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Interlinkages of energy SDG 7, poverty SDG 1 and inequalities SDG 10 in the context of the 17 SDGs

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Energy Engineering and Management

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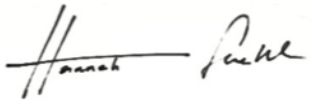
Affidavit

I, Hannah Scheikl, confirm that this thesis is my own work and all the used sources are cited properly. This thesis is for publication at the Instituto Superior Tecnico and is not submitted to another examination board or published elsewhere.



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Date

Abstract

The aim of this thesis is to show interlinkages of access to electricity and clean cooking (SDG 7.1) with poverty (SDG 1) and inequality (SDG 10) reduction in the context of the 17 SDGs. The analysis in Sub-Saharan Africa is an attempt to show interlinkages among the selected SDGs with empirical data in Ethiopia and Ghana.

In both countries access to electricity and clean cooking was improved while extreme poverty was reduced. This implies a likely synergetic interlinkage between the SDG 7.1 and SDG 1. By expanding the perspective towards interlinkages in the context of the SDGs, the MPI (multidimensional poverty index) was explored. Zooming into specific deprivations, the analysis shows in both countries the Food-Water-Energy Nexus could be a helpful tool to meet the SDG 1 target. Moreover, rural areas are identified as the geographical hotspot, with clean cooking accounting for the biggest deprivation.

Due to the lack of data regarding inequalities in Sub-Saharan Africa, only one data point was found during the selected timeframe. Therefore, the findings of this thesis strongly call for more accessible quality data regarding SDG 10. Moreover, findings regarding human development suggest that in Ethiopia and Ghana socio-economic inequalities got reduced. Overall, the findings of this thesis imply that poverty is effected by many other SDGs and that monetary poverty reduction has a synergetic interlinkage with access to electricity and clean cooking. Therefore, effective poverty reduction requires interlinkages assessment rather than assessing poverty in isolated clusters.

Keywords

SDG Interlinkages, Sub-Saharan Africa, energy, poverty

Resumo

O objetivo desta tese é mostrar as interligações do acesso à eletricidade e cozinha limpa (SDG 7.1) com a redução da pobreza (SDG 1) e da desigualdade (SDG 10) no contexto dos 17 SDG. A análise na África Subsaariana é uma tentativa de mostrar as interligações entre os SDG selecionados com dados empíricos na Etiópia e em Gana.
Em ambos os países, o acesso à eletricidade e cozinha limpa foi melhorado, enquanto a pobreza extrema foi reduzida. Isso implica em uma provável interligação sinérgica entre o SDG 7.1 e o SDG 1. Ao expandir a perspectiva de interligações no contexto dos SDG, o MPI (índice de pobreza multidimensional) foi explorado. Analisando as privações específicas, a análise mostra que, em ambos os países, o nexo alimento-água-energia pode ser uma ferramenta útil para cumprir a meta do SDG 1. Além disso, as áreas rurais são identificadas como o hotspot geográfico, com a culinária limpa sendo responsável pela maior privação.
Devido à falta de dados sobre as desigualdades na África Subsaariana, apenas um ponto de dados foi encontrado durante o período selecionado. Portanto, os resultados desta tese exigem fortemente dados de qualidade mais acessíveis em relação ao SDG 10. Além disso, os resultados relativos ao desenvolvimento humano sugerem que na Etiópia e no Gana as desigualdades socioeconómicas foram reduzidas. No geral, os resultados desta tese implicam que a pobreza é afetada por muitos outros SDG e que a redução da pobreza monetária tem uma interligação sinergética com o acesso à eletricidade e cozinha limpa. Portanto, a redução efetiva da pobreza requer uma avaliação de interligações, em vez de avaliar a pobreza em grupos isolados.

Palavras-chave

SDG Interligações, África Subsaariana, energia, pobreza

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List of Figures

List of Acronyms

G

GNI
gross national income, 30, 58, 60

H

HDI
Human Development Index, 30, 31

I

IEA, 38
International Energy Agency, x, xii, 20, 22, 38, 39, 44, 46, 47, 73
IHDI
Inequality-adjusted Human Development Index, 31
IPL
International Poverty Line, ix, 3, 5, 6, 18, 24, 26, 28, 36, 48, 50, 51, 52, 54, 56, 63, 64, 65, 66, 68, 69

L

LDCs
Least Developed Countries, 37
LMIC
lower-middle income countries, 24
LMIPL
lower middle income poverty line, ix, 3, 5, 6, 18, 24, 36, 48, 49, 50, 52, 65, 68, 69
LPG
liquefied petroleum gas, 22, 47

M

MPI
multidimensional poverty index, 24

P

PPP
purchasing power parity, 24, 30, 48, 50, 58, 60

S

SDG
Sustainable Development Goal, i, 3, 12, 13, 18, 20, 23, 28, 37, 38
SDGs
Sustainable Development Goals, 1

U

UMIC
upper-middle income countries, 24
UMIPL
upper middle income poverty line, ix, 3, 5, 6, 18, 24, 36, 48, 49, 50, 51, 52, 65, 68, 69
UN
United Nations, 1

W

WEF
World Economic Forum, 13

1. Introduction, Objective and Methodology

1.1. Introduction

1.1.1. Sustainable Development and the 2030 Agenda

The 2030 Agenda is a framework to address sustainable development for people, planet and prosperity. To address its' universal goal regarding well-being for all people, empowering peace and partnerships are addressed, in the context of leaving no one behind (The Sustainable Development Agenda, 2015). The Agenda 2030 was adopted in 2015 by all Member States of the United Nations (UN) and is supposed to be a 15 yearlong (not legally binding) guideline to fulfil the 17 Sustainable Development Goals (SDGs). The 17 SDGs demonstrate the common universal policy agenda regarding sustainable development and are described in Table 1. They incorporate 169 Targets and 230 indicators, which have been integrated to assess the realisation progress of the SDGs (2030 Agenda, 2015).
Targets and indicators of a SDG are influenced by each other and among all 17 goals (GSDR, 2019). These interlinkages must be identified in order to successfully implement Agenda 2030 (Nilsson M., Griggs D., Visbeck M., 2016). In particular, addressing interlinkages by identifying potential synergy effects and reducing trade-offs within the SDGs enhances a positive basis for decision making (GSDR, 2019).

Table 1 The Sustainable Development Goals (SDGs)
Copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform: https://sustainabledevelopment.un.org/post2015/transformingourworld online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

The Sustainable Development Goals (SDGs)	
Goal 1.	End poverty in all its forms everywhere
Goal 2.	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3.	Ensure healthy lives and promote well-being for all at all ages
Goal 4.	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5.	Achieve gender equality and empower all women and girls
Goal 6.	Ensure availability and sustainable management of water and sanitation for all
Goal 7.	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8.	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Goal 9.	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
Goal 10.	Reduce inequality within and among countries
Goal 11.	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12.	Ensure sustainable consumption and production patterns
Goal 13.	Take urgent action to combat climate change and its impacts
Goal 14.	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15.	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16.	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17.	Strengthen the means of implementation and revitalize the global partnership for sustainable development

1.1.2. Importance of SDG 7,1,10 in the context of the SDGs

In this thesis energy, poverty and inequalities are analysed in the context of the SDGs. Out of the 17 goals, energy (SDG 7) is put in the centre, because it is not only essential to sustainable development, but also actions on SDG 7 are positively pushing the other goals (the United Nations, 2018). The general goal of the Agenda 2030 is leaving no one behind. To meet that scope, ensuring "SDG 10 reducing inequalities within and among countries is necessary". (2030 Agenda, 2015, p. 14) (GSDR, 2019) For that reason, SDG 10 was chosen to be analysed in this thesis. In the Preamble of the Agenda 230 poverty is highlighted as "the greatest global challenge and an indispensable requirement for sustainable development." (2030 Agenda, 2015, p. 3) Due to its' conditional and pressing nature, SDG 1 was selected. Moreover, the Agenda 2030 "calls for action to change our world explaining, we can be the first generation to succeed in ending poverty; just as we may be the last to have a chance of saving the planet" (2030 Agenda, 2015, p. 12).

Energy

The urgent need for climate action is highly interlinked with actions in energy systems. This correlation is implied by the fact that energy accounts for approximately 70 % of world wide's Greenhouse Gases. This includes electricity and heat production as well as transport. Nowadays, the second target of SDG 7 regarding the proportion of renewables, is low in heat production and transport (below 10% in 2016), whereas electricity production is leading the energy transformation (25% in 2016) (GSDR, 2019) (the United Nations, 2019). Moreover,

electricity access is not only crucial for environmental related SDGs that are affected by climate action, it is also essentially correlated to social related SDGs. In particular, electricity access is highly interlinked to poverty by access and affordability of basic services which effect human well-being and human development. Moreover, lack of electricity access limits the creation of economic resources and jobs, which has possible negative effects not only on poverty but also inequalities. That is why this thesis focuses on electricity access, which is manifested in the first target of SDG 7 (the United Nations, 2018).
The first target of SDG 7 incorporates not only access to electricity but also access to clean cooking (2030 Agenda, 2015). The global clean cooking situation illustrates well the importance of the interlinkages of the SDGs, by addressing energy, poverty and health (GSDR, 2019). This is directly shown by "more than 3 billion people relying on polluting solid fuels for cooking, which causes an estimated 3.8 million premature deaths each year." (GSDR, 2019, p. xxvi) Furthermore, burning polluted fuels for cooking inefficiently (SDG 7.1 and 7.3) pushes climate change and highlights the connection to SDG 13 climate action. It needs to be pointed out that the majority of the firewood is collected by women and children, which demonstrates the interlinkage to SDG 5 gender equality and SDG 10 inequalities. All of that effects especially poor people (SDG 1) in Sub-Saharan Africa, that is why there is a focus on the first target of SDG 7, which incorporates access to clean cooking. Additionally, the geographical focus of the analysis in this thesis was selected as Sub-Saharan Africa, see chapter 5 (GSDR, 2019) (the United Nations, 2018).

Poverty
The fact that human well-being is an essential driver for socio-economic change, demonstrates the direct interlinkage of SDG 1 and SDG 10. Even though extreme poverty is decreasing world-wide, still, 10% of the global population lives in extreme poverty (below the IPL). The geographic focus of this thesis is Sub-Saharan Africa, because the majority of these extreme poor lives there. The extreme poor account for 700 million people world wide. However, to make progress towards sustainable development it is significant to protect not only them, but also those that have little economic resources, such as the bottom 40, who are the poorest 40% of the population. Additionally, to make progress in sustainable development, those that are deprived by basic needs (multidimensional poverty) need to be protected too, to ensure more resilience towards any kind of shocks and climate change (GSDR, 2019) (World Bank , 2018). Thus, in addition to monetary poverty (IPL, LMIPL, UMIPL), multidimensional poverty (MPI) and the bottom 40 are investigated and analysed in this thesis, see chapter 4.2.

Inequalities
It's noteworthy that inequalities are harmful to economic growth, drive conflicts and therefore are deeply connected to SDG 1 (UNDESA , n.d.). Inequalities have negative impacts on prosperity, in particular in those countries that face poverty and environmental changes. In this thesis, monetary inequality is analysed according to the first target of SDG 10 (bottom 40 growth rate). However, there are lots of parameters beyond income equality that have an impact on human well-being (Renner S.,Bok L.,Igloi N., Linou N., 2018). Deprivations like lacking basic needs, such as lack of electricity access and clean cooking or relative disadvantages such as exclusions lead to demographic inequality. Overall, in all societies, those that lack behind the most, often face many interlinked disadvantages (Renner S.,Bok L.,Igloi N., Linou N.,

2018). Hence, as an attempt to show these interlinkages synthesis indicators for poverty (MPI) and human development (HDI and IHDI) are explored in chapter 4 and chapter 5.

1.1.3. Motivation

Parts of this thesis were developed while I was working at the Division for the Sustainable Development Goals (DSDG). This Division is part of United Nations Department of Economic and Social Affairs (UNDESA) at the United Nations Headquarters in New York City.
During the Energy Transitions coalition, at the Climate Action Summit 2019, I was especially moved by the demonstration of the global level of access to electricity and clean cooking. Subsequently, in collaboration with Prof. Maria Rosario Partidario at IST Universidade de Lisboa and the Energy Branch at DSDG / UNDESA, I developed the structure of this thesis. The staff members at DSDG just recently released the SDG 7 Policy Briefs in support of the High Level Political Forum (HLPF) 2019 (United Nations, 2019). This work gave me a great overview on SDG 7 and its' interlinkages in the context of the 17 SDGs. My work on Stakeholder engagement and partnerships as well as supporting the UN Secretariat during the Energy Resolution at the 74th General Assembly, let me focus on developing countries, and after considerations, I decided to focus on Sub-Saharan Africa.

1.2. Objective

The objective of this thesis is to show how the first target of SDG 7, demonstrated by electricity access and clean cooking, is interlinked and effects poverty and inequality (reduction) in the context of the SDGs in Ethiopia and Ghana. To show interlinkages between the selected SDGs, energy is put in the centre and correlations with empirical data on practical examples are shown.
Special emphasis is placed on Sub-Saharan Africa, which is investigated from a global perspective. Afterwards, in the analysis section the geographical focus will be on Ethiopia and Ghana in the context of Sub-Saharan Africa.

The research Question was defined as the following: How does access to electricity and clean cooking effect poverty and inequality (reduction) in the context of the SDGs in Ethiopia and Ghana?

1.3. Methodology

The research process of this master thesis started by defining the scope of the thesis. First the research area was selected as interlinkages of the SDGs (Sustainable Development Goals). Then I chose the research field, demonstrated by interlinkages of SDG 7 energy in the context of the 17 SDGs.
Reviewing scientific papers and grey literature such as documents by the United Nations and articles was an attempt to get an overview of the theory of interlinkages of SDGs, which special emphasis to SDG 7.

The focus area was established by putting SDG 7 in the centre of the interlinkages among the 17 SDGs. Selecting the focus contains two steps. First 2 highly interlinked priority SDGs were chosen, according to their urgency and importance to the scope of the Agenda 2030. Then within SDG 7, the first target was selected, due to its' interlinkages with the selected priority SDGs (SDG 1 and SDG 10). Second, a geographical focal point (Sub-Saharan Africa) was investigated by analysing the global status of SDG 7.1.
For the analysis, several common measurement methods and their global status of the selected SDGs were investigated. Common indicators for the chosen SDGs were selected. In particular, there was a focus on access to electricity and clean cooking (SDG 7.1), the international poverty line IPL (SDG 1) and growth rate of the bottom 40 (SDG 10). The growth rate of the bottom 40 indicates how the monetary poor in a country participate in the economic success (World Bank , 2018).
An attempt to broaden the perspective was to investigate urban and rural differences. Moreover, synthesis indicators are introduced as an attempt to show interlinkages between the SDGs. For example, the MPI (Multidimensional poverty index), HDI (human development index as well as the IHDI (inequality-adjusted HDI).
The geographical focal point (Sub-Saharan Africa) was investigated regarding its' progress on SDG 7.1 in order to select 2 priority countries for the analysis. In the analysis, the previously discussed common indicators and the synthesis indicators are analysed on empirical data in Ethiopia and Ghana.
In the Conclusion, the main points of the analysis are discussed in the scope of the thesis.

1.4. Structure

In the six chapters of this thesis, the interlinkages of energy, poverty and inequalities are shown from different perspectives.
The introduction provides a summary of the importance of the three chosen SDGs in the context of Sustainable Development.
The Literature Review provides an overview of reviewed scientific papers as well as UN documents and articles to show the state-of-the-art research in sustainable development, with a special emphasis to energy, poverty and inequalities in the context of the SDGs.
In chapter 3, energy is put in the centre of the SDGs to show interlinkages, as well as potential synergy effects and trade-offs.
Afterwards, the three chosen SDGs energy, poverty and inequalities are looked at from a global perspective, which is demonstrated in chapter 4.
In order to analyse the global status in each SDG, the indicators and targets are defined first.
Moreover, by investigating the different SDGs from different perspectives, the following indicators for the analysis in Chapter 5 are found, see Figure 1:

SDG 7.1 is looked from 2 different perspectives, the access to electricity from the total population as well as from urban and rural perspective. Additionally, access to clean cooking is explored.

Then two angles to measure SDG 1 are introduced. In particular, monetary poverty by the three main international poverty lines (IPL 1.9 USD/ day, LMIPL 3.2 USD/ day and UMIPL 5.5 USD / day, 2011 PPP) in contrast to the Multidimensional poverty index (MPI).

SDG 10 is first introduced in a broad context. However, a special emphasis is given to socio-economic inequality, by introducing synthesis indicators such as the human development index (HDI) and the inequality-adjusted HDI (IHDI), as well as a monetary indicator for inequality, the bottom 40.

Common indicators (SDG 7.1: access to electricity and clean cooking, SDG 1: IPL, LMIPL, UMIPL , SDG 10: bottom 40) were chosen to measure interlinkages among the selected SDGs. The reasoning behind choosing synthesis indicators (SDG 1: MPI, SDG 10: HDI, IHDI) is an attempt to show the interlinkages of the selected SDGs in the context of the 17 SDGs.

In order to be able to answer the research question - How does access to electricity and clean cooking effect poverty and inequality (reduction) in the context of the SDGs in Ethiopia and Ghana? (see chapter 1.2) - SDG 7 is extracted from the global look at the SDGs in Chapter 5. In particular, electricity access and clean cooking challenges in Sub-Saharan Africa are investigated. Afterwards, in the applied analysis Ethiopia and Ghana are analysed by the indicators defined in Chapter 4. First the countries are analysed separately and subsequently, the results in each indicator are compared. In the discussion the interlinkages of SDG 7.1, 1 and 10 are investigated in Ethiopia and Ghana.
In the conclusion the findings of the analysis are discussed and put in the context of the initial scope of the thesis.

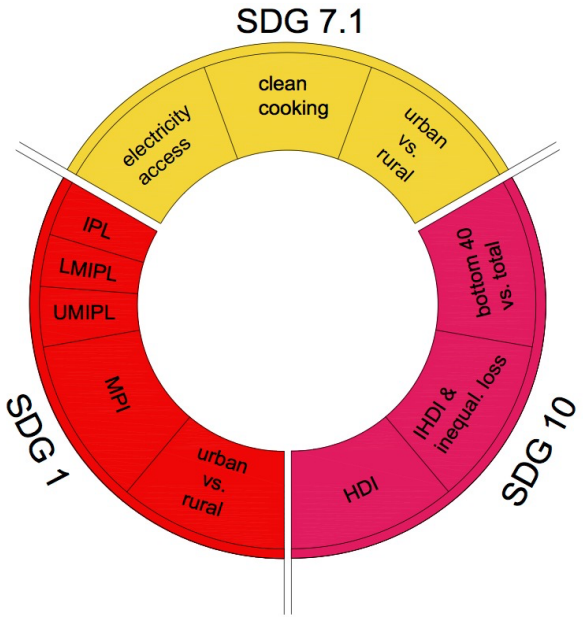

Figure 1 Indicators for the Analysis of Ethiopia and Ghana,
SDG 7.1 contains the following indicators: access to electricity and clean cooking, and urban vs. rural electricity access
SDG 1 contains the following indicators: international poverty line (IPL) global poverty lines for higher standards (LMIPL, UMIPL), multidimensional poverty (MPI of the total population and urban and rural),
SDG 10 contains the following indicators: monetary inequality (bottom 40 vs. total income growth rate) and human development (HDI, IHDI and loss due to inequalities)

2. Theory/ Literature Review

2.1. SDG Interlinkages assessment

Nilsson *et. al* and McCollum *et. al* highlighted the importance of displaying the interlinkages of the SDGs for successful practices, when implementing SDGs into policies, strategies and actions, rather than working in isolated clusters (Nilsson M., Griggs D., Visbeck M., 2016) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018). In that context, the need for tools to display the state-of the art empirical knowledge to identify how the goals (and targets) affect each other is pointed out (Nilsson M., Griggs D., Visbeck M., 2016) Cameron *et. al* analysed several tools and state of the art knowledge for SDG interlinkage assessment (Cameron A., Metternicht G., Wiedmann T., 2018). The main tools to analyse SDG interlinkages will be reviewed and further discussed.

1. **Network analysis**

In 2015, before the official adoption of the SDGs, Le Blanc analyzed the interlinkages of the SDGs with global network analysis, by creating a link when goals refer to targets through keyword connection. According to that method, some SDGs, such as inequalities and poverty had more interlinkages than others, like energy. Inequalities where ranked on second place of the most interlinked goals by finding connections with 12 goals. Followed by poverty, where 10 connections have been found, and energy ranked on place 14, showing 3 connections to other SDGs. Additionally, the link between poverty and inequalities was identified as the strongest (Le-Blanc, 2015).

2. **Synergy/ trade-offs**

Identifying possible synergy effects and eliminating the need for trade-offs is a highly effective way to assess SDG implementation (GSDR, 2019).

Cameron *et. al* reviewed SDG implementation in 26 countries (including Ethiopia) and pointed out that even though countries reflect the need to assess interlinkages, key gaps are built when putting it into practice. These gaps are mainly formed in the assessment of the interlinkages between SDGs as well as identifying synergy effects and trade-offs (Cameron A., Metternicht G., Wiedmann T., 2018).

Scherer *et. al* investigated the interlinkages between poverty and inequalities and environmental goals, such as water and sanitation, climate action and life on land, in 166 countries. The research indicates that there are trade-offs between social and environmental SDGs. In particular, low-income countries should prioritize social SDGs and therefore need to focus more on SDG 1 poverty and SDG 10 inequalities. Additionally, research indicated that countries with a low HDI (human development index) show tendencies to lack behind in SDGs related to the environment (Scherer L., Behrens P., Koning A., Heijungs R., Sprecher B., Tukker A., 2018).

Pradhan *et. al*, analysed synergy effects and trade-offs within and among SDGs in 227 countries, with statistical correlations using the spearman correlation method. They showed

that within and among SDGs synergies (positive correlations) outweigh trade-offs (negative correlations). Moreover, they emphasized that finding these correlations is crucial to implement the Agenda 2030. (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017).

3. Scales:

A more specific way to measure SDG interlinkages is with point scales. Two of them will be discussed further below.

A 3 point scale including several subcategories was developed to show an approach to identify interlinkages, by a stakeholder forum study. The scale ranges from supporting, enabling/ disenabling and relying. Whereas supporting indicates targets that fulfil each other and has two subcategories (commonly and mutually supporting), enabling and disenabling indicate positive and negative impacts that targets have on each other. This section has four subcategories (disenabling, indirect and direct enabling, direct enabling in both directions). Relying indicates the necessity between targets and has two subcategories (partial and full reliance) (Coopman A., Osborn D., Ullah F., Auckland E., Long G., 2016).

A more specific point scale for assessment of SDG interlinkages was developed by Nilsson *et. al*, which demonstrates a 7 point scale. The scale ranges from positive scores, which indicate synergies (supportive interlinkages), to negative scores, which indicate trade-offs. The most positive score is defined by +3 points (indivisible), demonstrating inseparable interlinkages. A neutral score is defined by 0 points (consistent), which implies neither positive nor negative interlinkages. The most negative score is defined by -3 points (cancelling), which shows a constraint to fulfil another goal (Nilsson M., Griggs D., Visbeck M., 2016).

4. Nexus approach

The nexus approach is a method to identify synergy effects and trade-offs among selected SDGs (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018)).

According to Cameron *et. al* Nexus was defined as focus not only on selected but also on highly interlinked goals and targets. This research showed that the Nexus approach is even likely required for effective SDG implementation (Cameron A., Metternicht G., Wiedmann T., 2018).

However, Nexus approaches are more expensive, due to the fact that more expertise and resources are required. Additionally, data collection as well as coordination is even more challenging than for isolated cluster approaches (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018)).

Allen *et. al* reviewed 80 modelling tools for SDG implementation and describes the Nexus approach as the most robust one. However, to get the best result, several modelling tools should be combined. This analysis shows that energy (SDG 7) modelling tools are widely spread, whereas poverty (SDG 1) and inequality (SDG 10) tools indicate severe gaps with poor coverage. The food-water-energy nexus is among the most analyzed ones and will be further discussed in chapter 3 (Allen C., Metternicht G., Wiedmann T., 2016).

5. Multicriteria Analysis

Reyers *et. al* developed a multicriteria analysis to assess interlinkages and monitor gaps in SDG monitoring. With this system approach, essential SDG variables (ESDGVs) are developed to identify priorities in SDG monitoring systems (Reyers B., Stafford-Smith M., Erb K.H., Scholes R. J., Selomane O., 2017).

By reviewing the different tools for SDG interlinkage assessment, one could see that there is not one single strategy to identify SDG interlinkages. However, there are some tools that have been highlighted as especially promising and that are more common lately, such as synergy and trade-off approaches and nexus approaches (Cameron A., Metternicht G., Wiedmann T., 2018) (GSDR, 2019) (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018)). These tools will be used in the analysis and will be discussed more in-depth in the next chapter.

2.2. Literature on the selected SDGs

In this chapter I would like to give an overview of literature on the selected SDGs, firstly on SDG 7 energy, followed by SDG 1 poverty and SDG 10 inequalities.

Energy

Research that put SDG 7 energy in the center of SDG interlinkages assessment, will be further discussed.

According to Pradhan *et. al* analysis of 227 countries showed that trade-offs are particularly high regarding SDG 7 (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017). Fuso Nerini *et. al* supported Pradhan *et. al* by showing that trade-offs within SDG 7 are rooting from possible contradictions between the first target (SDG 7.1 access to energy) and the second one (SDG 7.2 increase the share of renewables). These contradictions are often based on time constraints between quick access to energy and planning of an efficient and sustainable energy system. This contradiction will be elaborated more in-depth in chapter 3.3 (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017) (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

Fuso Nerini *et. al*, D.L McCullum *et. al* and the policy briefs towards the HLPF analysed SDG 7 energy in the centre of the SDGs and analysed possible synergy effects and trade-offs between SDG 7 and all other targets (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) (the United Nations, 2018) (the United Nations, 2019). Due to their importance for this thesis, a closer look on these papers and reports will be taken in Chapter 3.

According to Fuso Nerini, the majority of SDG targets need change in energy systems. Additionally, research indicates that between SDG 7 and all other targets synergy effects outweigh trade-offs (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

McCullom *et. al* followed Nilsson *et. al*s' scale to assess the nature of the interlinkages between SDG 7 and the others and showed that synergy effects outweigh trade-offs not only in numbers, but also in scope (positive points) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018). Hence, both research groups came to the same conclusion, that there are more synergies than trade-offs among the SDGs.

Poverty

In the energy policy briefs to the HLPF (high level political forum) 2018, the interlinkages of SDG 7 energy and SDG 1 poverty and SDG 10 are addressed. (the United Nations, 2018)
It is highlighted that "SDG 7 is a condition for economic development, poverty alleviation (SDG 1) and reducing inequalities (SDG 10)." (the United Nations, 2018, p. 64) Moreover, it indicates that energy is essential to fulfil the Agenda 2030's target to leave no one behind (the United Nations, 2018). Due to the importance of these interlinkages, further discussions will be addressed in chapter 3.

When analysing poverty in the context of the SDGs, Pradhan *et. al* analysed interlinkages within and among SDG 1. This analysis indicated that SDG 1 poverty had the most synergies within SDGs, partially due to its' widespread "disaggregated indicators such as sex, age, employment status, and geographical location." (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017, p. 1171) Moreover, among SDGs, SDG 1 poverty accounts for the most synergetic one, accounting for the most synergy pairs (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017).

By investigating energy with its' interlinkages, McCollum *et. al* highlighted confident scientific agreement between the interlinkage of SDG 7 and SDG 1, by analysing scientific literature. Additionally, it is shown that ensuring SDG 7 targets are beneficial to achieving SDG 1 targets (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018).

Fuso Nerini *et. al* shows that actions in energy systems effect the majority of all targets of SDG 1. Moreover, the assessment of the interlinkages between SDG 7 and SDG 1 indicated that synergies outweigh trade-offs by a factor of 2 (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

Reviewing literature of SDG interlinkages with a focus on poverty revealed, that poverty is the most synergetic SDG in the context of the 17 goals. Moreover, it is particularly synergetic with SDG 7 energy and closely interlinked to SDG 10 inequalities (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017) (the United Nations, 2018) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

Inequalities

Inequalities within the context of the SDGs were addressed in 2015, when Lu *et. al* called for monitoring progress of the SDGs with devise metrices. In that context the importance of finding more parameters such as income inequality in addition to conventional ones, such as economic growth (Lu Y., Nakicenovic N., Visbeck M., et. al, 2015).

According to Le Blanc, SDG 10 has the second most interlinkages to other SDGs. Regarding SDG 10 the strongest connection is to poverty, through access to basic capabilities such as "energy, water, health housing and greenspace and resources." (Le-Blanc, 2015, p. 180)

Pradhan *et. al* supports Le Blanc results on SDG 10, by showing that it is among the most synergetic SDGs (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017).

By investigating energy with its' interlinkages, McCollum *et. al* found out that not all interlinkages are equally well explored and highlighted that especially the interlinkages between SDG 7 energy and SDG 10 inequalities need further research (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018).

Fuso Nerini *et. al* shows that actions in energy systems effect the first target of SDG 10 inequalities. The assessment of the interlinkages between SDG 7 and SDG 10 indicated that there are far more synergies than trade-offs between those two SDGs (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

The energy policy briefs to the HLPF (high level political forum) provide an overview of the interlinkages between SDG 7 and selected SDGs (the United Nations , 2019). In 2019, the interlinkage with SDG 10 is discussed, by showing that "unequal access to energy and low human development are highly correlated." (the United Nations , 2019, p. 72)

Geographic location:
According to Weitz *et. al*, SDG interlinkages vary from nation to nation (Weitz, N, Persson, Å. Nilsson, M. and Tenggren S., 2015). Pradhan *et. al*, support that by showing that synergy effects and trade-offs depend on the analysed location (Pradhan, P., Costa, L., Rybski, D., Lucht, W. and Kropp, J.P., 2017).

The energy policy briefs to the HLPF (high level political forum) provide an overview of SDG 7 in different geographic locations. It highlights that even though Africa improved electricity access in recent years, access to clean cooking remains problematic (the United Nations , 2019).

Scientific involvement, Data:
In 2015, Lu *et. al* called for enhanced scientific involvement to better measure progress, monitor practices and create standards for SDG interlinkage assessment. In particular, the importance of quality data, including consistent methods, standards and open access was highlighted (Lu Y., Nakicenovic N., Visbeck M., et. al, 2015).
In 2018, Cameron *et. al* analysed 26 countries regarding their SDG implementation and concluded on the gaps of analytical approaches and tools to evaluate interlinkages. Among others, lack in technical training, system thinking and analysis were identified as possible reasons. The importance of consistent methods and standards was highlighted (Cameron A., Metternicht G., Wiedmann T., 2018).
McCollum *et. al* calls for the importance of systematic review methodologies and interdisciplinary scientific collaboration when analyzing the SDGs (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018)**.**

3. Putting SDG 7 at the centre of SDGs

This chapter deals with my findings on the interlinkages of the SDGs, in particular SDG 7 in context with all other SDGs. In this thesis, SDG 7 is put at the centre, but with preferred interlinkages with SDG 1 and SDG 10, therefore I'll firstly look broadly at the possible impacts of putting SDG 7 at the centre of all 17 goals. Afterwards, I zoom-in to Food-Water-Energy Nexus and its need to fight poverty and inequalities is being highlighted. In particular, this is an attempt to show its' likely impacts on energy system analysis and the connections to Sub-Saharan Africa.
Thereafter, the subsequent focus on electricity access is pointed out.

3.1. SDGs Interlinkages with the other SDGs

Putting SDG 7 at the center of all SDGs – Interlinkages
To implement the Agenda 2030 successfully, it is essential to identify interlinkages across the SDGs. Latest studies show, that 113 out of all 169 targets, which account for roughly 65%, need changes in energy systems. This connection is demonstrated in Figure 2a, where the interlinkage of actions on energy systems in relation to the SDGs is shown (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018). Whereas "Energy systems were defined broadly to include all components of anthropogenic and environmental systems related to the production, conversion, delivery and use of energy." (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018, p. 10) These actions are crucial for enhancing progress for human well-being, infrastructure and environment (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

Figure 2 Interlinkages between energy systems the SDGs and targets. a–c, Specific targets recognized in the 2030 Agenda for Sustainable Development are grouped together under each associated SDG. Targets are ordered clockwise; for example, Target 1.1 in each diagram is represented by the leftmost circle in the group associated with SDG1.

a: Targets highlighted black (and indicated with black lines) call for action in relation to energy systems.

b: For targets highlighted green (and indicated with green lines), we identified published evidence of synergies with decisions in pursuit of SDG7.

c: For targets highlighted orange (and indicated with orange lines), we identified published evidence of trade-offs with decisions in pursuit of SDG7. In b and c, the absence of highlighting indicates the absence of identified evidence.

Description copied and reprinted from Fusu Nerini, F., Tomei, J., To, L.S., et. al., *Mapping synergies and trade-offs between energy and the Sustainable Development Goals, Nature, 2018*, doi:10.1038/s41560-017-0036-5

3.1.1. SDG 7 in the context of 17 SDGs

Energy impacts on climate change have already been discussed in the introduction (GSDR, 2019). Nevertheless, the urgency of acting on SDG 7 is highlighted by the fact that the World Economic Forum (WEF) ranked climate action failure as the top global risk in terms of impact in 2020 (Edmond, 2020). Consequently, the second target SDG 7.2 is needed to aim to ensure

an increase of renewables. Additionally, a push towards more renewables in urban areas, is a possible step for climate action and enhances more resilient communities, which is highlighted in SDG 11. Moreover, renewable energies support and access to electricity and clean cooking are increasing work force (SDG 8) and economic growth (SDG 10) (the United Nations, 2019). Moreover "Energy contributes to the resilience of infrastructure, sustainable industrialization (SDG9) and sustainable production and consumption (SDG12)." (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018, p. 12). According to the policy briefs to the HLPF (High level political forum), renewable energies (SDG 7.2) could potentially contribute to SDG 16 greater peace and institutions, because they are geographically flexible (the United Nations, 2019).
The global clean cooking situations interlinkages to health, climate change, gender equality and poverty have already been highlighted in the introduction (GSDR, 2019).
Another important connection of lacking electricity access (SDG 7.1) is education, where globally 230 million children in primary schools are particularly effected. Additionally, lacking electricity access hinders modern communication technologies, which effects education (SDG 4) as well and increases inequalities (SDG 10) (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

As pointed out in the literature review, one of the most researched SDG interlinkages is the Food-water-energy Nexus, because "without adequate water and energy, global food needs cannot be met". (the United Nations, 2018, p. 71) (Allen C., Metternicht G., Wiedmann T., 2016) In next chapter the direct interlinkages of energy, water and hunger and their possible implications towards poverty and inequalities are going to be discussed (the United Nations, 2018).

3.2. Zooming in Food-Water-Energy Nexus

As previously discussed in the introduction, the focus of this thesis is on energy, poverty and inequalities in the context of the 17 SDGs.
In this chapter I would like to emphasise the Food-Water-Energy Nexus, because it is relevant to fight poverty and reduce inequalities. Moreover, it is an attempt to show interlinkages between the selected SDGs (SDG 7, SDG 1, SDG 10) in the context of the 17 SDGs. Therefore, the Food-Water-Energy Nexus is also used in the analysis.
Nexus approaches show correlations among selected SDGs, to identify synergy effects and trade-offs (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018)). This can lead to enhanced policy planning for sustainable development by "promoting higher resource use efficiency, lower production of pollutants and wastes, and more coherent policy." (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018), p. 467)

The food-water-energy nexus approach is defined by the close interlinkages of SDG 1,2,6, and SDG 7, shown in Figure 3 and Figure 4. One of those demonstrates that energy is required to for clean water and sanitation (Mainali, B.; Luukkanen, J.; Silveira, S.; Kaivo-oja, J., 2018). Moreover, "the roots of the crisis in water can be traced to poverty, inequality and unequal power relationships." (Pedro Conceição, 2019, p. 191) Today this correlation effects roughly a quarter of the global population which is deprived in SDG 6. Access to drinking water is particularly severe in Sub-Saharan Africa, especially in rural areas. Basic sanitation is a severe problem of LDCs (least developed countries), many of them are located in Sub-Saharan Africa

and one of them is Ethiopia, which is selected for the analysis in chapter 5 (Mainali, B.; Luukkanen, J.; Silveira, S.; Kaivo-oja, J., 2018).

Additionally, water and energy are both essential to ensure food security. Moreover, energy has an impact on food economically (price regulation) and environmentally. Also, renewable energy and energy efficiency impacts water environmentally (water footprint, freshwater). All of these deeply affect the extreme poor, who likely lack access to water and energy and have difficulties in income generation, not only but also due to their dependency on traditional farming. Leading to the fact that the SDG 1 poverty eradication cannot be fulfilled without acting on SDG 2,6, and SDG 7. However, meeting the SDG 2 targets for food security and productivity likely increases the energy demand and therefore synergetic sustainable energy system planning is needed (Mainali, B.; Luukkanen, J.; Silveira, S.; Kaivo-oja, J., 2018).

It is essential to consider the food-water-energy nexus approach to ensure basic needs and reduce poverty (Mainali, B.; Luukkanen, J.; Silveira, S.; Kaivo-oja, J., 2018). This will become more important globally in the future, because "it has been projected that the demand for freshwater will increase by 30%, energy by 50% and food by 40% until 2030 in comparison to the current demand due to cumulative effects of population growth and mobility, economic development, urbanization, cultural and technological changes and climate change." (Mainali, B.; Luukkanen, J.; Silveira, S.; Kaivo-oja, J., 2018, p. 2) However, other studies show that the energy demand will only increase by 25% until 2040, compared to the todays standard. The later studies have a very different projection due to their different energy efficiency projections (GSDR, 2019). Due to the current pandemic, these predictions will likely need to be reassessed. Nevertheless, in future energy policy research it will become even more crucial to assess SDG interlinkages to enhance SDG 7 policy recommendations (Liu, J., Hull, V., Godfray, H.C.J. et al., (2018)).

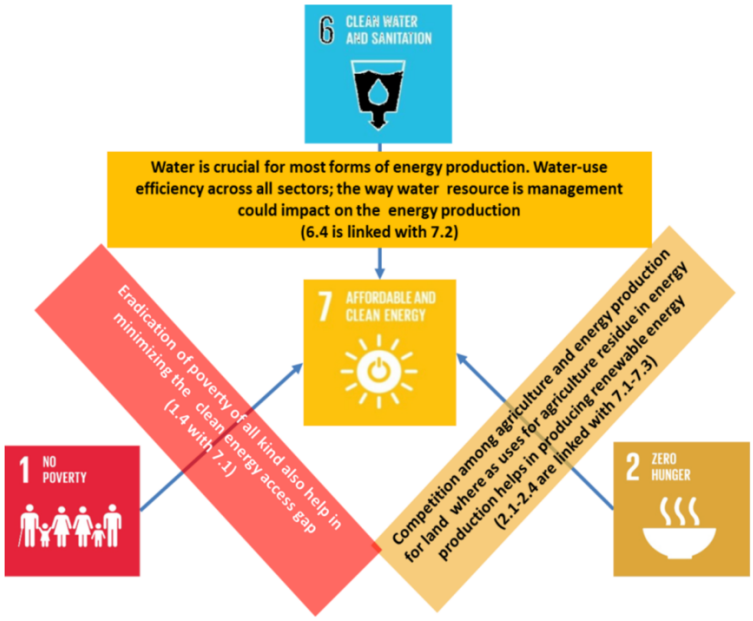

Figure 3 Interlinkages of SDG 1,2,6,7 in the context of the food-water-energy nexus, putting SDG 7 in the center, Reprinted from *Mainali, B., Luukkanen, J., Silveira, S., & Kaivo-Oja, J. (2018). Evaluating Synergies and Trade-Offs among Sustainable*

Development Goals (SDGs): Explorative Analyses of Development Paths in South Asia and Sub-Saharan Africa. Sustainability, 10(3), 815., p.11 doi: 10.3390/su10030815, https://www.mdpi.com/2071-1050/10/3/815#framed_div_cited_count

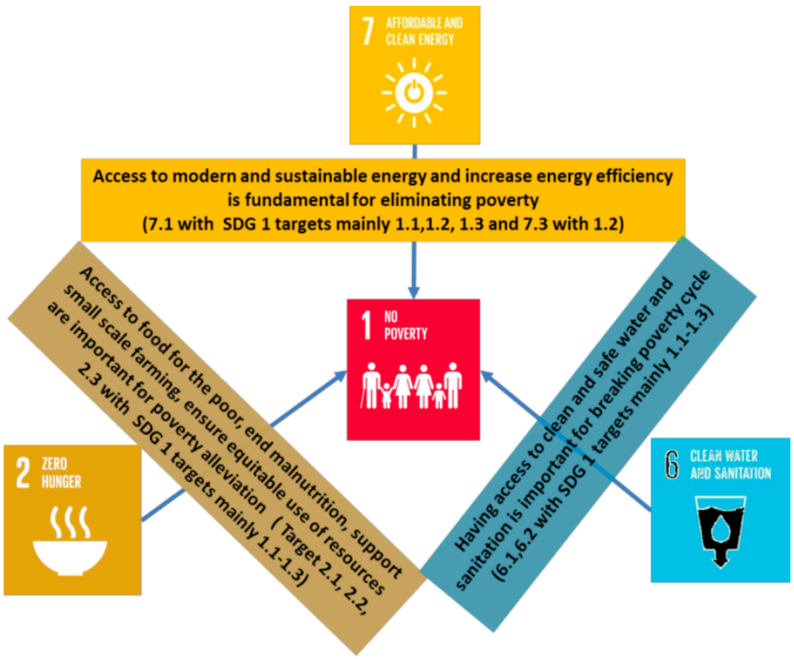

Figure 4 Interlinkages of SDG 1,2,6,7 in the context of the food-water-energy nexus, putting SDG 1 in the center, Reprinted from: *Mainali, B., Luukkanen, J., Silveira, S., & Kaivo-Oja, J. (2018). Evaluating Synergies and Trade-Offs among Sustainable Development Goals (SDGs): Explorative Analyses of Development Paths in South Asia and Sub-Saharan Africa. Sustainability, 10(3), 815., p.7, doi: 10.3390/su10030815, https://www.mdpi.com/2071-1050/10/3/815#framed_div_cited_count*

3.3. Synergy effects and trade-offs

According to Fuso Nerini *et. al* the interlinkages of SDG 7 and all other targets show 143 synergies out of 169 targets, versus to 65 trade-offs, see Figure 2b and in Figure 2c respectively. This means that 143 targets which account for roughly 85% of all SDGs, are mutually supporting SDG 7. Overall, most trade-offs show that on the one hand there is the urgent need for change to enhance human well-being, such as providing access to basic services, SDG 7.1 targets. On the other hand, it needs sufficient time and planning to create a sustainable energy system based on renewables and energy efficiency, SDG 7.2 and SDG 7.3 targets (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018).

Whereas a synergy effect implies that the group of things working together is more powerful than working individually, a trade-off marks balancing a negative situation with an opposed situation (n.d, 2020) (n.d., 2020).

Fuso Nerini *et. al* investigated SDG 7 in relation to all other SDGs and supported research that was discussed in the literature review by showing that synergies among SDGs outweigh trade-offs. The interlinkages between energy and human wellbeing-related SDGs accounted for 60 synergies and 34 trade-offs. Whereas energy and infrastructure related SDGs indicated the

most synergies with 109 synergies and 47 trade-offs. Moreover, energy and environmental SDGs showed the least amount of synergies and trade-offs, by 46 synergies versus 31 trade-offs (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018). These findings show that SDG 7 is essential and likely more synergetic to all elements of sustainable development. Moreover, SDG 7 is particularly more synergetic to social SDGs such as poverty and inequalities, which is beneficial to the objective of this thesis.

3.4. Addressing SDG 7 in connection to SDG 1 and SDG 10

Why focusing on SDG 7 and its interlinkage with SDG 1 and SDG 10
In this thesis, the interlinkages of SDG 7 in relation to the 17 Goal has been discussed. However, subsequently there is a special focus on the interlinkages of SDG 1 and SDG 10, because "SDG 7 is a condition for economic development, poverty alleviation (SDG 1) and reducing inequalities (SDG 10). Progress on SDG 7 can be seen as a means towards achieving other SDGs and the principle Leave no one behind". (the United Nations, 2018, p. 64)

Why focusing on electricity access SDG 7.1 only electricity access and clean cooking
Basic reasoning to answer that question has already been discussed in the introduction. An additional point is related to multidimensional poverty, which will be discussed in chapter 4.2. In particular, by measuring multidimensional poverty, access to electricity and clean cooking accounts for one-third of the standard of living parameter. That is why, the first target of SDG 7 with its' two indicators, is crucial to highlight the interlinkage of poverty and SDG 7 in the context of the 17 SDGs (Oxford Poverty & Human Development Initiative (OPHI), n.d.).

4. Global perspective on SDG 7, SDG 1 and SDG 10

The key role of SDG 7 is to ensure affordable and clean energy. "Access to energy is universally recognized as key to economic development and to the realization of human and social well-being." (GSDR, 2019, p. xxvi) This chapter tries to share my findings of the global status and progress in achieving SDG 7.1, SDG 1, SDG 10 worldwide. In particular, it is an attempt to illustrate how low-income population is lagging behind in monetary and non-monetary terms.
Firstly, I introduce each SDG with its targets and indicators. Afterwards, the global progress of each SDG is analysed with the aim to find possible indicators that measure relevant aspects of the SDG. These indicators will later be used in the analysis in chapter 5.

I begin by taking a closer look at SDG 7 targets and indicators. Then I zoom into SDG 7.1, access to electricity and clean cooking from the global perspective and then I attempt to show the contrast between urban and rural access.

Secondly, poverty is defined in the context of SDG 1, including targets and indicators. Subsequently, I introduce several options to measure monetary poverty (IPL, LMIPL, UMIPL). Beyond monetary poverty, multidimensional poverty (MPI) is presented as a synthesis indicator to measure poverty in the context of the SDGs. All of these different measurement methods are presented to find implications on the global progress of poverty eradication and which countries eradicated poverty most successfully (top15). Afterwards, the question of who are the most poor within a society will be addressed.

Thirdly, inequalities are defined in the context of sustainable development and SDG 10, including targets and indicators. Then I'm looking at the 5 key factors to measure inequalities. Subsequently, I zoom into socio-economic inequalities by introducing synthesis indicators for human development (HDI and IHDI) in the context of the SDGs. To investigate monetary inequality according to the first target of SDG 10, a measurement method for monetary inequality (bottom 40 growth rate) is introduced.

4.1. SDG 7.1, Targets and Indicators, world status

SDG 7 targets and indicators
Highlighted in the 2030 Agenda, Sustainable Development Goal (SDG) 7 aims to "ensure access to affordable, reliable, sustainable and modern energy for all". (2030 Agenda, 2015, p. 19) Its' targets and indicators are defined in Table 1.

Table 2 SDG 7 Ensure access to affordable, reliable, sustainable and modern energy for all, 7.1-7.3 are the targets of SDG 7, 7.a and 7.b are the indicators of SDG 7
Copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform:
https://sustainabledevelopment.un.org/post2015/transformingourworld
online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (page 19/35)

SDG 7 access to affordable, reliable, sustainable and modern energy for all	
7.1	By 2030, ensure universal access to affordable, reliable and modern energy services
7.2	By 2030, increase substantially the share of renewable energy in the global energy mix
7.3	By 2030, double the global rate of improvement in energy efficiency
7.a	By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology
7.b	By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support

4.1.1. Measuring Electricity Access, global access for all?

2019 marks a crucial timeframe for SDG 7, because it defines the half time of the UN Decades focus on energy (2014-2024) (the United Nations, 2019). As of 2017, globally around 840 million people lack access to electricity (GSDR, 2019). This includes grid- and decentralized -electrification systems, such as off-grid renewable energy solutions. However, the electrification trend since 2010 is very promising. In the following seven years, the global electrification rate increased from 83% in 2010 to 89% in 2017, indicated by Figure 5. Leading to the fact that 920 million people gained access to electricity, over that time period (IEA, IRENA, UNSD, WB, WHO, 2019). Additionally, the global population lacking electricity access, mainly located in developing countries, "fell from 1.2 billion in 2010 to 840 million in 2017". (IEA, IRENA, UNSD, WB, WHO, 2019, p. 17) As shown in table 1, the aim of SDG 7, target 7.1 requires global access to electricity by 2030 (2030 Agenda, 2015). However, to meet the Agenda 2030 target, the global average electrification rate needs to increase further (IEA, IRENA, UNSD, WB, WHO, 2019).

There are several factors that increase the gap between countries that are on track with SDG 7.1 and those lagging behind. For instance, it's becoming harder to reach people who lack electricity access, because they either live in informal settlements (see chapter 5.1), or are displaced and/ or hard to reach. Therefore, the latest research indicates that the goal will be

failed by 650 million people worldwide in 2030, which is illustrated in Figure 5 by 92% of the total population world-wide that is served with electricity (IEA, IRENA, UNSD, WB, WHO, 2019).

In order to fight the electricity access gaps, the United Nations suggest a variety of actions, such as strategic planning including interlinkages assessment and clear frameworks, economic participation of the private sector and development of sustainable decentralized systems (the United Nations, 2019) (the United Nations, 2018).

Figure 5 Percentage of global population with access to electricity (%) reprinted from *tracking SDG 7: the Energy Progress Report 2019,* IEA, IRENA, UNSD, WB, WHO (2019), Washington DC

4.1.2. Electricity access, Rural vs. Urban

As indicated by Figure 6 and Figure 7 the global average, as well as in all critically important areas the electricity access has increased between 2000 and 2017. However, the difference between urban and rural areas remains high. As shown in Figure 6, the global average electricity access in rural areas is 80.8 %, leaving 728 million people unserved in 2017. On the other hand, on a global average in urban areas 97,4 % of the global population are served, leaving 108 million people behind in 2017, see Figure 7.
Moreover, the global electrification pace in rural areas was increasing faster than in urban areas, between 2010 and 2017. This trend is different in Sub-Saharan Africa, where rural and urban electrification had a similar pace (9% of the population increase) between 2010 and 2017. It's noteworthy that regarding electricity access in rural as well as in urban areas Sub-Saharan Africa lacks behind the most, that is why this area is chosen as the geographical focus in this thesis (IEA, IRENA, UNSD, WB, WHO, 2019).

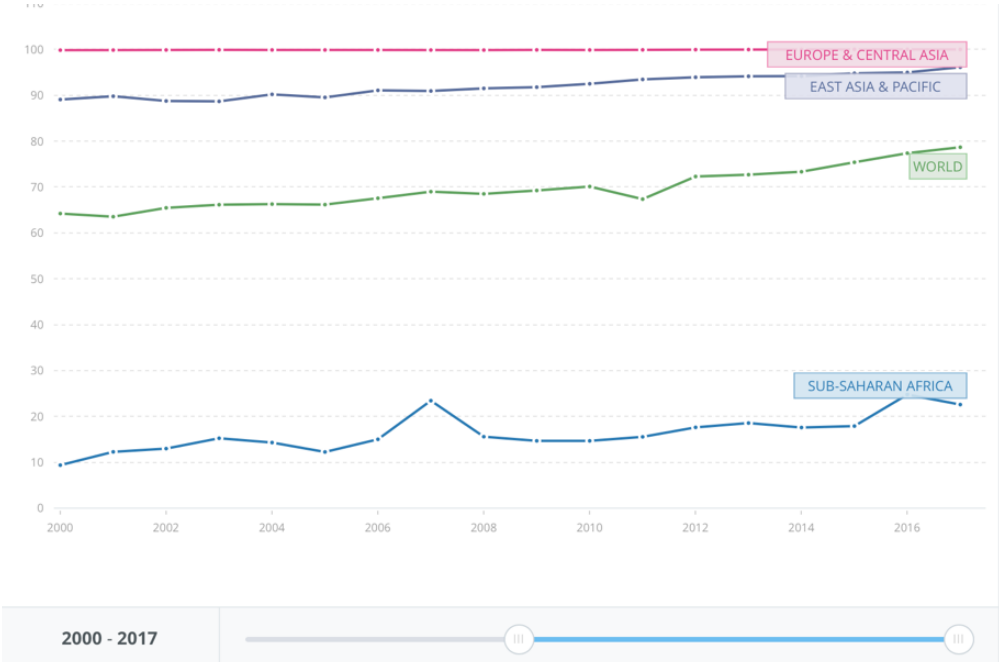

Figure 6 Access to electricity in rural areas (% of the population) from 2010 to 2017 in World (global average), East Asia and Pacific, Europe and Central Asia and Sub-Saharan Africa. *Retrieved from the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.* Available online (select: 2000-2017): https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?end=2017&locations=ZG-1W-Z4-Z7&start=2010

Figure 7 Access to electricity in urban areas (% of the population) from 2010 to 2017 in World (global average), East Asia and Pacific, Europe and Central Asia and Sub-Saharan Africa. Retrieved from *the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.* Available online (select: 2000-2017): https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?end=2017&locations=ZG-1W-Z4-Z7&start=2010

4.1.3. Clean Cooking, globally

In 2017, 38% of the global population, which accounts for 3 billion people, has no access to clean cooking fuels (IEA, 2017). This is particularly important in developing countries, where 50 % of the population is affected. Moreover, polluting fuels and technologies are mainly used in LDCs, particularly in Sub-Saharan Africa and Asia (IEA, IRENA, UNSD, WB, WHO, 2019). In 2017, only 20% of the population in Sub-Saharan Africa had access to clean cooking. "To reach universal clean cooking targets by 2030 and outpace population growth, especially in the Sub-Saharan Africa region, the annual rate of access expansion needs to increase to around 3.0 percentage points from the rate of 0.5 percentage points observed between 2010 and 2017 (IEA, 2017, p. 41)." According to latest scenarios, Sub-Saharan Africa is not on track to achieve clean cooking for all. Probably more than half of its' residents will be left behind in 2030, accounting for 820 million people in Sub-Saharan Africa (IEA, 2017).

The majority of globally used polluted cooking fuels, accounting for 33% of the global population, which corresponds to 2.5 billion people, uses solid biomass for cooking. Since 2010, progress to shift from solid biomass cooking to clean cooking has been slow and could only be reduced 3%. Coal and kerosene are used by 2.2% (accounting for 170 million people) and 1.6% (accounting for 120 million people) of the global population, respectively. Since 2010, there was a shift from kerosene and coal towards non-polluting cooking fuels. Most of the access in developed countries was achieved with LPG, electricity and natural gas (IEA, 2017).

There is a huge variety of cookstoves, which show several synergy effects and trade-offs, see Figure 8. As discussed in the introduction, traditional use of solid fuels, coal and kerosene have severe impacts on health. Moreover, traditional biomass requires fuel collection which has an impact on biodiversity and is mostly done by women and children, demonstrating gender inequality and inequality towards the most vulnerable. Whereas LPG and solar cookers have high investment costs, electricity cookers show disadvantages such as high fuel cost, low reliability and availability of fuel, see Figure 8 (IEA, 2017).

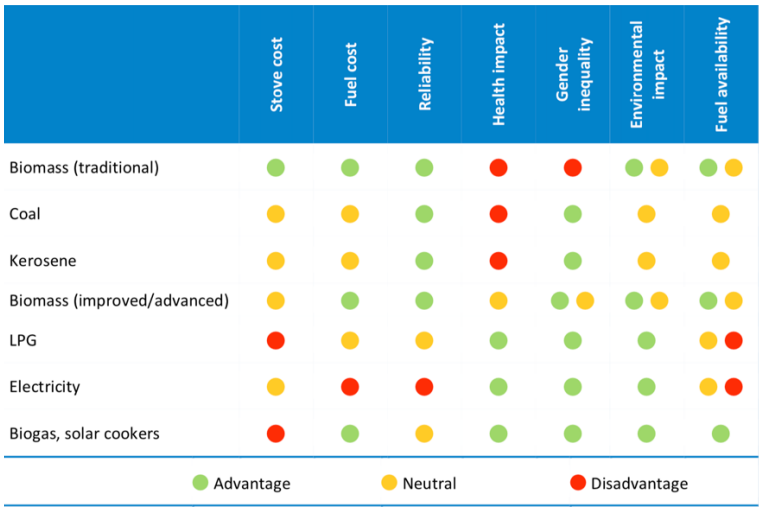

Figure 8 Trade-offs between different cooking fuels and technologies from a developing country perspective, *Reprinted from: Energy Access Outlook 2017, IEA, Paris, page 59, online available via: https://www.iea.org/reports/energy-access-outlook-2017*

4.2. SDG 1, Targets and Indicators, world status

SDG 1 Targets, Indicators

Recognized as the world's biggest challenge and the most crucial requirement for Sustainable Development, in the 2030 Agenda, SDG 1 symbolizes the essential requirement for a dignified live. The 2030 Agenda, specifically addresses the need to empower the most vulnerable to have a chance of a dignified, prosperous live (2030 Agenda, 2015). Goal 1 aims to "end poverty in all its forms everywhere" and is defined as in Table 3 (2030 Agenda, 2015, p. 15).

Table 3 SDG 1 ensures ending poverty in all its forms everywhere, 1.1-1.5 are the targets of SDG 1, 1.a and 1.b are the indicators of SDG 1
Copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform:
https://sustainabledevelopment.un.org/post2015/transformingourworld
online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (page 15/35)

SDG 1 ending poverty in all its forms everywhere	
1.1	By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day
1.2	By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable
1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance
1.5	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters
1.a	Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions
1.b	Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions

4.2.1. Measuring poverty

global international poverty line 1.9 USD a day

Extreme Poverty, on a monetary basis, is universally defined as "living below the international poverty line (IPL), currently set at US$1.90 in 2011 purchasing power parity (PPP) dollars." (World Bank , 2018, p. 19) Due to a changing economy, the IPL is regularly updated. It reflects PPP for food, clothing and shelter, whereas the PPP is functioning as a universal currency to make local income and consumption comparable. In addition to the IPL, often referred to as absolute poverty, usually every country has it's individual monetary poverty lines, based on it's socio-economic conditions, also known as relative poverty. The IPL is the global instrument to measure and compare poverty (world bank, 2015).

Higher standards:

But complementary monetary poverty lines, mostly accounted in lower-middle (LMIC) and upper-middle income countries (UMIC). These are defined as 3.20 USD per day for the lower middle income poverty line (LMIPL) and 5.50 USD per day as upper middle income poverty line (UMIPL) respectively, in 2011 PPP. (World Bank , 2018) When looking at the monetary poverty lines for higher standards it is demonstrated that," a quarter of the world was living on less than US$3.20 per person per day, and close to half the world was living on less than US$5.50 per person per day." (World Bank , 2018, p. 67) This leads to the fact that in 2015, the most poor rather lived in middle income countries than in low income countries. Therefore, for the analysis a low income country (Ethiopia) and a middle income country (Ghana) was chosen. Moreover, monitoring more poverty factors than the former World Bank's goal of bringing extreme poverty according to IPL beneath 3%, becomes more important (World Bank , 2018).

Multidimensional poverty:

Human wellbeing cannot be measured on a monetary basis only. Either because services essential for wellbeing are not obtained through markets or payment for services doesn't reflect the consumption value. For instance, there is an essential need for electricity access, however uptake costs for electricity grids are not necessarily reflected in electricity bills (World Bank , 2018). That is why the multidimensional poverty index (MPI) measures people's well-being and through deprivations and vulnerability in several dimensions (GSDR, 2019). In addition to income (consumption) the MPI incorporates, the right of access to basic services, such as access to electricity (SDG 7), clean drinking water and sanitation (SDG 6), adequate housing (SDG 11) and education (SDG 4), and health (SDG 3), assets (SDG1) and nutrition (SDG2), see Figure 9 and Figure 10 (World Bank , 2018).

All key pillars of the MPI (health, education and standard of living) are represented in Figure 9. The key pillars are all weighted equally, contributing 1/3 of the MPI. Additionally, all indicators in a key pillar (e.q. the key pillar standard of living has the indicators: cooking fuel, sanitation, drinking water, electricity, housing and assets) are equally distributed as well, as indicated in Figure 9 (World Bank , 2018).

The MPI ranges from 0 to 1 and is calculated by multiplying the headcount ratio times the intensity, see Figure 9 and Figure 10. The headcount ratio (H) is the share of population

identified as 'MPI poor' (score same or greater deprivation in 1/3 out of 10 weighted indicators). Whereas the Intensity is the average percentage of weighted indicators across the deprived people (Oxford Poverty & Human Development Initiative (OPHI), n.d.).

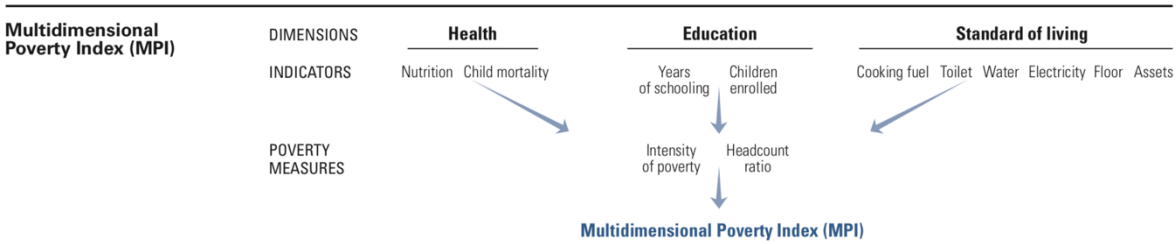

Figure 9 Calculating the Multidimensional Poverty Index (MPI), *Human Development Report 2019, Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century, published for UNDP reprinted from: http://hdr.undp.org/sites/default/files/hdr2019_technical_notes.pdf*

Dimension	Indicator	Deprived if ...	Related to	Weight
Health	Nutrition	Any person under 70 years of age for whom there is nutritional information is **undernourished**.[1]	SDG 2	$\frac{1}{6}$
	Child mortality	A child under 18 years of age has died in the family in the five-year period preceding the survey.[2]	SDG 3	$\frac{1}{6}$
Education	Years of schooling	No household member aged 10 years or older has completed **six years** of schooling.	SDG 4	$\frac{1}{6}$
	School attendance	Any school-aged child[3] is not attending school up to the age at which he/she would complete **class 8**.	SDG 4	$\frac{1}{6}$
Living Standards	Cooking fuel	A household cooks with dung, agricultural crop, shrubs, wood, charcoal or coal.	SDG 7	$\frac{1}{18}$
	Sanitation	The household's **sanitation facility** is **not improved** (according to SDG guidelines) or it is **improved but shared** with other households.[4]	SDG 6	$\frac{1}{18}$
	Drinking water	The household does **not have access** to **improved drinking water** (according to SDG guidelines) or safe drinking water is at least a **30-minute walk** (roundtrip) from home.[5]	SDG 6	$\frac{1}{18}$
	Electricity	The household has **no electricity**.[6]	SDG 7	$\frac{1}{18}$
	Housing	The household has **inadequate housing**: the floor is of natural materials or the roof or walls are of natural or rudimentary materials.[7]	SDG 11	$\frac{1}{18}$
	Assets	The household does **not own more than one** of these **assets**: radio, TV, telephone, computer, animal cart, bicycle, motorbike, or refrigerator, and does not own a car or truck.	SDG 1	$\frac{1}{18}$

Notes: The global MPI is related to the following SDGs: No Poverty (SDG 1), Zero Hunger (SDG 2), Health & Well-being (SDG 3), Quality Education (SDG 4), Clean Water & Sanitation (SDG 6), Affordable & Clean Energy (SDG 7), Sustainable Cities & Communities (SDG 11).

[1] Adults 20 to 70 years are considered malnourished if their Body Mass Index (BMI) is below 18.5m/kg^2. Those 5 to 19 are identified as malnourished if their age-specific BMI cutoff is below minus two standard deviations. Children under 5 years are considered malnourished if their z-score of either height-for-age (stunting) or weight-for-age (underweight) is below minus two standard deviations from the median of the reference population. In the global MPI, most surveys had anthropometric information for children under 5 years. In addition most DHS surveys had nutrition information for women 15 to 49 years of age, and a few had nutrition information adult men.

[2] The child mortality indicator of the global MPI is based on birth history data provided by mothers aged 15–49. In most surveys, men have provided information on occurrence of child mortality as well but this lacks the date of birth and death of the child. Hence, the indicator is constructed solely from mothers. However, if the data from the mother is missing, and if the male in the household reported no child mortality, then we identify no occurrence of child mortality in the household.

[3] Data source for age children start compulsory primary school: DHS or MICS survey reports; or http://data.uis.unesco.org/

[4] A household is considered to have access to improved sanitation if it has some type of flush toilet or latrine, or ventilated improved pit or composting toilet, provided that they are not shared. If survey report uses other definitions of adequate sanitation, we follow the survey report.

[5] A household has access to clean drinking water if the water source is any of the following types: piped water, public tap, borehole or pump, protected well, protected spring or rainwater, and it is within 30 minutes' walk (round trip). If survey report uses other definitions of safe drinking water, we follow the country survey report.

[6] A number of countries do not collect data on electricity because of 100% coverage. In such cases, we identify all households in the country as non-deprived in electricity.

[7] Deprived if floor is made of mud/clay/earth, sand, or dung; or if dwelling has no roof or walls or if either the roof or walls are constructed using natural materials such as cane, palm/trunks, sod/mud, dirt, grass/reeds, thatch, bamboo, sticks, or rudimentary materials such as carton, plastic/polythene sheeting, bamboo with mud, stone with mud, loosely packed stones, adobe not covered, raw/reused wood, plywood, cardboard, unburnt brick, or canvas/tent.

Figure 10 Definition of the key pillars (dimensions) and the indicators of the Multidimensional Poverty Index (MPI), Reprinted from: Oxford Poverty and Human Development Initiative (2019). "Ethiopia Country Briefing", page 10, Multidimensional Poverty Index Data Bank. Oxford Poverty and Human Development Initiative, University of Oxford. Available at: www.ophi.org.uk/multidimensional-poverty-index/mpi-country-briefings/.

According to the MPI, the majority of multidimensionally poor people lives in South Asia (546 million), followed by 342 million in Sub-Saharan Africa. However only in Sub-Saharan Africa, the number of extreme poor is increasing (GSDR, 2019). The geographical distribution of the most poor and their evolution over time will be investigated next.

As pointed out in the Literature Review, the lack of common standards and clear data is challenging (World Bank , 2018). However, regularly updated Data is a key element to analyze peoples situation. Obviously, there are still other factors that are essential for human well-being but are not included in the MPI, such as health care, or resilience towards natural disasters and crimes (World Bank , 2018).

4.2.2. Global poverty eradication

Are we on track? Where are the most poor?
From 1990 to 2015, the share of the global population below the IPL declined significantly, so that one billion people have been uplifted form extreme poverty. In particular the global share of population below the IPL decreased from 36% to 10% in these 25 years. (World Bank , 2018) However, this means that "1 person in every 10 in the world was living in extreme poverty", in 2015 (World Bank , 2018, p. 19).

As indicated in Figure 11, economic resources are distributed very differently among the world regions. From 1990 to 2015, the strongest uplift from extreme poverty was demonstrated in East Asia and Pacific, due to China's economic growth and rising economic success in the area. In East Asia and Pacific, the average poverty rate declined from 62% to 3% from 1990 to 2015 respectively (World Bank , 2018).
However, opposing the global trend, the number of people living in extreme poverty in Sub-Saharan Africa increased, demonstrated by the height difference in the yellow band in Figure 11. "Extreme poverty is becoming more concentrated there because of the region's slower rates of growth, problems caused by conflict and weak institutions, and a lack of success in channeling growth into poverty reduction." (World Bank , 2018, p. 2) This leads to the fact, that in 2015 more people live in extreme poverty in Sub-Saharan Africa than adding up all those living in other regions globally. The shift of the extreme poor from Asia to Sub-Saharan Africa is also indicated by India, which is making further progress in poverty eradication, the latest business as usual outlook by the World Bank, indicates that more than 25% will live in extreme poverty in Sub-Saharan Africa, compared to 2% on a global average in 2030. As a consequence, it is unlikely to meet the SDG 1 target, to eradicate poverty in all its' forms, everywhere (World Bank , 2018).

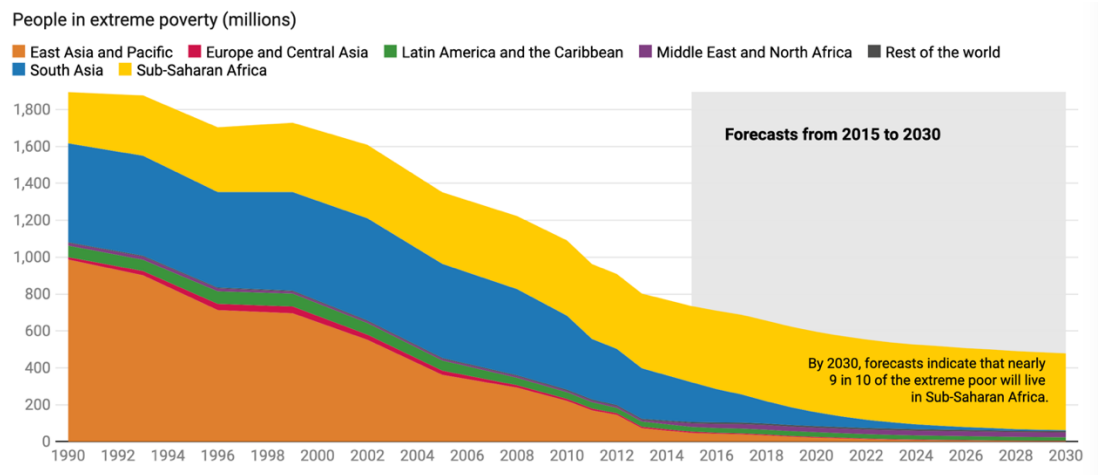

Figure 11 People living in extreme poverty (millions) from 1990 to 2030, East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, Rest of the World, South Asia and Sub-Saharan Africa. Retrieved from *Countdown to 2030: A race against time to end extreme poverty*, by Carolina Sánchez-Páramo, 2020, Data Source: *the World Bank, World Bank PovcalNet and Poverty & Equity Data Portal,* Available online: http://blogs.worldbank.org/voices/countdown-2030-race-against-time-end-extreme-poverty?cid=ECR_LI_worldbank_EN_EXT

Zooming into the country level in 2015, one can see that half of most poor live in 5 key countries located in South Asia and Sub-Saharan Africa, see Figure 12. Namely in Bangladesh and India (South Asia) and Democratic Republic of Congo, Ethiopia and Nigeria (Sub-Saharan Africa). (GSDR, 2019) Even though India has a fairly low poverty rate, due to its' large population it accounts for 80% of the most poor in South Asia (World Bank , 2018).

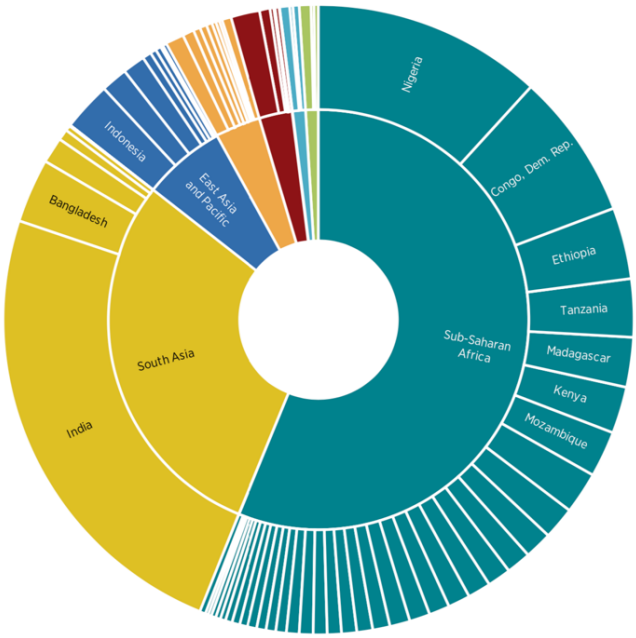

Figure 12 Global Distribution of the Extreme Poor by Region and Country in 2015. The inner circle is divided proportionally to each region's share of the total population living in extreme poverty. The outer circle is similarly proportionate, but at the country level. The 10 countries with the most extreme poor in the world are listed. Reprinted from the *World Bank,* Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle, License: Creative Commons Attribution CC BY 3.0 IGO, Washington DC, Washington, 2018

Who are the most poor ?
The most poor usually live in large households, with lots of children and commonly lack basic services as discussed in the MPI (Emma Seery, Joab Okanda and Max Lawson, 2019).
Women and children need special attention, since they belong to a excluded group that is most likely to be affected with extreme poverty in poor countries. Especially women in a fertile age, are significantly higher affected than men. Moreover, children under the age of 14 have the highest poverty rate and account for 46% of the poor globally in 2015. This needs special attention, because childhood poverty is inherited through generations (World Bank , 2018).
It's noteworthy that most of the global extreme poor people are living in rural areas (World Bank , 2018).

Overall, there are many forms of poverty as indicated by the MPI, so to eradicate poverty, looking only at monetary forms of poverty and fostering economic growth is not enough. It is important to look at the close interlinkages to all SDGs that ensure human well-being and capabilities. Therefore, the MPI can be potentially helpful. However, when looking at deprivations of human-wellbeing, the global poverty situation loos different. According to latest MPI in 2018, 1.3 billion people had severe deprivations, which is far more than according to the IPL. Additionally, the progress of eradicating multidimensional poverty is much slower than monetary poverty (GSDR, 2019).

4.3. SDG 10, Targets and Indicators, world status

SDG 1 Targets, Indicators, Importance:
Fighting inequalities within and among states is another key factor to human development, inequality is therefore highlighted in the 2030 Agenda as SDG 10, see Table 4 (2030 Agenda, 2015).

Table 4 SDG 10 ensures reducing inequality within and among countries, 10.1-10.7 are the targets of SDG 1, 1.a - 1.c are the indicators of SDG 1
Copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform:
https://sustainabledevelopment.un.org/post2015/transformingourworld
online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (page 21/35)

SDG 10 reducing inequality within and among countries	
10.1	By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average
10.2	By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status
10.3	Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard

10.4	Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality
10.5	Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations
10.6	Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions
10.7	Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies
10.a	Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organization agreements
10.b	Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries, African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes
10.c	By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent

4.3.1. Key factors to measure inequalities

Basically, when quantifying inequalities there should be 5 key factors considered: “Geography, Demographics, Shocks and Fragility, Socio-Economics and Governance” (Foundation, 2019, p. 3). These are demonstrated in Figure 13, where obstacles are shown from a female (Melinda) and male (Bill) perspective. It is evident that if inequalities would not be present, the obstacles formed as a curve would become a straight line. Whereas geography is only defined by the location where people live, demographics includes several parameters such as gender, race, religion, age and ability and is often also referred as discrimination. Due to recent events regarding climate change, it become more important to focus also on shocks and fragility, especially towards those that have just been uplifted from poverty. (see chapter 4.2). The Socio-Economics factor measures not only income inequalities but also education and access to basic services, similarly to the multidimensional poverty index and is represented by the human development index (HDI). Governance is taking a closer look at the effectiveness of institutions on all levels (global, national, sub national) (Foundation, 2019) (Renner S.,Bok L.,Igloi N., Linou N., 2018).

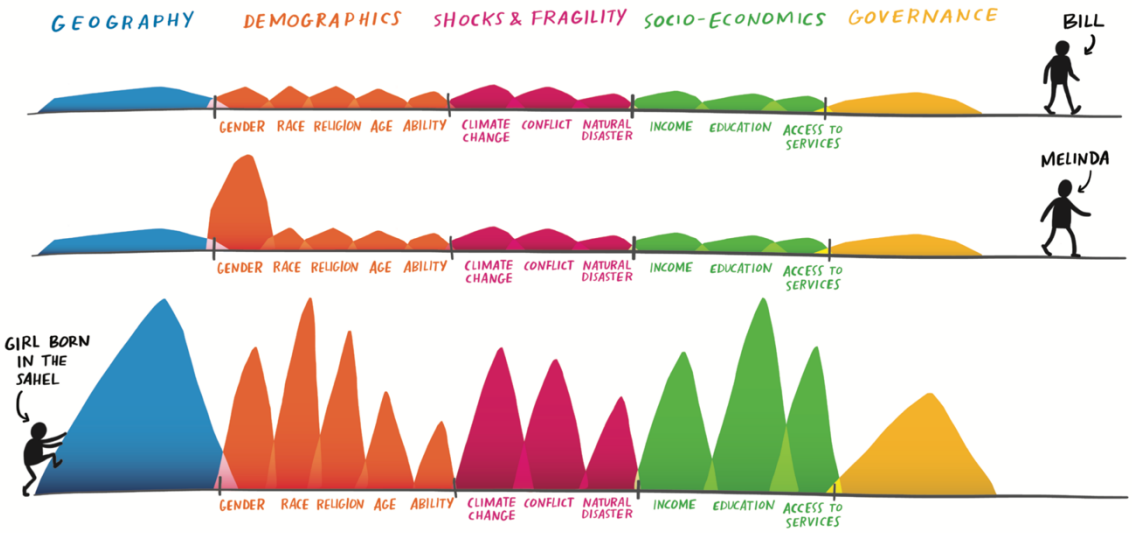

Figure 13 the 5 key factors to measure inequalities, *The Goalkeepers Report 2019, Examining inequalities: how geography and gender stack the deck for (or against) you, Bill and Melinda Gates Foundation, Goalkeepers, 2019. Reprinted from: https://www.gatesfoundation.org/goalkeepers/report/2019-report/#ExaminingInequality*

4.3.2. Human Development

Why HDI, IHDI and bottom 40 are used as indicators

The common indicator for inequalities is highlighted in the first target of SDG 10, namely the bottom 40, see Table 4. This indicator is demonstrated by the average "income growth rate of the poorest 40 percent of the population" (bottom 40). (2030 Agenda, 2015, p. 21) Moreover, it is also a measure of shared prosperity and therefore closely interlinked to SDG 1 poverty (World Bank , 2018).

In addition to that, synthesis indicators are selected, as an attempt to show SDG 10 in the context of the 17 SDGs. We have seen that inequalities have many angles. Nevertheless, quantifying the socio-economic angle and measuring humans' capabilities beyond income leads to human development. Human development is influenced by a lot of SDGs, such as directly from SDG 1,3,4,8 indirectly by SDG 2 and SDG 16 (Conceição, 2019).

HDI

"Capabilities are people's freedoms to choose what they want to be and do—regardless of whether they actually make those choices." (Pedro Conceição, 2019, p. 31) Hence, the Human Development Index (HDI) measures the "capability to live a long and healthy life, to acquire knowledge and to earn income for a basic standard of living." (Pedro Conceição, 2019, p. 31) As indicated in Figure 14, the HDI is calculated with 3 main indicators: life expectancy, level of education, and wealth. A persons wealth is estimated as gross national income (GNI) per capita in 2011 PPP (purchasing power parity). The indicators are equally distributed and have different minimum and maximum values (life expectancy: 20-85 years, expected years of schooling: 0-18 years, mean years of schooling: 0-15 years, GNI: 100-75000 in 2011 USD PPP per capita). (technical notes, 2019) The Dimension Index is calculated as followed:

"Dimension Index= $\frac{actual\ value - minmum\ value}{maximum\ value - minimum\ value}$ " (technical notes, 2019, p. 2)

To put the HDI values of all countries in perspective the cut-off points are introduced. These cut-off points split human development into sections of low (HDI <0.550) , medium (HDI 0.550-0.699), high (0.700-0.799), and very high human (HDI >0.800) development. (technical notes, 2019, p. 3)

IHDI

To measure not only the inequalities among countries but also within a specific country the Inequality-adjusted Human Development Index (IHDI) is defined, see Figure 14. (Pedro Conceição, 2019) The IHDI measures how the indicators are distributed among society of a country. Hence, when inequality is fully reduced and full equality is established, IHDI and HDI have the same value. (technical notes, 2019) Additionally, "the loss of human development due to inequality is given by the difference of HDI and IHDI." (n.d., 2019, p. 4)

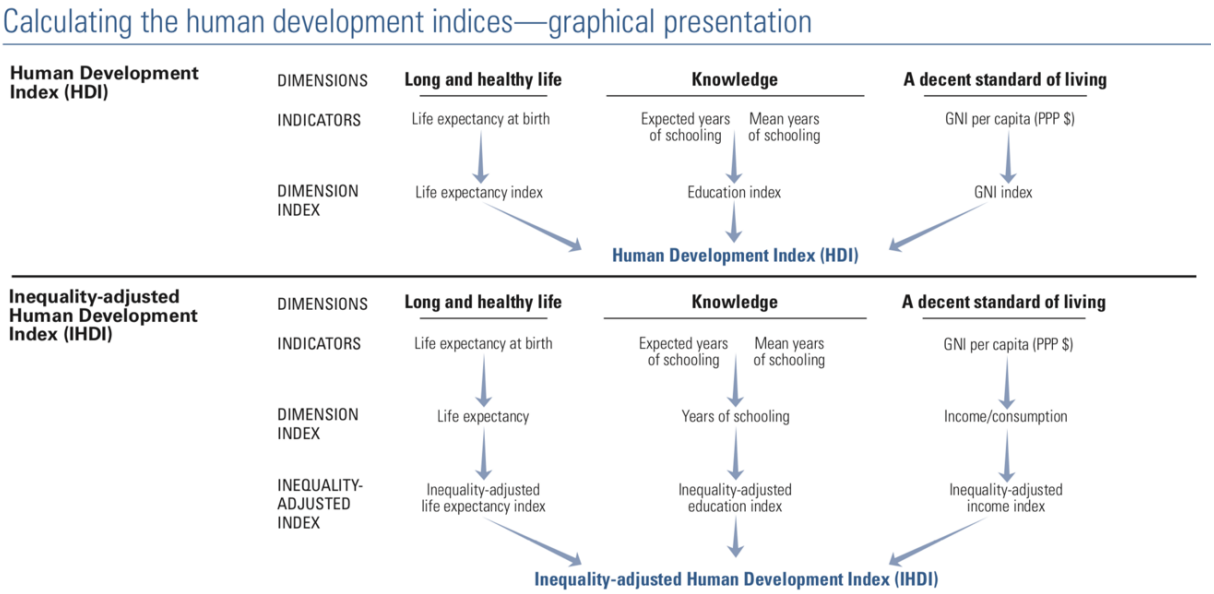

Figure 14 Calculating the human development indices, top: The Human Development Index (HDI), bottom: Inequality-adjusted Human Development Index (IHDI*), Human Development Report 2019, Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century, published for UNDP*
reprinted from: http://hdr.undp.org/sites/default/files/hdr2019_technical_notes.pdf

One can differentiate between basic and enhanced capabilities. Basic capabilities are early childhood survival, primary education, basic technology access and resilience to recurrent shocks, which are quantified in the HDI and IDHI. Whereas enhanced capabilities include quality health and education, state of the art technologies and resilience to unknown shocks. (Pedro Conceição, 2019) The resilience to unknown events and shocks, such as climate change, is also important for poverty eradication and therefore has been briefly addressed in chapter 4.2. Generally, on a global average, inequalities within enhanced capabilities are bigger than in basic capabilities. (Pedro Conceição, 2019) Because inequalities in basic capabilities are so high among the human development groups, one country from low- (Ethiopia) and one from medium-human development group (Ghana) was selected to be analyzed in chapter 5.

Bottom 40

Another important way to measure monetary inequalities and poverty and quantifying the first target of SDG 10, is to determine the share and participation of the poorest 40% of the population (bottom 40) in a country's economic success. "This is measured by monitoring the average consumption (or income) growth rate of the poorest 40 percent of the population (the bottom 40) within each and every country." (World Bank , 2018, pp. 1,2)

On a global average the majority of the bottom 40 had an average of 1.9% of the economic progress. However, data is only available for 62% of the global population. In Sub-Saharan Africa the average was 1.8%. But most of the extreme poor countries don't have data on the bottom 40. Within the most poor countries that share data, the vast majority shows a similar behavior of a lower growth rate behavior when compared to the global average. (World Bank , 2018)

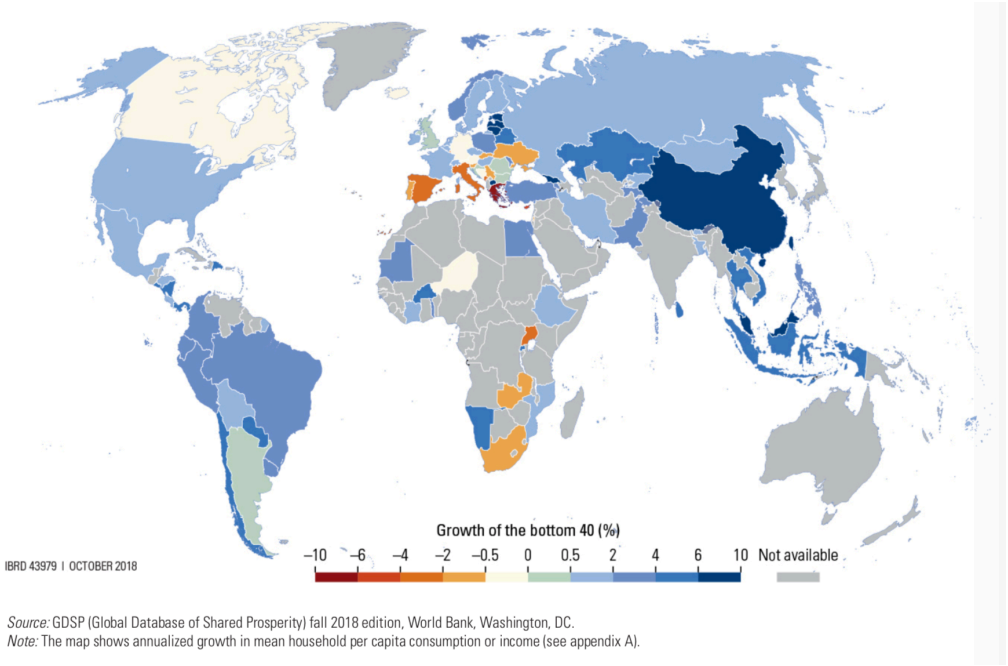

Figure 15 Shared Prosperity across the World, 91 Economies, circa 2010–15, Screenshot from the World Bank, Poverty and Shared Prosperity 2018: Piecing Together the Poverty Puzzle, page 52, License: Creative Commons Attribution CC BY 3.0 IGO, Washington DC, 2018

4.4. Interlinkages of SDG 7 and SDG 1

Ensuring SDG 7 modern sustainable energy for all is closely connected to SDG 1. (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) Table 5 shows the most relevant interlinkages in this connection according to published evidence.

On the one hand, ensuring SDG 7 is necessary to eliminate poverty. On the other hand, lacking SDG 7 "is a form and an outcome and a cause of poverty". (the United Nations, 2018, p. 65) Forming poverty roots from low human development, where people are not able to meet basic capabilities, which is demonstrated by SDG 10. The outcome and cause of poverty results from the limitation of economic resources of poor people for basic services. (the United Nations, 2018)

Table 5 Interlinkages of SDG 7 and SDG 1 poverty, Reasoning for interlinkage ro SDG 7:
Targets 1.1, 1.2, 1.3, 1.4 retrieved from: Fuso Nerini, F., Tomei, J., To, L.S. et al. (2018). Mapping synergies and trade-offs between energy and the Sustainable Development Goals. Nature, doi:10.1038/s41560-017-0036-5, 10-15.
Targets 1.1 , 1.2, 1.4 retrieved from: D. L McCollum, L.G. Echeverri, S. Busch, et. al. (2018, https://doi.org/10.1088/1748-9326/aaafe3). Connecting the sustainable development goals by their energy inter-linkages. Environ. Res. Lett. , 13 033006.
Targets 1.1 , 1.2, 1.5 retrieved from: the United Nations . (2018). Accelerating SDG 7 achievement SDG 7 policy briefs in support of the High-Level Political Forum 2018. United Nations, Division for Sustainable Development Goals, Department of Social and Economic Affairs. the United Nations.
Definition of SDG 1 targets (1.1- 1.5) copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform: https://sustainabledevelopment.un.org/post2015/transformingourworld
online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (page 15/35)

Interlinkages of SDG 7 to SDG 1		
SDG 1 targets		**Interlinkage to SDG 7**
1.1	By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day	Electricity access and clean cooking is essential for human development and necessary to eradicate poverty. Modern energy access could enable more time and economic resources and support the creation of jobs.
1.2	By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions	
1.3	Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable	Reasoning of targets 1.1 and 1.2 applies here too. "Social protection measures can include also protection on energy access." (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018, p. supported table)
1.4	By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Modern energy access could enable more time and economic resources and support the creation of jobs.
1.5	By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters	Sustainable energy has positive impacts on health and improves resilience towards extreme events (e.q. climate-related and others).

4.5 Interlinkages of SDG 7 and SDG 10

Ensuring SDG 7 modern sustainable energy for all is closely connected to SDG 10 reducing inequalities. (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) Table 6 shows the most relevant interlinkages in this connection according to published evidence. According to the policy brief to the HLPF, "SDG 7 is a condition for economic development, poverty alleviation (SDG 1) and reducing inequalities (SDG 10). Progress on SDG 7 can be seen as a means towards achieving other SDGs and the principle "Leave no one behind." (the United Nations, 2018, p. 64)

Table 6 Interlinkages of SDG 7 and SDG 10 inequalities, Reasoning for interlinkage to SDG 7
Targets 10.1, 10.2, 10.3, 10.4 retrieved from: Fuso Nerini, F., Tomei, J., To, L.S. et al. (2018). Mapping synergies and trade-offs between energy and the Sustainable Development Goals. Nature, doi:10.1038/s41560-017-0036-5, 10-15.
Targets 10.1 , 10.2, 10.4 retrieved from: D. L McCollum, L.G. Echeverri, S. Busch, et. al. (2018, https://doi.org/10.1088/1748-9326/aaafe3). Connecting the sustainable development goals by their energy inter-linkages. Environ. Res. Lett. , 13 033006.
Targets 10.1 , 10.2, 10.4 retrieved from: the United Nations . (2018). Accelerating SDG 7 achievement SDG 7 policy briefs in support of the High-Level Political Forum 2018. United Nations, Division for Sustainable Development Goals, Department of Social and Economic Affairs. the United Nations.
Definition of SDG 10 targets (10.1 – 10.7) copied from: Transforming our world: the 2030 Agenda for Sustainable Development, A call for action, United Nations, 2015, Sustainable Development Knowledge Platform: https://sustainabledevelopment.un.org/post2015/transformingourworld
online available via: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (page 21/35)

Interlinkages of SDG 7 to SDG 10		
SDG 10 targets		**Interlinkage to SDG 7**
10.1	By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average	"Income growth needs access to modern energy to support livelihoods through access to e.g. improved agriculture, machinery, ICT and support for small businesses." (Fuso Nerini, F., Tomei, J., To, L.S. et al., 2018, p. supported table) Modern energy access could enable more time and economic resources and support the creation of jobs.
10.2	By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status	Unpaid labour of women and children could be shifted to modern energy access (follow reasoning above, 10.1)
10.3	Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard	

10.4	Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	Reasoning of target 10.1 applies here too. Poor people often require large portions of their economic resources for electricity access and/ or clean cooking and therefore affordability is key.

5. Interlinkages of SDG 1,7,10 in Sub-Saharan Africa

This chapter intends to look at the Sub-Saharan African region to select two specific countries according to their priority in SDG 7.1 to the region. In the second part, the 3 SDGs and their interlinkages will be analysed in those countries, namely in Ethiopia and Ghana.

Firstly, I zoom into electricity access in Sub-Saharan Africa from different angles, the global perspective, zooming into regional differences, urban and rural differences.

Looking at Sub-Saharan Africa in a global context, highlights the importance of Sub-Saharan Africa to fulfil the Goals of the Agenda 2030 and explains the geographical focus of this thesis. The fact that two-thirds of the global population that lack electricity access are located in Sub-Saharan Africa, shows that Sub-Saharan Africa is the global hotspot regarding electricity access (IEA, IRENA, UNSD, WB, WHO, 2019).

Zooming into regional differences, reveals the difference in electrification rates of west and east Africa and demonstrates the recent electrification success, where Ethiopia is a forerunner in electrification per capita, in Africa. Subsequently, the focus on the achievements of SDGs will be addressed in two countries, namely Ethiopia (East Africa) and Ghana (West Africa). The second, because it has made severe progress in electricity access, especially for a west African country. Ghana as well as Ethiopia belong to Africas key countries, according to the IEAs African Energy Outlook 2019 (IEA, 2019).
Urban vs. rural discrepancy, demonstrates that recent electrification programmes and policies have prioritized urban population. Additionally, the lack of access to basic services for people in rural areas is highlighted. Accordingly, I zoom into informal settlements. This enhances a new angle to urban electricity access, because 20% of people lacking electricity access in Africa live in urban areas close to the grid.

The second part is an attempt to look in dept and analyse the progress of the 3 SDGs and their interlinkages in Ethiopia and Ghana. In particular the analysis is an attempt to compare the development progress of electricity access, poverty and inequalities in Ethiopia and Ghana. Firstly, the specific indicators in each Country will be addressed and subsequently the comparison in the indicators of Ethiopia and Ghana follows.
Regarding SDG 7.1, I'll look at electricity access from different perspectives. Namely, the electrification rate (% of the population), differences in urban vs. rural electrification and clean cooking access rate.
Regarding SDG 1, the international poverty line (IPL share of people living with less than 1.9 USD/ day) as well as the two poverty lines for higher standards (UMIPL and LMIPL, share of people living with less than 3.2 and 5.5 USD/ day, respectively) will be analysed followed by the multidimensional poverty index.
Afterwards, there will be an attempt to investigate the difference of the poverty situation from both views, the international and multidimensional one.
Regarding SDG 10, the HDI as well as the IHDI will be analysed. Followed by the attempt to look at the difference between the economic situation (growth rate) for the bottom 40 as well

as per capita. Lastly, overall the interlinkages of SDG 7.1, 1 and 10 will be analysed in the Discussion. In the conclusion, the final results are discussed within the scope of the thesis.

5.1. Sub-Saharan Africa (scopes)

5.1.1. Sub-Saharan Africa's electricity access in a global perspective

As discussed in Chapter 4.1, Sub-Saharan Africa is the global hotspot of electrification deficit, accounting for two-thirds of people lacking electricity access (IEA, 2019). That is why the geographical focus of this thesis is Sub-Saharan Africa.
Even though Sub-Saharan Africa made electrification progress over the past 20 years, the access deficit (people without access) is the highest in the world, see Figure 16 and Figure 17. According to the World Bank, a likely explanation for this electricity trend is, that the population increased so much, that it outpaced the electrification process.
In 2017, not even half of the population in Sub-Saharan Africa had access to electricity (see Figure 16), which accounts for almost 600 million people being left behind (see Figure 17) (IEA, IRENA, UNSD, WB, WHO, 2019).
Even though the SDG 7.1 target claims universal electricity access by 2030, latest prognoses show that goal will be failed by 530 million people in Sub-Saharan Africa (IEA, 2019). It's noteworthy that all of these people will live in Least Developed Countries (LDCs) (the United Nations, 2019). That is why for the analysis one country that belongs to LDCs and one that belongs to a lower-middle income country were selected.

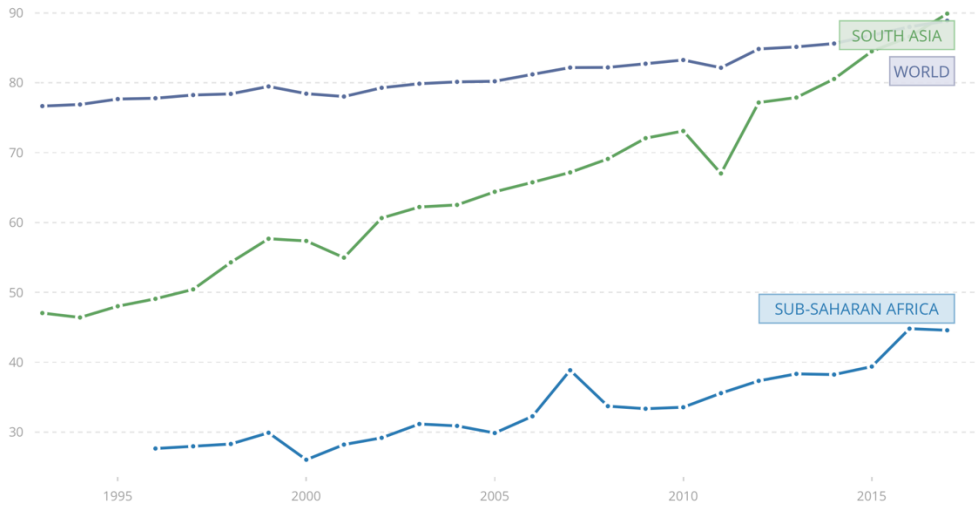

Figure 16 Access to electricity (% of population) - Sub-Saharan Africa, South Asia, World from 1993 to 2017, Retrieved from *the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.* Available online: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?end=2017&locations=ZG-8S-1W&start=1993&type=points&view=chart

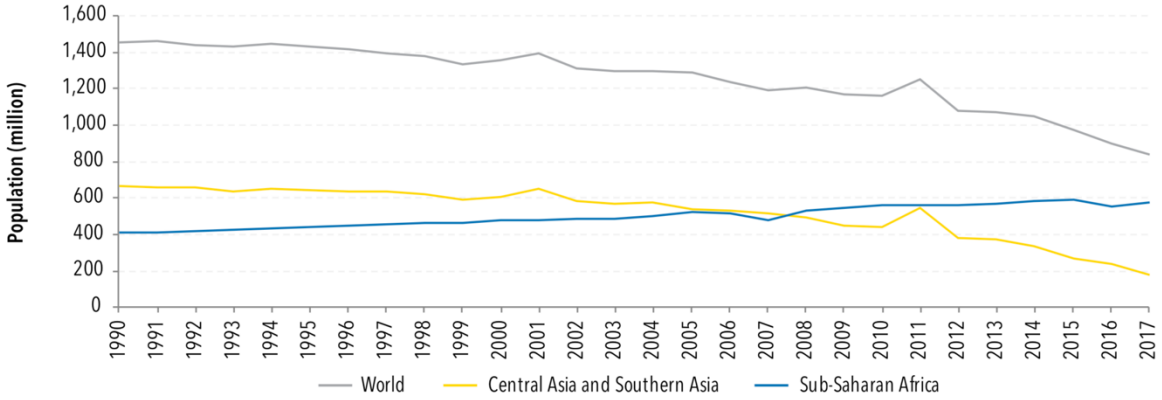

Figure 17 Access deficit (millions of people) in Sub-Saharan Africa, South Asia, World (global average) from 1990 to 2017, reprinted from *tracking SDG 7: the Energy Progress Report 2019,* IEA, IRENA, UNSD, WB, WHO (2019), Washington DC

5.1.2. Regional differences and reasoning behind focusing on Ethiopia and Ghana

The electrification progress in Sub-Saharan Africa varies strongly within regions. As shown by Figure 18, between 2010 to 2018, East Africa made the biggest progress, opposed to Central Africa, which had the least increase in electricity access out of the African regions. East Africa is also lacking behind compared to West and Southern Africa in 2017 (IEA, 2019).
For the analysis, one East African country is chosen, because it made the biggest electrification progress out of the African regions, from 21% in 2010 to 43% in 2017, see Figure 18. Moreover, for the analysis, one West African country is chosen, because it has the highest access rate with 53% out of the African regions, see Figure 18.

The IEA (International Energy Agency) selects key countries in Africa according to their importance to the continent. Most recently, "Angola, Côte d'Ivoire, Democratic Republic of the Congo (DR Congo), Ethiopia, Ghana, Kenya, Mozambique, Nigeria, Senegal, South Africa and Tanzania", were chosen (IEA, 2019, p. 23). "Together, they represent three-quarters of sub-Saharan Africa's 2018 gross domestic product (GDP) and energy demand, and two-thirds of population. They also account for the majority of Africans without access to modern energy services (IEA, 2019, p. 23)."

As the West African country Ghana is chosen, because it is the only West African Country out of the key countries, that has made significant electrification progress from 2013-2018, see Figure 18.

For the East African country, I wanted to select another key country, that made significant electrification progress. About half of the Sub-Saharan African population without access to electricity lives in five countries: "Nigeria, Democratic Republic of Congo, Ethiopia, Tanzania and Uganda. It's noteworthy that 3 out of these 5 countries, namely Ethiopia, Tanzania and Kenya connected the highest number of people between 2014 and 2018, accounting for more than 50% of those gaining access in Sub-Saharan Africa." (IEA, 2019, p. 42) Out of the East

African countries, Ethiopia connected the most people to electricity between 2014 and 2018. For this reason, the second country that has been chosen for the analysis is Ethiopia.

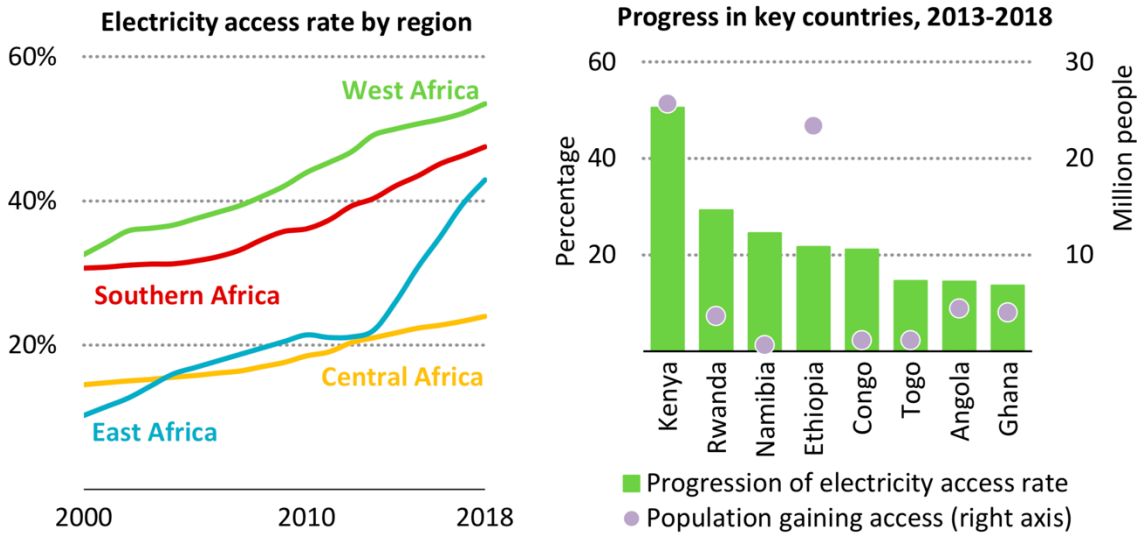

Figure 18 Electricity Access progress in Sub Saharan Africa, left: Electricity access rate (%) by region from 2000 to 2018, right: Progress in key Countries from 2013 to 2018, reprinted from *Africa Energy Outlook 2019 - p.43,* IEA (2019), Paris

As discussed in chapter 4.2, in 2015 the majority of extreme poor people lived in 5 key countries. Whereas 3 of these countries are located in Sub-Saharan Africa, namely Democratic Republic of Congo, Ethiopia and Nigeria (GSDR, 2019). In particular, when comparing extreme poverty reduction, globally between 2000 and 2015, Ethiopia was selected as one of the most successful countries in the world. (Asaidaniel M., Mahlersilvia G., Narayanminh M., Nguyen C., 2019) That was another factor that contributed to the selection of Ethiopa as the East African country.

As discussed in chapter 4.3, inequalities in basic capabilities vary among the human development groups. To potentially show the differences in inequalities, selected countries should preferably be in different human development groups. Therefore, one country from the low human development group (Ethiopia) and one country from the medium human development group (Ghana) was chosen. (Pedro Conceição, 2019)

5.1.3. Urban vs. rural electricity access in Sub-Saharan Africa

In Sub-Saharan Africa the average electrification rate has similar tendencies to the global average, as discussed in Chapter 4.1. It increased from 2010 onwards, nevertheless the difference between urban and rural areas remains high.
In rural areas in Sub-Saharan Africa, 15% and 22% of the population had access to electricity in 2010 and 2017 respectively, shown by Figure 19. Especially in rural areas affordable, reliable off-grid solutions that include peoples' willingness to pay are crucial. However, grid connections have high upfront connection costs. That's why profitability is best in densely populated areas. (IEA, 2019) Therefore, affordable off-grid solutions, such as solar and small hydro, are crucial to meet the demand of the poor. Nonetheless, countries in Sub-Saharan Africa are still prioritizing on-grid power in urban areas. (the United Nations, 2019)

Overall, 80% of the population that doesn't have access to basic services, such as electricity, clean water and sanitation and education, lives in rural areas. (GSDR, 2019)
As indicated by Figure 19, access to electricity in Sub-Saharan Africa is much higher in urban areas, demonstrated by 69% and 79% in 2010 and 2017 respectively. Additionally, Figure 19 shows that electrification pace was faster in urban than in rural areas. Nevertheless, urban electrification in Sub-Saharan Africa still faces challenges, one of them is regarding informal settlements.

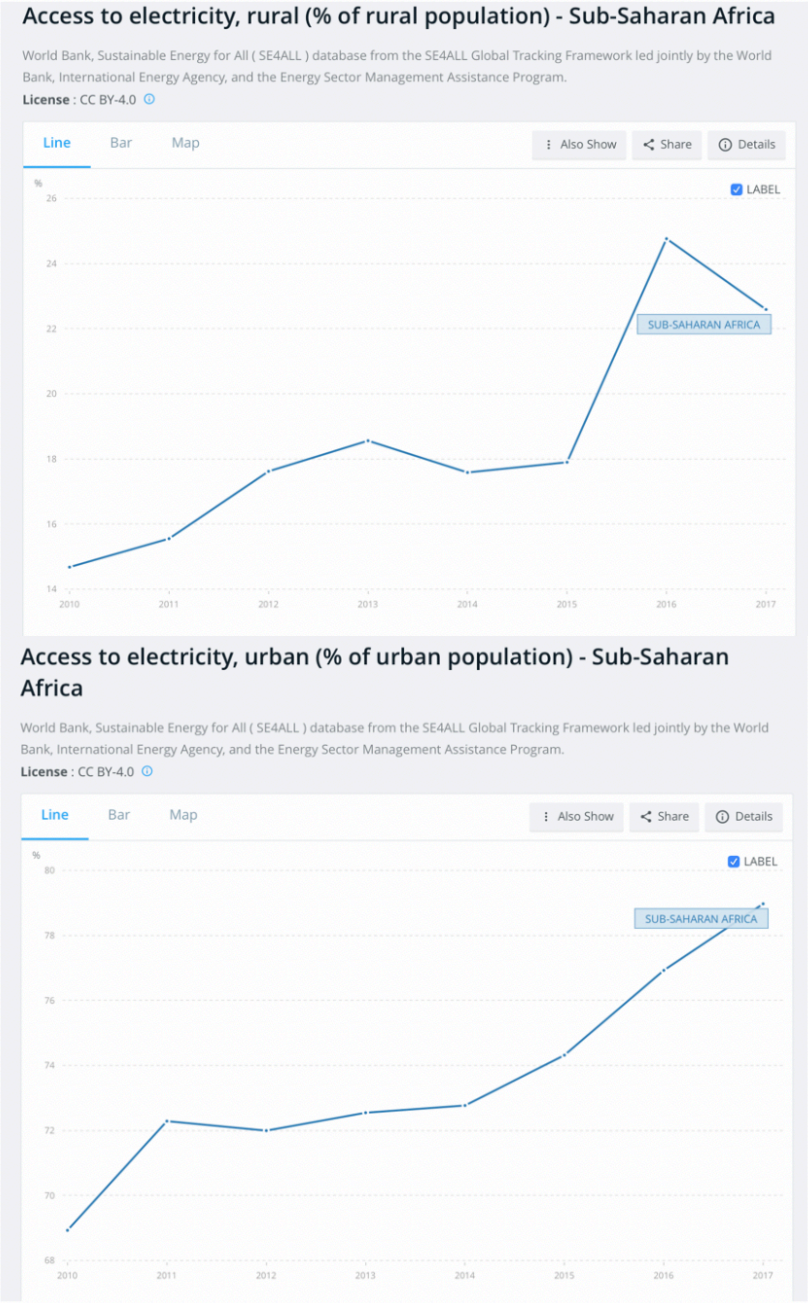

Figure 19 Access to electricity (% of population) in rural and urban areas in Sub-Saharan Africa from 2010 to 2017, *Retrieved from the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program. Available online: rural:* https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?end=2017&locations=ZG&start=2010 *urban:* https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?end=2017&locations=ZG&start=2010

5.1.4. Informal settlements

More than half of the urban population in African countries lives in informal settlements often lacking access to basic services such as electricity and clean cooking. (IEA, 2019, p. 46) Lacking basic services has direct implications to humans' safety and wellbeing, as presented in chapter 3 Food-Water-Energy Nexus and Chapter 4 multidimensional poverty index and chapter 5 human development.

Almost 20% of people without access in the continent of Africa, which account for 110 million people in Africa, live in urban areas close to the grid. (IEA, 2019, p. 46) Some of them are illegally connected, which also affects utility losses and affordability. One of the main reasons why the residents are not connected is affordability, not only but also because of low incomes. (IEA, 2019) Affordable access to modern energy services is a key factor to eradicate poverty and reduce inequalities. It's interlinkages have been discussed in Chapter 4.4 and chapter 4.5, see Table 5 and Table 6. (the United Nations, 2018)

Considering the fact that Africa's population growth is increasing from 1.2 million in 2015 to 2.5 billion in 2050, ensuring save housing and basic needs is vital. Nonetheless, latest research shows that while urban areas increase, informal settlements will increase as well. According to Tusting *et. al* more people will live in informal settlements and those will lack basic services (Tusting, L. et. al, 2019).

5.2. Applied Analysis of Ethiopia and Ghana

5.2.1. SDG 7.1 – ELECTRICITY ACCESS and CLEAN COOKING

In this chapter SDG 7.1, electricity access and clean cooking is analysed, starting with Ethiopia and Ghana individually. Subsequently the two countries are compared regarding the selected indicators. The indicators for SDG 7.1 are access to electricity and clean cooking as a share of the total population. Whereas electricity is analysed from 3 different angles, as a share of the total population, urban access and rural electricity access. The values of these indicators for Ethiopia and Ghana can be found in Table 7 and Table 8, respectively.

Electricity access (share of the population)

Ethiopia electricity access

The electricity access in Ethiopia has increased from 13% in the year of 2000 to 43% of the population in 2017, see Table 7 and Figure 20. The most recent value is meeting the average of East African countries, which demonstrates the highest improvement of electrification rates in Africa, as discussed in the previous chapter, see Figure 18.

When having a closer look at the evolution of access to electricity, one can see a peak in the year 2007, see Figure 20. In 2007, Ethiopia in cooperation with the world bank aimed to

increase rural electrification. A new strategy for electrification affordability was developed, so that poor people could get loans to pay a little at a time instead of right away. This enabled particularly poor rural population to get electricity access, see Figure 21. (Barnes Douglas, Golumbeanu Raluca, Diaw Issa, 2016) The impact of access to rural electrification (see Figure 20) can be seen in the electrification rate, because a lot of people gained access in a short amount of time, see Figure 20.

The qualities and levels of electricity access in Ethiopia have been recently analysed by the World Bank. (Gouthami Padam, Dana Rysankova, Elisa Portale, Bryan Bonsuk Koo, Sandra Keller, Gina Fleurantin, 2018) However, over the selected timeframe (2000-2016) data regarding the differences in electricity access according to Multi Tier Framework was not found, since the Multi Tier Framework was only developed in 2015. (Mikul Bhatia, Nicolina Angelou, 2015)

Table 7 Ethiopia, SDG 7.1 Indicators in the following years: 2000, 2004, 2010, 2016, Retrieved from the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.
(*https://data.worldbank.org/country/ethiopia*)
Electricity access (% of population): Available Data online:
https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=ET
Clean cooking access (% of population): Available Data online:
https://data.worldbank.org/indicator/EG.CFT.ACCS.ZS
Urban vs. rural (% of population): Available Data online:
urban: https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=ET
rural: https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=ET

Ethiopia, SDG 7.1 common indicators in the years 2000 to 2016		
Electricity access	**Year**	**% of population**
	2000	12
	2004	28
	2010	33
	2016	43
Clean cooking access	**Year**	**% of population**
	2000	1
	2004	2
	2010	3
	2016	4
Urban electricity access	**Year**	**% of the urban population**
	2000	76
	2004	81
	2010	86
	2016	86

	Year	% of the rural population
Rural electricity access	2000	2
	2004	18
	2010	22
	2016	32

Ghana electricity access

As indicated by Figure 20 and Table 8, electricity access in Ghana has increased from 44% in the year of 2000 to 80% of the population in 2016. The most recent value is one of Sub-Saharan Africa's highest and above the average of West-African countries, which demonstrate the highest electrification rates in Africa, see Figure 18. (IEA, 2019)

Due to the lack of data, it is not possible to investigate what level of electricity access according to the MTF (Multi Tier Framework) is present in Ghana. (Mikul Bhatia, Nicolina Angelou, 2015)

Table 8 Ghana, SDG 7.1 Indicators in the following years: 2000, 2005, 2010, 2016, Retrieved from the World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program. (*https://data.worldbank.org/country/ghana*)
Electricity access (% of population): Available Data online:
https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=GH
Clean cooking access (% of population): Available Data online:
https://data.worldbank.org/indicator/EG.CFT.ACCS.ZS?locations=GH
Urban vs. rural (% of population): Available Data online:
urban: https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=GH
rural: https://data.worldbank.org/indicator/EG.ELC.ACCS.RU.ZS?locations=GH

Ghana, SDG 7.1 common indicators in the years 2000 to 2016		
Electricity access	**Year**	**% of population**
	2000	44
	2005	55
	2010	64
	2016	80
Clean cooking access	**Year**	**% of population**
	2000	6
	2004	10
	2010	16
	2016	22
Urban electricity access	**Year**	**% of the urban population**
	2000	80
	2004	81

	2010	72
	2016	86
Rural electricity access	**Year**	**% of the rural population**
	2000	15
	2004	31
	2010	55
	2016	67

Comparison electricity access

Whereas the population increased from 66 million in 2010 to 106 million in 2017 in Ethiopia. (population ethiopia, world bank, 2019) Ghana's number of residents increased from 19 million in 2010 to 29 million in 2017. (population Ghana, world bank , 2019)

Because the electrification rate of both countries was similar during the analysed timeframe, much more people in Ethiopia gained access to electricity. In particular, Ethiopia's electrification rate increased 31%, whereas Ghana's electrification rate increased 35%. (IEA, 2019)

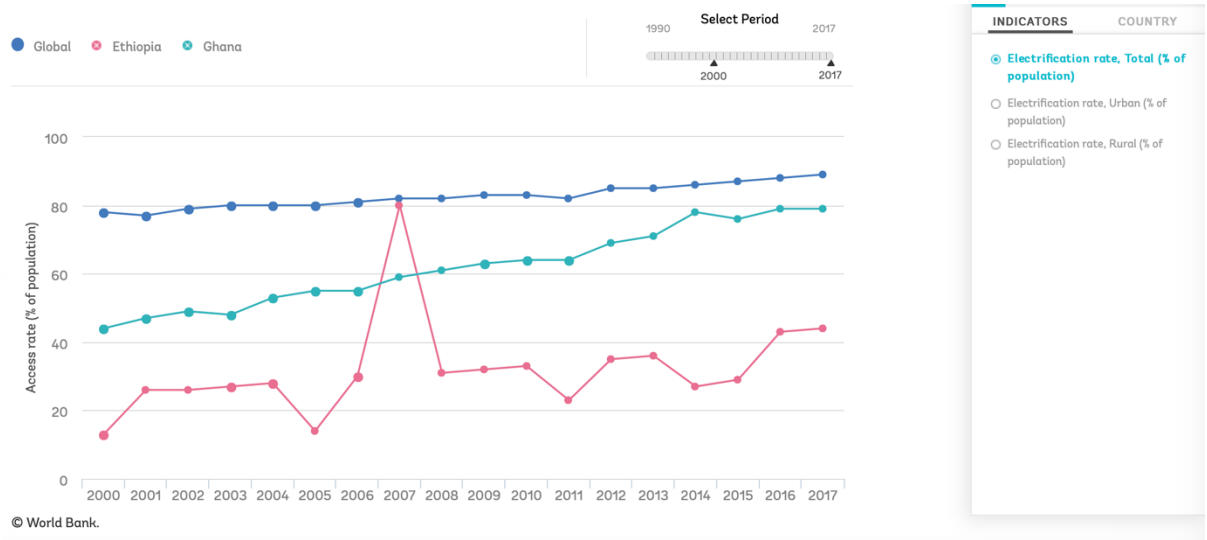

Figure 20 Electricity access (% of the population) of Ethiopia (red line), Ghana (green line) and global average (blue line), Retrieved from *Tracking SDG7: The Energy Progress Report, ESMAP, joint website of the Custodian Agencies – the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).*
Available online: *https://trackingsdg7.esmap.org/time?country=Ghana*
full data sets in table format available under: *https://trackingsdg7.esmap.org/data/files/download-documents/7.1.1_electrification_dataset.xls*

Electricity access urban vs. rural (% of the population)

Ethiopia access urban vs. rural

As indicated by Table 7 and Figure 21, the urban electricity access in Ethiopia has increased from 76% of the population in the year of 2000 to 86% of the population in 2016. The latest electrification effort is even above the average of Sub-Saharan Africa, as discussed in Chapter 5.1, accounting for 76% of the population in Sub-Saharan Africa, see Figure 19.

However, electricity access in rural areas is, as expected, on a different level, see the global view section 4.1, page 20, as well as the Sub-Saharan Africa scope section 5.1, page 39. Nevertheless, the electrification rate of Ethiopia's rural population increased tremendously over the past 17 years. From 2% in 2000 to 32% in 2016. The most recent value is again higher than the average of Sub-Saharan Africa rural electrification, which is 23% of total Sub-Saharan Africa's rural population, shown in Figure 19.

Ghana access urban vs. rural

Demonstrated by Figure 21 and Table 8, urban electricity access in Ghana has increased from 80% of the population in the year of 2000 to 90% of the population in 2016. The most recent data indicates that Ghana is almost fulfilling the SDG 7.1 target for it's urban population. Nevertheless, the progress over the analysed timespan was slow, compared to the average efforts in Sub-Saharan Africa, shown in Figure 19. Additionally, it's noteworthy that the last 10% of the population that lacks electricity access, is harder to reach, see section 4.1, page 19.

The rural electricity access in Ghana has increased from 15% in the year of 2000 to 67% of the population in 2016, see Table 8 and Figure 21. These values align with fact that globally as well as in Sub-Saharan Africa the rural electrification pace is much faster than the urban one, see section 4.1, page 20.

Comparison access urban vs. rural

Both countries demonstrated urban electrification success since the year 2000, however Ethiopia's increased 21%, whereas Ghana's increased 9% of the population, see Figure 21, Table 7 and Table 8. As a result, Ethiopia made bigger progress in urban electrification than Ghana. It's noteworthy that the population increase during the given timespan is also bigger in Ethiopia than in Ghana. (population ethiopia, world bank, 2019), (population Ghana, world bank , 2019)
Ethiopia as well as Ghana demonstrated a high rural electrification pace during 2000 to 2016, which is higher than the urban ones. This aligns with the average in Sub-Saharan Africa, as well as the global average, see Figure 19 and section 4.1, page 20, respectively.

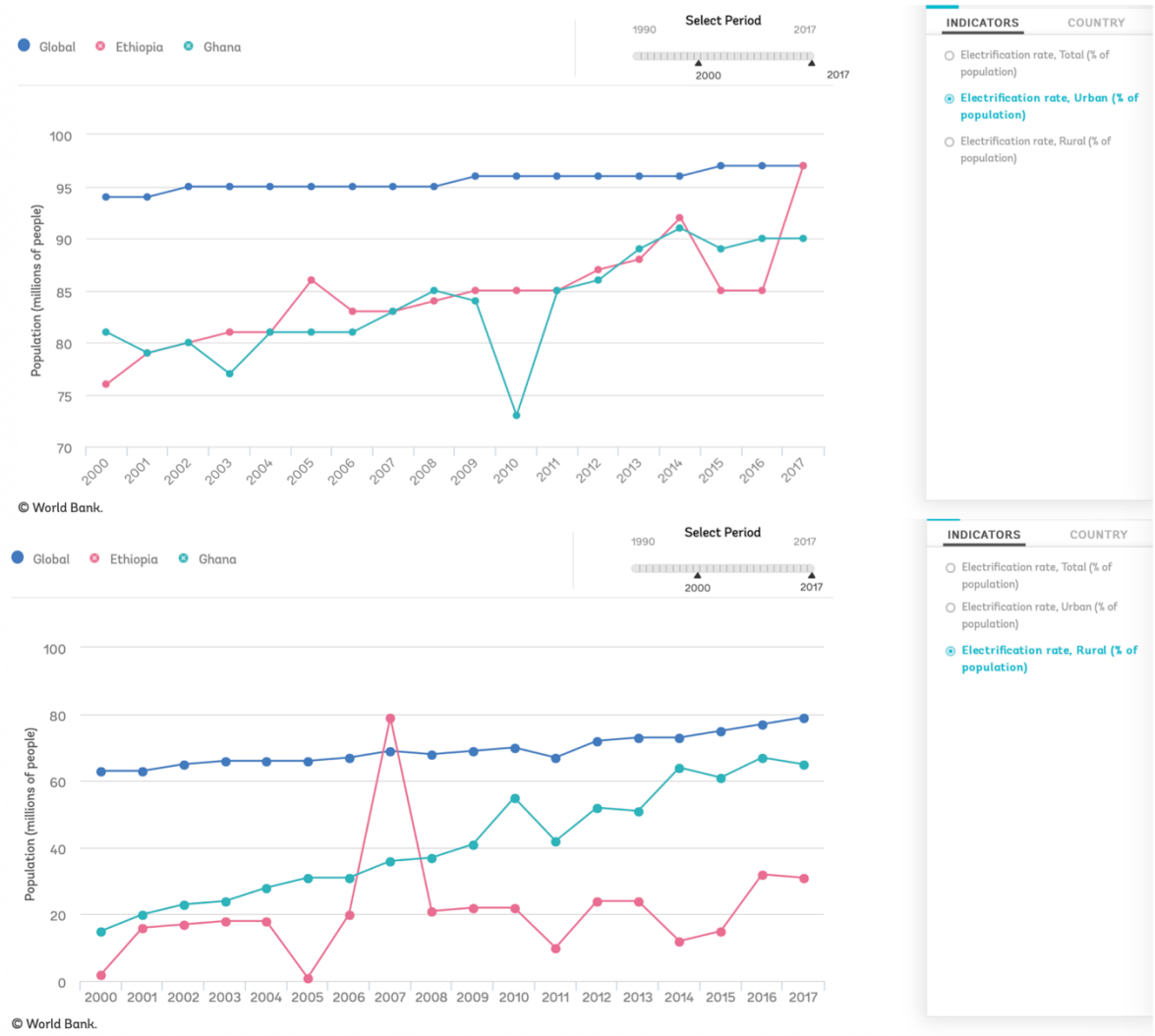

Figure 21 Access to electricity urban vs. rural (% of population) of Ethiopia (red line), Ghana (green line) and global average (blue line), access to electricity urban (% of population) is shown in the top figure,), access to electricity rural (% of population) is shown in the top figure, Retrieved from *Tracking SDG7: The Energy Progress Report, ESMAP, joint website of the Custodian Agencies – the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).* Available online: *https://trackingsdg7.esmap.org/time?country=Ghana*
full data sets in table format available under: *https://trackingsdg7.esmap.org/data/files/download-documents/7.1.1_electrification_dataset.xls*

Clean Cooking Access rate (% of the population)

Ethiopia Clean Cooking Access rate

As indicated by Figure 22, the access to clean cooking in Ethiopia has increased from 1% in 2000 to 4% of the population in 2016. Both of these values, as well as the gradient is significantly lower than the global average.

According to the IEA, in 2019, the vast majority of Ethiopia's population uses solid biomass (84%), followed by Charcoal (8%), clean cooking solutions (7%) and kerosene and coal (1%) (IEA, 2019). Ethiopia's fuels and technologies used for cooking align with the global average that lack clean cooking solutions, where the majority uses solid biomass, coal and kerosene, see section 4.1, page 22.

Ghana Clean Cooking Access rate

As indicated by Figure 22, the access to clean cooking in Ghana has increased from 6% in 2000 to 22% of the population in 2016. Both of these values, as wells as the gradient is significantly lower than the global average.

According to the IEA, in 2018, 39% of Ghana's population uses Charcoal, followed by 36% solid biomass and 24% LPG and 1% other clean cooking solutions. (IEA, 2019) Therefore 25% use clean cooking solutions, mostly coming from liquefied petroleum gas (LPG). This aligns with the global average, that indicates that the biggest progress for clean cooking comes from LPG, natural gas and electricity, see section 4.1, page 22.

Due to the lack of data, statistics of the cook stoves technology used in Ghana were not found.

Comparison Clean Cooking Access rate

Ethiopia as well as Ghana are lacking behind the global average on offering clean cooking solutions. Ethiopia's access rate has increased only 2 %, whereas Ghana managed, mainly due to LPG, and increase of 19%. However, in order to fulfil the second indicator of SDG 7.1 and meet the target, both countries need a faster pace regarding clean cooking. New policies with a focus on affordable, reliable clean cooking solutions, that meet cultural factors, are needed.

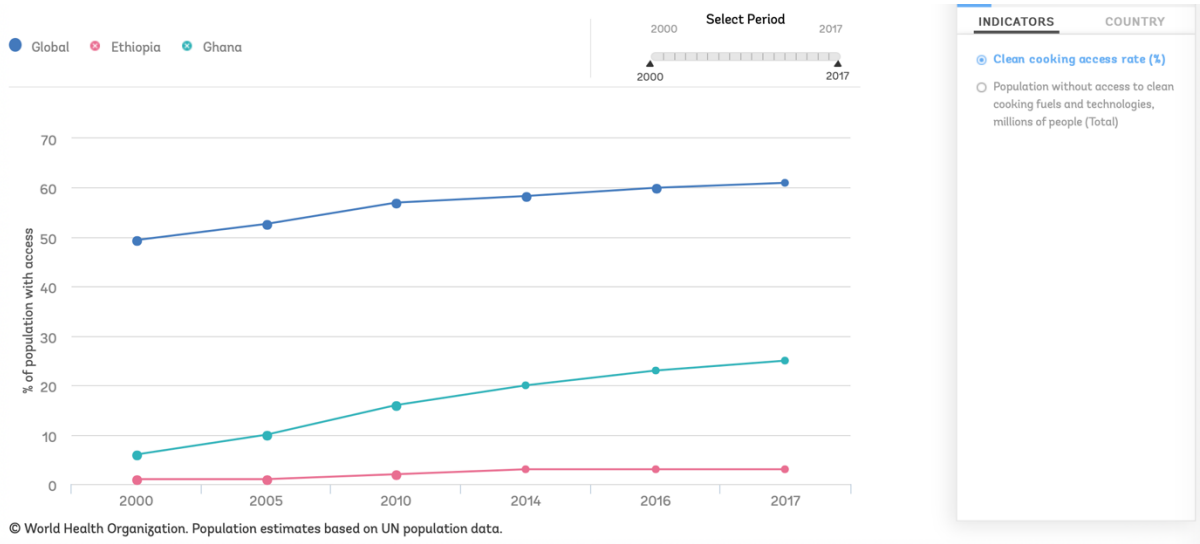

Figure 22 Access to clean cooking (% of population) of Ethiopia (red line), Ghana (green line) and global average (blue line), Retrieved from *Tracking SDG7: The Energy Progress Report, ESMAP, joint website of the Custodian Agencies – the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank, and the World Health Organization (WHO).*
Available online: https://trackingsdg7.esmap.org/time?country=Ghana
full data sets in table format available under: *https://trackingsdg7.esmap.org/data/files/download-documents/7.1.2_clean_fuels_and_technologies_for_cooking_dataset.xls*

5.2.2 SDG 1 – POVERTY

In this chapters SDG 1 poverty is analysed first for Ethiopia and Ghana individually. Subsequently the two countries are compared in the indicators. The indicators for SDG 1 are the international poverty lines (IPL, LMIPL, UMIPL) and multidimensional poverty (MPI of the total population and urban vs. rural) The values for Ethiopia can be found in Table 9, Table 11 and Table 12. The values for Ghana can be found in Table 10, Table 13 and Table 14.

Poverty thresholds Ethiopia:

The distribution of Ethiopia's population between different poverty thresholds from 1999 to 2015 is demonstrated in Table 9 (share of the population). Similar context is shown in Figure 23, where the distribution of poverty thresholds is shown in absolute values (million people) from 1995 to 2015.

Ehtiopia's extreme poor, in particular the share of population living with less than 1.9 USD per day, almost halved from 1999 to 2015 (from 61.2% to 30.8% respectively). Whereas demonstrated in the second international poverty line for higher standards (LMIPL), the share of population living with less than 3.2 USD per day decreased 20% between 1999 and 2015. The highest international poverty line (UMIPL) demonstrates still the majority of people and decreased only 7% from 97.6% in 1999 to 90.2% in 2015.

Overall, between 1999 and 2015 the biggest share of Ethiopia's population has been uplifted from extreme poverty (IPL 1.9 USD per day) whereas the slowest progress demonstrated for people living below the third poverty line (UMIPL, 5.5 USD per day). Obviously, in 2015 most people are living below the third poverty line (UMIPL, 5.5 USD per day), as indicated in Figure 23. However, the biggest share of population living in poverty lives below the second poverty line (LMIPL, 3.2 USD per day), see Table 9, (68.9 – 30.8 = 38.1% of the population living between 1.9 and 3.2 USD per day). This aligns with the global average, see chapter 4.2.

Table 9 Ethiopia Distribution of population between different poverty thresholds measured in Poverty headcount ratio at $1.90, $3.20 and $5.50 a day (2011 PPP) (% of population) in the following years: 1999, 2004, 2010, 2015, Retrieved from the World Bank, Development Research Group. Data are based on primary household survey data obtained from government statistical agencies and World Bank country departments. For more information and methodology, please see PovcalNet (*iresearch.worldbank.org/PovcalNet/index.htm*)
Share of people living less than 1.9 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.DDAY?end=2015&locations=ET&start=1999
Share of people living less than 3.2 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.LMIC?end=2015&locations=ET&start=1999
Share of people living less than 5.5 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.UMIC?end=2015&locations=ET&start=1999

Ethiopia, Distribution of population between different poverty thresholds, 1999 to 2015		
IPL: **Share of people living with less than 1.9 USD/day (% of population)**	**Year**	**% of population**
	1999	61,2
	2004	37,2
	2010	33,5
	2015	30,8

LMIPL: Share of people living with less than 3.2 USD/day (% of population)	Year	% of population
	1999	90,4
	2004	78,7
	2010	73,1
	2015	68,9
UMIPL: **Share of people living with less than 5.5 USD/day (% of population)**	**Year**	**% of population**
	1999	97,6
	2004	95,6
	2010	93,1
	2015	90,2

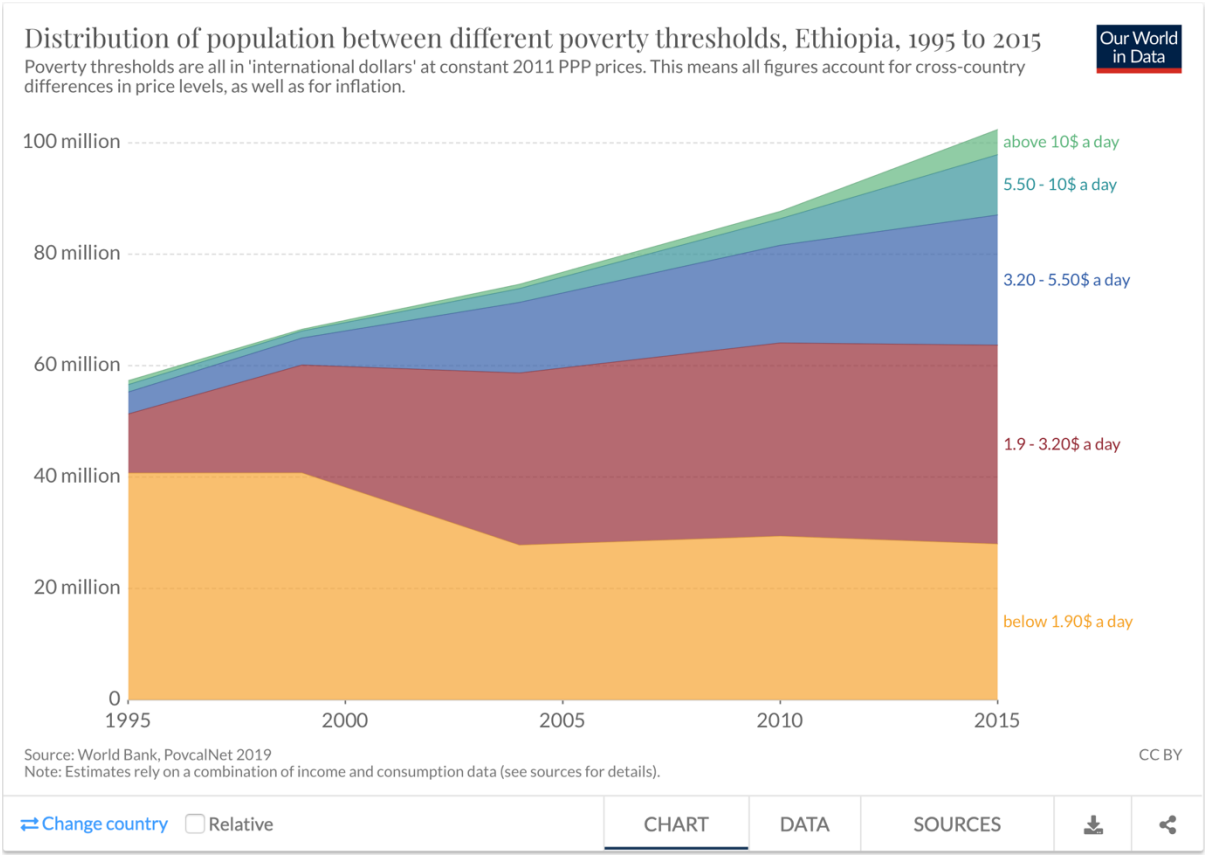

Figure 23 Ethiopia, Distribution of population between different poverty thresholds from 1995 to 2015, Retrieved from Max Roser and Esteban Ortiz-Ospina (2020) - "Global Extreme Poverty". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/extreme-poverty'
Available online: https://ourworldindata.org/grapher/distribution-of-population-poverty-thresholds?stackMode=relative&country=ETH
Full data sets available online via: http://iresearch.worldbank.org/PovcalNet/povDuplicateWB.aspx

Poverty thresholds Ghana:

The distribution of Ghana's population between different poverty thresholds from 1998 to 2015 is demonstrated in Table 10 (share of the population). Similar context is shown in Figure 24, where the distribution of poverty thresholds is shown in absolute values (million people) from 1987 to 2016.

Ghana's extreme poor, in particular the share of population living with less than 1.9 USD per day, more than halved from 1998 to 2016 (from 35.7% to 13.3% respectively). Additionally, demonstrated in the second international poverty (LMIPL), the share of population living with less than 3.2 USD per day almost halved as well during the same time span. The highest international poverty line (UMIPL) demonstrates still the majority of people and decreased 28.5% from 85.4% in 1998 to 56.9% in 2016.

It's noteworthy, that the progress of uplifting poverty in Ghana between 1998 and 2016 has been fairly equally distributed among the different international poverty lines (IPL, LMIPL and UMIPL), see Table 10.
The biggest progress was achieved for people living below LMIPL, accounting for a change of 32.8%, see Table 10. This was followed by the share of population below the UMIPL, with a change of 28.3%. The least progress was achieved by uplifting people out of the IPL, accounting for a change of 22.4%.
In 2016 most people, the majority of poor people lives below poverty lines of higher standards (LMIPL and UMIPL), see Table 10, Figure 23. This relation was expected, due to the fact that according to the world bank Ghana is a medium developed country.

Table 10 Ghana Distribution of population between different poverty thresholds measured in Poverty headcount ratio at $1.90, $3.20 and $5.50 a day (2011 PPP) (% of population) in the following years: 1998, 2005, 2012, 2016, Retrieved from the World Bank, Development Research Group. Data are based on primary household survey data obtained from government statistical agencies and World Bank country departments. For more information and methodology, please see PovcalNet (*iresearch.worldbank.org/PovcalNet/index.htm*)
Share of people living less than 1.9 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.DDAY?end=2016&locations=GH&start=1998
Share of people living less than 3.2 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.LMIC?end=2016&locations=GH&start=1998
Share of people living less than 5.5 USD/day: Available Data online:
https://data.worldbank.org/indicator/SI.POV.UMIC?end=2016&locations=GH&start=1998

Ghana, Distribution of population between different poverty thresholds, 1998 to 2015		
IPL: **Share of people living with less than 1.9 USD/day (% of population)**	**Year**	**% of population**
	1998	35,7
	2005	24,5
	2012	12,0
	2016	13,3
	Year	**% of population**

LMIPL: Share of people living with less than 3.2 USD/day (% of population)	1998	63,3
	2005	50,1
	2012	32,5
	2016	30,5
UMIPL: Share of people living with less than 5.5 USD/day (% of population)	**Year**	**% of population**
	1998	85,4
	2005	77,1
	2012	60,5
	2016	56,9

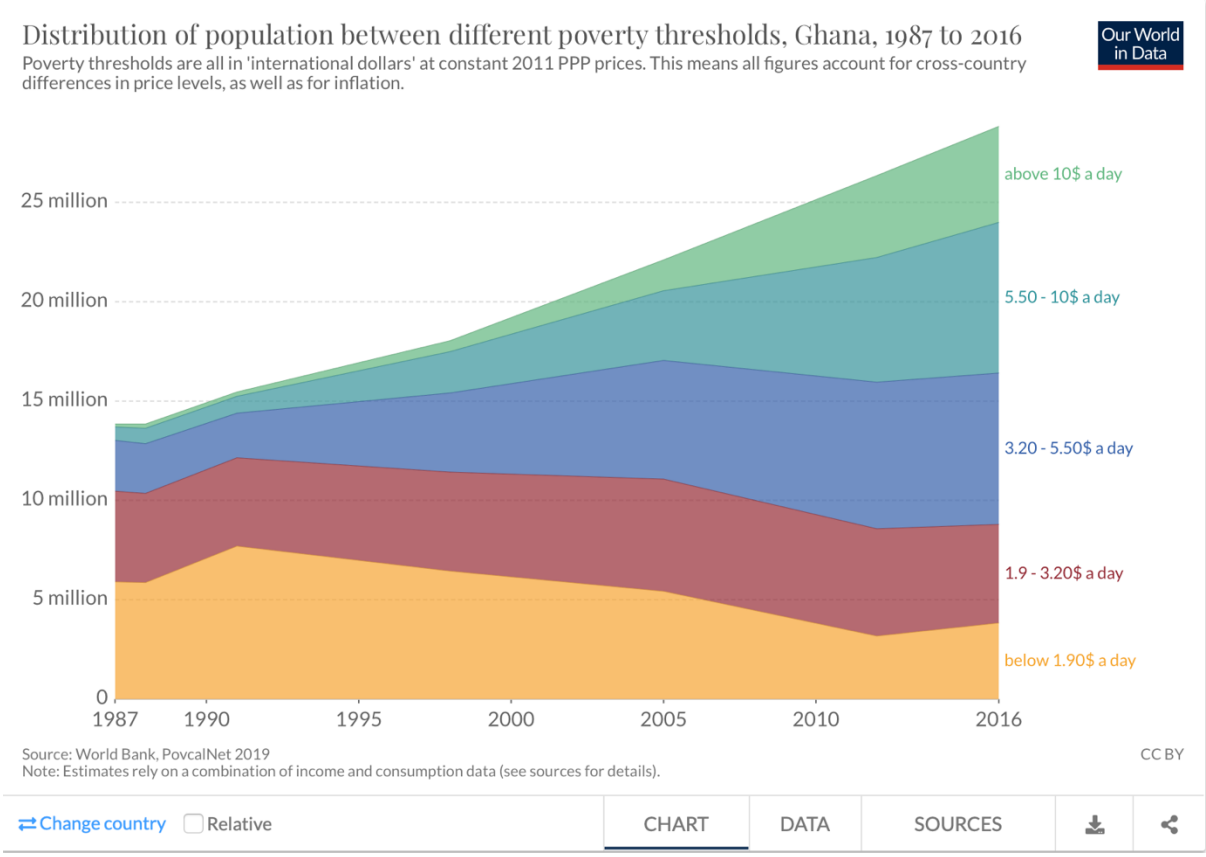

Figure 24 Ghana, Distribution of population between different poverty thresholds from 1987 to 2015, Retrieved from Max Roser and Esteban Ortiz-Ospina (2020) - "Global Extreme Poverty". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/extreme-poverty'
Available online: https://ourworldindata.org/grapher/distribution-of-population-poverty-thresholds?country=GHA
Full data sets available online via: http://iresearch.worldbank.org/PovcalNet/povDuplicateWB.aspx

Poverty Thresholds Ethiopia vs. Ghana:

Whereas on average the share of extreme poor (IPL) in Sub-Saharan Africa increased, in Ethiopia and Ghana the situation evolved differently. Ethiopia's as well as Ghana's share of extreme poor (IPL), roughly halved over the analyzed time period (Ethiopia: 1999 to 2015,

Ghana: 1998 to 2016). As discussed in the previous chapter, Ethiopia still belongs to LDCs (Least Developed countries), but it ensured significant progress in poverty reduction, see chapter 4.2, which is even more remarkable is considering Ethiopias population size.

It's noteworthy that Ethiopias' share of extreme poor (IPL: 61% in 1999) and its population size (66 million people) were much bigger than Ghanas (IPL: 36% in 1998, 18 million people).

Whereas uplifting poverty was rather evenly distributed among the 3 different poverty thresholds in Ghana (changes in IPL: 22.4 %, LMIPL: 32.8%, UMIPL: 28.5%) during the selected timeframe. In Ethiopia the progress varied more strongly over the different international poverty lines (changes in IPL: 30.4%, LMIPL: 21.5%, UMIPL 7.4%) see Table 9 and Table 10.

Hence, the biggest shift was achieved by Ghana, as a medium developed country, for people living below LMIPL. On the other hand, the slowest progress was obtained by Ethiopia, still belonging to the LDCs, decreasing the share of population below UMIPL.

Overall, it is demonstrated that Ghana has managed to decrease poverty regarding the three international poverty lines very successfully, while its' population increased from 18 to 29 million people over the selected time frame.
Ethiopia has successfully decreased the share of population living in extreme poverty (IPL) by half and living below the LMIPL by around one quarter. However, the share of population living below the UMIPL has decreased below 10%, while the population increased from 66 million to 102 million people, during 1999 to 2015.

Multidimensional Poverty Ethiopia:

Between 2005 and 2016 the MPI decreased in Ethiopia, because both the share of 'MPI poor' people (headcount ratio) as well as the indicators across deprived people (average intensity) decreased, see Table 11. Hence in 2005, 'MPI poverty deprivations' in Ethiopia accounted for 56.2 %, which changed to 49 % of deprivations in 2016.

In 2004 and 2015, the data closest to the start/ end of MPI data (2005 / 2016), the headcount ratio for income poverty was much lower for the most poor (37.2% and 30.8% respectively, see Table 9). This suggests that monetary poverty alone doesn't show the whole picture of poverty in Ethiopia. Thus, a non-monetary approach is needed in addition to a monetary momentum.

Looking at the specific deprivations, most of them decreased except the share of malnourished population and access to drinking water, which both increased. Within the standard of living indicators, access to assets decreased the most, followed by electricity deprivation. Clean Cooking deprivations decreased only slightly and therefore still accounts for the biggest share of deprived people together with adequate housing, in 2016.

Table 11 Ethiopia, Multidimensional Poverty Index and it's composition in the years 2005 and 2016, Retrieved from Oxford Poverty and Human Development Initiative (OPHI), Country Briefings, All Datasets available online: https://ophi.org.uk/wp-content/uploads/Table-7-All-MPI-Data-Since-2010-Dec.xlsx

Ethiopia, Multidimensional Poverty Index 2005 and 2016			
		2005	**2016**
MPI – Value (national)		0.562	0.490
Headcount ratio (H)		88.6 %	83.8 %
Average Intensity of Deprivation (A)		63.5 %	58.5%
Contribution of Deprivations (% of the population)			
Health	Nutrition	21	53
	Child Mortality	38	6
Education	Years of Schooling	62	52
	School Attendance	56	34
Standard of living	Cooking Fuel	88	83
	Sanitation	84	80
	Drinking Water	54	61
	Electricity	85	75
	Housing	87	83
	Assets	88	66

In Ethiopia, multidimensional poverty varies strongly between urban and rural areas, see Table 12. The correlation is similar to the global average, where the majority of extreme poor lives in rural areas, see chapter 4.2. When zooming into the specific deprivations in 2016, it is evident that the biggest differences of urban and rural areas are based on the Water-Energy nexus (including deprivation regarding cooking fuel, drinking water, sanitation, electricity) and housing as well as assets, see Figure 25. Whereas the difference in nutrition is not that high.
Moreover, the interlinkage of SDG 10 to SDG 1 is demonstrated through access to basic capabilities such as energy, water, housing etc. (Le-Blanc, 2015, p. 180) Which indicates that SDG 10 indicators will be affected by these deprivations.
Moreover, on a global average the difference in education is a strong indicator for rural poverty, see chapter 4.2. In Ethiopia in 2016, this correlation can be seen by high deprivations in education and strong rural poverty during the time period of 2005 to 2016.

Table 12 Ethiopia, Multidimensional Poverty Index in national, urban and rural areas in the years 2005 and 2016, Retrieved from Oxford Poverty and Human Development Initiative (OPHI), Country Briefings
Data 2016: Retrieved from Global MPI Country Briefing 2019: Ethiopia (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/CB_ETH_2019_2.pdf
Data 2005: : Retrieved from Global MPI Country Briefing 2011: Ethiopia (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/Ethiopia-OPHI-UNDP_2011.pdf

Ethiopia, Multidimensional Poverty Index, national, urban, rural in 2005 and 2016		
	2005	**2016**
MPI – Value (national)	0.562	0.490
MPI – urban	0.160	0.160
MPI – rural	0.610	0.547

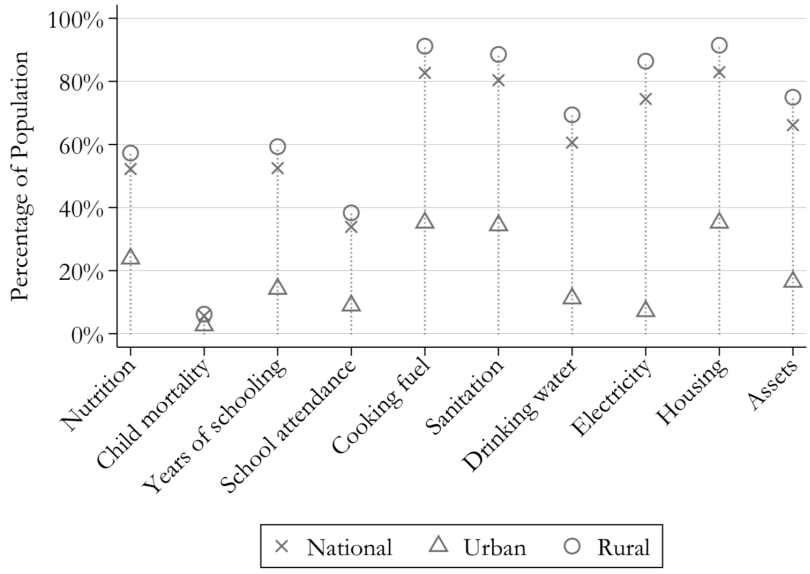

Figure 25 Ethiopia 2016, Censored Deprivations by Indicator from national, urban and rurals perspectives Retrieved from (Screenshot) Global MPI Country Briefing 2019: Ethiopia (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/CB_ETH_2019_2.pdf

Multidimensional Poverty Ghana:

Between 2008 and 2014 in Ghana the MPI decreased, because both the share of 'MPI poor' people (headcount ratio) as well as the indicators across deprived people (average intensity) decreased, see Table 13. In particular, in 2008, 'MPI poverty deprivations' in Ghana accounted for 14.4 %, which changed to 13 % of deprivations in 2014.

When comparing monetary poverty (timeframe: 2005-2016) and MPI (timeframe: 2008-2014), the headcount ratio for monetary poverty according to the IPL (24.5% and 13.3% respectively, see Table 10) was lower than the MPI (31.2% and 28.9%) .

Looking at the specific deprivations, most of them decreased except the share of deprivations regarding malnourished population, access to drinking water and inadequate housing, which increased. Within the standard of living part, no access to electricity decreased the most. Clean Cooking deprivations decreased slightly between 2008 and 2014. However, the progress is far too slow to meet the SDG 7.1 target. Additionally, it represents the biggest deprivation in Ghana in 2014, followed by sanitation.

Table 13 Ghana, Multidimensional Poverty Index and it's composition in the years 2008 and 2014, Retrieved from Oxford Poverty and Human Development Initiative (OPHI), Country Briefings, All Datasets available online: https://ophi.org.uk/wp-content/uploads/Table-7-All-MPI-Data-Since-2010-Dec.xlsx

Ghana, Multidimensional Poverty Index 2008 and 2014			
		2008	**2014**
MPI- Value (national)		0.144	0.132
Headcount ratio (H)		31.2 %	28.9 %
Average Intensity of Deprivation (A)		46.2 %	45.5%
Contribution of Deprivations (% of the population)			
Health	Nutrition	7	13
	Child Mortality	10	3
Education	Years of Schooling	16	15
	School Attendance	12	10
Standard of living	Cooking Fuel	31	28
	Sanitation	30	27
	Drinking Water	12	15
	Electricity	24	15
	Housing	11	17
	Assets	17	10

In Ghana, multidimensional poverty varies between urban and rural areas, see Table 14. The correlation is similar to the global average, where the majority of extreme poor lives in rural areas, see chapter 4.2. When zooming into the specific deprivations in 2016, it is evident that the biggest differences of urban and rural areas are based on the Water-Energy nexus (including cooking fuel, drinking water, sanitation, electricity) and housing, see Figure 26 . Whereas the difference in nutrition is not that strong. It's noteworthy that no access to clean cooking accounts for the highest share of deprivations in rural Ghana.

Table 14 Ghana, Multidimensional Poverty Index in national, urban and rural areas in the years 2005 and 2016, Retrieved from Oxford Poverty and Human Development Initiative (OPHI), Country Briefings
Data 2014: Retrieved from Global MPI Country Briefing 2019: Ghana (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/CB_GHA_2019_2.pdf
Data 2008: : Retrieved from Global MPI Country Briefing 2011: (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/Ghana-OPHI-UNDP_2011.pdf

Ghana, Multidimensional Poverty Index, national, urban, rural in 2008 and 2014		
	2008	**2014**
MPI – Value (national)	0.149	0.138
MPI – urban	0.051	0.056
MPI – rural	0.0214	0.218

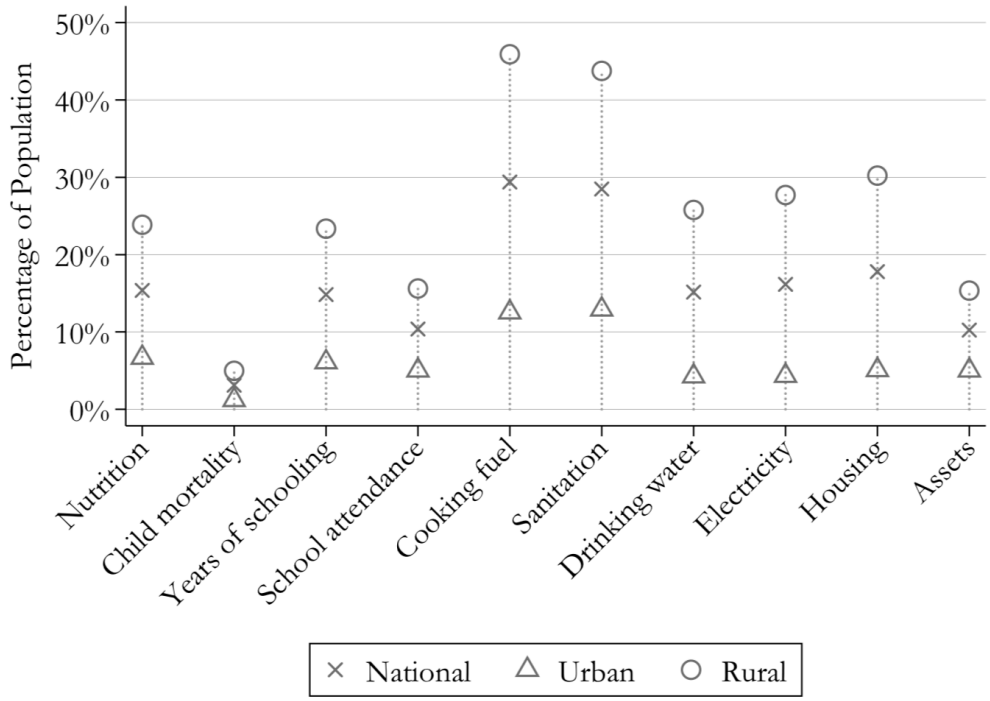

Figure 26 Ghana 2016, Censored Deprivations by Indicator from national, urban and rurals perspectives
Retrieved from (Screenshot) Global MPI Country Briefing 2019: Ghana (Sub-Saharan Africa), Oxford Poverty and Human Development Initiative (OPHI), Oxford Department of International Development Queen Elizabeth House, University of Oxford, Available online: https://ophi.org.uk/wp-content/uploads/CB_GHA_2019_2.pdf

Multidimensional Poverty Ethiopia vs. Ghana:

Regarding multidimensional poverty, Ethiopia and Ghana decreased their MPI-value, by decreasing the headcount ratio and the average intensity over the specific time frames.
The MPI reduction was stronger in Ethiopia (7%) than in Ghana (1.2%).

When comparing extreme monetary poverty (IPL) with multidimensional poverty (MPI), in both countries multidimensional poverty is higher. This aligns with the theory, see chapter 4 and suggests that in both Countries, monetary poverty is not enough to understand human suffering. The difference between MPI and IPL was stronger in Ethiopia than in Ghana, because the poverty rates are higher.

Zooming into the specific deprivations in Ethiopia and Ghana, the majority of MPI indicators decreased, except depravations regarding nutrition and drinking water. In Ghana inadequate housing increased as well. As previously mentioned, both countries achieved success in electricity access, leading to the fact that electricity deprivations decreased tremendously in Ethiopia (10%) and Ghana (9%) over the specific timeframes. On the other hand, clean cooking deprivations decreased only slightly in Ethiopia (5%) and in Ghana (3%). Leading to the fact that, clean cooking still accounts for the biggest share of deprivations in both countries, in 2016 and 2014, respectively.

Thus, to meet the SDG 1 target in Ethiopia and Ghana, the monetary momentum needs to continue and non-monetary approaches especially towards nutrition (SDG 2), sanitation (SDG 6) and cooking fuel (SDG 7.1) are needed. In fact, the food-water-energy nexus combined with synergetic sustainable energy planning (see chapter 3.2, page 14) could be a great way to meet these challenges.
In both countries, rural multidimensional poverty is far bigger than in urban areas, which aligns with the global average, see chapter 4.2. The difference of urban and rural multidimensional poverty is also the highest in deprivations regarding the Water-Energy nexus (including cooking fuel, drinking water, sanitation, electricity) and housing, whereas the difference regarding food is not that high. However, especially rural areas could benefit from potential synergies like Food-Water-Energy-Nexus to get on track and be able to fulfil the Agenda 2030 goals.

5.2.3. SDG 10 – INEQUALITIES

In this chapter SDG 10 inequalities is analysed first for Ethiopia and Ghana individually. Subsequently the two countries are compared in the indicators. The indicators for SDG 10 are human development (HDI and IHDI) and monetary inequality (income growth rate bottom 40) The values for Ethiopia can be found in *Table 15*, Table 16. The values for Ghana can be found in *Table 17* and Table 18.

Inequalities in Ethiopia

In Ethiopia all indicators have inproved, see *Table 15*. According to its' HDI, Ethiopia ranges in the low human development sector (HDI <0.550, see chapter 4.3). Which was expected, since Ethiopia belongs to the LDCs.

Between 2000 and 2016 the HDI increased 63% in Ethiopia (from 0.283 to 0.460), because all indicators increased, especially wealth per capita and expected years of schooling more than doubled, see *Table 15*. Additionally, the life expectancy at birth increased by almost 14 years, and mean years of schooling by 1 year, within the selected timeframe.

In 2016, Ethiopias HDI was a bit lower (0.46) than the average HDI of Sub-Saharan Africa (0.52) (UNDP, 2016). However, the difference of HDI and IHDI was lower in Ethiopia (0.460 - 0.347 = 0.113), than in the Sub-Saharan African average (0.52 - 0.347 = 0.173).

If HDI and IHDI would be the same value, there would be no inequality. The bigger the difference, the bigger the inequality. However, in Ethiopia the IHDI falls below the HDI in every year, showing inequality. The decreasing difference between HDI and IHDI indicates that loss due to inequality decreased (in year 2010 the difference was 0.141, in year 2016 the difference was 0.113, see *Table 15*).

As indicated by Table 16, between 2011 and 2015 the bottom 40 had a growth rate per capita of 1.5%, whereas the total population had an average growth rate per capita of 1.6%. Since the participation in the economic success of Ethiopia of the bottom 40 was lower than the total population, Ethiopia couldn't meet the SDG 10.1 target yet. Nevertheless, the bottom 40 participated in the economic progress of Ethiopia. However, the participation was lower than the global and the Sub-Saharan African average.

Table 15 Ethiopia, Inequalities in the following years: 2000, 2004, 2010, 2016, Retrieved from Human Development Reports from United Nations Development Programmes (*http://hdr.undp.org/en)*
Available online: *http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ETH.pdf*
Data available online: http://hdr.undp.org/en/data#
HDI full Data sets available online: *http://hdr.undp.org/sites/default/files/hdro_statistical_data_table_2.xlsx*
HDI Contribution of Indicators full Data sets available online: *http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/ETH.pdf*
IHDI full Data sets available online:http://hdr.undp.org/en/data#, select: dimension: inequality, inequality adjusted HDI (IHDI)
bottom 40 full Data sets available online: *http://hdr.undp.org/sites/default/files/hdro_statistical_data_table_3.xlsx*

Ethiopia, HDI and IHDI from 2000 to 2016						
Low human development			**Contribution of Indicators**			
HDI	**Year**	**value**	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2011 PPP$)
	2000	0.283	51.9	4.3	1.5	617
	2005	0.346	56.2	6.6	1.9	734

	2010	0.412	61.6	8.2	2.3	1071
	2016	0.460	65.5	8.7	2.6	1612
IHDI	**Year**	**value**				
	2010	0.271				
	2012	0.292				
	2014	0.315				
	2016	0.347				

Table 16 Ethiopia bottom 40, consumption (or income) growth rate in per capita of the bottom 40% of the population, in the year 2015, from household surveys over a 5 year period, vs. the) growth rate in per capita of the total population, in the year 2015, Retrieved from the World Bank Global Database of Shared Prosperity (GDSP) circa 2011-2015
(worldbank.org/en/topic/poverty/brief/global-database-of-shared-prosperity)
Available online: https://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_ETH.pdf
Full data available online: bottom 40: https://data.worldbank.org/indicator/SI.SPR.PC40.ZG?locations=ET
total population: https://data.worldbank.org/indicator/SI.SPR.PCAP.ZG?locations=ET

Ethiopia, growth rate 2015	
Common indicator SDG 10	**Value (%)**
Bottom 40	1.5
Total population	1.6

Inequalities in Ghana

Between 2000 and 2016 the HDI increased 21% in Ghana (from 0.483 to 0.587), because all indicators increased, especially wealth per capita and expected years of schooling increased stronlgy, see *Table 15*. Additionally, the life expectancy at birth increased by around 6 years, and mean years of schooling by 1 year, within the selected timeframe.

In 2016, the average HDI and IHDI in Sub-Saharan Africa was 0.52 and 0.35, respectively. (UNDP, 2016) Therefore, Ghana still ranges slightly above the regions average regarding the HDI and the IHDI. In particular, according to its' HDI, Ghana ranges in the medium human development sector (HDI: 0.550 to 0.699, see chapter 4.3).

If HDI and IHDI would be the same value, there would be no inequality. The bigger the difference, the bigger the inequality. However, in Ghana the IHDI falls below the HDI in every year and over the whole time period the difference of HDI and IHDI increased (in year 2010 the difference was 0.140, in year 2016 the difference was 0.170), see *Table 17*. This means that inequality rises.

Between 2011 and 2016 the bottom 40 had a growth rate per capita of -0.2%, see Table 18. Thus, the bottom 40 didn't participate in the economic progress of Ghana, but the total population did, see Table 18. This leads to Ghana failing the SDG 10.1 target in the analysed timespan.

Table 17 Ghana, Inequalities in the following years: 2000, 2005, 2010, 2016, Retrieved from Human Development Reports from United Nations Development Programmes (*http://hdr.undp.org/en)*
Available online: *http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/GHA.pdf*
Data available online: http://hdr.undp.org/en/data#
HDI full Data sets available online: *http://hdr.undp.org/sites/default/files/hdro_statistical_data_table_2.xlsx*
IHDI full Data sets available online:http://hdr.undp.org/en/data#, select: dimension: inequality, inequality adjusted HDI (IHDI)
bottom 40 full Data sets available online: *http://hdr.undp.org/sites/default/files/hdro_statistical_data_table_3.xlsx*

Ghana, HDI and IHDI from 2000 to 2016						
Medium human development			**Contribution of Indicators**			
HDI	**Year**	**value**	Life expectancy at birth	Expected years of schooling	Mean years of schooling	GNI per capita (2011 PPP$)
	2000	0.483	57.0	8.0	6.1	2152
	2005	0.508	58.7	8.7	6.4	2575
	2010	0.554	61.0	10.9	6.7	2977
	2016	0.587	63.1	11.6	7.1	3756
IHDI	**Year**	**value**				
	2010	0.414				
	2012	0.386				
	2014	0.386				
	2016	0.417				

Table 18 Ghana, bottom 40, consumption (or income) growth rate in per capita of the bottom 40% of the population, in the year 2016, from household surveys over a 5 year period, vs. the) growth rate in per capita of the total population, in the year 2016,
Retrieved from the World Bank Global Database of Shared Prosperity (GDSP) circa 2011-2016 (worldbank.org/en/topic/poverty/brief/global-database-of-shared-prosperity)
Available online: https://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_GHA.pdf
Full Data available online: bottom 40: https://data.worldbank.org/indicator/SI.SPR.PC40.ZG?locations=GH
total population: https://data.worldbank.org/indicator/SI.SPR.PCAP.ZG?locations=GH

Ghana, 2016 growth rate	
Common indicator SDG 10	**Value (%)**
bottom 40	-0.2
Total population	1.3

Inequalities in Ethiopia vs. Ghana

Between 2000 and 2016, basic capabilities improved in Ethiopia and Ghana, therefore both HDI increased, see Figure 27. However, human development in Ethiopia increased more strongly (see *Table 15*), even though it still remains in the low human development section below the Sub-Saharan Africa's average of 0.52. (UNDP, 2016)

During the selected timeframe, both IHDI differ from the corresponding HDI, which means that local loss of human development exists in both countries. It's noteworthy that in 2010, both Countries had the same loss of human development (difference of HDI and IHDI) but their situation evolved differently. Ethiopia managed to decrease the difference (because the HDI increased faster than the IHDI), whereas Ghana shows the opposite tendency (the difference of HDI and IHDI increased). This means that Ethiopia managed to decrease the loss of human development due to inequality.

Whereas the bottom 40 participated in Ethiopias economic progress, the participation wasn't higher than the national average, as the SDG 10.1 target aims. Ghanas population couldn't participate at all. Therefore, both Countries couldn't meet the SDG 10.1 target yet. Moreover, in both countries the bottom 40 gained less than the Sub-Saharan African average.

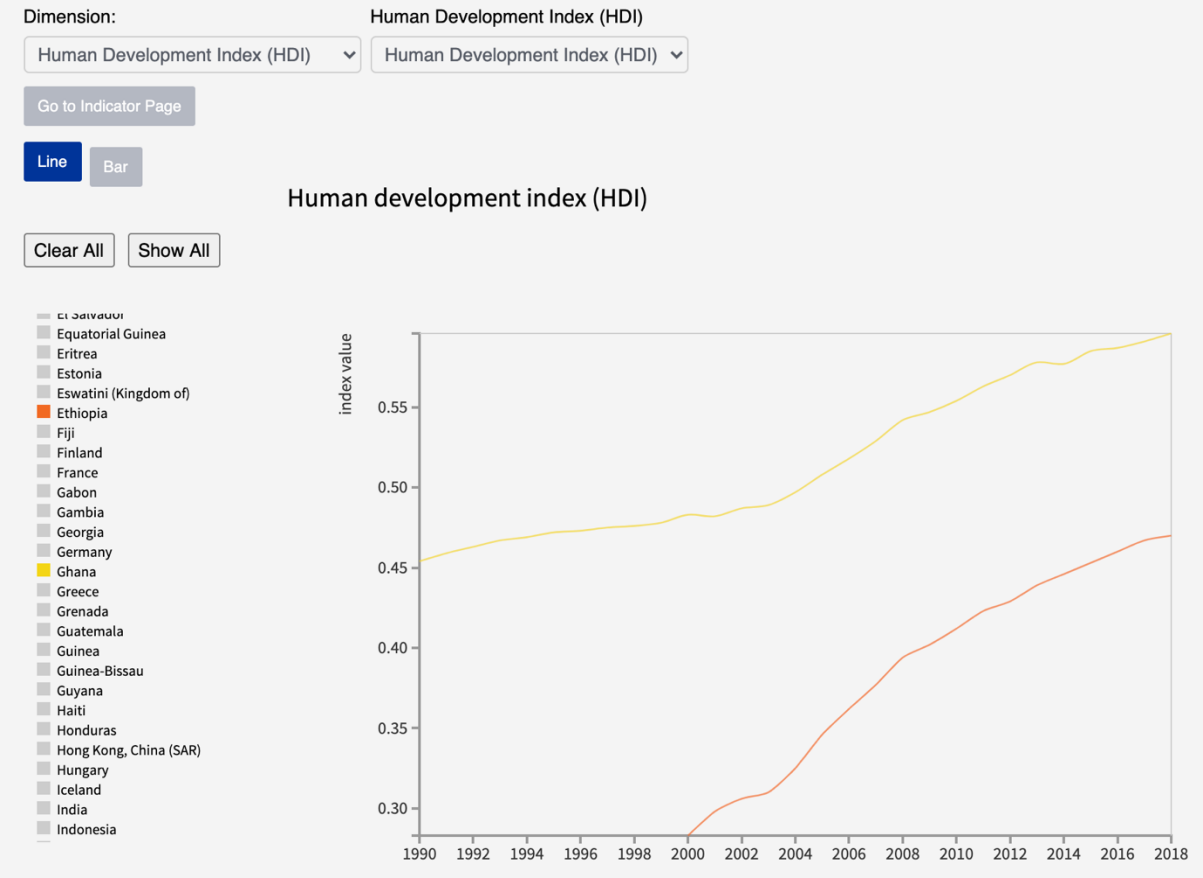

Figure 27 Human Development Index (HDI), Ethiopia (red line) vs. Ghana (yellow line) Retrieved from Human Development Reports from United Nations Development Programmes (*http://hdr.undp.org/en*)
Available online: http://hdr.undp.org/en/data# select: inequality, human development index (HDI), 2010-2018

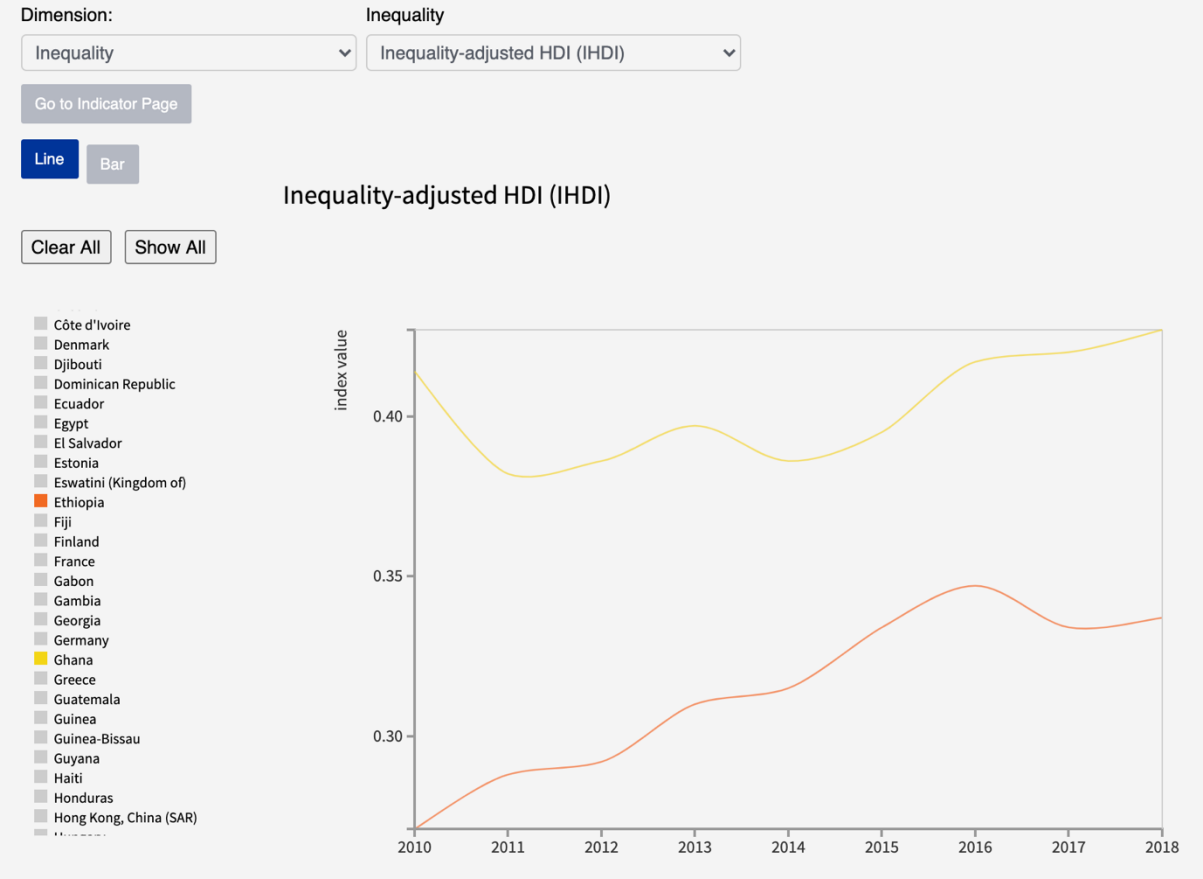

Figure 28 Inequality adjusted Human Development Index (IHDI), Ethiopia (red line) vs. Ghana (yellow line) Retrieved from Human Development Reports from United Nations Development Programmes (*http://hdr.undp.org/en*)
Available online: http://hdr.undp.org/en/data# select: inequality, Inequality- adjusted HDI (IHDI), 2010-2018

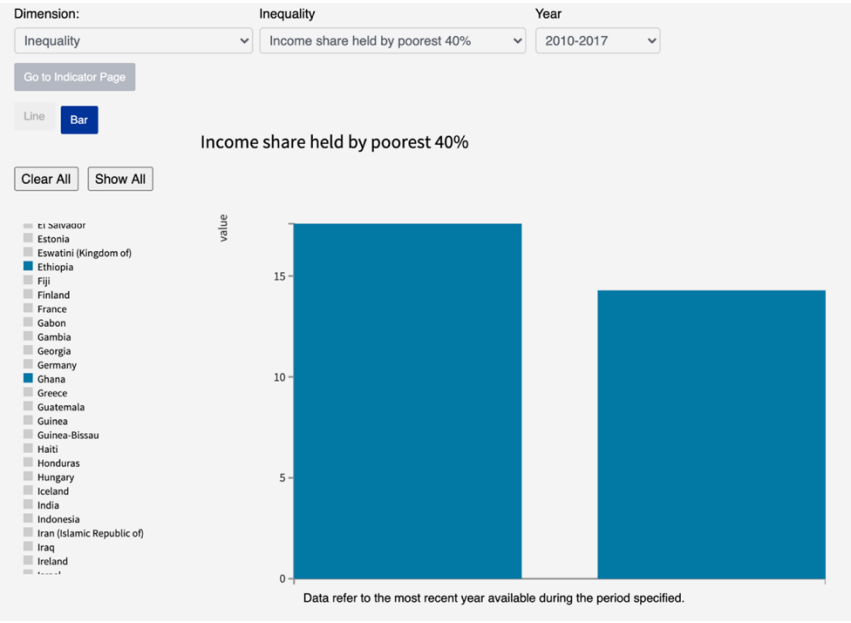

Figure 29 bottom 40 Ethiopia (left, 17.6%) vs. Ghana (right, 14.3%) Retrieved from Human Development Reports from United Nations Development Programmes (*http://hdr.undp.org/en*)
Available online: http://hdr.undp.org/en/data#, select: inequality, income share held by poorest 40%, 2010-2017

6. Discussion and Conclusions

6.1. Discussion

6.1.1. General Indicators

Overall, taking a look at the general indicators for SDG 7.1, SDG 1, and SDG 10 (electricity access, clean cooking access, IPL, bottom 40 vs. total population) in Ethiopia and Ghana between the years 2000 and 2016, it seems that all indicators of SDG 7.1 and SDG 1 evolved positively, which is positive for the objective of the 3 SDGs.

Both countries managed to double electricity access and improve access clean cooking fuels, while halving the share of population living in extreme poverty (IPL). It seems likely that this synergy is effecting Ethiopia and Ghana, showing a positive correlation between the SDG 7.1 Indicators (electricity access and access to clean cooking, see Table 19) and the SDG 1 Indicator (IPL, see Table 19), during the selected timeframe. This finding is supported by further research, as previously discussed in chapter 1 and chapter 4.

However, due to lack of data, the SDG 10 indicator (bottom 40) could only be analyzed in one year during the selected timeframe. Therefore, no correlations between SDG 7.1 and SDG 10 could be analyzed regarding the common indicators. Analyzing this data point reveals that the average citizen in Ethiopia and Ghana could benefit from the local economic progress. Regarding the bottom 40s' participation in the economic success, in Ethiopia they could benefit, whereas in Ghana they didn't. This implies that in the selected year, Ethiopias inequality is lower than Ghana.
Data shortage is particularly high in countries with poor economic resources, where 75% don't collect data. The situation is similar in the Sub-Saharan African region, where only a little bit more than a quarter (26.67%) of countries have available data on SDG 10. (World Bank , 2018) Data regarding the economic participation of the bottom 40 was only found after 2015 (see references in Table 16 and Table 18). This leads to the fact that the sample size in this thesis is not big enough to analyse correlations over the selected timeframe. Therefore, correlations between SDG 7 and SDG 10 are not examined.

To understand the level of electricity access and clean cooking and the nature of peoples' participation (willingness to pay, gender differences in access, level of access, cook stove safety etc.) the Multi-Tier-Framework is very helpful, which was developed in 2015. (IEA, 2019) (the United Nations, 2018) However, due to the lack of Data regarding the Multi-Tier Framework, it was not possible to analyse the levels of electricity access in Ethiopia and Ghana.

Table 19 Ethiopia SDG common Indicator summary results over the selected time period (around year 2000 to 2016) all references and more in debt data can be found in
SDG 7.1 Data: Table 7
SDG 1 Data: Table 9
SDG 10 Data: Table 16

Ethiopia, SDG common indicators results			
SDG 7.1	**Electricity access:**	**Year**	**% of population**
		2000	12
		2004	28
		2010	33
		2016	43
	Clean cooking access:	**Year**	**% of population**
		2000	1
		2004	2
		2010	3
		2016	4
SDG 1	**IPL:** **Share of people living with less than 1.9 USD/day**	**Year**	**% of population**
		1999	61,2
		2004	37,2
		2010	33,5
		2015	30,8
SDG 10	**Bottom 40 vs. Total population**	**Year**	**Growth rate (%)**
		2015	1.5
		2015	1.6

Table 20 Ghana SDG common Indicator summary results over the selected time period (around year 2000 to 2016) all references and more in debt data can be found in
SDG 7.1 Data: Table 8
SDG 1 Data: Table 10
SDG 10 Data : Table 18

Ghana, SDG common Indicators results			
SDG 7.1	Electricity access:	Year	% of population
		2000	44
		2005	55
		2010	64
		2016	80
	Clean cooking access:	Year	% of population
		2000	6
		2005	10
		2010	16
		2016	22
SDG 1	IPL: Share of people living with less than 1.9 USD/day	Year	% of population
		1998	35,7
		2005	24,5
		2012	12,0
		2016	13,3
SDG 10	Bottom 40 vs. Total population	Year	Growth rate (%)
		2016	-0.2
		2016	1.3

6.1.2. Synthesis Indicators

Including synthesis indicators for SDG 1 (MPI) and SDG 10 (HDI and IHDI) and looking at differences in urban and rural evolution of electricity access and poverty, as well as analyzing poverty lines for higher standards (LMIPL, UMIPL) is an attempt to broaden the perspective of the selected SDGs. Its aim is to show interlinkages in the context of the 17 and SDGs evaluate a countries development progress.

The summary of all the synthesis indicators for Ethiopia and Ghana between 2000 and 2016 can be found in Table 21 and Table 22, respectively. Analyzing the synthesis indicators

suggests that, even though Ethiopia has a lower development status than Ghana, it made more significant progress in all analyzed SDGs. The following paragraphs will explain the reasoning behind this relation.

When extending the analysis from extreme poverty towards poverty of higher standards (LMIPL and UMIPL), the findings indicate that Ghana made successful progress among all poverty thresholds (IPL, LMIPL and UMIPL). Ethiopia managed to reduce poverty among all poverty thresholds as well, however, the share below the UMIPL remained high. This is likely due to the lower development status of Ethiopia.

To extend the perspective of poverty beyond monetary deprivations towards multiple criteria, synthesis indicators such as the MPI were analyzed. As expected from the theory part (Chapter 4.2), in both countries multidimensional poverty was higher than poverty measures of the IPL demonstrate. (World Bank , 2018) This suggests that monetary poverty alone doesn't show the whole picture of poverty in Ethiopia and Ghana. Therefore, SDG interlinkage assessment is needed to improve basic capabilities and human-wellbeing for poverty reduction.

Due to the fact that Ethiopia belongs to the LDCs over the selected timeframe, it was expected that the MPI will remain still high over the timeframe. Due to its' higher development status, Ghana has a lower MPI than Ethiopia.

Moreover, when zooming into specific deprivations of the MPI, the analysis shows that Ethiopia and Ghana need non-monetary approaches to improve nutrition (SDG 2), sanitation (SDG 6) and cooking fuel (SDG 7.1). This could suggest that the food-water-energy nexus could be a good way to help meeting the SDG 1 target.
The difference of urban and rural multidimensional poverty is also the highest in deprivations regarding the Water-Energy nexus (including cooking fuel, drinking water, sanitation and electricity) as well as housing, whereas the difference regarding food is not that high. Moreover, clean cooking still accounts for the biggest share of deprivations in both countries, in 2016 and 2014, respectively. Therefore, without creating positive impact in access to clean cooking, multidimensional poverty will not be significantly reduced.

The analyzed data also supported the fact that rural areas are the hot spot for deprivations and lack of basic capabilities and typically have higher MPI rates. (the United Nations, 2019) (Pedro Conceição, 2019)

The broader analysis of SDG 1 aligns with the former one on the general indicators (IPL) and shows that even though Ethiopia has a lower development status and higher population growth, managed to reduce poverty (including multidimensional poverty) at a faster pace than Ghana.

Overall, Ethiopia and Ghana increased access to electricity in urban and rural areas, but the difference remains high. As expected, (see Chapter 4.2, who are the most poor?), in both countries multidimensional poverty is higher in rural than in urban areas. Whereas electricity access in rural areas is still low, the electrification pace was higher than in urban areas.

Ethiopia decreased the MPI in urban and rural areas, whereas Ghanas' MPI in urban and rural areas increased. Anyhow, the correlations between MPI and SDG 7.1 are not analyzed in this thesis, because influential indicators on the MPI is a complex matter that cannot be explained by only energy related factors. Therefore, this is matter is beyond the scope of this thesis but could be answered in further research.

Even though "the MPI is constructed using three main datasets: the Demographic and Health Survey (DHS), the Multiple Indicators Cluster Survey (MICS), and the World Health Survey (WHS)." (Rosner M., Ortiz-Ospina E, 2013, p. Poverty across multiple dimensions) When analysing SDG 1 poverty only DHS Datasets are used due to availability and consistency at the decided timeframes in Ethiopia and Ghana.

Ethiopias' lower development status is also reflected when looking at human development (demonstrated by lower HDI than Ghana). However, the HDI increased more strongly, due to its positive influences in health (SDG 3), schooling (SDG 4) and income (SDG 8) than in Ghana. Additionally, Ethiopias loss of human development (HDI -IHDI) decreased, whereas Ghanas increased. This supports the data from the general indicators (growth rate of the bottom 40 vs total population), that Ethiopia reduced inequalities and inequalities in Ghana increased. Data for the IHDI was only established recently (start 2010), therefore the difference of HDI and IHDI could only be estimated between 2010 and 2016. Regarding the income shares held by the bottom 40%, there was no data found before 2010. (UNDP, 2020) Therefore, only latest data (2011 to 2016) can be examined for this analysis. Due to the lack of enough data points, the correlations between SDG 7.1 and SDG 10 couldn't be analyzed.

However, as research indicates Data availability and the lack of consistent methods, makes SDG interlinkage analysis challenging. (Lu Y., Nakicenovic N., Visbeck M., et. al, 2015) (Cameron A., Metternicht G., Wiedmann T., 2018) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) These points brought this research analysis towards its limitations. The main limiting points were first and foremost related to the scope of this master thesis. Meaning the limitations of the number of indicators, since both countries should be analyzed in more detail to seek more factors that could have contributed to the variations. It would be interesting to find out how other SDGs interlink (indirectly) with the selected SDGs. For that reason, the food-water-energy nexus as well as the synthesis indicators (MPI, HDI and IHDI) were introduced. However, going more into detail would exceed the limitations of this policy-based thesis. The main second limitation point is data availability and consistency, especially regarding SDG 10 indicators.

To conclude, it seems that analyzing how SDGs targets effect each other and broadening the perspective by introducing synthesis indicators enhances the perspective on a countries development. My findings could support the reviewed scientific literature as well as UN Documents, in the sense that for effective SDG implementation, the SDGs must be analysed as interlinkages rather than in isolated clusters. (Nilsson M., Griggs D., Visbeck M., 2016) (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) (GSDR, 2019) (the United Nations, 2019) (the United Nations, 2018) (World Bank , 2018)

Table 21 Ethiopia SDG synthesis Indicators summary results over the selected time period (around year 2000 to 2016) all references and more in debt data can be found in
SDG 7.1 Data: Table 7
SDG 1 Data: Table 9, Table 11 and Table 12
SDG 10 Data: Table 15 *and Table 16*

Ethiopia, SDG synthesis indicators results					
SDG 7.1	**Electricity access: (% of population)**	**Year**	**total population**	**urban**	**rural**
		2000	12	76	2
		2004	28	81	18
		2010	33	86	22
		2016	43	86	32
SDG 1	**Poverty Lines (Share of people living with less than …)**	**Year**	**IPL (1.9 USD/day)**	**LMIPL (3.2 USD/day)**	**UMIPL (5.5 USD/day)**
		1999	61,2	90,4	97,6
		2004	37,2	78,7	95,6
		2010	33,5	73,1	93,1
		2015	30,8	68,9	90,2
	Multidimensional Poverty	**Year**	**MPI**	**urban**	**rural**
		2005	0.562	0.160	0.610
		2016	0.490	0.160	0.547
SDG 10		**Year**	**Bottom 40**	**Total population**	
	Growth rate (%)	2015	1.5	1.6	
	Human Development	**Year**	**HDI**	**IHDI**	**HDI -IHDI**
		2000	0.283	-	-
		2005	0.346	-	-
		2010	0.412	0.271	0.411
		2016	0.460	0.347	0.113

Table 22 Ghana SDG synthesis Indicators summary results over the selected time period (around year 2000 to 2016) all references and more in debt data can be found in
SDG 7.1 Data: Table 8
SDG 1 Data: Table 10, Table 13 and Table 14
SDG 10 Data: Table 17 *and Table 18*

Ghana, SDG synthesis indicators results					
SDG 7.1	Electricity access: (% of population)	**Year**	**total population**	**urban**	**rural**
		2000	44	80	15
		2005	55	81	31
		2010	64	72	55
		2016	80	90	67
SDG 1	Poverty Lines (Share of people living with less than …)	**Year**	**IPL (1.9 USD/day)**	**LMIPL (3.2 USD/day)**	**UMIPL (5.5 USD/day)**
		1998	35,7	63,3	85,4
		2005	24,5	50,1	77,1
		2012	12,0	32,5	60,5
		2016	13,3	30,5	56,9
	Multidimensional Poverty	**Year**	**MPI**	**urban**	**rural**
		2008	0.144	0.051	0.021
		2014	0.132	0.056	0.218
SDG 10	Growth rate (%)	**Year**	**Bottom 40**	**Total population**	
		2015	-0.2	1.3	
	Human Development	**Year**	**HDI**	**IHDI**	**HDI -IHDI**
		2000	0.483	-	-
		2005	0.508	-	-
		2010	0.554	0.414	0.410
		2016	0.587	0.417	0.170

6.2. Conclusion

Based on all analyzed data for the selected indicators and timeframe, in Ethiopia and Ghana, it seems that overall the general situation regarding SDG 7.1, SDG 1 and SDG 10 has improved, which is beneficial for the objective of the SDGs.

When examining the objective of this thesis – Are there any interlinkages between SDG 7.1 and SDG 1 and SDG 10 ? – the following results were obtained:

The findings of the common indicator analysis between SDG 7.1 and SDG 1, show in both countries a positive correlation between access to electricity and clean cooking and extreme poverty reduction. This implies a likely synergetic interlinkage of the SDG 7.1 targets and extreme poverty reduction, in both countries during the selected timeframe.
As an attempt to show how SDG 7.1 targets and SDG 1 poverty are interlinked in the context of the 17 SDGs, the synthesis indicator, namely the MPI was analyzed. Zooming into specific deprivations of the MPI revealed, that Ethiopia and Ghana need to improve nutrition (SDG 2), sanitation (SDG 6) and cooking fuel (SDG 7.1). This likely suggests that the Food-Water-Energy Nexus could be an efficient tool to support meeting the SDG 1 target in both Countries. When changing the perspective towards the difference of urban and rural multidimensional poverty, the findings reveal that especially rural multidimensional poverty lacked regarding the Water-Energy Nexus (including access to electricity and clean cooking, drinking water and sanitation) as well as housing.

In this thesis an attempt to find possible interlinkages among SDG 7.1 and SDG 10 was made. However, due to the lack of data regarding the inequalities of the bottom 40 (SDG 10), only one data point was found during the selected timeframe in both countries. This data point indicates that inequality of the bottom 40 in Ethiopia is lower (participation of the bottom 40 in the local economic success) than in Ghana (no participation of the bottom 40 in the local economic success). Moreover, in both countries the average population could participate in the local economic success. Hence, the average person in Ethiopia and Ghana could benefit from economic progress, whereas inequality of the poorest 40% is different in both countries.
Apart from this data point, there was a severe lack of data regarding SDG 10. Therefore, this thesis suggests more quality data needs to be accessible, in order to find interlinkages among SDGs. This suggestion is supported by other research as well (D. L McCollum, L.G. Echeverri, S. Busch, et. al, 2018) (Lu Y., Nakicenovic N., Visbeck M., et. al, 2015) (World Bank , 2018).

As an attempt to show how SDG 7.1 targets and SDG 10 inequalities are interlinked in the context of the 17 SDGs, the synthesis indicator, namely the HDI and IHDI were analyzed. Results of the HDI imply that both countries improved human development, while access to electricity and clean cooking improved as well. Due to the fact that human development is influenced by many factors, correlations among SDG 10 synthesis indicators (HDI and IHDI) and SDG 7.1 were not analyzed. When looking at human development, Ethiopia improved it more strongly, but still ranges in the low human development sector, whereas Ghana belongs to medium human development. Zooming into the HDI, all contributing factors, such as life expectancy/ health (SDG 3), education (SDG 4) and income (SDG 8) improved in both

countries over the selected timeframe. Hence, overall findings suggest that in Ethiopia and Ghana socio-economic inequalities got reduced. Due to the lack of data regarding the IHDI, only data after 2010 could be found. These data points suggest, loss of human development due to inequality decreased in Ethiopia and increased in Ghana.

To conclude, it seems that analyzing how SDGs targets effect each other and broadening the perspective by introducing synthesis indicators enhances the perspective on a countries development. The analysis showed, that monetary poverty reduction correlates with access to electricity and clean cooking. Moreover, multidimensional poverty is effected by many other SDGs. Therefore, the findings of this thesis imply, that effective poverty reduction requires interlinkages assessment rather than assessing poverty in an isolated cluster.

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