has increased even more with a 35% and 72% increase from 1995-2008, respectively (Pothen, 2017). Much of the increase comes from domestic demand within China and India to meet their growing economies with 123% and 70% increase in domestic consumption between 1980 and 2002, respectively, while countries in Latin America saw a large increase in domestic extraction due to higher exports of ore-products (Behrens et al., 2007).

2.3.4 Land use footprint[6]

A land use footprint, which includes both agricultural and forest land, is per now mostly measured as a reference's total land use in m^2 or ha (Tukker et al., 2016). To measure a persons or a country's LU can be complex, due to the many uncertainties one can find in land use requirements for different products and how exported agricultural goods should be allocated. E.g. a study from 2014 claims that to consuming 1 kg of retail beef would require 3-7% of a person's annual land use footprint (Ridoutt et al., 2014), but how would one allocate the LU two different consumers in different countries, if the animal, e.g. cow, is used both for dairy products and for meat? Additionally, it has got some criticism for not including land productivity or quality (Tukker et al., 2016).

Land is today a scarce resource and is widely used for different purposes, such as for food, timber and biofuel production (Ridoutt et al., 2014, van Vuuren et al., 2013). With a growing population leading to a future increase in food demand, it is estimated that there will be an 60% increase in agricultural production in the next four decades (van Vuuren et al., 2013), thus making it essential to map the available productive land in addition to implementing strict land control. However, reserving land in one region might just lead to displacement and an increase in land use somewhere else (Ridoutt et al., 2014). In 2015, 30% (40 million km^2) of the Earth's surface was covered by forest, with around 67% of this found within ten countries (World Bank, 2017). Even though there is lost around 3% of forest since 1990 due to the consequences of population and a declining growth in agricultural productivity, some countries have had an increase in forest areas through implementing reforestation (World Bank, 2017). China and India have increased their forest surface by 33% (510 000 km^2) and 11% (70 000 km^2) since 1990, respectively, while countries with large amounts of agricultural activities, like Brazil, have lost 10% (530 000 km^2) in the same period (World Bank, 2017).

In 2007, 65 million km^2 land was required to meet the annual household demand, where 46% of this is due to food consumption, followed by shelter and services, with 26% and

[6] Parts of this section is based on previous work: ibid.

15%, respectively (Ivanova et al., 2015). It is estimated that around 30% of the world's land use alone goes to livestock production (Ridoutt et al., 2014). The impacts of excessive land use can be grave, and is today one of the main drivers of loss in biodiversity and is also predicted as the main biodiversity loss driver in the future (de Baan et al., 2013). However, in contrast to the carbon footprint, the land use footprint is a physically constrained footprint by land available and need not to be zero because not all land use is harmful to humans or other species (Peters et al., 2016). Peters et al. (2016) continues to argue that international trade may not influence but will rather *be* influenced by land scarcity, especially in those countries dependent in food imports. Additionally, international trade may actually contribute to keeping the overall land use footprint lower than it would have been if all countries were to produce its own food, as it is estimated that global land use would increase by 8% if this were to happen (Peters et al., 2016).

2.4 Interconnectedness between poverty, inequality, and environment

2.4.1 The Sustainable Development Goals

The Sustainable Development Goals (SDGs) are, shortly put, a set of goals set by the UN that addresses how the world should deal with what they claim are the largest global challenges we face today (UN DESA, 2018). All seventeen goals have a common end-goal of ensuring a sustainable future for the generations to come. The goals are not in any way legally binding; however, all UN member states are expected to put national plans in motion in order to achieve the goals by 2030 (UN DESA, 2018). In a report published in 2018, the UN stated that while people are generally living better today than they have been before, there are still many people that have been left behind in the current economic growth. While there have been improvements, the recent progress is not good enough to meet the goals by 2030, thus implying that a larger effort need to take place by the member states (UN DESA, 2018).

To somewhat restrict the focus area of this thesis in addition to finding SDGs relevant to the research question, the thesis will have focus on the interconnectedness of the following three SDGs;

1) Goal 1: End poverty in all its forms everywhere
2) Goal 10: Reduce inequality within and amongst countries
3) Goal 13: Take urgent action to combat climate change and its impacts

As recalled from the thesis' introduction, it seems that the research to date on the SDGs have mainly focused on specific SDGs rather than on their interactions with each other. Only a handful of papers were found on the SDGs interactions (McCollum et al., 2018, Le Blanc, 2015, Nilsson et al., 2016, Scherer et al., 2018), while none being truly relevant for this thesis. However, according to the study conducted by Le Blanc (2015) there is a very high interconnectivity between goal 1 of eradicating poverty through economic growth and goal 10 of reducing inequality. Scherer et al. (2018) analyzed the interaction between two social goals (goal 1 and 10) with three environmental goals; for land use, carbon and water, goal 13, 15 and 6, respectively. They did not focus on the consequences of eradicating inequalities, but on the actual footprint inequalities. They concluded that pursuing the social goals in general will lead to higher environmental impacts, but that is also depends on the country in question. Additionally, as mentioned in section 2.3, enhanced climate change and growing income levels are highly connected, thus making eradicating poverty and reducing inequalities particularly interesting when focusing on climate change mitigation.

2.4.2 *Economic development and environmental consequences*

Several papers have addressed the interconnected link between environmental consequences and economic or social development (Ghisellini et al., 2016, Hertwich and Peters, 2009, Schandl et al., 2016, Sommer and Kratena, 2017, Destek et al., 2018, Kasman and Duman, 2015, Akizu-Gardoki et al., 2018, Hubacek et al., 2017b, Moran et al., 2018, Minx et al., 2013), so this is a much discussed and researched thematic. However, the potential effects economic development and environmental consequences can have on each other is seemingly too complex to fully agree upon, and will change based on current economic status, political powers, technologies and different environmental factors. The findings in the different research papers addressing this interconnectedness are therefore relatively wide and seems to be dependent on the method of study, data availability, the specific focus of the study, and how deep into the subject the researches have dug, however, all seem to agree that generally, an environmental footprint is driven by human consumption.

As mentioned in 2.4.1, the research on the possible consequences of meeting the SDGs is not sufficient. There are however multiple studies looking at the consequences of eradicating poverty (Rao et al., 2014, Hubacek et al., 2017b, Scherer et al., 2018). The three papers additionally discuss briefly whether it is possible to reach the SDGs simultaneously or not, and if having too much focus on the environmental aspects will hinder the developing countries' economic growth in any way or vice versa. Achieving the 2-degree goal is currently dependent on a massive decrease in current emissions and decarbonization in the industrialized countries (Rao et al., 2014), and this is excluding the possible increase of emissions from the developing countries as their energy sector and overall wealth grows. Hubacek et al. (2015) shows that eradicating extreme poverty has little impact on the global emission levels, and one large reason for this being that the bottom half of the world's population only were responsible for 13% of the global carbon emissions in 2010. To elaborate, the top 10% richest in the world were responsible for 36% of the global emissions, while the poorest only accounted for 4%, still while representing 12% of the global population (Hubacek et al., 2017b). However, moving the poor to the next income level, yet still earning much less than in the average developed countries, would potentially lead to an additional increase of 0.6 degree Celsius by the end of the century (Hubacek et al., 2017b). It has further been argued that the disparity in carbon footprints will decline as a country experiences economic growth, yet the average footprint will increase with higher income; i.e. the carbon intensity decreases but the total county carbon footprint will increase (Jorgenson et al., 2019), as also mentioned in 2.3.2. Followingly, it was argued that the decrease in carbon intensity for a country experiencing economic growth is due to the lower carbon consumption expenditures (such as better healthcare and education) that will be included in the consumption mix (Jorgenson et al., 2019).

A study conducted by Rao et al. (2014) argues that much of the current research on the relationship between GHG emission pathways and eradicating poverty lacks a broad set of poverty eradications, and that the researches per now too often define poverty in form of pure income or GDP and that the inclusion of poverty in human well-being is insufficient. However, some studies do focus on the concept of well-being, and those conclude that as a poor country obtains higher levels of HDI the amount of emissions also increases, nevertheless, there are also known countries that have obtained a high human development index with relatively low emissions (Rao et al., 2014). Additionally, it is claimed that several upper-middle-income countries[7] have full access to a good living standard with relatively low emissions per capita, however, this cannot be assumed to yield for all developing countries as they seek financial growth (Rao et al., 2014). It is estimated that upper-middle-income countries have obtained over 90% access to food nourishment, electricity, water and sanitation over the last two decades with emission levels below the world average (6,3 ton CO_2eq/capita), while the high-income countries have almost 100% access but with emissions well above the world average (Rao et al., 2014). However, their numbers show that the degree of living standards does not necessarily correlate with equally high emissions. Disaggregating the emissions into sectors shows that the highest emitters are the countries having at least 75% of the population living within decent living standards, while the group of countries having 90% and 50% of their population with decent living standards have lower sectoral emissions than the high emitters (Rao et al., 2014). As Rao et al. (2014) points out, this may be an indication that there is not required any “minimum amount of emissions” in

[7] This refers to the World Bank’s country classifications based on average income, an overview of the country classifications can be found in Appendix E – Countries aggregated into income groups.

order to achieve satisfactory life standards. However, these numbers are based on the lowest-emitting countries in each category. Looking at the high-emitters in each classification, the countries having 90% of their population within high life standards are by far the ones with highest emissions.

2.4.3 *Inequality in environmental footprints*

Environmental footprints and its impacts are closely connected with inequality both in who has the largest footprints and in who has to suffer the consequences of the footprints' impacts (Hubacek et al., 2017a).

It has been stressed in the literature that we need to drastically reduce our GHG emissions if we are to meet the 2-degree goal. Additionally, if the future predictions of an alarmingly high population increase are realized, the global average GHG emissions need to stay below 2.5 ton per person (Tukker et al., 2016). However, today EU has an average GHG emission of 13.8 ton per person (Tukker et al., 2016), over five times the recommended value.

As beforementioned, the global CO_2-emissions have increased over the past two decades, but the emissions have not grown evenly across all countries. As Teixidó-Figueras et al. (2015) mentions in their paper, the developed countries' emissions have stagnated while the developing countries' emissions has grown at a high pace. The same conclusion can be seen in Figure 1 below, where it is clear that the upper-middle income country group[8] has seen a large increase in CO_2-emissions over the last decade, especially since the 2000s, while the high-income countries have seen a certain stabilization. The low-income countries have not seen much growth, while the lower-middle income group have had a slow, but steady, increase since around 2000.

[8] A classification of the World Bank's country classifications will be further explained in Chapter 4. However, a brief overview can be found in Appendix E – Countries aggregated into income groups.

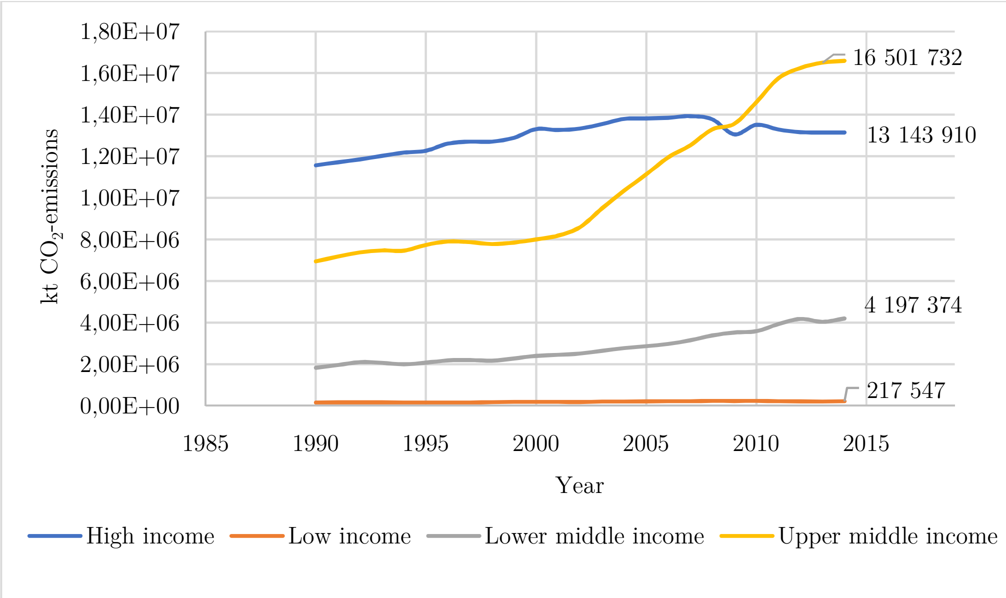

Figure 1: Trend of CO2-emissions based on World Bank country income classifications. Extracted from the results of previous work (Snemyr, 2018).

Even though there has been an increase in energy consumption over the last year, only 87% of the world has access to electricity (UN DESA, 2018), and the level of inequalities in access to energy are wide. To exemplify; Ethiopia has an electricity consumption 0.4% the size of the US consumption, with a consumption of 51 kWh/capita and 12 564 kWh/capita, respectively (Moss et al., 2014), and over half of the countries in Africa only have a 10-50% share of the population with access to energy (UN DESA, 2018) and over 30% of African hospitals operate without electricity (Moss et al., 2014).. The consequences of lack of access to energy can be grave as lack of electricity forces people to cook, heat and light with fire, leading to much indoor pollution (Nejat et al., 2015) and currently 41% of the world population doesn't have access to clean cooking options (UN DESA, 2018).

Material consumption varies a lot between different countries due to their economic status, but also between those countries with similar income levels (Steinberger et al., 2010). Additionally, material resources are distributed unequally between countries due to the geographical availability and necessity of the resources (Schandl et al., 2016). Consider for example two different regions; Scandinavia and Sub-Saharan Africa. These two regions differ not only in economic status and development, but also in e.g. climate and landscapes. These two differences will affect the material use e.g. by the amount of firewood needed (both cooking and heat), number of cars driven by petroleum, availability of wood, agricultural products, and so forth. Point being, the amount of material use consumption is not only driven by monetary forces, but consists of a larger nexus of influences, something one need to consider when assessing potential impacts on material use when a country experience economic growth.

In terms of direct environmental inequality measurement, it is found that the Gini-coefficient is 0.71 for the carbon footprint and 0.57 for the land use footprint (Scherer et al., 2018). The study further argues that the food sector is the dominant footprint of all income groups and comprises 28% of the household's total carbon footprint. The lowest income group in this study only has a 14% share of the world land use, even with a population of 45% of the world total, where 55% of the land use is directly connected to food (Scherer et al., 2018). It is concluded that the footprint inequality is higher for the carbon footprint than for land use or water use, and this is naturally due to an increasing amount of high-carbon intense activities as the income level rises.

For intra-country footprint inequalities, few studies have been done that cover all footprints. Those that have assessed this mainly focuses on carbon footprint inequalities in specific countries, e.g. China (Wiedenhofer et al., 2016, Golley and Meng, 2012), UK (Minx et al., 2013), Turkey (Akbostancı et al., 2009), India (Grunewald et al., 2019), and globally (Grunewald et al., 2017), where they all have concluded that the carbon footprint is just as, and often more, unequally distributed within a country as between countries, especially was this observed in China and India. However, the study conducted by Scherer et al. (2018) briefly address intra-country footprint inequalities and states that high environmental inequalities and Gini-coefficients can be found in e.g. Brazil (0.47-0.57) and in Botswana (0.59-0.73), while being significantly lower in high-income countries as e.g. USA which have an environmental Gini-coefficient lower than 0.1, thus implying that there are indeed cases where intra-country inequalities are lower than inter-country footprint inequalities.

2.4.4 *Ensuring decoupling and reducing consumption footprints*

Understanding the current and historical drivers of climate change, their impact on the world today and the processes which drives human behavior and consumption is essential in order to develop new mitigation and adaption efforts (Jorgenson et al., 2019). One much discussed concept is the possible decoupling of environmental consequences from economic development (Ghisellini et al., 2016, Schandl et al., 2016, Akizu-Gardoki et al., 2018, Sommer and Kratena, 2017). By this, it is meant that the economic development and the environmental consequences should not go together, but rather, ideally, affect each other positively.

One way of working towards decoupling is by decarbonization. This would imply that the economy within a country, or globally, shift to being a low-carbon economy (Jorgenson et al., 2019). There is per today not observed any nations that have systematically decarbonized, however, there is an increased literature on the feasibility of decarbonizing a nation (Geels et al., 2017, Dubois et al., 2019, Jorgenson et al., 2019) which addresses several challenges with decarbonizing in addition to its possibilities. Decarbonization would require grand policy and societal changes in addition to large alternations in current energy systems (Jorgenson et al., 2019), however, with the increasing amount of renewable energy implementations and increased focus on sustainability, a shift towards a more decarbonized society might already be happening.

Recalling the current growth in world energy use, as addressed in 2.3 and 2.4.2, there is a sore need of energy source options other than fossil fuels and biomasses, in addition to phasing out old, CO_2 intensive energy sources (Geels et al., 2017). However, "*Energy use has evolved over a millennia*" (Jorgenson et al., 2019) and change might therefore be challenging both because it is deeply rooted in the infrastructure but also because it could threaten some of the most powerful global industries (Geels et al., 2017). Nevertheless, there is an increasing amount of literature on the new energy possibilities (Yadav et al., 2019, IEA, 2016, Chaurey et al., 2004, Meckling and Hughes, 2018). Although one still lacks proper empirical evidence of the actual implementation effects on many of these new energy source methods, renewable energy is currently outgrowing oil use and more people get access to electricity (IEA, 2016), which is a trend essential to have if one wants to decouple high CO_2-emissions from energy use. Several ideas has been proposed to ensure this, some being global carbon prices, investment in resource efficiency, green investments and dematerialization (Schandl et al., 2016), which of many have been theoretically proven efficient, however currently lacking a empirical consensus of efficiency (Schandl et al., 2016, Jorgenson et al., 2019).

Another way of reducing footprints even though income level rises, is through limiting the level of consumption. If all humans want to be satisfied simultaneously with the current consumption levels of the rich, there is no place for sustainability (Di Giulio and Fuchs, 2014). Therefore, one interesting perspective on reducing environmental footprints, is through defining a consumption level which both satisfies basic needs and still is sustainable. This may intuitively seem difficult, as there per today are such substantial differences in living conditions. However, Di Guilio and Fuchs (2014) introduces, through the philosopher Kant's concept of regulative ideas, the idea of a relative view of sustainable living, where sustainable living is not finally materialized, but a rather defined by the societal goals of the current generation. Currently, all individuals have an idea of what a good life means to them, however, the line between the individual satisfactions and the actual basic needs need to be defined (Di Giulio and Fuchs, 2014). They conclude in their study that even though they believe that defining such a consumption level and implementing it can be feasible, there still lacks transdisciplinary discussions about the objective needs for a decent living, in addition to lack of current regulatory power to be able to control those who consume well above a sustainable level (Di Giulio and Fuchs, 2014). Dario Kenner (2015) also address the concept of reducing the level of consumption, with focus on the wealthiest, and agrees that in order to properly regulate the consumption of the richest, there is a need for policies that specifically targets those with high consumption, however, this would imply considerable amount of political play, which might not be an easy task considering the power the very rich has on both politics and in the market (Kenner, 2015).

2.4.5 General methodologies

Those studies conducting analysis on environmental impacts from consumption most often choose to do an environmentally extended input-output analysis (EE-IO), either by using the consumption values given from the input-output database, or by using data direct from consumer expenditure surveys (Steen-Olsen et al., 2016, Moran et al., 2018, Grunewald et al., 2019, Grunewald et al., 2017, Rolke et al., 1998). As Steen-Olsen et al. (2016) points out, EE-IO is currently the most common method used to conduct analysis on national environmental footprints. However, there are other methods available as well such as life-cycle assessment (LCA), but as of now, this lacks much data as it demands very high levels of detail, which is usually not found for household consumption. Additionally, the EE-IO's takes a top-down approach while LCA does the opposite. Moran et al. (2018) also conducted a study of the spatial distribution of carbon footprint at a household level using a top-down model, which was argued to be more appropriate than a detailed bottom-up method for several reasons; the top-down method is more comprehensive and can give results for all cities and countries, additionally, it is more consistent than a bottom-up approach as they often use different inventories and datasets.

Multi-regional EE-IO's (EE-MRIO) considers the inter-country flows of goods and services and is therefore a suitable method to allocate emissions and footprints to countries based on imports and exports based on different sectors. However, when one wants to assess the household demand and its impacts specifically, the disaggregation in a global EE-MRIO may not be sufficient enough. A study done on the carbon footprints of cities in the UK used a combined approach, where they combined a global EE-MRIO with information on local geo-demographic consumption (Minx et al., 2013). A study conducted by Steen-Olsen et al. (2016) evaluated the carbon footprint of Norwegian households by combining an EE-MRIO with national consumer expenditure surveys. By doing this, their aim was to obtain data with a higher detail of household consumption by getting information on specific purchases and consumer activities. Additionally, making it less challenging to analyze specific consumption patterns and lifestyles (Steen-Olsen et al., 2016), which in turn will make an understanding how and where in the consumption structure one needs to improve in order to achieve a higher level of consumer sustainability.

3 Methods

As one can recall, the main goal of this thesis is to evaluate the environmental consequences of eradicating poverty and reducing inequalities, and there are several steps that needs to be taken before reaching this goal. Firstly, I need to map the trade flows and their connecting environmental footprints for all countries by using a multi-regional input-output table. How this is done is further explained in section 3.1. Secondly, I need to disaggregate the countries' consumption into social-economic structures, which will provide information on how the consumption is distributed within a country; both between sectors and between income groups. This is done by using information given in consumer expenditure surveys. Section 3.2 will further elaborate on this, in addition to explaining the steps taken to make the data from the consumer expenditure surveys compatible with the multi-regional input-output table. Section 3.3 explains which scenarios that are run to obtain the results needed to answer the research questions of this thesis.

3.1 Input-Output Analysis

3.1.1 *The concept of Input-Output modelling*[9]

Input-Output analysis (IO) is said to have been developed by Wassily Leontief in 1936 in order to understand the linkages in the US economy, and was in 1953 extended to map the role of international trade on national capital and labor (Owen, 2017). IOs have since become an important player in developing the System of National Accounts[10], e.g. for the European System of Accounts (Eurostat, 2008). Eurostat have stated that the supply and use tables, which is the core of the IO-structure, "[...] *constitute the centre piece of the internationally compatible accounting framework for a systematic and detailed description of the economy, its various components on the supply and demand side and its relations to other economies"* (Eurostat, 2008).

Summarized, a symmetrical IO-table is a way of expressing all flows or transactions occurring between different sectors within an economy (Peters et al., 2016). Based on a combination of two tables; one for supply and one for use. The basic structure of an IO table is shown in Figure 2

Figure 2: A simplified IO-table

[9] Parts of this section is based previous work: SNEMYR, H. 2018. Inequality and Environmental Consequences NTNU.

[10] For further information: https://unstats.un.org/unsd/nationalaccount/sna.asp

where the flows in the square represented by *Z* is the intermediate consumption by a product or an industry, also known as the transaction matrix. *V*, primary inputs, can also be defined as value added per industry or product and can be classified as e.g. wages or taxes on production. Final demand, *y*, is the demand from e.g. household or governmental consumption. The total output and input, *x*, need to be balanced, i.e. total output = total input, where total output is the output from the industry/product given a final demand and total input represents the total requirements of the industry or product.

	Industry/product	Final demand	Total output
Industry/product	Z	y	x
Primary inputs	V		
Total input	x		

Figure 2: A simplified IO-table

By deriving the A-matrix from the Z-matrix, where *A* represents the total inter-industry requirements consisting of the coefficients $a_{ij} = {}^{z_{ij}}/_{x_j}$ where z_{ij} is the flow from an industry *i* to industry *j* for a given final demand and x_j is the total output of industry *j* (Hubacek et al., 2017b) one can express the two following equations:

$$Zi + y = x \quad (1)$$

$$Z = A\hat{x} \quad (2)$$

Further, merging the two above equations, the total output, *x,* can then be expressed as in equation (3):

$$Ax + y = x \quad (3)$$

One can followingly rewrite equation (3) to equation (4) by introducing *L*. Here *L* represents the Leontief matrix, $L = (I - A)^{-1}$, and *I* is the identity matrix (diagonal of ones, the rest zeroes).

$$Ly = x \quad (4)$$

It is possible to use an IO-table when assessing the flows from industry to industry, but also from product to product. Which one to choose depends on what the desired output is, but as a general rule, the industry by industry IO-tables are more based on statistical estimates, while the product by product IO-tables gives a more realistic insight of the economy by using the actual market transactions and analytical assumptions (Eurostat, 2008).

3.1.2 *Multi-regional input-output analysis*[11]

Multi-Regional Input-Output (MRIO) tables are similar of the traditional IOs and includes cross-country trading, i.e. they also describe and map the exchange of goods and services between countries (Hubacek et al., 2017b). Additionally, one may use the MRIO-tables to trace emissions through complex trade nexuses to a final demand (Lenzen et al., 2012). However, to calculate environmental impacts in trade, it is necessary to include an extension. Environmentally extended multi-regional input-output (EE-MRIO) analysis merge the inter-country consumption with environmental consequences by introducing vectors of environmental stressors. The environmental stressors provide information of the possible environmental impacts caused by each unit of input.

EE-MRIOs, as presented in Figure 3, can be derived from using supply and use tables, primary inputs and final demand, flow of imports and exports between countries, and the environmental satellite accounts (stressors). In the same figure, two countries are assessed. The first column in the figure represents the flows of inputs to country 1, from two sectors in the two countries, e.g. how much from sector 1 in country 2 is required in country 1's production of sector 1. Column one and the two first rows represent the domestic flows within country 1 while column one and row three describe the flow from sector 1 from country 2 to country 1. The total inputs needed within a country is then summed into a total input. Further, the environmental stressors, i.e. environmental impacts, are used to calculate the impacts allocated to each input.

The environmental stressors are needed as an extension to the MRIO in order to track environmental impacts to the final demand categories of the products or services (Galli et al., 2013). The EE-MRIO can in this way be used to allocate environmental responsibility across trade flows (Galli et al., 2013, Peters et al., 2016, Hertwich and Peters, 2009, Aichele and Felbermayr, 2012, Scherer et al., 2018). Mathematically, this can be expressed as:

$$\mathrm{F} = \mathrm{SLy} \qquad (5)$$

Where *S* is the stressor matrix (the environmental extension), and L and y as presented earlier in this section. Equation 5 essentially then represents the environmentally extended Leontief model showing the total impact given a final demand for a given set of environmental stressors.

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[11] Parts of this section is based on previous work: SNEMYR, H. 2018. Inequality and Environmental Consequences NTNU.

Sector	**S1, C1**	**S2, C2**	**Final demand**		**Total output**
S1, C1	C1 to C1	C1 to C2	C1	C2	S1, C1
S2, C1	C1 to C1	C1 to C2	C1	C2	S2, C1
S1, C2	C2 to C1	C2 to C2	C1	C2	S1, C2
S2, C2	C2 to C1	C2 to C2	C1	C2	S2, C2
Total input	C1	C2			
Env stressors	C1	C2			

Figure 3: A simplified MRIO table with environmental impacts for one country

Source: Figure made based on information given in (Lenzen et al., 2013). "S" stands for sector which can be an industry, product or service, "C1" stands for country 1.

Several MRIO databases are available to do this kind of analysis, however, they differ in several aspects relevant for this thesis: region and sector detail, time series, and environmental extensions. A compressed overview of the available databases is given in Table 2. The table only includes four databases, yet, Owen (2017) mentions six MRIO's as the main global databases. However, some does not include environmental extensions, and some are outdated compared to other databases. In the same paper, only three EE-MRIOs are evaluated further (Owen, 2017), with the exclusion of Exiobase. Nevertheless, Exiobase should not be excluded in the evaluation of possible EE-MRIO databases available for this thesis. Therefore, the four main resulting EE-MRIO databases evaluated for this thesis are the following; Eora, Exiobase, World Input-Output Database (WIOD), and Global Trade Analysis Project (GTAP).

Table 2: Available EE-MRIO databases

Database	Sectors	Countries	Environmental extensions	Time series
Eora	26-511	190	GHG emissions, labor, energy use, air pollution, water use, land use, material use	1990-2015
Exiobase	163 indu, 200 pro	43, 5 RoW	GHG, energy, water use, land use, material use, etc (broad specter).	2007
WIOD	56	43	Emissions, employment, water use, land use, material use	2000-2014
GTAP	57	140	Emissions, land use	2004, 2007, 2011

Source: Table based on (Owen, 2017), however, the values are updated to the current status the databases' website.

The different MRIOs may yield different results based on which one that is used for analysis, however, there does not exist one MRIO-database that is generally better than another as all have some sort of shortcomings (Geschke et al., 2014, Owen, 2017). The exact reason as to why they deviate from another has not been proven, but theories include conceptual biases especially in the environmental satellite accounts, i.e. how the environmental impact inventory is constructed, and how it allocates the impacts to different sectors. Additionally, also the differences in how the economic flows are described (Moran and Wood, 2014) with varying levels of aggregation, different classifications, and diverging use of data sources (Geschke et al., 2014). However, some of the differences found between the MRIO databases are constant over the years, and as Moran and Wood (2014) stated "[…] *we may end up with quantitively different results, but in general, we have qualitatively similar outcomes* […]" when using the different MRIO models.

Based on the information given in Table 2, the Eora database is clearly the one with the largest group of countries while Exiobase has the largest group of sectors. GTAP has also a large amount of countries, however, the environmental satellite accounts are limited. The WIOD database has few countries, but a fair number of sectors included. For this thesis the Eora database will be used. This is mainly due to its large amount of included countries. Having a broad set of countries included in the analyses, both developing and developed, is essential to reach the goal of this thesis. The Eora database has 189 different countries included, and a last "country" defined as statistical discrepancies. Exiobase, however, has 43 independent countries, mostly European countries, and 5 rest-of-world (RoW) regions. It would not possible to disaggregate the RoW-groupings into separate countries, thus making this database less relevant for this thesis. GTAP has in turn many relevant countries, however, they lack the broad set of environmental stressors. Lastly, WIOD has too few countries to be relevant for this thesis.

3.1.3 Price structures

The price of any product or service depends heavily on where in the supply chain the focus lies. One can consider a fish filet as an example. The fish filet will naturally be more expensive for the final consumer than for the producer, and this due to several reasons. Figure 4 visually explains how the price is built from its basic price to its purchaser price. The necessary information to construct this figure in addition to the rest of this sub-section is retrieved from Mahajan et al. (2018), unless otherwise specified.

Figure 4: The price structure of a product

Source: The figure is self-made, based on information found in (Mahajan et al., 2018).

Basic price is the actual value the producer receives after selling a good or service, minus taxes and plus any subsidies provided by selling the good. Taxes deducted can e.g. be cost of production, salaries, property taxes, and so forth, while subsidies may come from governmental arrangements. Producer price then becomes the basic price plus any taxes of the production less subsidies on the product. Purchaser price is the price payed by the consumer of the good. This price includes transport costs, trade margins and non-deductible taxes, in addition to the producer price.

In the Eora database, it is possible to extract the tables both in purchaser's prices and in basic prices. When to use each depends on what kind of analysis that is to be done. The standard set by the System of National Accounts (SNA) is to use basic prices when doing MRIO analysis. As this thesis will have a mix of doing standard MRIO analysis, in addition to doing environmentally extended work connected to final household demand, the choice between basic prices and purchaser prices may not be so straightforward. However, the norm when conducting an IO-analysis is to work with basic prices (Steen-Olsen et al., 2016, Mahajan et al., 2018), and this is also what will be done in this thesis. Additionally, for other studies doing environmental analysis combined with CES, conducting the analysis with basic prices seems to be the norm (Steen-Olsen et al., 2016).

3.1.4 Environmental satellite accounts

The Eora database have several environmental indicators available for analysis covering a broad set of footprint categories. However, not all are relevant for this thesis. Table 3 shows the selected indicators and in which footprint category they belong.

Table 3: Environmental indicators

Footprint category	Indicator	Metric
Carbon footprint	Greenhouse gases	1 kiloton CO_2-eq
Material use footprint	Biomass, raw material input	1 ton
Material use footprint	Ores, raw material input	1 ton
Material use footprint	Construction materials, raw material input	1 ton
Material use footprint	Fossil fuels, raw material input	1 ton
Land use footprint	Total cropland area	ha
Land use footprint	Total crop and pasture land	ha

The environmental indicators were selected based on: (1) the Eora database authors' recommendations of which indicator is most up-to-date and detailed, and (2) indicators fully representing the footprint categories assessed in this thesis; carbon footprint, material use footprint and land use footprint. There were several options for the carbon footprint category, however, the row containing GHG values from PRIMAPHIST is the one recommended by the database's developers, thus is the one used in this thesis. To measure the material use footprint, four different indicators were used to distinguish between the raw materials: biomass, ores, construction materials and fossil fuels. There was also provided a material use-total in Eora, however, it may be interesting to see which parts of the material use footprint that increases or decreases the most when changing the consumption levels. The land use footprint was a little more difficult to properly choose as the Eora26 authors did not recommend any specific environmental indicator for land use, in addition to there being several possible options to cover the land use footprint. Yet, when evaluating the data given for the given indicators, the most reasonable seems to be the data provided by the FAO due to the data seemingly being more detailed.

3.2 Consumer expenditure surveys

3.2.1 Background

The Eora26 database provide data on final household consumption, in addition to several other final demand categories for all countries. However, what is lacks is further disaggregation into the social-economic structures within the countries, and thus not indicating how the household demand is distributed within the country. To be able to analyze the environmental impacts of reducing inequalities and eradicating poverty by using income groups as study points, this piece of information is crucial. Followingly, this is where the consumer expenditure surveys (CES) can assist with information. CES are conducted by most countries through a national statics office in order to map household purchases on a detailed, yet varied, product level (Steen-Olsen et al., 2016). The CES can be used as an extension of a MRIO analysis in order to get an even further detailed analysis of household consumption (Steen-Olsen et al., 2016) and can be used by anyone interested in trying to understand consumer behavior.

Several CES were assessed when choosing the ones suitable for the work of this thesis. In order to find the right one(s), some key points were considered in every case: (1) the database needs to contain household consumption data; (2) the consumption data needs to be aggregated to several consumption sectors in order to use it with the EE-MRIO; (3) consumption needs to be aggregated into different income groups, and (4) the data has to be deemed credible and come from extensive household surveys, or through a secondary source who has gathered data from several credible household surveys.

For this thesis, one of the main goals is to get as a broad group of countries included as possible, especially those defined as low-income countries which inhabits most of the extremely poor. It is therefore chosen four different databases: Eurostat, World Bank, USA and Australia. The Eurostat database represents only developed countries in the EU, or in EFTA if they belong to the high or upper-middle income country groups[12]. The World Bank Consumption database, however, represent only developing countries, most of which are found in the low or lower-middle income category. As an extra, USA and Australia were included in the analysis. Together, these databases cover the vast majorities of the world's countries and 88% of the total population in 2010. Nevertheless, future studies should focus on including other large economies, especially developing countries in Latin-America and Asia.

3.2.2 *World Bank expenditure survey*

The World Bank database (WB) originally have consumption data for 90 countries, however, Timor Leste is not part of the Eora26 database and was therefore eliminated from the WBD calculations, leaving 89 countries for assessment. The values in WB were extracted as current 2010 USD which is directly compatible with the Eora26, hence not needing any further transformation. This data is also collected from national statistical offices and standardized through six comprehensive steps before it being published on their website. For further information of the standardization process, see (The World Bank, 2019a).

Differently from Eurostat, WB only disaggregates into four different income groups; lowest, low, middle and higher. These income groups are based on global income distribution data, specifying how much each person in each group have of capita per

[12] See Appendix E – Countries aggregated into income groups for how the countries are classified by the World Bank.

day. This is also different from the Eurostat database, where the income quintiles are based on national groupings and not global income distribution. One must therefore be careful not to compare the lowest income share in one country from the WB with the lowest income quintile in another from Eurostat as they are not based on the same monetary ground.

3.2.3 *Eurostat, USA and Australia expenditure surveys*

Eurostat provides household consumption expenditure data for all EU countries, Candidate Countries, EFTA countries and other countries on an ad-hoc basis (Eurostat, 2017), resulting in values for a total of 38 countries. However, as Kosovo is treated as an own state in Eurostat but not in Eora26, it is eliminated for further analysis, leaving 37 countries for consideration.

The data in Eurostat is collected by each country's national statistical offices and is transmitted to Eurostat at different frequencies and made comparable by using a common framework (European System of Accounts). The data is then processed and published with several units of measure, classifications, and other aggregations based on e.g. population, income, demography, etc. For this thesis, it is relevant to extract data both based on consumption category and income group. Eurostat provides consumption expenditure of households by several consumption categories, defined by the Classical Of Individual COnsumption by Purpose (COICOP) classification system, which is further elaborated in Appendix A – COICOP classifications. This data was, amongst others, presented in million local currency (LCU) in current prices, which is the one unit of measure used and converted to current 2010 USD using exchange rates from 2010. However, there were not found any data tables providing data by consumption categories and by income group simultaneously in LCU. Therefore, another dataset was found providing final household consumption expenditure by income group and consumption group, however given in PPS[13]/EUR. Nevertheless, the income group's share of the final household consumption expenditure is assumed to be the same regardless of which unit of measure is used, and the consumption shares of each income group given in the PPS/EUR-dataset is therefore used in the LCU-dataset.

Most countries were represented in both datasets from Eurostat, however, no quintile information was provided for Iceland and Switzerland. To make an estimation of the distribution of household expenditure between the countries' quintiles, the shares of

[13] PPS = Purchasing Power Standard, is an artificial currency unit used by Eurostat, see https://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Purchasing_power_standard_(PPS)

Sweden were used for Iceland and the shares in France were used for Switzerland, this due to the similarities of geographical location and their Gini-coefficient[14] in 2010.

In addition to the World Bank and Eurostat database, two national CES were included: USA and Australia. Both CES were found for 2010 and on a quintile level. For Australia the currency exchange rate from 2010 was used to convert from Australian dollars to USD. Otherwise, the implementation of these two national CES were straightforward, and as both provided consumption levels on a quintile level in addition to being developed countries, they were merged with the Eurostat CES resulting in a common group called "EUA" (Eurostat, USA, Australia).

3.2.4 *Limitations by using CES*

There are several challenges connected to using consumer expenditure surveys in an EE-MRIO analysis.

The general quality of the data provided by EUA and the World Bank may differ quite much. The structure of the national surveys and their reach amongst the population depends much on monetary factors as well as locational factors. The area where a national CES reaches, may be highly affected by the level of urbanization and level of persons living in rural areas. People living in rural areas may be hard to reach as the means of and access to communication tools may be limited, thus making those underrepresented in the survey results. This can be troublesome for those countries having a large share of their population in rural areas and can then obviously raise some issue when analyzing the poor, as they are often found in rural areas without much access to general communication.

The time-lag between the surveys can also provide some inaccuracies. The World Bank consumption database, which provides the consumption data for the developing countries, have the largest time-span between the surveys utilized. Since doing national consumer surveys are both time consuming and expensive (Balestra et al., 2018), the frequency of conducting surveys is very different between the countries included. E.g. the World Bank used CES from 1996 (Djibouti), 2000 (Guatemala) and 2003 (Chad). It can be seen in their overview[15] that many countries have not conducted CES since the early 2000's, while for Eurostat, most countries conduct CES annually (or even more often). In highly developed countries the statistical system of the country is often at an adequate level, whereas in many developing countries they still lack the structure

[14] Gini-coefficients: Switzerland 0.296, France 0.298, Iceland 0.257 and Sweden 0.255. Extracted from Eurostat: *http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di12*

[15] http://datatopics.worldbank.org/consumption/detail, under "Sources of data"

and resources to carry out proper statistical analyses on a regular basis (Balestra et al., 2018).

Higher income can also contribute to less accurate data. It is found that groups with higher income tends to be harder to conduct surveys on due to not wanting to spend time on surveys in addition to not wishing to reveal their full financial situation, which leads to survey bias and generally less responsiveness (FAO and The World Bank, 2018, Keeley, 2015).

3.2.5 Main CES conversion steps taken in this thesis

There are several measures that need to be taken before it is possible to use the CES data in Eora26. The procedure is developed for this thesis, with several sources as inspiration (Scherer et al., 2018, Moran et al., 2018, Hubacek et al., 2017b).

First, the CES' sector groupings need to match the 26 sectors given in Eora26. There are four different sets of CES that need to be converted, or manipulated, into matching the 26 sectors in Eora, therefore it was necessary to run four different processes. Fortunately, the principles behind all four are the same. A so-called bridging matrix was constructed for all CES which allocates parts of each sector in the CES into sectors in the Eora26 database. This means that e.g. a sector called "Food" in a CES might fit multiple sectors in Eora26; "Agriculture", "Fishing" and "Food and Beverages". In some cases, one sector in the CES fits perfectly into a sector in Eora26, which makes the bridging straightforward. In other cases, there may be several CES sectors that match one sector in Eora26, in which the bridging is straightforward as well. Yet, there are some cases, as given in the example above, where one sector in the CES needs to be split. There is no perfect way to obtain a fully fair distribution of this as the description of all the sectors are complex, however, it is possible to do some assumptions. The approach taken in this thesis was to find the share each matching sector in Eora26 had with the total final demand of all the other matching sectors, and then decide a bridging coefficient based on this. To do this, first a group of countries from each CES were taken, where the countries were selected with respect to two things; (1) the countries should represent all continents, and (2) there needs to be a mix of developed and developing countries. For Eurostat's CES, geographical locations were taken into consideration as well. To explain the process further in the simplest way, an example taken from the thesis is used. The process repeats itself for all CES and sectors.

To decide the bridging coefficients for the World Bank database, the countries chosen from Eora that matches the countries in WB were grouped together. After they were grouped, the average final demand for each sector *given in Eora26* was calculated. After this, the sectors in WB that needed to be split into different Eora26-sectors were grouped together. For example, see Table 4 below.

Table 4: Example of a sector in WB that needs to be split into different Eora26 sectors

World Bank sector		Relevant Eora sectors
"Energy"	Can be matched to	*"Electricity, gas and water"*
		"Mining and quarrying"

In this table, the relevant Eora sectors are classified. After they are found, the total shares for each sector is calculated based on their combined total, where EGW = *electricity, gas and water [$]*, and MQ = *mining and quarrying [$]*.

$$Share\ EGW = \frac{\text{"Electricity, gas and water"}}{\text{"Electricity gas and water"} + \text{"mining and quarrying"}} \tag{6}$$

$$Share\ MQ = \frac{\text{"Mining and quarrying"}}{\text{"Electricity gas and water"} + \text{"mining and quarrying"}} \tag{7}$$

If we then get *share EGW = 0.1* and *share MQ = 0.9,* this would give a bridging coefficient for the "electricity, gas and water"-sector of 0.1 and for the "mining and quarrying"-sector a bridging coefficient of 0.9.

Secondly, as mentioned earlier, the World Bank database consist of four defined income groups while the EUA-database has divided the consumption into quintiles. This means that the two databases can't be merged, thus making it necessary to do two separate analyses. The alternatives were to either make an effort to linearly interpolate the quintiles into four income groups, however, this would not be comparable to the World Bank's income groups since they are defined by specific income levels (and unequal population shares), while the quintiles are made up of equal shares of the population and not on monetary levels. Second, one could manually take all World Bank data and make quintiles, however, this is thought to be an extremely time-consuming task and not in the scope of this thesis. Nevertheless, such a database would be helpful for further work, and should be something to consider doing further work on. Therefore, each income group and quintile were assessed separately for the two databases, giving nine new final demand matrices.

Thirdly, the data from the different CES needs to be made comparable for further analysis through having the same size structure. The Eora final demand matrix consist of 189 countries plus a "statistical differences"-country. Each country has six different final demand categories, making the total column size 1140. However, in this thesis, only the final household consumption demand will be assessed, thus excluding the other five categories and resulting in a column size of 190. Next, there are 26 sectors given in

Eora and one can find information of the inter-country sector flows for each country in the same column, making the row size of the final demand countries*sectors. However, the “statistical differences”-country does not have any exports to other countries thus making the last row of the final demand matrix only consist of zeros. These facts result in the final demand matrix in Eora being a (26*189+1)x190, or (4915x190), matrix.

3.3 Scenario analysis

Recall that part of the objective of this master thesis is to get a deeper understanding of how eradicating poverty and reducing inter- and intra-country inequalities will affect the global land use, material use and carbon footprint. To meet this objective, three main what-if scenarios are set up: (1) poverty is eradicated, (2) inter-country inequalities are reduced, and (3) intra-country inequalities are reduced. All scenario calculations can be found in the attached Excel-files, while a summary of all the main results are given in the Excel-file “HeidiMaster_Results”. The analyses in this will further be conducted as follows.

Firstly, the levels of current footprint inequalities are calculated. The objective of this is to get an understanding of the inequalities’ status quo, both on an inter- and intra-country level. However, these results will not be directly relevant with answering the research question but rather give an indication of where the inequalities that are most stressing to reduce lies.

Secondly, there is run a scenario where poverty is eradicated. To do this analysis, the average consumption level of the low-income group was calculated and multiplied with the population of the lowest-income group, thus replacing the average per capita footprint level of the lowest-income group with the average per capita footprint for the low-income group. The scenario assumes that the lowest-income group will have the same consumption structure and level as the low-income group, which will in practice not necessarily be the case. It is further assumed that all those living in extreme poverty are found in the World Bank countries and if there are any living in extreme poverty within the EUA countries, it would be a marginal amount compared to the number of extremely poor in the WB countries.

Thirdly, a regression analysis is conducted. This is explored to get information of how and if the different footprints are correlated to GDP. The national total GDP was found and divided on the total national population to make an estimation of the average GDP/cap for each country. For the footprints, the results obtained from the first scenario were used.

Lastly, three scenarios of reducing inequalities are explored. The first on reducing inter-country inequalities by using current consumption levels, the second on reducing inter-country inequalities by redistributing current global footprints, and the third on reducing intra-country inequalities by redistribution. There were additionally four scenarios run for the inter-country inequality reduction scenario based on current consumption levels. In these scenarios, the countries are grouped together based on the World Bank's country-income classification system. The average per capita footprint of these country-groupings was calculated, and followingly, all countries were set to consume all four consumption levels to see the change in global footprint levels if all had the same per capita footprints. The inter-country inequality- and intra-country inequality reduction scenarios redistributes the current total footprint levels (globally and nationally, respectively) equally between the countries or income groups relative to their population share, thus making all have the same per capita footprint levels between and within the country.

4 Results

In this chapter, the results of this thesis are presented. In section 4.1, the current environmental footprint inequalities are shown, both on inter- and intra-country levels. In section 4.2, the consequences of eradicating poverty and lifting the consumption level of the poorest are presented, for both the WB and EUA countries. The correlation between the footprints, i.e. biomass, construction material, fossil fuel, GHG, ore and crop and pasture area, and GDP is given in section 4.3. At the end of the chapter, sections 4.4 and 4.5 present the environmental consequences of reducing both inter-and intra-country footprint inequalities in and between the WB and EUA countries.

4.1 Levels of footprint inequality

4.1.1 Intra-country footprint inequalities in WB countries

Figure 5 shows the inequality between the four different income groups in the developing countries for all footprint categories. It is based on the weighted average per capita footprint level of all countries in each income group, with the total per capita average of all income groups and countries combined displayed as a red line.

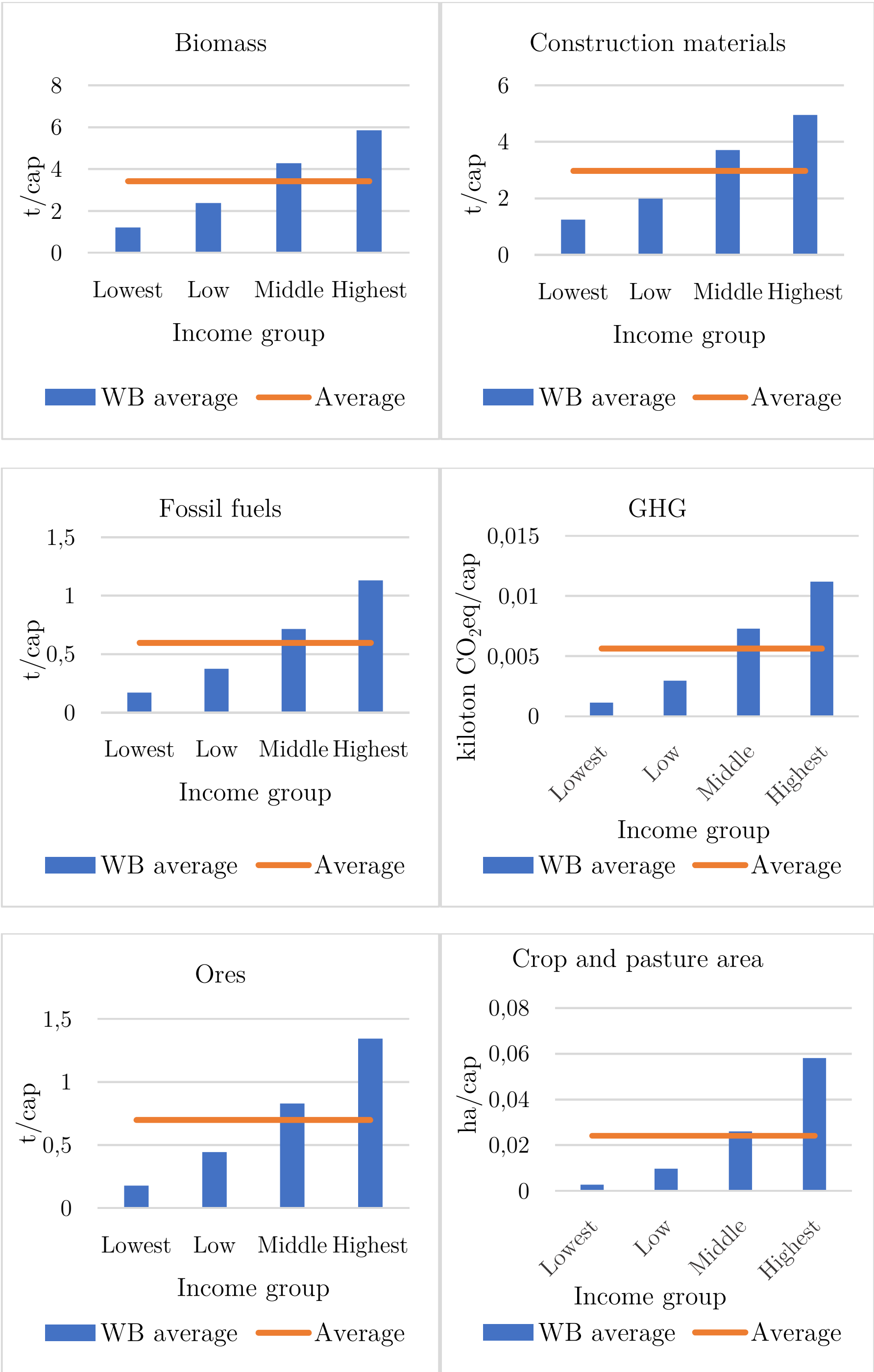


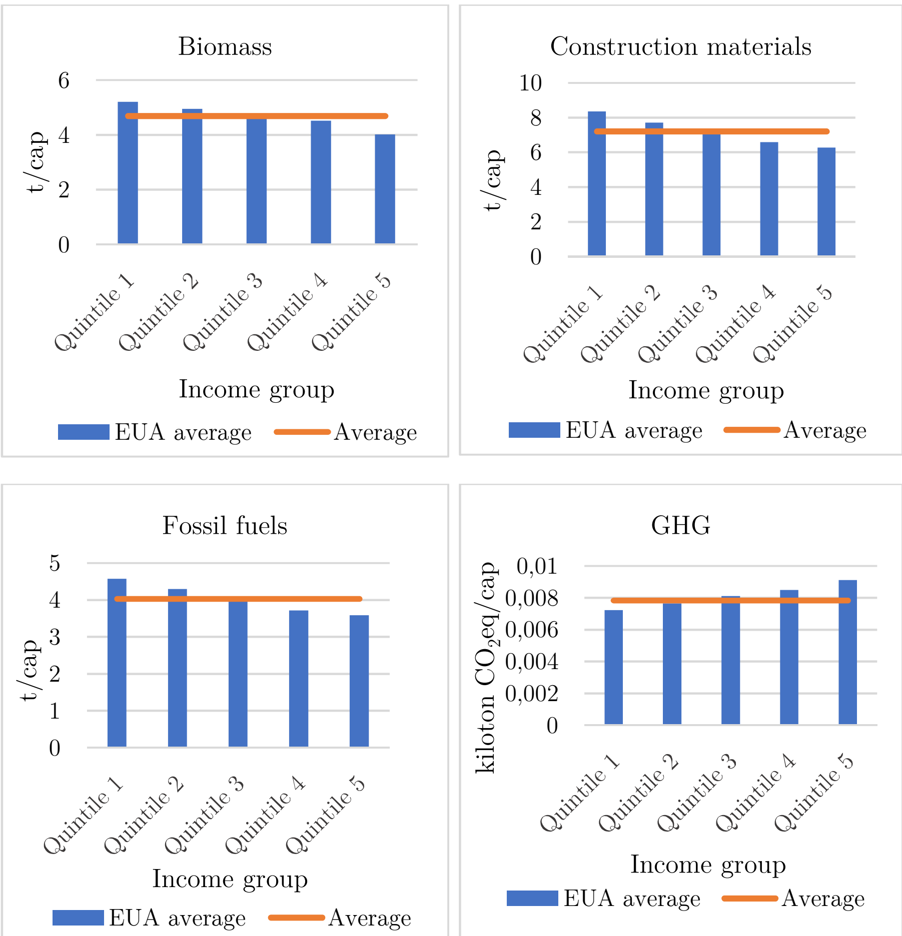
Figure 5: The six figures above show the average per capita biomass-, construction material-, fossil fuel-, GHG-, ore- and crop and pasture area footprints of each income group in the developing countries and the corresponding average footprint

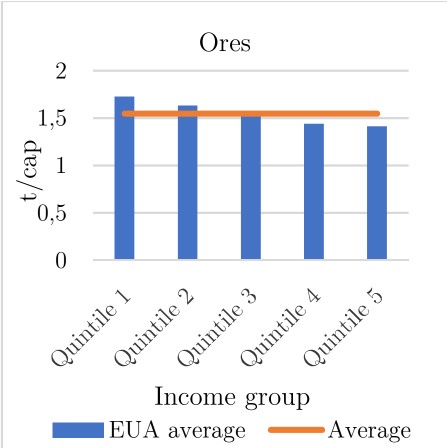
The general trend is that the highest income group on average has three times or more the footprint per capita than the lowest-income group. The middle-income group generally has footprint levels above the average footprint line, while the low- and lowest-income group always has a footprint level well below the average. The lowest inequality can be found in the biomass and construction material footprints, while the highest level of inequality is seen in GHG, fossil fuels and crop and pasture area.

In all six footprint categories, there are certain countries that drive the footprint inequalities more than others. For the biomass footprint, the least unequal countries are Brazil, China, Albania, Bosnia, El Salvador and Malawi. For construction materials, ores and fossil fuels, there are generally high inequalities in all countries, however Armenia, Honduras, Egypt and Burkina Faso stand out as particularly unequal. The GHG footprint is the most unequal of the footprints and all countries have in general high inequality levels here. However, a few countries particularly stand out with high inequality levels, such as Ethiopia, Yemen, and Gambia. For crop and pasture area, Nepal, Ethiopia, Ghana, Chad and Zambia have the largest inequalities.

4.1.2 *Intra-country footprint inequalities in EUA countries*

Figure 6 shows the inequality between each income quintile in all EUA countries. It is based on the weighted average per capita footprint level in each quintile for all countries combined. The red line represents the average per capita footprint level per capita for all quintiles, and for all countries.





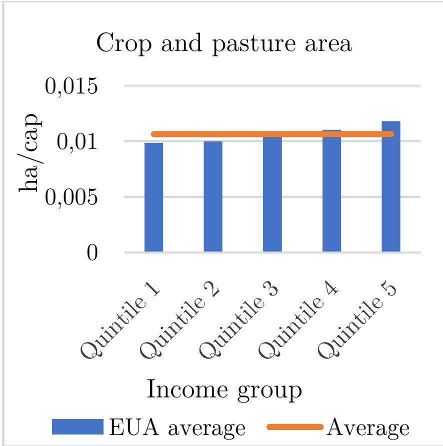


Figure 6: The six figures above show the average per capita biomass-, construction material-, fossil fuel-, GHG-, ore- and crop and pasture area footprint of each income quintile in the EUA-countries and the corresponding average footprint

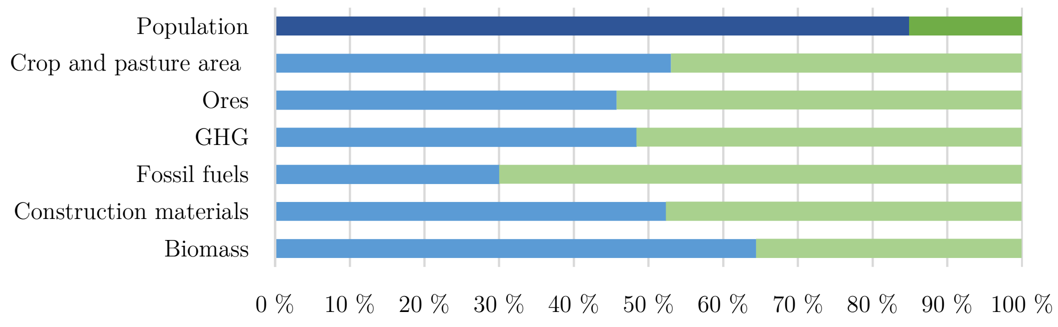
Generally, one can see that the average footprint inequalities in the EUA countries are much lower than for the WB countries, also, the figures shows marginally different footprint levels. However, the first quintile has in in general the highest footprint level per capita, except for GHG, where the fifth quintile has the highest footprint level.

When looking further at the results, one must note that the per capita footprint values are the average of all countries included in the EUA-group and naturally, the inequality levels will differ between the countries. When assessing the country-specific values the footprint levels vary quite much. USA has for all footprint categories a much higher level in the fifth quintile than the first quintile, especially for GHG and crop and pasture area where the fifth quintile need to reduce their footprint by 50% and 47%, and the first quintile must increase by 164% and 121%, respectively, to reach the average footprint level, i.e. the red line. There are only three countries in the EUA-group that have on average higher footprint levels in the fifth quintile than in the other four quintiles for all footprint categories: Australia, Norway, and USA. The exception is for GHG and crop and pasture area where most countries have the highest footprint in the fifth quintile. When looking at the raw data, it becomes clearer why the first quintile has higher footprint levels in certain footprint categories than in others, as they generally have a much higher consumption in e.g. food and beverages, housing, water, gas and electricity, while the fifth quintile has a much larger transport consumption. It is also worth mentioning that the fifth quintile of all countries combined, only spend approximately $1 000 000 more than the first income group within a year, thus implying that the general inequality in consumption is relatively low for the EUA-group.

Take note that for GHG, biomass and crop and pasture area, the highest-income group in the WB countries have higher per capita footprints than the quintiles in the EUA countries. For some countries, that may be the reality, however, the average per capita footprint levels of all countries in the WB country group is most likely not higher that the average footprint levels of all countries in the EUA country group. Even though it was strived to filter out those values that seemed biased in the WB footprints, there are probably occurrences that weren't detected. These values will naturally affect the average per capita footprints.

4.1.3 Inter-country footprint inequalities

Figure 7 shows both country groups' (WB and EUA) shares of the global footprint levels and population.



	Biomass	Construction materials	Fossil fuels	GHG	Ores	Crop and pasture area	Population
WB	64%	52%	30%	48%	46%	53%	85%
EUA	36%	48%	70%	52%	54%	47%	15%

Figure 7: WB and EUA shares of total world footprints and population

From the figure, one can easily see that the inequality levels are high, in favor of the EUA-countries. The EUA countries, having only 15% of the population have a 29-63% share of each of the total world footprint levels. Fossil fuels is the most unequal of the six, and biomass the least unequal.

Figure 8, 9 and 10 show the differences in average footprint levels per capita for the two country groups.

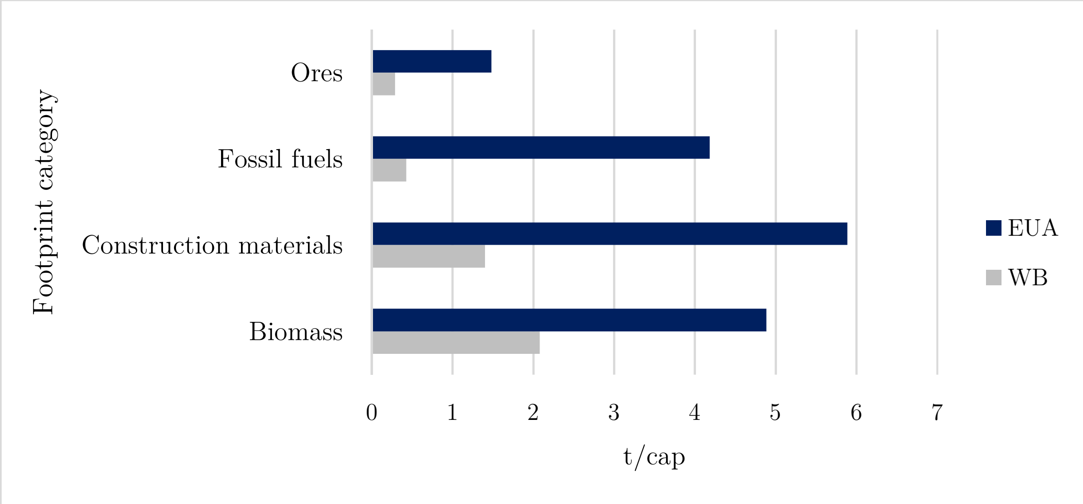


Figure 8: Average footprint per capita for four footprint categories in the EUA and WB countries

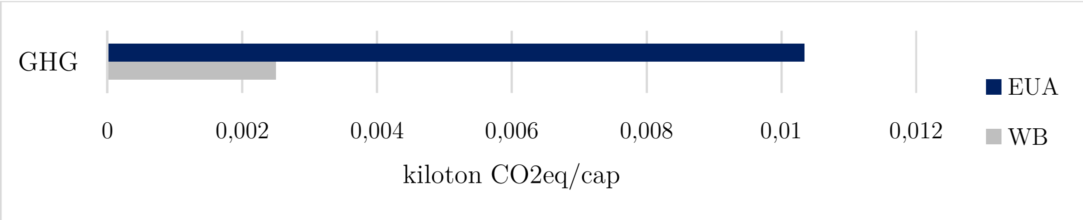


Figure 9: Average footprint per capita for GHG in the EUA and WB countries

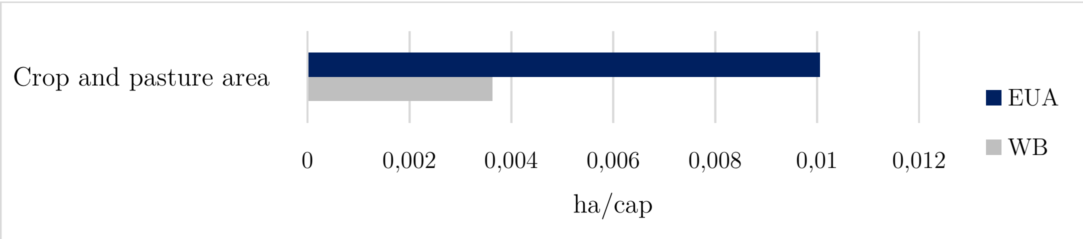


Figure 10: Average footprint per capita for crop and pasture area in the EUA and WB countries

As mentioned earlier, the EUA countries have a higher footprint per capita than the WB countries have. Based on the three figures, one can range the highest to lowest footprint inequality as follows; fossil fuels (9.8 times higher for the EUA), ores (5.1 times higher), construction materials (4.2 times higher), GHG (4 times higher), crop and pasture area (2.8 times higher), and biomass (2.4 times higher).

4.2 Lifting the consumption level of the poorest

Figure 11 show the percentage increase in the total footprint values for the WB countries when the lowest-income group obtain the low-income group's per capita footprint level. Table 5 presents the changes in metric values.

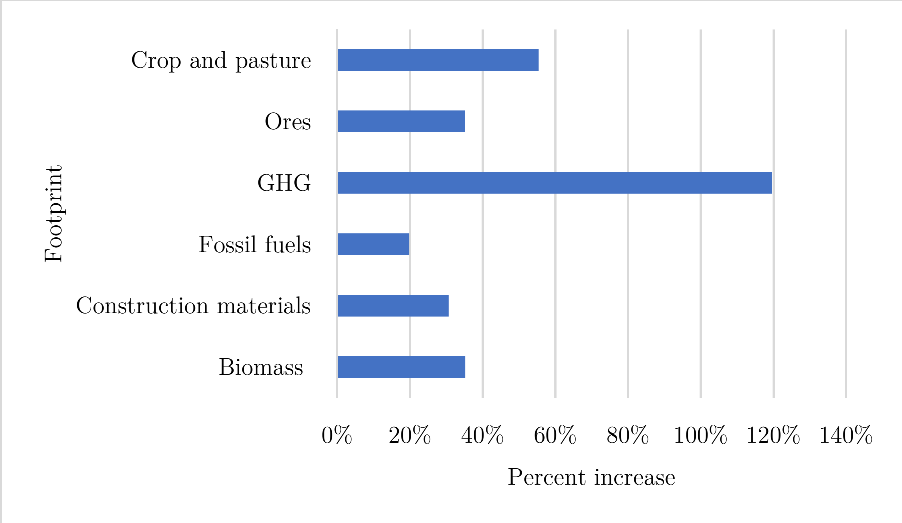


Figure 11: Increase in total footprint level for the World Bank database countries when the lowest-income's per capita footprint value is set equal to the low-income's per capita footprint value

Table 5: Increase in metric values for the total footprint levels for the World Bank database countries when the lowest-income's per capita footprint value is equal to the low-income's per capita footprint value

Footprint	Metric	Current value	Total values moving Lowest to Low
Crop and pasture	ha	18 373 211	28 557 393
Ores	t	1 495 462 335	2 020 779 072
GHG	kt CO_2eq	12 908 760	28 350 108
Fossil fuels	t	2 234 077 082	2 676 159 807
Construction materials	t	7 313 520 855	9 555 588 624
Biomass	t	10 763 302 470	14 555 048 903

Figure 11 and Table 5 show that the impact of making the lowest-income group consume as the ones in the low-income group is of great importance. The largest growth is seen in the GHG footprint, while the lowest increase is seen in fossil fuels. Crop and pasture area also experience a high increase, which may be connected to higher food consumption. Ores and biomass both increase around 35%, and construction materials around 30%.

The differences in total footprints when setting the first quintile's per capita footprint value equal to the second quintile's per capita footprint value in the EUA countries are displayed in Figure 12 and Table 6.

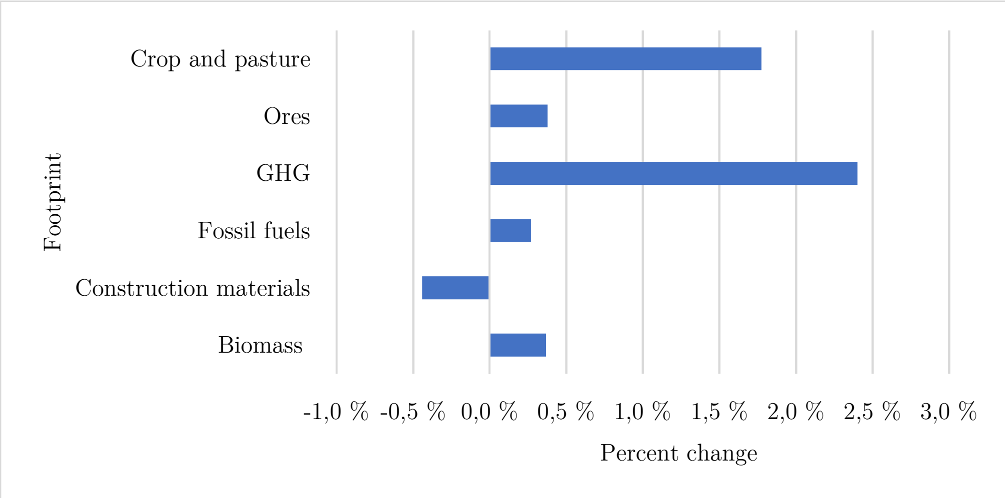


Figure 12: Increase in total footprint level for the EUA-countries when moving the lowest quintile's (Q1) consumption level to the second quintile's (Q2) consumption level

Table 6: Increase in metric values for the total footprint levels for the EUA countries when moving the first quintile's consumption level to the second quintile's consumption level

Footprint	Metric	Current value	Total value moving Q1 to Q2
Biomass	ton	4 521 477 044	4 538 137 799
Construction materials	ton	5 452 466 818	5 428 430 178
Fossil fuels	ton	3 872 066 576	3 882 498 314
GHG	kiloton	9 570 050	9 799 893
Ores	ton	1 370 793 788	1 375 994 766
Crop and pasture	ha	9 315 226	9 480 654

The highest increase can be found in GHG which almost increases by 2,5%. Land use also see a relatively high increase of almost 2%, while the others have marginal changes compared to GHG and land use. Interestingly, there is a small decrease in construction materials. Take note that in section 4.1.2, the average per capita footprints were higher for the first quintile in all footprints except GHG and crop and pasture area. The increase in total footprint levels seen in Figure 12 is driven by the increase in footprint totals for mainly Australia, USA, UK, Czech Republic, France, Iceland, Ireland, Poland, Slovenia, Turkey and Switzerland, which in total account for 64% of the population in the EUA countries.

4.3 Correlation between GDP and footprint levels

I conducted six different regression analyses, one for each footprint, as shown in Figure 13. The figure displays the correlation between GDP per cap and footprint per cap and includes both EUA and WB countries. In Appendix G – Results of regression analyses, further results are presented and will be referred to in chapter 5.

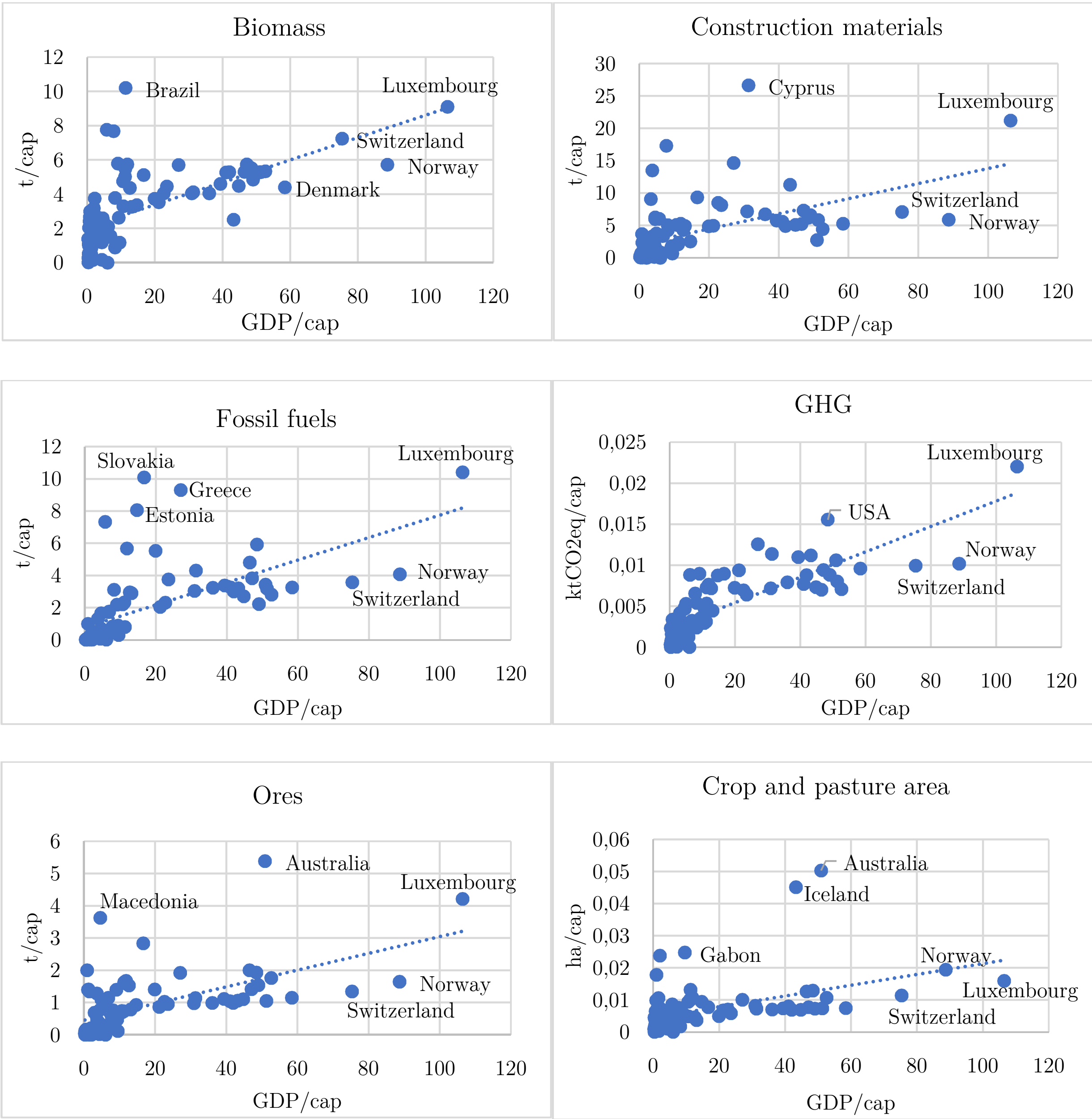


Figure 13: Regression analysis of the correlation between GDP/cap [current 2010 '000 USD] and each separate footprint [per cap]

From the results, the clearest correlation can be observed for GHG, biomass and fossil fuels and GDP. For crop and pasture there is a weak correlation with GDP, however, Australia and Iceland stand out. The highest correlation in all footprints, except for crop and pasture area, is in Luxembourg. Take note that the WB countries are not properly shown in these figures since their footprint levels and GDP are much lower than for the EUA countries. Nevertheless, regression analyses was also conducted for the EUA and WB countries separately, which can be seen in Appendix G – Results of regression analyses.

Table 7 show the calculated correlation and determination coefficients for each footprint.

Table 7: Correlation coefficients between GDP/cap and each footprint per cap

Coefficient	Biomass	Construction materials	Fossil fuels	GHG	Ores	Crop and pasture area
Correlation (R)	0.657	0.539	0.633	0.826	0.595	0.460
Determination (R^2)	0.432	0.291	0.401	0.682	0.354	0.212

For all footprints, the correlation coefficient is moderate to high. The highest is found for GHG followed by biomass and fossil fuels. The coefficient of determination shows that for both construction materials and crop and pasture areas only 20-30% of the variation in the footprints can be explained by the GDP levels, however for GHG, almost 70% can be explained by the level of GDP. For biomass, fossil fuels and ores, the level of determination is moderate, as between 35-43% of the footprint can be explained by the GDP.

4.4 Consequences of reducing inter-country inequalities

4.4.1 Reducing inter-country footprint inequalities by using current per capita consumption levels

I now move on to show the results of four different scenarios where all countries are set to consume as the average consumption level found in four different country groups. The four country groups are defined by the World Bank as: low-income, lower-middle income, upper-middle income and high-income, and is a concept used to classify a country based the average income levels within that country. An overview of which group each country belongs to is found in Appendix E – Countries aggregated into income groups. The average footprints of each country group were calculated and then multiplied with the population of *all* countries to find what the world total footprint value would be in the four different scenarios.

Table 8 shows the global footprint values when all countries have a household income level equal to the average level within the different country groupings.

Table 8: Total global footprints when all have the same per capita footprint level. The four different per capita footprint levels are the per capita averages found within each of the four country groups; high-income, upper-middle income, lower-middle income and low-income countries.

Consumption level	**Biomass**	**Construction materials**	**Fossil fuels**	**GHG**	**Ores**	**Crop and pasture area**
	Gt	*Gt*	*Gt*	*Gt CO_2eq*	*Gt*	*ha*
High-income	30,0	45,1	26,3	5,6	9,5	69 659 190
Upper-middle income	17,8	22,6	7,0	2,2	5,8	60 674 976
Lower-middle income	11,2	6,4	1,4	1,8	2,1	50 391 819
Low-income	8,2	3,5	0.2	0,9	1,0	34 659 819
Current world total	**15,4**	**12,8**	**6,1**	**2,3**	**2,9**	**28 258 086**

If all consumed as the high-income countries, the footprints would at least double. For fossil fuels, the footprint would be four times the current value, and for ores three times the current value. For both lower-middle- and low-income consumption levels, all footprint values would be below the current world total.

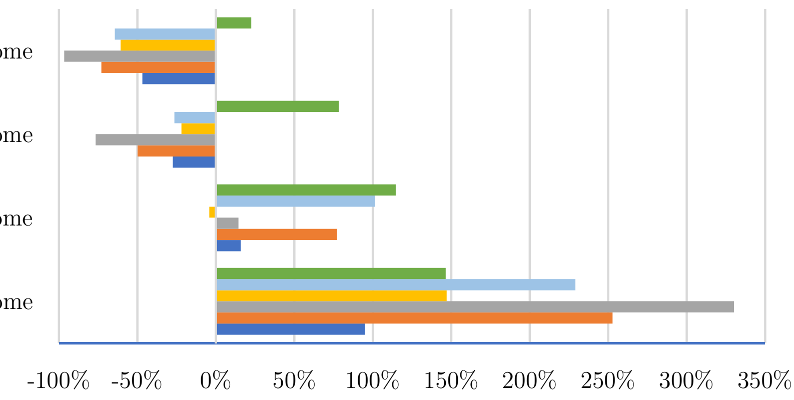
Table 9 shows the difference of the total footprints between each income-scenario. The difference in this table is defined as the total increase in value when moving from one scenario to the higher scenario, e.g. when moving from the upper-middle income group to the high-income group, the footprint value for biomass will increase by 12,2 Gt.

Table 9: Total footprint difference between the four different consumption level scenarios

Difference in scenarios	**Biomass**	**Construction materials**	**Fossil fuels**	**GHG**	**Ores**	**Crop and pasture area**
	Gt	*Gt*	*Gt*	*Gt CO_2eq*	*Gt*	*ha*
Upper-middle to High	12,2	22,4	19,3	3,4	3,7	8 984 215
Lower-middle to Upper-middle	6,7	16,2	5,6	0,4	3,7	10 283 102
Low to Lower-middle	3,0	3,0	1,2	0,9	1,1	15 732 053

For most footprints, the largest increase is experienced when moving from the upper-middle income consumption level to the high-income consumption level. The exception is for crop and pasture area, where the largest increase is seen from low-income consumption to lower-middle consumption. Additionally, the ore-footprint increase just as much from the lower-middle income to the upper-middle income consumption level.

Figure 14 shows the relative change of each footprint in all four scenarios.



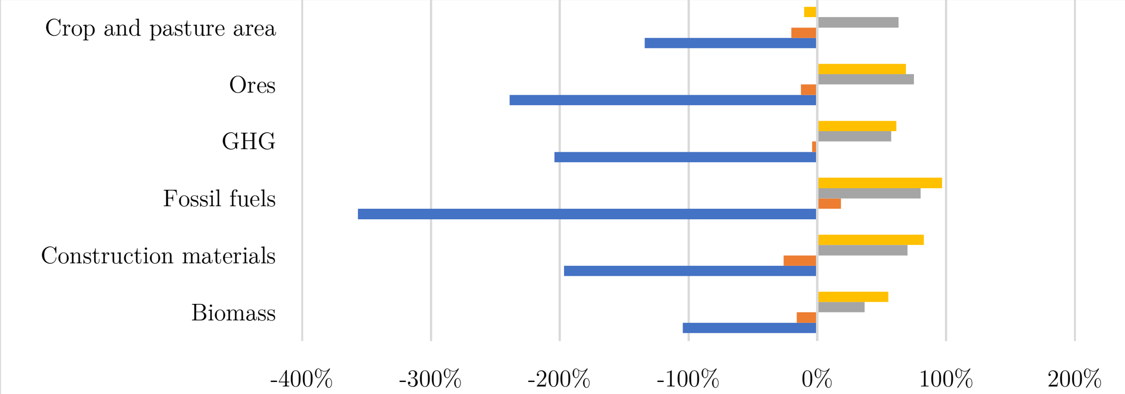
	All with High-income	All with Upper-middle income	All with Lower-middle income	All with Low-income
Crop and pasture area	147%	115%	78%	23%
Ores	229%	102%	-26%	-64%
GHG	147%	-4%	-22%	-61%
Fossil fuels	330%	14%	-77%	-97%
Construction materials	253%	77%	-50%	-73%
Biomass	95%	16%	-27%	-47%

Figure 14: Percent increase or decrease in total footprint values for the four different consumption scenarios compared to the current world total footprint.

The only footprint that increases in all scenarios is the crop and pasture area, which in the low-income scenario increases by 23%. This increase is mostly due to a very high increase in certain countries; Bangladesh (1526%), Burundi (499%), India (542%), Iraq (479%), Sri Lanka (725%), Rwanda (380%) and Vietnam (422%). What characterizes the countries with the highest footprint growth, not only in crop and pasture, but also in general, is that they either have an average income well below the low-income line of $996/cap/year, or that they have an average income over this line, but a high level of inequality.

4.4.2 Reducing inter-country inequalities by redistributing current global footprints

Figure 15 show the consequences in the per capita footprint levels for a person living in the different country-groups when the current global footprint levels are redistributed equally. In this scenario, the global footprint level is redistributed to the country groups relative to their population share, i.e. all have now a same per capita footprint.



	Biomass	Construction materials	Fossil fuels	GHG	Ores	Crop and pasture area
Low-income	55%	83%	97%	61%	69%	-10%
Lower-middle income	37%	70%	80%	57%	75%	63%
Upper-middle income	-16%	-26%	19%	-4%	-13%	-20%
High-income	-104%	-197%	-357%	-204%	-239%	-134%

Figure 15: The relative change in per capita footprint for a person living in the four different country groups when the global footprint level is redistributed equally to all

Table 10 present the same results as Figure 15, however given in metric values. The last row shows the per capita footprints when the global footprint value is distributed fairly amongst the country groups, relative to their population share.

Table 10: Metric changes in per capita footprints when all countries have an equal per capita footprint level, based on a redistribution of current global footprint levels

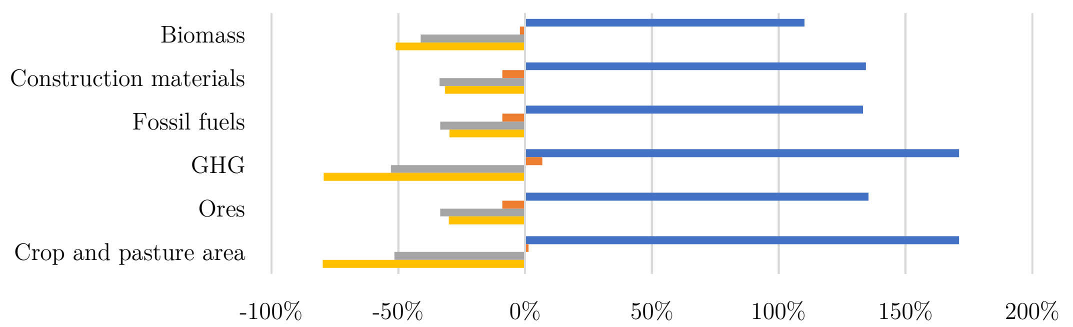
Country group		Biomass	Construction material	Fossil fuels	GHG	Ores	Crop and pasture area
		t/cap	*t/cap*	*t/cap*	*ktCO₂eq/cap*	*t/cap*	*ha/cap*
Current footprint	High-income	5.07	5.99	4.39	0.01	1.57	0.01
	Upper-middle income	2.88	2.55	0.78	0.003	0.52	0.005
	Lower-middle income	1.57	0.61	0.19	0.002	0.12	0.002
	Low-income	1.11	0.35	0.03	0.001	0.14	0.005
New footprint		**2.4805**	**2.0225**	**0.9605**	**0.0037**	**0.4624**	**0.0046**

In Figure 15, it is shown that a person living in the high-income countries will drastically have to reduce its average footprint. The highest reduction is in fossil fuels, where the per capita footprint level is reduced from 4.39 to 0.96 t/cap, as presented in Table 10. There are additionally high reductions (around 200%) in ore-, GHG- and construction material footprints, with the lowest reduction being in biomass, though it would need to be halved. Take note that the low-income and lower-middle income groups can generally increase their per capita footprints. Somewhat surprisingly, the low-income group need to reduce their per capita crop and pasture area footprint by 10%, while the rest of the footprints can be increased by 55-97%. A person living in an upper-middle income country must reduce in all footprints except the fossil fuel footprint, where it is increased by 19%.

4.5 Consequences of reducing intra-country inequalities

In this section, the results I obtained when redistributing the national total footprint level equally amongst the income groups based on their population share are presented.

Figure 16 show the relative change of each income group in the WB countries when the total national footprint levels are redistributed based on each income group's population share.

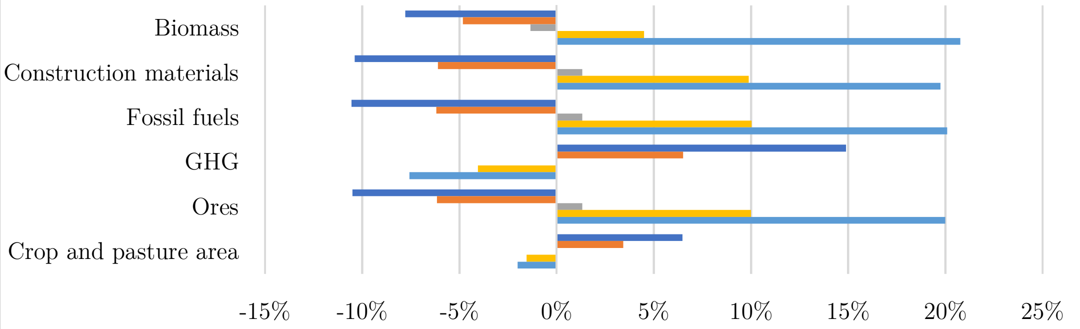


	Crop and pasture area	Ores	GHG	Fossil fuels	Construction materials	Biomass
Lowest	171%	135%	171%	133%	134%	110%
Low	1%	-9%	7%	-9%	-9%	-2%
Middle	-51%	-33%	-53%	-33%	-34%	-41%
Highest	-80%	-30%	-79%	-30%	-31%	-51%

Figure 16: Percent increase or decrease of consumption for each income group for the WB countries when the total national footprints are redistributed

The lowest income group will have a footprint increase of at least double the current level. For GHG and crop and pasture area, the footprints for the lowest-income group will increase by 171% while the lowest increase is in biomass (110%). For the low-income group, the changes in footprint levels are moderate for all footprints, while both the middle-income and highest-income needs to reduce their footprints substantially. The highest-income group have to reduce their crop and pasture area and GHG emissions by around 80%, while the least change is needed in ores and fossil fuels (30% reduction for both).

The relative changes in footprint values for each quintile when the national footprint totals are distributed equally within the EUA countries are shown in Figure 17.



	Crop and pasture area	Ores	GHG	Fossil fuels	Construction materials	Biomass
Quintile 1	6%	-11%	15%	-11%	-10%	-8%
Quintile 2	3%	-6%	7%	-6%	-6%	-5%
Quintile 3	0%	1%	0%	1%	1%	-1%
Quintile 4	-2%	10%	-4%	10%	10%	5%
Quintile 5	-2%	20%	-8%	20%	20%	21%

Figure 17: Percent increase or decrease in footprints for each income group in the EUA when each country has no inequality and all income groups within the country consume equally

In contrast to the WB countries, the fifth quintile, i.e. the richest, have an increase in most footprints, except in GHG and crop and pasture areas, while the first and second quintile in general need to reduce their footprints. This is connected to the first quintile generally having higher footprint levels, as found in section 4.1.2.

5 Discussion

Recall that the scope of this thesis is to analyze the consequences eradicating poverty and reducing world inequalities will have on the carbon-, land use- and material use footprint. Additionally, recall that biomass, ores, fossil fuels and construction materials all are part of the material footprint, GHGs are part of the carbon footprint, while crop and pasture area is part of the land use footprint.

In the following sections, the results of this thesis will be discussed in line with the literature review and research questions. Section 5.1.1 discusses the intra-country and inter-country footprint inequalities for both the WB and EUA countries. Section 5.1.2. evaluates the correlation results, given in section 4.3. Sections 5.1.3, 5.1.4 and 5.1.5 discuss the consequences of reaching Goal 1 and Goal 10 of the SDGs, i.e. eradicating poverty and reducing inter-and intra-country inequalities. Section 5.2 will briefly summarize the interpretations given in 5.1 and define the results' main implications. In section 5.3, there will be a discussion of the policy measures that can be taken to realize eradicating poverty and inequalities based on the results and the literature review. Section 5.4 will present the weaknesses and limitations found in this thesis, and lastly, section **Feil! Fant ikke referansekilden.** will discuss some points for future studies.

5.1 Interpretation of the main findings

5.1.1 Footprint inequalities

Larger intra-country footprint inequalities are found in developing countries than in developed countries. This does not come as any surprise as it was found in section 2.1.2 that income inequalities are wider in the developing countries than in the developed. The carbon footprint is one of the most unequal of all footprints in favor of the rich, both for the developed and the developing countries, yet in very different magnitudes. This goes in line with what Hubacek et al. (2017a) presented in their paper; that the carbon footprint is closely connected to the general income level.

The results show that the developing countries have high intra-country footprint inequality, which is not surprising based on what previous studies on income inequality have found (Alvaredo et al., 2018, Balestra et al., 2018). Nor is it surprising that some of the highest inequalities are in the GHG- and fossil fuel footprints, while the lowest are in the biomass- and construction material footprints. When assessing the raw data from the WB database, as presented in Appendix F – Raw data information, this is somewhat confirmed as it clearly shows which sectors have the highest and lowest levels of consumption inequality. The are several dominant sectors with high inequality that are relevant when assessing why the footprint inequalities are so high for GHG, fossil fuels, and crop and pasture area in the WB countries. These are petroleum, food and beverages, wood and paper, and electrical and machinery. Also, there are several sectors that are relevant when explaining why the biomass- and construction material footprints have lower inequalities than the other footprints, which are construction, agriculture and electricity, gas and water.

The very unequal footprints found especially in the African countries, but also the rest of the WB countries, do suggest that their recent economic growth (Menyah et al., 2014, Rodrik, 2016) has not been distributed equally. However, even though many of the results do seem reasonable both intuitively and based on the literature review (sections 2.1.2 and 2.4.3), it is important to take notice that many of the African countries have not had a proper CES conducted in many years (some in a decade) and even though the World Bank aimed to extrapolate to make all data for both population and consumption represent a common year 2010 (The World Bank, 2019a), this can be a factor that gives some misleading results. This possible source of miscalculation could affect the results in both favor of the rich and the poor, thus making it difficult to interpret how the results would be in practice.

The very equal footprints in the EUA countries may indicate that low income inequality results in low footprint inequality. This is further confirmed when looking at the specific countries and their inequalities, i.e. for USA and Australia, where the trend seems to be that those with higher income inequalities indeed have higher footprint inequalities. However, the results showing a higher footprint for the lower quintiles than for the higher quintiles for the European countries might be a misrepresentation. As mentioned when discussing the limitations of CES, the underreporting from the higher income groups may be an issue when doing this kind of analysis, as one might miss a substantial part of their consumption levels (Steen-Olsen et al., 2016).

As USA and Australia have much higher levels of consumption inequalities than the rest of the EUA countries, it can be interesting to exclude them from the raw data in order to properly assess why the first quintile generally have higher consumption levels than the fifth quintile for the Eurostat countries. When looking at the filtered table in Appendix F – Raw data information, one can easily see why the footprints of the first quintile are higher in most of the footprint categories for the Eurostat countries. The first quintile has the highest consumption of agricultural products, fishing, and food and beverages, which are all related to the crop and pasture- and biomass footprint. Additionally, they have higher consumption levels of electricity, gas and construction materials, and this is reflected in their ore-, fossil fuel- and construction material footprints. The fifth quintile has a larger consumption of transportation and petroleum, which might reflect their high GHG footprint. Additionally, they have a larger consumption of textiles and wood and paper than the first quintile, which can impact their biomass footprint.

Over-consumption and inter-country inequality seem to go together when assessing the total footprints rich countries have compared to the poorer countries. The developed countries having a 15% share of the population should ideally not have more than a 15% share of the total world footprints. However, this share is found to be up to 63% (fossil fuels) with the lowest share being 29% (biomass), see Figure 7. A common result of this kind of footprint inequality analysis is that the developed countries in general have higher footprints than the developing countries, especially for the GHG- and fossil fuel footprints (recall section 2.4.3). This is again confirmed in the results, even though there are other footprints with equally high inequalities. Furthermore, it seems reasonable that the lowest inter-country inequality is in the biomass- and crop and pasture area footprints. This since food and nutritional products are often more prioritized amongst the poor than buying luxuries and other non-necessities (Scherer et al., 2018), in addition to biomass often being used as an energy source in the developing countries (section 2.3.3).

5.1.2 *Is there a correlation between environmental footprints and GDP?*

To analyze the consequences of eradicating poverty and reducing inequalities, understanding how an increasing or decreasing level of income, or GDP, will affect the footprints is essential. The regression analysis results, presented in section 4.3, give an indication of how dependent the footprint levels are on the GDP levels. GHG was the footprint with the highest correlation to GDP, with a determination coefficient of 0.682, which means that well over half of observed variations in the GHG footprint can be explained by changes in GDP.

It is important to reduce this interdependency between the footprints and GDP is important to reduce, especially for those countries that are in the developing phase. There are several countries that have a low correlation between the footprints and GDP, which is an indication that improvements for many countries are feasible. For example, Norway and Switzerland have both very high levels of GDP/cap, but generally low correlation between GDP and the footprints, as is seen in Figure 13 (section 4.3). This low correlation can easily be linked to how the Norwegians and Swiss produce their energy (European Commission, 2018), and is thus not necessarily explained by consumption behavior, but rather intra-country infrastructural factors.

Given in Appendix G – Results of regression analyses are the extended results of the regression analyses. When looking at the regression results for EUA and WB separately, it is clear that the WB countries have slightly more fluctuation than the EUA countries.

However, for fossil fuels, both country groups have high amounts of fluctuation between the countries. For the EUA, the fossil fuel regression analysis shows diverging results for the different countries, as can be seen in Appendix G. A group of countries with relatively low GDP, but with high fossil fuel footprints is shown in the figure. Those countries are mostly East European countries (e.g. Czech Republic, Slovakia, Estonia, Lithuania, Latvia, Greece) where the share of solid fuels and petroleum in the national energy mix is high compared to other European countries (European Commission, 2018). A general observation is that the fluctuations in the regression analysis for the EUA countries are often driven by the East European countries. However, there are exceptions. For the crop and pasture area, Australia and Iceland stand out (Figure 13) with high levels of crop and pasture area relative to their GDP.

5.1.3 *Reducing intra-country footprint inequalities*

When redistributing the current national footprint levels within each country, as done in section 4.5, the results show that the per capita footprint levels will need to be drastically reduced in the developing countries for the most affluent in. Given the WB countries' high footprint inequalities, found in section 4.1.1, this is highly expected. In this scenario, it is generally the lowest-income group that will experience increasing per capita footprints. However, also the low-income group will have an increasing GHG- and crop and pasture area footprint, yet, only marginally. The fact the results given in Figure 16 show that the highest-, middle- and lowest-income groups all need to reduce their per capita footprints in some way, while the lowest-income group can on average increase their footprints by 143%, further illustrates the enormous inequalities found within these countries.

The redistribution of footprints within the EUA countries does not show any drastic changes in either of the five quintiles. Since the intra-country footprint inequalities are generally low (Figure 6) for the EUA countries, the required shift in consumption level for a quintile was not expected to be grand. However, this is relative to each country. As mentioned in sections 4.1.2 and 5.1.1, USA and Australia have higher footprint inequalities than the rest of the EUA countries, in favor of the fourth and fifth quintile. A redistribution of the footprint levels will require high changes for the fifth quintile in USA and Australia as they will on average have to reduce their footprints by 46% and 24%, respectively. Furthermore, another important observation from this analysis is that practically all countries within the EUA-group show a continuously increasing per capita footprint for GHG and crop and pasture area from the first to the fifth quintile. This result can in turn both strengthen and diminish the findings presented in section 4.3, as there was found a strong correlation between GDP and GHG emissions, but a weak correlation between GDP and crop and pasture area.

5.1.4 *Reducing inter-country footprint inequalities*

The environmental consequences of reducing inter-country footprint inequalities depend heavily on the consumption scenario, as presented in Figure 14 (section 4.4). However, the results obtained are in no way shocking for either of the scenarios. Shortly put, the richer everyone becomes, the more the footprints will increase. There are massive differences in total global footprints if all consume as the poorest countries compared to the richest countries.

The global footprint levels will increase drastically if all have the same consumption level as the average person in a high-income country. The results show that all footprints will increase by at least 100%, however most will increase by more. The fossil fuel footprint will see an alarming increase of more than four times the current level, from 6.1 to 26.3 Gt, while GHG increases from the current level of 2.3 Gt to 5.6 Gt. The large increase in the crop and pasture area footprint when raising the consumption level from the average consumption level in a low- to a lower-middle income country group, may not come as a surprise. As mentioned previously, food is a bare necessity for survival and is the main priority when the income level rises for the poorest. The fact that the increase in crop and pasture area decreases as the income level rises does not come as any surprise either, as people generally does not eat excessively even though the income increases.

Reducing inter-country inequalities by redistributing the current footprint levels will in theory mostly affect the local environmental issues, since the global-affecting footprints will not be enhanced. Followingly, the increased material use and land footprint for the low- and lower-middle income countries can affect the countries in terms of inducing higher land-stress and material extractions, as the average per capita footprint will increase by 55-97% in the relevant footprints (biomass, fossil fuels, ores and construction materials). However, to fully understand the probable effects of redistributing the footprints between the country groups the footprints are too complex to discuss in this thesis, as it would include (amongst other factors) national export, import and technology efficiency aspects on a country-specific level.

5.1.5 *Eradicating poverty and lifting the consumption level of the poorest*

Eradicating poverty by itself is not something analyzed in this thesis, since lifting the consumption level of the poorest is a part of the analysis. However, as it was found in previous studies (Hubacek et al., 2017b) that lifting the extremely poor to a consumption level only slightly above the extremely poor-threshold would not induce any high increases in the carbon footprint, there was no need to conduct this analysis again. Additionally, the extremely poor are not the only ones being poor, as the lowest income group defined by the World Bank live with less than $2.97 per capita per day.

It is therefore more interesting to lift this whole group to the consumption level of an average person in the low-income group (which we can recall have between $2.97-$8.44 per cap per day).

As seen in the results (section 4.2), eradicating poverty and changing the lowest income group's per capita consumption level to a higher consumption level for the WB countries will have great effects on the current level of world footprints, and GHG especially. The high increase in GHG might be affected by faults in the data, which will be further discussed in 5.4, but to what degree is hard to define. Nevertheless, having a highly increasing carbon footprint when the poorest obtain more wealth is not unrealistic. Nevertheless, the fact that the carbon footprint increases by over 100% when lifting the consumption of the poor is alarming, as the impacts of higher levels of GHG in the atmosphere can be greatly destructive. Additionally, the high increases in crop and pasture area and biomass will prove difficult in many countries with high land stress, however, not necessarily in all countries, as addressed in section 2.3.4. The main issue with an increases crop and pasture area is that the food demand is the main driver, and as several studies have addressed (FAO, 2009, Kenner, 2015), it can be difficult to meet the increasing food demand when the developing countries evolve economically in addition to experiencing population growth. It is important to further note that this thesis has not included all countries, in addition to several countries being excluded in the analysis due to bad data. Consequently, this can result in the environmental consequences being underestimated.

Further, as it is assumed that there is a very low share of people living in extreme poverty in the developed countries, it consequently makes it reasonable that eradicating extreme poverty and increasing the per capita consumption of the lowest quintile in the EUA countries does not induce any substantial increase in footprints. In fact, as found in 4.1.2, the average per capita footprints of the first quintile are higher for most footprints (except GHG and crop and pasture area) than the other quintiles within the EUA countries. This causes the footprints to decrease for many countries when lifting the consumption levels of the first quintile. Additionally, as mentioned in section 4.1.2, the increase in the footprint levels, seen in Figure 12, is mainly driven by a handful of countries, and will thus not be representative for all EUA countries. Although the changes in footprints for the EUA countries are considerably smaller than for the WB countries, the increases in GHG and crop and pasture area are not to be neglected. The impact a 2.5% increase in GHG footprint will cause heavily depends on what the original value is. Since the EUA countries generally have high levels of GHG footprints, the increase of 2.5% will lead to an increase of 300 000 kiloton CO2eq, which is indeed an influential amount.

5.2 Main implications of the results

The largest increase in global footprints is induced if all consume as the average person in the high-income countries. Given the inter-country inequalities found in section 4.1.3, this is not a surprising finding, although disturbing. This is a result stressing the need to find a new way of consuming.

From section 2.2.2, we know that 42% of the inhabitants in Sub-Saharan Africa (413 million) are extremely poor. This will imply that eradicating poverty and reducing inequalities within these countries will have a considerable effect on the global footprint levels. It is therefore of great importance to ensure their sustainable development and properly working governmental functions. If all these countries were to develop in the same manner the West did during the Industrial Revolution and obtain the same consumption levels and footprints, the world would obviously not be able to handle the increased demand of resources and emissions, as it is already under high pressure. It is estimated by Tukker et al. (2016) that the global average GHG emissions need to stay below 2.5 ton per person (see 2.4.3) to reach the 2-degree target. If the world inequalities are reduced by redistributing the current global footprints, each person would emit approximately 3.7 ton, as presented in Table 10. Consequently, to meet the demand of 2.5 ton per person, we need to have the consumption level somewhere between the level of the upper- and lower-middle income countries, which currently emit 3.0 and 2.0 ton GHG per capita, respectively.

It is estimated that the food sector accounts for 28% of a household's carbon footprint (Scherer et al., 2018). As food production is directly related to land use, the increase in crop and pasture area footprints can generate problems for many countries. As was argued in 2.3.4, increasing land use is one of the main drivers of losses in biodiversity. Without any scenarios with no poverty and no inequalities, but rather with current growth levels in mind, it was estimated in section 2.3.4 that there will be a 60% increase in agricultural production in the next four decades due to a growing population, which will be an issue for the global land use. For countries with a current high agricultural activity, both for domestic and export purposes, like Brazil, an even further increase in land pressure can prove difficult both for the wildlife and the surrounding people. As the results have shown, the consequences if all are to have the same lifestyle as the average person in a high-, upper-middle-, or lower-middle income country, are increased land use footprints of 147%, 115% and 78%, respectively, which will be well exceeding the 60%-scenario presented above.

Additionally, it is predicted in the literature an even further increase in material consumption, i.e. in biomass, ores, fossil fuels and construction materials, which is currently driven by economic growth in China and India (OECD, 2018). As discussed in section 2.3.3, the increasing rate of material extraction is currently one of the most effective drivers of climate change. Additionally, the high exploitation of raw materials has become a major concern for many as most raw materials are non-renewable and have in many cases become a scarce resource (Valéry, 2014, Wiedmann et al., 2015). The increased demand and population growth have been considerable drivers of the reduction in lifespan for many metal reserves, and it is estimated that for every 10% increase in GDP, the material demand will increase by 6% (Wiedmann et al., 2015). The increases in material footprint from eradicating poverty (Figure 11) of around 32%, from 21,0 to 29,0 billion tons only for the WB countries, will then be a highly stressing issue. Additional issues will occur if inter-country inequalities are reduced by lifting the low-income countries to a higher consumption level, where the increase in material footprint will be 226% if all consume as the high-income countries or 56% if all consume as the upper-middle income countries.

If the SDG of eradicating inter-country inequality is to be achieved, the average consumption level we would choose to have is of great importance. As mentioned in section 2.4.4, a redefinition of the high-income countries' expected life standard is essential. However, there are known cases where countries have obtained a high human development index with relatively low emissions (section 2.4.2), and it is found that several upper-middle income countries have obtained high access to food, electricity, sanitation and water with emission levels well below the world average, which is also confirmed in the results of this study (see Table 10). Nevertheless, the other footprints are proven higher for the upper-middle income countries compared to the world average, which is an indication that both the high-income and upper-middle income countries need to reduce their footprint levels in order to obtain a fair distribution.

If the world wants to secure a sustainable development and ensure that poverty is eradicated and inequalities are reduced, some shift in consumption is needed. Based on the results, it has become clear that we either need to have drastic changes in technology which makes it possible to live a comfortable life without damaging the Earth, or the most affluent need to reduce their consumption levels. Both the results of the regression analysis and the arguments addressed in section 2.4.2, indicate that not all need to pollute and consume as the richest countries do to have a satisfactory life. However, to be able to live sustainably would require both governmental influences and behavioral changes, which is further discussed in the coming section 5.3.

5.3 Policy actions

5.3.1 How would it be possible to have consumption regulations?

The consumption and general wealth in the developed countries, especially for USA and the Western-European countries, is found extreme in comparison to the poorest in the developing countries. The overconsumption that has evolved after the Industrial Revolution has put the world in a difficult situation environmentally, and as mentioned in section 2.4, it is the developing countries that will suffer the worst consequences.

As mentioned in section 2.4.4, the concept of having a consumption regulation is per today not a concept that is implemented. Yet, it has been argued feasible by some, but the literature per today is not transdisciplinary nor broad enough to settle on a final conclusion of how this would work in practice. However, there can be observed some version of consumption regulations, e.g. through carbon taxes. One should in the case of implementing carbon taxes carefully discuss who are affected by this kind of regulation, as the very rich often have the means to pay the taxes and continue polluting, while the middle-class has to take the main sacrifice (Otto et al., 2019).

Current climate change mitigation methods have a large focus on reducing the emissions from energy supply, transportation, buildings and by afforestation. However, focus on the sectors highly influenced by the very rich; fashion, real estate, finance and investments (Otto et al., 2019), is lacking. One could discuss the feasibility and efficiency of the current global environmental agreements up and down and would most likely not be able to draw any conclusions anyhow, as the levels of consumption are highly divergent between different countries, as seen in the regression analysis. One of the largest issues concerning such global agreements is the responsibilities that are laid to each separate nation and how that responsibility is further handled. As we know, the global emissions and material uses have grown over the last decades and have continued to grow even after implementation of a handful of international climate change mitigation strategies (section 2.3). The continued growth is seen to be driven mostly by the over-consumption of the rich and developed countries, in addition to the lift in economic status for the developing countries and the emerging upper-middle income countries, as both the literature in section 2.4.3 and results (Figure 7-10) have shown. The upper-middle income countries have the fastest-growing footprints of the four country income groups, and if they reach the same consumption levels as the high-income countries, the consequences can be large. There is a need for green alternatives for energy, transportation and material consumption to ensure that the emerging countries do not have the same impact on the environment as the countries experiencing the Industrial Revolution had. Nevertheless, finding out ways to ensure a lower consumption for the rich is something that needs to be handled simultaneously, by targeting them specifically. Even though targeting the rich may be a controversial statement, their high level of consumption and footprints, as discussed in section 2.4.4 and shown in Figure 14, makes it a necessity to better understand their consumption behavior and find specific ways to reduce the footprints connected to their lifestyle. Ideas that have been presented includes; (1) compulsory restrictions on individual consumption; (2) compulsory restrictions on emissions from households; (3) building code regulations; (4) obligatory installation of renewable energy in households over a certain size (Otto et al., 2019), however this is a subject otherwise undiscussed in the literature.

5.3.2 Feasibility

Several ideas for how the consumption of the richest can be regulated are presented in the previous section 5.3.2. If they are all feasible is as per now unknown as no countries, to my knowledge, have implemented any form of individual regulations for the rich. There are nevertheless several cases where governments have implemented restrictions for businesses; carbon taxes, building regulations, or other sector-specific requirements. However, any regulation for those who have high levels of personal over-consumption is currently lacking. To implement individual regulations can be hard for several reasons: (1) the rich within a country often have connections high up in the political sphere, in addition to having additional power through their wealth. As regulations often comes from a political threshold, controlling the rich can be a challenge for many countries as the rich can be a part of the political scene, e.g. Dubai. (2) to define where the line of over-consumption goes can be challenging. All within a country, but also between countries, have a different perspective on what level of material goods is essential to live a satisfactory life. If one were to first ask an average person in Nigeria what is expected of wealth and consumption in order to live a good life, and then ask the same question to a person in Monaco, the answers would probably belong in two different worlds. To then define an upper-bound for consumption for all, would therefore probably become problematic.

5.4 Weaknesses and limitations

After producing the results, it has become clear that much of the data from the World Bank, where the consumption is divided into income groups, includes some insufficient datapoints. There were on several occasions scenarios where the lowest income group had two-three times the consumption of the highest income group in certain consumption sectors. Additionally, there were cases where the highest-income group had zero consumption in some sectors, e.g. the highest income group in DR Congo has zero transport consumption while it has 46 250 $/cap in health services, Chad's richest have zero energy consumption and 75% of their consumption in transport services. As does Nepal's middle- and high-income groups. Madagascar's richest use 99% of their consumption on food and beverages, while their poorest spend more on housing and transport than the richest. Since the data is not completely trustworthy, it has been hard to do a proper analysis of what consequences one can expect when reducing the intra-country inequalities. To reduce the miscalculations, the most obviously biased countries were eliminated from the analysis[16]. It was difficult to sort out those countries that were too biased, as drawing the line of where a result was too high or too low was challenging. Additionally, the results for some countries seemed reasonable in one footprint category, and not the other. When the value of an income group's footprint seemed unreasonable, the possible reasons were investigated in the World Bank's raw data. Often, there were biased values for transport, and also with health and energy in some cases. In case of biased values only for an income group or for only one footprint, that value was set to zero, i.e. the country was not necessarily deleted from the whole analysis.

Also, this study only focuses on household consumption, which excludes other possible sources of emissions; governmental expenditure, gross fixed capital formation, changes in inventories, and the like. The coverage of air and boat travel is in this study uncertain, as this is not fully specified in the consumer expenditure survey.

This study is a what-if-scenario based study and is therefore in general not meant to give accurate values of the impacts reaching the SDGs will give. Rather, the analysis is meant to give an indication of what one can expect the impacts to be as we come closer to achieving the chosen SDGs for this thesis.

One large assumption in this thesis is that the consumption structure of the bottom and top income levels will stay constant as the inequalities are reduced. It is not obvious

[16] Excluded countries: Cambodia, Cameroon, Congo, Cote d'Ivore, DR Congo, Madagascar, Mali, Mauritania, Mongolia, Montenegro, Morocco, Mozambique, Nicaragua, Niger, Pakistan, Papa New Guinea, Peru, Philippines, Romania, Russia, Rwanda, Sao Tome and Principe, Senegal, Serbia, Sierra Leone, South Africa, Sri Lanka, Swaziland, Tajikistan, Thailand, Macedonia, Togo, Turkey, Uganda, Ukraine, and Tanzania.

that when the extremely poor move up the economic ladder they will have the same footprint as the poor. Neither is it obvious that the very rich will have the same footprint as the economic class below when they reduce their wealth. However, if one accepts that there may be a correlation between wealth and consumption, where more wealth equals more consumption, these assumptions may not yield too much deviation from the actual scenario. Additionally, it seems fair to assume that the poorest income groups have somewhat the same consumption structures and a relatively stable growth, as the largest share goes to basic necessities and not luxuries.

Another assumption is that technology remains constant in all scenarios. This most likely is not the case, however it is difficult to estimate in which direction technology will evolve and which income groups will use which technologies. The data extracted from the MRIO database is based on current emissions, which are affected both by policies and current technology. The differences in technology access in developing and developed countries might differ quite much, however, no information about this is given in the CES nor in the MRIO database and was neither a priority to analyze in this thesis.

Population growth is also a factor that needs to be considered in this kind of scenario, to understand how many will be moved out of extreme poverty each year and how many need to be moved down from the top income group. However, to do this accurately, one would have to know how many are born into poverty and to wealth, and equally how many die from those groups on a yearly basis. One must therefore either; assume that everyone can be lifted out of poverty and inequalities reduced momentarily, or that the rate of population growth is constant and known and from there calculate the average amount of people that need to be lifted out of extreme poverty, and reduce their wealth in each year until the SDGs are supposed to be achieved. Nevertheless, this thesis only analyzes the effects of redistributing and changing the consumption levels of 2010 between the income groups, thus not making the actual population growth relevant. However, this is crucial to discuss if one were to analyze the future impacts of eradicating poverty and reducing inequalities.

Another assumption is that all the extremely poor fall under the lowest-income category of the World Bank, as it is assumed that close to none, or relatively few compared to the developing countries, live in extreme poverty in the developed countries. It is additionally assumed that the lowest-income category of the World Bank has a relatively correct number of persons included in this group, even though an exact count of persons living in extreme poverty can be hard to estimate.

Lastly, the study is conducted for the reference year 2010. This due to the World Bank consumption database giving consumption data only for 2010. The fact that 2010 is almost ten years ago will imply that the results will in some way be outdated, as there has been a massive economic growth over the last nine years. This will to a large degree have affected both the level of consumption and the level of inequalities. However, the thesis aims to discuss the concept of inequality, poverty, consumption and how all can be reduced in general, with no dependency on it being 2010.

5.5 Future studies

One factor that has been an important limitation in this study is the data quality. The trustworthiness of the data for the developing countries has generally been low due to the lack of recent and detailed consumer expenditure surveys in relevant countries. This is however expected as the cost and infrastructure needed for conducting a detailed CES is high. Nevertheless, having data that can be fully trusted will make future studies more persuasive in their conclusions. It is therefore highly important to continuously increase the quality of the consumption data, especially if one desires to draw genuine conclusions of the consequences of eradicating poverty.

Additionally, a study similar to the WB's CES should be exerted on all countries, to make results across all countries more comparable and also include the rest of Latin-America and Asian countries. This would make an even more fair picture of reducing inequalities, as many countries in these continents have high levels of intra-country inequalities. Even though there are many countries included in this analysis, there are many Latin-American countries with high levels of inequality that need to be included in a further analysis to properly define the environmental consequences of eradicating intra-country inequalities, even though some of the most unequal countries are included, i.e. South Africa and Brazil.

This thesis did not focus on future eradication of poverty and inequalities and did not include any scenarios containing the interconnectivity between environmental consequences, population growth, technology changes, policy changes, and eradication of poverty and inequality. Future perspectives would be an important and interesting field to have more studies on, as it is very limited today. Especially the efficiency and probability of meeting both the social and environmental aspects of the Sustainable Development Goals in 2030 should be given more focus.

Another interesting aspect is the policy requirements of reducing over-consumption. This would most likely be most effective to do on a national basis, as all nations have their own policies in place. However, it would be highly interesting to have some research on which ground regulations all nations should have in place in order to suppress over-consumption of the rich within the country. Some papers have already mentioned this (Otto et al., 2019), however, they lack in-depth studies.

Lastly, to further understand the drivers of consumption is essential and should be more in focus. How could one motivate the rich to consume less and more environmentally friendly? Is it possible to ensure that the growing upper-middle income countries make it trendy to consume less, and how could one decouple them from the desire to live in the luxurious way the very-rich currently do?

6 Conclusion

This study provides a deeper understanding of the environmental and social consequences of reaching the Sustainable Development Goals of eradicating poverty and reducing inequalities. Previous studies have focused on how eradicating poverty will affect the carbon footprint, and a few on how reducing inter-country inequalities will affect different footprint categories. However, an in-depth understanding of how poverty, environmental footprints, and inter- and intra-country inequalities are interconnected is lacking. This thesis is therefore meant as a first step into obtaining a more in-depth study of the interconnections. As the SDGs are currently a frequently-used tool when working towards sustainable development, it is essential that also the feasibility of simultaneously implementing these goals are studied. In this thesis, the interconnections between three of the SDGs are analyzed; eradicating poverty, reducing inequalities and mitigating climate change. The choice of SDGs is based on their seemingly contradictory nature; how is it possible to achieve higher welfare and reduce inequalities, while at the same time consume sustainably?

In addition to confirming that the current levels of footprint inequalities are high, especially within developing countries, but also between the developed and the developing countries, several consumption scenarios are explored. The scenarios confirm that the richest, both in terms of persons and nations, carry the main responsibility of reducing their consumption and footprint levels, as their consumption levels are extreme compared to the other's. Furthermore, the results show that eradicating extreme poverty and lifting the lowest income group up to a higher income level will have damaging effects on the environment. Increasing the income level of the poorest lead to large increases in the carbon footprint, both in the WB and EUA countries, which will directly work against climate change mitigation. Additionally, when reducing world inequalities by redistributing the current global footprint levels, the per capita carbon footprint would still be well above the acceptable level if we aim to meet the 2-degree target.

The results further indicate that eradicating poverty and reducing inequalities both lead to an increase in current land stress and overexploitation of material resources with possible consequences both at a local and global level. The results suggest that to ensure sustainable consumption, we cannot consume more than the current average per capita consumption level of the upper-middle income countries; and ideally not much above the lower-middle income countries' consumption level. Conclusively, if the world aims to secure a sustainable development, to ensure that poverty is eradicated and reduce inequalities, a shift in consumption and reduction of over-consumption is crucial.

The results I found in this analysis show that reducing inequalities by lifting the wealth of the poorest is indivisible from eradicating poverty. Additionally, eradicating poverty have a negative effect on the environment in all footprint categories. By redistributing current global footprint levels, thus having no poverty and no inequality, the per capita footprint levels would still be unsustainable. This implies that it is currently impossible to meet the three SDGs simultaneously. However, the results show that if the richest reduce their consumption levels, and all have a consumption level equal to the current consumption level of a person in a lower-middle income country, we would see drastic reductions in global footprints, thus making the three SDGs simultaneously achievable.

A strong correlation between the footprints and GDP was not found, but the correlation seems stronger among the WB countries than in the EUA countries. This may imply that after a country has reached a certain level of average income, the footprint levels become somewhat decoupled from GDP, but this is a highly controversial theory in current literature. Nevertheless, I found that this correlation is highly influenced by the energy consumption mix within each country, thus suggesting that an implementation of renewable energy can have a high impact on the per capita footprints.

The effect of regulation of personal consumption is currently an unexplored area, and needs to be handled with caution, due to possible protests from the richest. Additionally, reducing the consumption levels of people having lived with a high level of comfort their whole life, would either require a shift in the mindset or in technology, which can be a challenge for both the consumers and the policy makers.

The results I found in this thesis show the clear levels of inequalities in the world, in addition to the importance of working towards sustainable consumption. As mentioned in the introduction of this thesis, there are currently over 700 million people living in extreme poverty. If the poor obtain a higher level of wealth, which they indeed should and some already are experiencing, ensuring that they do not consume as the Western world does per today is essential to ensure a future for the generations to come. Consequently, the last concluding remark of this thesis is to stress the importance of doing more in-depth studies of how we can ensure a more sustainable consumption of the richest, in addition to focusing on which technologies and policies are needed to ensure that also the developing countries can evolve sustainably.

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Appendix A – COICOP classifications

COICOP is an international reference classification system used to classify household expenditure consumption purposes (United Nations, 2018). One can obtain COICOP in several digit-levels, however, in this thesis the two-digit level is utilized. Under each two-digit category is a further explanation of what each consumption category entails. Further disaggregation and its explanations, i.e. into four- and five-digit categories, can be found at (United Nations, 2018). Take note that a revised COICOP-system was introduced in 2018 where category 12 is split into two, however, this is not yet found in Eurostat's databases.

01 – Food and non-alcoholic beverages

Food, non-alcoholic beverages and services for processing primary goods for food and non-alcoholic beverages

02 – Alcoholic beverages, tobacco and narcotics

Alcoholic beverages, alcohol production services, tobacco, narcotics

03 – Clothing and footwear

Clothing, footwear

04 – Housing, water, electricity, gas and other fuels

Actual rentals and imputed rentals for housing. Maintenance, repair and security of the dwelling. Water supply and miscellaneous services relating to the dwelling. Electricity, gas and other fuels.

05 – Furnishings, household equipment and routine household maintenance

Furniture, furnishings, and loose carpets. Household textiles and appliances. Glassware, tableware and household utensils. Tools and equipment for house and garden. Goods and services for routine household maintenance.

06 – Health

Medicine and health products. Outpatient and inpatient care services. Other health services.

07 – Transport

Purchase of vehicles. Operation of personal transport equipment. Passenger transport services. Transport services of goods.

08 – Information and communication

Information and communication equipment and services. Software excluding games.

09 – Recreation and culture

Recreating durables. Other recreational goods. Garden products and pets. Recreational services. Cultural goods and services. Newspapers, books and stationary. Package holidays.

10 – Education

Early childhood, primary, secondary, post-secondary non-tertiary, and tertiary education. Education not defined by level.

11 – Restaurants and hotels

Food and beverage serving services. Accommodation services.

12 – Miscellaneous goods and services

Personal care, prostitution, personal effects, social protection, insurance, financial services, and other services.

Appendix B – Dataset overview

Dataset 1:

Name	*Final consumption expenditure of households by consumption purpose (COICOP 3 digit)*
Provider	*Eurostat*
URL	*https://ec.europa.eu/eurostat/web/products datasets/product?code=nama_10_co3_p3*
Unit	*Million LCU*
Groupings	*COICOP consumption classification*

Dataset 2:

Name	*Structure of consumption expenditure by income quintile and COICOP consumption purpose*
Provider	*Eurostat*
URL	*https://ec.europa.eu/eurostat/web/products-datasets/product?code=hbs_str_t223*
Unit	*Per mille PPS/EUR*
Groupings	*Income quintile, COICOP consumption classification*

Dataset 3:

Name	*2010 Expenditure table, Quintiles of income before taxes*
Provider	*Bureau of Labor Statistics*
URL	*https://www.bls.gov/cex/csxstnd.htm*
Unit	*Million USD*
Groupings	*Income quintile, independent consumption classification*

Dataset 4:

Name	*Global consumption database: Household Consumption 2010 by country, sector, area and consumption segment in $PPP (million)*
Provider	*World Bank*
URL	*http://datatopics.worldbank.org/consumption/detail*
Unit	*Million $PPP*
Groupings	*Four income groups, independent consumption classification*

Dataset 5:

Name	*Global consumption database: Per capita consumption by country, sector, area and consumption segment in $PPP*
Provider	*World Bank*
URL	*http://datatopics.worldbank.org/consumption/detail*
Unit	*Million $PPP*
Groupings	*Four income groups, independent consumption classification*

Appendix C – Footprint values per capita

Country	Biomass	Construction material	Fossil fuels	GHG	Ores	Crop and pasture area
Afghanistan	1.07	0.05	0.02	0.0006	0.01	0.0045
Albania	2.26	13.47	1.31	0.0025	0.46	0.0042
Armenia	2.19	0.82	0.16	0.0016	0.69	0.0036
Azerbaijan	1.46	0.49	0.46	0.0023	0.08	0.0025
Bangladesh	1.23	0.36	0.09	0.0007	0.01	0.0003
Belarus	0.00	0.00	0.00	0.0000	0.00	0.0000
Benin	2.55	3.28	0.03	0.0019	0.02	0.0034
Bhutan	3.75	0.91	0.14	0.0000	0.16	0.0073
Bolivia	3.17	0.25	0.11	0.0124	0.20	0.0238
Bosnia and Herzegovina	2.60	6.22	3.44	0.0048	0.78	0.0045
Brazil	10.20	2.35	0.78	0.0053	1.64	0.0132
Bulgaria	1.53	3.33	1.72	0.0032	1.13	0.0033
Burkina Faso	2.03	0.33	0.02	0.0016	0.16	0.0040
Burundi	1.34	0.10	0.01	0.0003	0.04	0.0009
Cambodia	1.26	1.15	0.08	0.0026	0.04	0.0032
Cameroon	1.43	0.21	0.06	0.0034	0.02	0.0039
Cape Verde	1.29	9.05	0.24	0.0017	0.27	0.0033
Chad	1.39	0.03	0.01	0.0022	0.01	0.0178
China	1.70	2.90	0.68	0.0026	0.34	0.0017
Colombia	2.10	0.79	0.56	0.0088	0.27	0.0055
Congo	1.14	0.27	0.11	0.0021	0.06	0.0144
Cote dIvoire	0.28	0.68	0.16	0.0006	0.07	0.0022
DR Congo	1.29	0.10	0.03	0.0021	0.31	0.0086
Djibouti	1.52	0.33	0.09	0.0012	0.08	0.0072
Egypt	1.68	2.21	0.48	0.0023	0.07	0.0027
El Salvador	2.67	2.49	0.22	0.0019	0.17	0.0019
Ethiopia	0.01	0.02	0.01	0.0000	0.00	0.0000
Fiji	2.55	3.26	0.33	0.0024	1.28	0.0053
Gabon	1.18	0.67	0.29	0.0030	0.12	0.0247
Gambia	0.98	0.69	0.04	0.0008	0.03	0.0020
Ghana	0.89	1.50	0.04	0.0004	1.41	0.0018
Guatemala	1.44	1.41	0.18	0.0021	0.25	0.0021
Guinea	2.42	0.08	0.02	0.0019	0.04	0.0065

Honduras	1.70	1.34	0.12	0.0029	0.18	0.0029
India	1.43	0.48	0.15	0.0008	0.09	0.0009
Indonesia	1.89	0.53	0.38	0.0042	0.17	0.0020
Iraq	0.16	0.14	0.05	0.0009	0.02	0.0010
Jamaica	1.58	3.74	0.33	0.0029	4.72	0.0019
Jordan	1.19	1.95	0.44	0.0029	0.17	0.0034
Kazakhstan	5.79	1.43	2.19	0.0090	1.40	0.0498
Kenya	2.10	0.14	0.05	0.0005	0.03	0.0035
Kyrgyzstan	2.99	2.31	0.98	0.0034	2.00	0.0099
Laos	0.77	0.44	0.04	0.0028	1.40	0.0050
Latvia	4.75	1.97	2.20	0.0030	0.69	0.0094
Lesotho	1.55	0.41	0.13	0.0016	0.11	0.0046
Liberia	0.29	0.36	0.02	0.0023	0.12	0.0045
Lithuania	5.49	5.03	5.41	0.0073	1.60	0.0103
Madagascar	0.59	0.58	0.03	0.0022	0.02	0.0055
Malawi	0.54	0.29	0.03	0.0008	0.04	0.0016
Maldives	0.89	4.22	0.45	0.0024	0.30	0.0018
Mali	2.77	1.02	0.02	0.0018	1.80	0.0217
Mauritania	0.89	0.23	0.08	0.0015	0.16	0.0393
Mauritius	7.63	15.83	0.79	0.0065	0.53	0.0076
Mexico	2.63	1.79	0.88	0.0035	0.47	0.0055
Mongolia	2.77	0.57	0.30	0.0083	0.50	0.0892
Montenegro	3.73	13.35	0.70	-0.0099	1.94	0.0152
Morocco	0.79	1.31	0.10	0.0013	0.07	0.0025
Mozambique	0.90	0.36	0.08	0.0017	0.03	0.0083
Namibia	2.02	1.25	0.62	0.0053	1.10	0.0592
Nepal	1.29	0.16	0.03	0.0008	0.02	0.0012
Nicaragua	1.48	0.93	0.07	0.0036	0.20	0.0044
Niger	3.29	0.21	0.01	0.0013	0.18	0.0198
Nigeria	1.42	0.09	0.04	0.0012	0.02	0.0013
Pakistan	2.15	1.09	0.16	0.0014	0.03	0.0014
Papua New Guinea	0.25	0.15	0.07	0.0036	0.75	0.0084
Peru	1.78	0.76	0.22	0.0046	2.38	0.0112
Philippines	1.40	0.51	0.18	0.0009	0.10	0.0009
Moldova	0.16	0.06	0.00	0.0003	0.00	0.0003
Romania	3.58	4.77	2.93	0.0051	0.72	0.0053
Russia	4.96	0.77	0.46	0.0114	0.24	0.0264
Rwanda	1.66	0.44	0.02	0.0006	0.03	0.0012
Sao Tome and Principe	1.38	1.79	0.26	0.0026	0.33	0.0039
Senegal	1.03	1.59	0.05	0.0014	0.05	0.0037
Serbia	7.43	5.47	6.67	0.0011	0.92	0.0078
Sierra Leone	1.24	0.53	0.03	0.0014	0.63	0.0039
South Africa	3.55	1.18	1.05	0.0060	0.88	0.0074
Sri Lanka	0.43	1.39	0.10	0.0008	0.05	0.0007
Swaziland	8.50	1.26	1.44	0.0046	1.24	0.0081

Tajikistan	0.97	0.45	0.13	0.0011	0.19	0.0044
Thailand	2.29	1.51	0.73	0.0024	0.21	0.0022
TFYR Macedonia	2.06	5.94	1.64	0.0047	3.61	0.0050
Togo	1.09	1.24	0.05	0.0017	0.06	0.0027
Turkey	3.28	5.07	2.23	0.0046	0.73	0.0049
Uganda	1.79	0.69	0.03	0.0014	0.05	0.0022
Ukraine	4.58	1.60	1.40	0.0056	0.60	0.0062
Tanzania	0.78	0.22	0.03	0.0035	0.13	0.0036
Viet Nam	1.47	1.03	0.22	0.0018	0.10	0.0011
Yemen	0.43	0.14	0.05	0.0009	0.02	0.0037
Zambia	1.22	0.21	0.09	0.0135	1.23	0.0103
Australia	5.29	2.74	3.42	0.0106	5.38	0.0503
Austria	5.74	7.29	3.82	0.0094	1.41	0.0078
Belgium	4.48	5.07	2.70	0.0073	1.10	0.0069
Bulgaria	1.55	3.38	1.74	0.0032	1.14	0.0034
Cyprus	4.12	26.62	4.29	0.0114	1.13	0.0073
Czech Republic	3.73	4.86	5.53	0.0072	1.41	0.0050
Denmark	4.41	5.26	3.25	0.0096	1.15	0.0074
Estonia	3.37	2.53	8.04	0.0088	0.92	0.0094
Finland	5.30	5.20	4.79	0.0070	2.00	0.0126
France	5.26	5.58	3.25	0.0077	1.04	0.0080
Germany	5.28	4.89	3.00	0.0088	0.98	0.0069
Greece	5.71	14.63	9.29	0.0125	1.92	0.0101
Hungary	3.26	4.91	2.90	0.0044	0.78	0.0037
Iceland	2.50	11.28	3.20	0.0112	1.06	0.0451
Ireland	4.85	6.57	2.21	0.0088	1.53	0.0073
Italy	4.06	6.72	3.22	0.0079	0.98	0.0070
Latvia	5.02	2.08	2.33	0.0031	0.73	0.0100
Lithuania	5.74	5.27	5.66	0.0076	1.67	0.0107
Luxembourg	9.09	21.20	10.40	0.0220	4.21	0.0159
Malta	3.54	4.93	2.04	0.0094	0.86	0.0068
Montenegro	3.80	13.62	0.71	0.0000	1.98	0.0155
Netherlands	5.28	5.81	3.17	0.0080	1.05	0.0073
Norway	5.73	5.85	4.07	0.0102	1.64	0.0194
Poland	4.37	4.29	2.95	0.0072	1.53	0.0046
Portugal	4.05	8.50	2.31	0.0069	1.02	0.0070
Romania	3.78	5.04	3.10	0.0054	0.76	0.0056
Serbia	7.76	6.01	7.33	0.0012	1.01	0.0086
Slovakia	5.12	9.32	10.08	0.0089	2.84	0.0077
Slovenia	4.46	8.15	3.74	0.0064	0.95	0.0059
Spain	4.05	7.15	3.04	0.0072	0.98	0.0082
Sweden	5.33	4.40	2.80	0.0071	1.76	0.0106
Switzerland	7.24	7.07	3.57	0.0099	1.34	0.0113
TFYR Macedonia	2.07	5.96	1.65	0.0047	3.62	0.0050
Turkey	3.29	5.09	2.24	0.0047	0.73	0.0049
UK	4.61	5.73	3.37	0.0110	1.11	0.0073

USA	5.51	6.16	5.90	0.0155	1.91	0.0129

Appendix D - Consequences of no intra-country inequality

The tables below show the increase/decrease of having no inequality within each country.

	Biomass	Construction materials	Fossil fuels	GHG	Ores	Crop and pasture area
Afghanistan	91 %	106 %	95 %	564 %	96 %	305 %
Albania	39 %	14 %	14 %	68 %	15 %	65 %
Armenia	42 %	271 %	270 %	720 %	270 %	393 %
Azerbaijan	64 %	38 %	37 %	216 %	38 %	148 %
Bangladesh	151 %	142 %	138 %	844 %	138 %	413 %
Belarus	-10 %	5 %	5 %	1 %	5 %	-1 %
Benin	114 %	203 %	203 %	281 %	203 %	272 %
Bhutan	58 %	130 %	125 %	2478 %	125 %	219 %
Bolivia	44 %	63 %	63 %	60 %	63 %	76 %
Bosnia and Herzegovina	-24 %	-23 %	-23 %	-24 %	-23 %	-24 %
Brazil	29 %	17 %	16 %	50 %	16 %	40 %
Bulgaria	-4 %	-12 %	-13 %	4 %	-13 %	8 %
Burkina Faso	207 %	1004 %	1003 %	829 %	1003 %	1203 %
Burundi	197 %	170 %	167 %	1065 %	166 %	659 %
Cape Verde	-26 %	-27 %	-27 %	-11 %	-27 %	4 %
Chad	146 %	351 %	327 %	1562 %	328 %	866 %
China	93 %	97 %	97 %	153 %	97 %	123 %
Colombia	38 %	31 %	31 %	42 %	31 %	75 %
Djibouti	39 %	114 %	113 %	254 %	113 %	128 %
Egypt	123 %	230 %	230 %	387 %	230 %	373 %
El Salvador	308 %	40 %	40 %	156 %	40 %	210 %
Ethiopia	128 %	111 %	35 %	3222 %	39 %	1955 %
Fiji	93 %	93 %	92 %	178 %	92 %	218 %
Gabon	56 %	104 %	103 %	158 %	103 %	205 %
Gambia	175 %	391 %	390 %	608 %	391 %	762 %
Ghana	122 %	147 %	146 %	513 %	146 %	500 %
Guatemala	52 %	64 %	64 %	131 %	64 %	136 %
Guinea	61 %	103 %	102 %	169 %	102 %	160 %
Honduras	60 %	627 %	619 %	350 %	643 %	357 %
India	141 %	185 %	182 %	764 %	182 %	371 %
Indonesia	147 %	128 %	118 %	563 %	118 %	344 %
Iraq	55 %	65 %	64 %	150 %	64 %	207 %

Jamaica	31 %	52 %	52 %	117 %	52 %	137 %
Jordan	28 %	55 %	55 %	71 %	55 %	76 %
Kazakhstan	37 %	50 %	49 %	66 %	49 %	52 %
Kenya	295 %	447 %	442 %	507 %	442 %	589 %
Kyrgyzstan	207 %	162 %	162 %	276 %	162 %	245 %
Laos	151 %	105 %	102 %	583 %	102 %	491 %
Latvia	-3 %	-9 %	-9 %	10 %	-9 %	5 %
Lesotho	189 %	176 %	165 %	487 %	164 %	322 %
Liberia	53 %	261 %	261 %	218 %	261 %	258 %
Lithuania	5 %	19 %	19 %	23 %	19 %	22 %
Malawi	173 %	-20 %	-20 %	39 %	-20 %	27 %
Maldives	37 %	75 %	69 %	219 %	69 %	207 %
Mauritius	-6 %	4 %	4 %	9 %	4 %	2 %
Mexico	15 %	34 %	33 %	35 %	33 %	40 %
Namibia	125 %	105 %	105 %	201 %	105 %	205 %
Nepal	176 %	278 %	239 %	1957 %	238 %	7462 %
Nigeria	79 %	162 %	158 %	402 %	158 %	377 %
Moldova	12 %	29 %	29 %	73 %	29 %	67 %
Viet Nam	133 %	139 %	138 %	252 %	138 %	458 %
Yemen	55 %	79 %	75 %	387 %	75 %	240 %
Zambia	297%	422%	418%	1182%	418%	1027%

Appendix E – Countries aggregated into income groups

Income group	Low income	Lower-middle income	Upper-middle income	High income
GNI per cap	**< $996**	**$996-$3 895**	**$3 896-$12 055**	**> $12 055**
Country	Afghanistan	Bangladesh	Albania	Australia
	Benin	Bhutan	Armenia	Austria
	Burkina Faso	Bolivia	Azerbaijan	Belgium
	Burundi	Cambodia	Belarus	Cyprus
	Chad	Cameroon	Bosnia and Herzegovina	Czech Republic
	DR Congo	Cape Verde	Brazil	Denmark
	Ethiopia	Congo	Bulgaria	Estonia
	Gambia	Cote dIvoire	China	Finland
	Guinea	Djibouti	Colombia	France
	Liberia	Egypt	Fiji	Germany
	Madagascar	El Salvador	Gabon	Greece
	Malawi	Ghana	Guatemala	Hungary
	Mali	Honduras	Iraq	Iceland
	Mozambique	India	Jamaica	Ireland
	Nepal	Indonesia	Jordan	Italy
	Niger	Kenya	Kazakhstan	Latvia
	Rwanda	Kyrgyzstan	Maldives	Lithuania
	Senegal	Laos	Mauritius	Luxembourg
	Sierra Leone	Lesotho	Mexico	Malta
	Tajikistan	Mauritania	Montenegro	Netherlands
	Togo	Mongolia	Namibia	Norway
	Uganda	Morocco	Peru	Poland
	Tanzania	Nicaragua	Romania	Portugal
	Yemen	Nigeria	Russia	Slovakia
		Pakistan	Serbia	Slovenia
		Papua New Guinea	South Africa	Spain
		Philippines	Thailand	Sweden
		Moldova	TFYR Macedonia	Switzerland
		Sao Tome and Principe	Turkey	UK
		Sri Lanka		USA
		Swaziland		

		Ukraine		
		Viet Nam		
		Zambia		

Appendix F – Raw data information

These two matrices contain information about the raw data after it was bridged, thus presented in the Eora26 sector categories.

WB consumption levels, all values given in '000 USD/cap				
Sector	**Lowest**	**Low**	**Middle**	**Higher**
Agriculture	0.07	0.18	0.39	0.78
Fishing	0.01	0.03	0.06	0.11
Mining and Quarrying	0.00	0.01	0.02	0.04
Food & Beverages	0.10	0.29	0.63	1.25
Textiles and Wearing Apparel	0.02	0.09	0.27	0.79
Wood and Paper	0.02	0.10	0.27	0.95
Petroleum, Chemical and Non-Metallic Mineral Products	0.01	0.06	0.23	1.46
Metal Products	0.00	0.01	0.02	0.12
Electrical and Machinery	0.01	0.05	0.17	0.92
Transport Equipment	0.00	0.02	0.09	0.56
Other Manufacturing	0.01	0.03	0.08	0.45
Recycling	0.01	0.03	0.07	0.26
Electricity, Gas and Water	0.02	0.08	0.17	0.39
Construction	0.00	0.00	0.00	0.01
Maintenance and Repair	0.00	0.01	0.02	0.07
Wholesale Trade	0.00	0.01	0.02	0.11
Retail Trade	0.00	0.02	0.06	0.34
Hotels and Restraurants	0.01	0.02	0.05	0.10
Transport	0.00	0.01	0.04	0.28
Post and Telecommunications	0.01	0.06	0.22	0.69
Finacial Intermediation and Business Activities	0.00	0.01	0.03	0.31
Public Administration	0.00	0.00	0.00	0.01
Education, Health and Other Services	0.03	0.14	0.39	1.24
Private Households	0.00	0.01	0.02	0.09
Others	0.00	0.01	0.03	0.13
Re-export & Re-import	0.00	0.00	0.00	0.00

EUA consumption levels, all values given in '000 USD/cap					
Sector	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Agriculture	0.34	0.33	0.34	0.34	0.35
Fishing	0.02	0.02	0.02	0.02	0.02
Mining and Quarrying	0.08	0.07	0.06	0.06	0.05
Food & Beverages	2.52	2.51	2.62	2.65	2.86
Textiles and Wearing Apparel	0.59	0.70	0.78	0.89	1.20

Wood and Paper	0.20	0.24	0.29	0.34	0.48
Petroleum, Chemical and Non-Metallic Mineral Products	0.63	0.93	1.19	1.47	1.95
Metal Products	0.04	0.05	0.06	0.07	0.10
Electrical and Machinery	0.39	0.48	0.58	0.71	1.07
Transport Equipment	0.31	0.46	0.59	0.73	0.97
Other Manufacturing	0.05	0.06	0.06	0.07	0.08
Recycling	0.15	0.19	0.24	0.31	0.49
Electricity, Gas and Water	3.45	3.26	3.15	3.18	3.56
Construction	0.55	0.55	0.53	0.53	0.56
Maintenance and Repair	0.36	0.42	0.49	0.56	0.77
Wholesale Trade	0.03	0.04	0.05	0.06	0.06
Retail Trade	0.22	0.25	0.28	0.32	0.36
Hotels and Restaurants	0.65	0.76	0.92	1.09	1.31
Transport	0.45	0.59	0.70	0.81	0.96
Post and Telecommunications	0.40	0.38	0.37	0.36	0.31
Financial Intermediation and Business Activities	0.85	1.09	1.42	1.92	3.18
Public Administration	0.02	0.02	0.02	0.02	0.02
Education, Health and Other Services	1.87	2.18	2.48	2.87	4.02
Private Households	0.02	0.02	0.02	0.02	0.03
Others	0.10	0.16	0.22	0.29	0.48
Re-export & Re-import	0.00	0.00	0.00	0.00	0.00

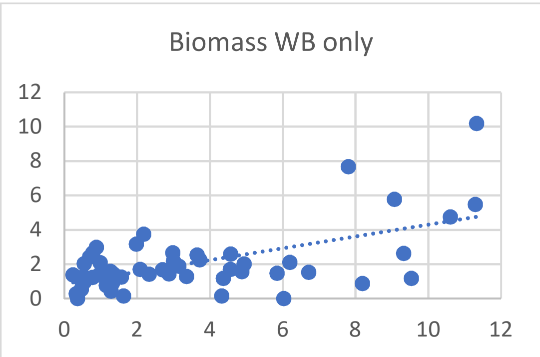
Only Eurostat, i.e. USA and Australia are excluded. All values in '000 USD/cap					
	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Agriculture	0.42	0.39	0.37	0.34	0.28
Fishing	0.03	0.02	0.02	0.02	0.02
Mining and Quarrying	0.11	0.10	0.09	0.08	0.07
Food & Beverages	3.00	2.78	2.64	2.44	2.02
Textiles and Wearing Apparel	0.70	0.79	0.86	0.94	1.02
Wood and Paper	0.17	0.19	0.21	0.22	0.28
Petroleum, Chemical and Non-Metallic Mineral Products	0.56	0.72	0.84	0.95	1.10
Metal Products	0.02	0.02	0.03	0.03	0.04
Electrical and Machinery	0.20	0.22	0.24	0.26	0.32
Transport Equipment	0.27	0.35	0.41	0.47	0.54
Other Manufacturing	0.07	0.08	0.09	0.09	0.10
Recycling	0.02	0.02	0.02	0.02	0.03
Electricity, Gas and Water	4.38	3.85	3.41	3.07	2.65
Construction	0.62	0.54	0.48	0.43	0.37
Maintenance and Repair	0.38	0.41	0.46	0.48	0.60
Wholesale Trade	0.04	0.04	0.05	0.05	0.05
Retail Trade	0.29	0.33	0.34	0.37	0.40
Hotels and Restaurants	0.93	1.08	1.28	1.49	1.76

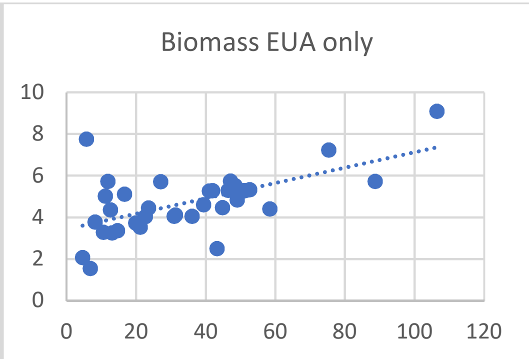
Transport	0.62	0.81	0.94	1.07	1.24
Post and Telecommunications	0.57	0.53	0.50	0.48	0.40
Financial Intermediation and Business Activities	1.12	1.24	1.31	1.40	1.53
Public Administration	0.02	0.02	0.02	0.03	0.03
Education, Health and Other Services	2.00	2.13	2.31	2.47	2.86
Private Households	0.02	0.03	0.03	0.03	0.03
Others	0.05	0.05	0.05	0.06	0.06
Re-export & Re-import	0.00	0.00	0.00	0.00	0.00

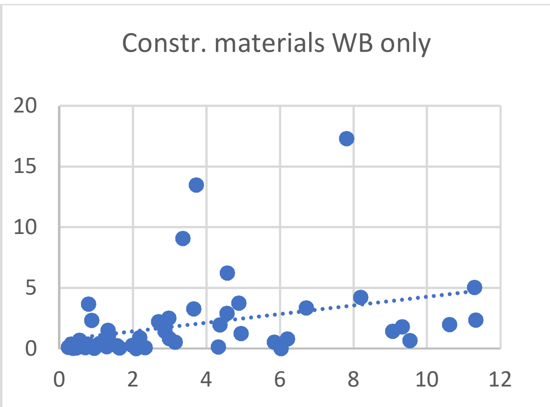
Appendix G – Results of regression analyses

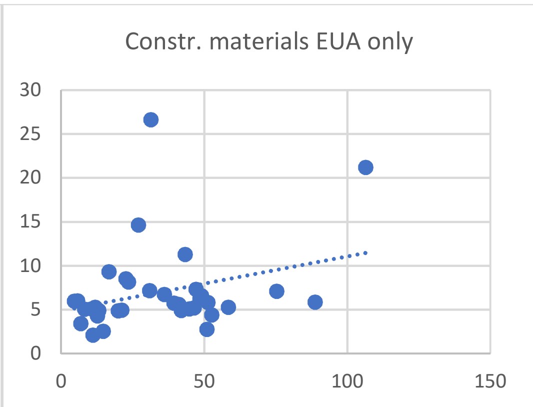
In all figures below, the x-axis is given in ‘000 current 2010 USD/cap (GDP/cap) and the y-axis is the respective footprint per cap. Given in: biomass = t/cap, construction materials = t/cap, fossil fuels = t/cap, GHG = ktCO2eq/cap, Ores = t/cap, and crop and pasture area = ha/cap.

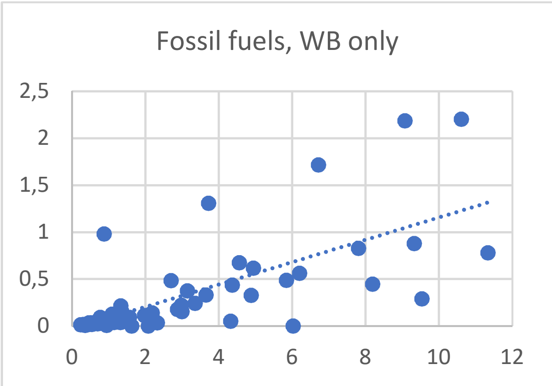
Inter-country

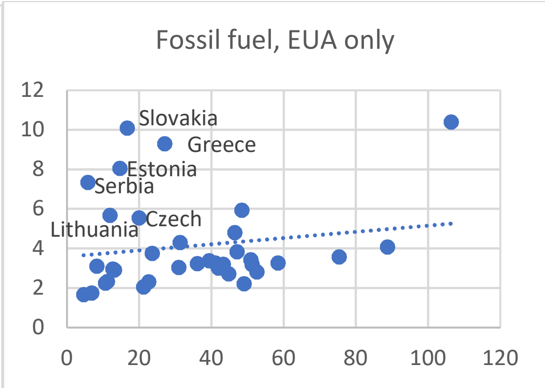


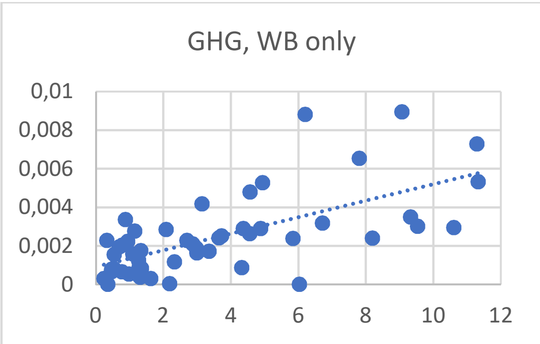


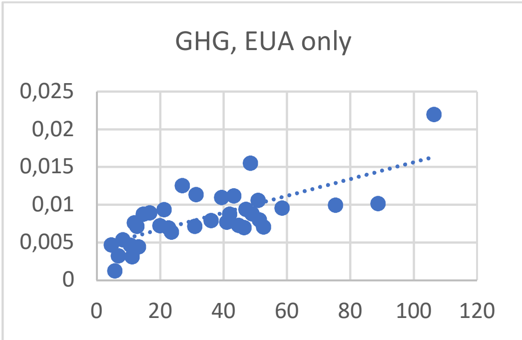


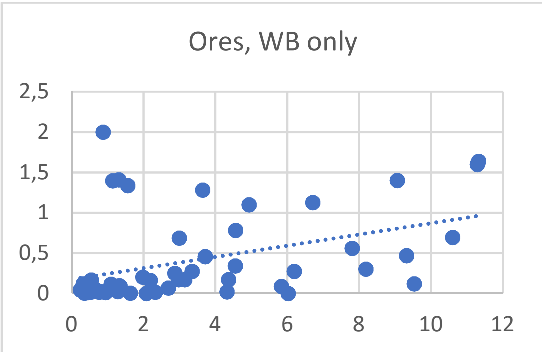


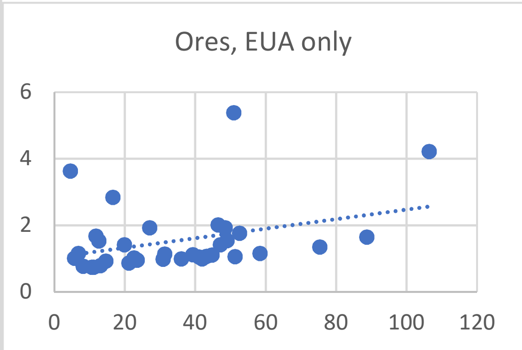

Fossil fuels, WB only
2,5
2
1,5
1
0,5
0
0 2 4 6 8 10 12

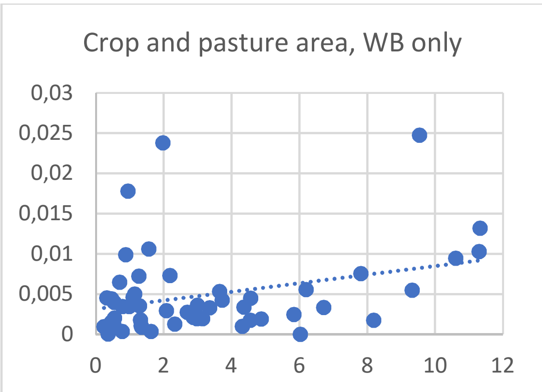

Fossil fuel, EUA only
12
10
8
6
4
2
0
Slovakia
Greece
Estonia
Serbia
Czech
Lithuania
0 20 40 60 80 100 120

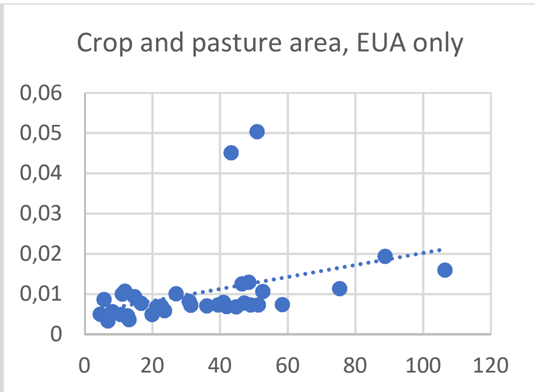

GHG, WB only
0,01
0,008
0,006
0,004
0,002
0
0 2 4 6 8 10 12


GHG, EUA only
0,025
0,02
0,015
0,01
0,005
0
0 20 40 60 80 100 120


Ores, WB only
2,5
2
1,5
1
0,5
0
0 2 4 6 8 10 12


Ores, EUA only
6
4
2
0
0 20 40 60 80 100 120


Crop and pasture area, WB only
0,03
0,025
0,02
0,015
0,01
0,005
0
0 2 4 6 8 10 12


Crop and pasture area, EUA only
0,06
0,05
0,04
0,03
0,02
0,01
0
0 20 40 60 80 100 120

Heidi Snemyr

Understanding the consequences eradicating poverty and reducing world inequalities will have on the environment

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