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Titled

The Role of Anthropogenic Stocks in ensuring Human Development and achieving the United Nation Sustainable Development Goals

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Abstract

This thesis investigates the role of anthropogenic stocks in achieving the United Nations Sustainable Development Goals (SDGs) and ensuring human welfare. The anthropogenic stocks are categorized based on their physical mobility to mobile and non-mobile stocks. The anthropogenic stock (material stock) is comprised of human built environment such as buildings, infrastructure, vehicles, machines and devices.

By assigning the material stock to corresponding SDG indicators; a detailed mapping of linkages is created, with 307 linkages between indicators and stocks, 155 of which are direct and 152 are indirect linkages. These linkages covered 82 indicators (71 targets) out of 244 indicators. 43 of the linkages arose with the non-residential buildings followed by machinery & equipment's then supply and disposal at 37 and 31 links respectfully. The energy infrastructure and waste services accounted for 12 linkages each, transportation infrastructure and virgin lands accounted for 6 links each. By mapping out the linkages; policy makers obtain sufficient information for devising robust plans for future coordination and implementation.

Furthermore, the thesis investigates the correlation between anthropogenic stocks and human wellbeing, by quantifying the material stocks used in daily activities. Through combining different stock types per single activity; some correlation arose between the stocks and welfare level. The golden ratio of Dwelling stocks is around 450 dwellings per thousand capita with 2 rooms per person. The optimum amount of passenger vehicles is around 500 cars per thousand capita. Though, other welfare indicators show low correlation to material stocks due to the role of other factors such as human or financial influences.

Dedication

The thesis is dedicated to close family and friends that encouraged and stood by me during this period. Without their support, this journey would have not happened. Furthermore, the thesis is also dedicated to new people that I met in this period abroad, that opened their hearts and mind, my time here in Denmark would have not been as enjoyable without them.

Acknowledgement

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Introduction

Decent standers of living are repeatedly debated worldwide. The argument is endless since different levels of society require different needs. To obtain a somewhat fair opportunity for self-development, it is important to declare the freedom of every person to pursue their goal(Bitker 1971). According to Kelli Ashton and Claire Jones (researchers from Global Education Project in Australia) human wellbeing is the acknowledgement that everybody everywhere in the world regardless of age, gender, nation, faith or political ideology, desires to live well(Ashton, Jones et al. 2013). The core motivation of human activity throughout the ages is driven by ambitions and dreams of achieving desirable living status. Living conditions vary from one place to the other depending on social, cultural or individual characteristics of the community.

Development of nations incorporate both human and economy wellbeing. There are numerous indicators for measuring sustainable development, whether it indicates human development or the development of infrastructure or economy. Traditionally Gross Domestic Production(GDP) is used as an indicator to measure the monetary value of goods and services for a specific year. However, income does not necessarily deliver wellbeing. As an example, According to International Monetary Fund(2017), Qatar came 6th place with a higher Gross Domestic Production per capita (GDP/cap) compared to Denmark which ranks at 10th place. Nonetheless, this does not mean that Qatari citizens have superior welfare to the Danes. Denmark ranked number 5 at the HDI while Qatar ranked 33 according to Human Development Report 2016 (Programme March, 2017).

Since wellbeing is a multi-dimensional spectacle that may not be demonstrated by income alone, relatively new indicators emerged to fill the social gaps founded by GDP. These Indicators such as Human Development Index(HDI), World Happiness Index(WHR), Better Life Index(BLI) and many other are used to portray and rank the level of wellbeing based on specific given fields, rather than the overall economy of the country.

On the global aspect, 193 countries came together in Mexico in 2010 and agreed to reduce global Greenhouse Gas(GHG) emissions to prevent the degradation of the environment. This agreement set the ground for further global cooperation in terms of sustainability and wellbeing. More agreements became known after Cancún, where world leaders strive to improve both human and environmental sustainability.

The most recent ambitious global collaboration is the Sustainable Development Goals(SDGs) which tackles planetary and economy sustainability alongside and human welfare. Some parties reassure that the implementation is feasible within the set timeframe, while others have a slightly negative view. Policymakers current biggest challenge is the effective and coordinated implementation of the SDGs. These goals should improve the livelihood in eradicating hunger, poverty, boost gender equality, health and education. However, in this report, the focus is on the linkages between the SDGs and material stocks, rather than the political stance of the cooperating nations.

Introduction of SDG and anthropogenic stocks

In the year 2000, 189 countries co-signed United Nation Millennium Development Goals (MDGs). The agreement consisted of eight major goals with clear targets and indicators to be delivered by 2015 (Assembly 2000).

Upon the success of the eight MDG in 2015, world leaders agreed to meet that same year in New York for the adoption of the 2030 Agenda of Sustainable Development Goals (SDGs), which set out measurable objectives across the social, economic, and environmental scopes of sustainable development. The summit arose 17 goals with corresponding targets and indicators. Some of the goals are a direct continuation of the MDGs, such as end hunger, end poverty, achieve gender equality, ensure inclusive and equitable quality education and the global partnership for sustainable development. The SDGs came accompanied by indicators and targets to ease the implementation, the list includes 232 indicators and 169 targets. The total number of indicators listed in the global indicator framework of SDG indicators is 244. However, since nine indicators repeat under two or three different targets, the actual total number of individual indicator is 232(UN 10 July 2017). Supplementary information regarding the targets and indicators of the 17 goals are present in the appendix page A.

To meet the SDGs within its predetermined deadline; global contribution is required on a national and international level. This is essentially goal number 17 in the SDG (cooperation). Cooperation can be done through communication, knowledge or resources. Most of the SDGs depend on resources and materials found in the ecosphere for achievement, goals that focus on shelter, communication, nourishment and healthcare are directly or indirectly dependent on the anthropogenic material stock for fulfilment. This leads to the second part of the thesis, which is the anthropogenic material stocks.

Anthropogenic stock can be defined as the accumulated resources which is currently in-use or in stock in the anthropogenic sphere. This contains roads, buildings, infrastructural constructions, cars, building inventory, etc. The article ''Mapping The Anthropogenic Stok in Germany'' best describes the term as The accumulated wealth of assets in the form of buildings, infrastructure and other durable goods (Schiller, Müller et al. 2017). From the description, these assets constitute a valuable reservoir of secondary raw materials, hence the use of the word 'stock' to demonstrate that the materials are deposited in the items and can be reused. The anthropogenic stock is not only the single or aggregated item but can also be classified as the materials making up this item. This can again be arranged on different levels such as material, resources or elements, that can be remanufactured in other applications.

The term 'anthropogenic stock' can also mean, the sum of all items found within the anthropogenic sphere, which resides in human possession. Anthropogenic stock can be categorized in many ways based on the scope or view of the researcher, however, in this report, the anthropogenic stock is divided into two categories based on its mobility; mobile and non-mobile. Moreover, the anthropogenic stock is referred to as stocks or material stock.

Literature review

Increasing numbers of studies have been published in the past recent years tackling the SDGs in different aspects. This has been done according to the fields and specialties of the researchers.

'' The U.S. Cities Sustainable Development Goals Index 2017''

A report named '' The U.S. Cities Sustainable Development Goals Index 2017'' took an approach to utilize the SDGs as indexes to categorize cities in the United States of America. The methodology used by the authors utilized 49 of the indicators that are related to income, health care, educational resources, gender, access to safe water and air quality safety, among others.

They chose 100 large cities for evaluation, referred to as Metropolitan Statistical Areas (MSA). The cities have a core urban population number of at least 50,000. Despite choosing large cities with abundant data, the US cities SDG index revealed numerous challenges regarding data collection for monitoring sustainable development. Few sustainable development indicators are consistently collected, whereas several basic crucial indicators are still not monitored at the local level. The authors furthermore stated that, some of the development goals could not be implemented in the report due to lack of tangible data, such as goal number 14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development), since not all the MSAs are coastal cities. After the collection of data, the indicators are then normalized. These values are transformed to a 0-100 scale for compatibility with other indicators.

Some cities ranked high in groups of goals but had poor ratings in others. After the goal-oriented rankings, the cities are ranked among themselves. San Jose, Santa Clara metro region (CA) is top of the Index, with an overall index score of 61.04. The San Jose MSA region also ranks in the top ten cities on 10 of the 16 goals monitored by this Index.

The worst performing urban areas, with the lowest U.S. Cities SDG Index scores, are Baton Rouge in Los Angeles, Cleveland-Elyria in Ohio and Detroit Michigan. However, the authors of this report have stated that the report does not reflect the views of any organization, agency or program of the United Nation.

The geographical boundaries of the cities caused some limitations that caused changes the initial coverage of the SDGs indicators. Some MSAs tend to have many fragmented counties, leading to estimates with high standard errors. Microdata are highly sensitive to identity disclosure. Also, some of the data was disclosed to the public by the Census Bureau so that its data do not disclose information about specific individuals and households(Mihir Prakash 2017).

To conclude the report, the authors stated that:

- Overall the MSAs see a poverty rate of %15. This translates to approximately 33.28 million people are living below the national poverty line, with Southern MSAs having considerably higher poverty rates.
- The percentage of children living in poverty in large urban areas is acute, reaching as high as %70.
- Malnutrition and obesity is a profound problem across the country. Even the best performing urban areas have adult obesity rates of %30.

On the last page of the report, the writers mention that USA is the world's richest large economy, with the world's leading technologies and institutes of higher education. Yet, it is falling behind other countries on a range of indicators involving quality of life, economic opportunity and environmental management. This implies that, despite the huge material stock represented in infrastructure, devices and machineries, the US does not have the highest rank in SDGs globally. Infect, US ranked number 25 with a score of 72.7, the first place went to Sweden with a score of 84.5(Index 2017).

''Integration: the key to implementing the Sustainable Development Goals''

Another article published in July 2016 titled ''Integration: the key to implementing the Sustainable Development Goals'' by Mark Stafford-Smith, David Griggs, Owen Gaffney, Farooq Ullah, Belinda Reyers, Norichika Kanie, Bjorn Stigson, Paul Shrivastava, Melissa Leach and Deborah O'Connell. The authors took a rather different approach in implementing the SDGs. The authors argued a need for a systematic global approach that unifies different bodies. This in turn implies that uncoordinated action may create internal conflicts. They furthermore, gave examples stating: subsidies for non-renewable fuel sources, will give access to the poor but at the same time drive funds away from renewable energy research. Hence, the authors demonstrate the need for interlinkages between sectors (finance, agriculture, energy, and transport) and across societal actors (local authorities, government agencies, private sector, and civil society).

The authors suggest greater attention to the interlinkages in three areas:

- across sectors (e.g., finance, agriculture, energy, technology, and transport)
- across societal actors (local authorities, government agencies, private sector, and civil society)
- between and among low, medium, and high-income countries.

The report provides seven recommendations to enhance the interlinkages and implementation at both global and national levels: finance, technology, capacity building, trade, policy coherence, partnerships, and, finally, data, monitoring and accountability. The report further describes the interlinkages in detail. To summarize the article, the headlines of the linkages are as following:

- Finance: link across sectors and countries through incentives for the long-term investment in early stage market development in lower income countries, particularly for products and services that support sustainable development.
- Technology: link across actors and countries by promoting an integrated global innovation system for sustainable development knowledge and for technology exchanges based on environmental, economic, and cultural affinities.
- Capacity building: links across sectors promoted through ensuring that new technologies are used to train all sectors of society in systems approaches to global sustainability.
- Trade: linking across countries and sectors by ensuring that trade systems at all levels promote trade in appropriate products and services for sustainable development.
- Policy and institutional coherence: link sectors and actors through strong global and national oversight of integrated development plans.
- Multi-stakeholder partnerships: link across sectors and actors by encouraging widespread adoption of the SDGs as a legitimate Common Standard package.
- Data, monitoring, and accountability: link across countries, sectors, and actors by developing a concise set of fully integrated indicators (essential sustainable development variables).

The article approaches the application of the SDGs by finding linkages to simplify and ensure proper implementation. However, the linkages are between sectors and governmental or social bodies. In spite of the cooperation between different bodies, the authors state that, it depend on the nation how it wants to implement the goals as they have further understanding to the situation the country is going through and the appropriate means of application. (Stafford-Smith, Griggs et al. 2017)

''A Guide to SDG Interactions: From Science to Implementation''

A similar report published in 2017 undertaking the discovery of linkages between four of the SDGs with each other. The report is titled ''A Guide to SDG Interactions: From Science to Implementation''. The focus of the report is to find a scientific analysis of connections crosswise SDGs to assist and support more articulate decision making and enable easy monitoring of progress. The authors justified the reason by saying: 'All SDGs interact with one another by design they are an integrated set of global priorities and objectives that are fundamentally interdependent. Understanding possible trade-offs as well as synergistic relations between the different SDGs is crucial for achieving long-lasting sustainable development outcomes'.

They claim through understanding the range of positive and negative interactions among SDGs is key to unlocking their full potential, as well as ensuring the progress made does not affect the progress in other areas.

The method used in the report is based on assigning scores. The scores are set according to positive or negative interactions, where positive are assigned scores of +1 ('enabling'), +2 ('reinforcing') or +3 ('indivisible'), while negative is scored with -1 ('constraining'), -2 ('counteracting'), or -3 ('cancelling') and neutral interactions between SDGs are assigned 0. By systematically assessing the interactions and relationships between goals and targets, this report supports coherence across sectors.
To further illustrate this method, the report gives an example, carbon-free sustainable energy is also pollution-free. This means, in most cases, efforts to increase energy access (target 7.1), expand the share of renewables in the energy mix (target 7.2), and promote energy efficiency (target 7.3) will lead to a simultaneous reduction in air pollutant emissions. Therefore, the interaction between SDG goal number 7 (sustainable and modern energy) and target 3.9 (reducing air pollution) is considered reinforcing and so is allocated a score of +2. Nevertheless, achieving SDG number 7 may not in itself be enough to meet the air quality targets of SDG number 3 (ensure healthy lives and wellbeing).

The key findings of the report can be summarized into:
-The four SDGs analyzed in detail (SDG 2,3, 7 and 14, end hunger, healthy lives, sustainable energy and sustainable use of oceans and seas, respectfully) are mostly synergistic with the other SDGs.
-Using a 7-point scale, the score most often allocated is +2 ('reinforcing').
-The assessment identified 316 target-level interactions overall, of which 238 are positive, 66 are negative, and 12 are neutral.
-This analysis found no target that would make it impossible to achieve another. However, it identifies a set of potential constraints and conditionalities that require coordinated policy interventions.

-This approach provides a basis for a science-policy dialogue helping achieve SDGs. It provides an understanding of the conflicts and synergies and identifies who needs to be brought to the table to achieve collective impacts across multiple interacting policy domains.

Finally, the report states that it's framework is not in itself a priority setting exercise nor is it an inclusive charting of all possible connections. It can be useful at multiple scales (international, national, sub-national) through a thematic or geographic entry, and the analysis is based on present literature and skilled judgment. There is evidently no one-size-fits-all method to understanding target interactions and building on this work will necessitate a commitment to continuous reiteration and enhancement(Nilsson, Griggs et al. 2017).

Gaps and limitations

The reviewed article and reports have a common and challenge represented in two aspects: the first aspect is, the availability of data: in the first reviewed report, the limitation in data changed the initial coverage of the SDGs indicators and the geographical boundaries of the cities. Also, some of the data is disclosed to the public. The data limitations in the second reviewed article (Integration: the key to implementing the Sustainable Development Goals) led to only four detailed SDG linkages rather that all the 17 goals. The third report took a different approach, rather than collecting data about the SDGs, it chose to score the indicators.

The second aspect is the implementation and future adoption: two of the reviewed literature denied their research being done on behalf of any governmental or global organization, rather their work being a study done by highly qualified individuals. This indicates that none of the mentioned bodies acclaims future participation in the studies yet. However, in the third report the authors state that, evidently no solid method to understand target interactions, it depends on the field of focus and building on this work will necessitate a commitment to continuous reiteration and enhancement.

Significance of study

From the past article and reports, each group of the others interpreted the SDGs in their own field. The group of others in 'The U.S. Cities Sustainable Development Goals Index 2017' chose to make the SDGs as ranking indicators. However, they did not breakdown the SDGS into their indicators, rather they collected data regarding activities as healthcare, nutrition, employment ratios…etc. the second group of authors chose to link the SDGs to governmental or social bodies to carry out. In this case the SDGs are segregated to area of specialty for implementation, taking a divided and conquer technique. The report 'A Guide to SDG Interactions: From Science to Implementation' also investigated linkages but among the indicators and targets within the different SDG.

This thesis report will attempt to fill the gaps found in reports; by better understanding of linkages between SDGs and stocks, this will help to assist future rankings for city by understanding the relation between the city's stock and welfare. Rather than using different welfare indicators to assess the SDGs. This will furthermore, motivate the statistical agencies to obtain more information regarding material stock. More ever, by linking the stock to SDGs it will help to realize the synergies among the 232 indicators. This will support the appropriate distribution of tasks through governmental or even businesses with exact

expertise and knowledge to improve the implementation of the indicators, which will lead to less contradiction among the targets by finding more interlinks among the SDGs.

Objectives

The thesis will attempt to interpret the linkages between the SDGs and material stock by categorizing the material stock to buildings, infrastructure, vehicles and devices and assigning them to the SDG indicator to provide an advanced understanding and implementation of the goals. Furthermore, this report will attempt to understand the correlation between the anthropogenic stocks and human well-being. This will provide an in-depth view of the indicator reliance to our daily surrounding objects and further adapt communities, cities and countries to support better human welfare.

Methodology

The thesis is constructed on a system analysis base study, a bottom-up approach to map the SDGs through the linkages of indicators to products and services used in daily human activities. A conceptual figure is developed to assist in linking the different SDGs indicators to material stocks. The thesis also assesses the human wellbeing activities and how it correlates to current material stocks. Furthermore, the project will allocate future demands for materials and energy requirements as the populations and quality of life increase in Africa. The report contains three segments linking human wellbeing with the materials stock and the African leapfrog impacts. The three analyzed segments are shown as the following:

Social welfare

The different human wellbeing indicators are utilized to convey the level of workability obtained from the material stocks. The different welfare indicators appeal to different aspects of services that assist in different human activities. The activities are broken down to nutrition, reside/work, sanitation and transportation/communication. The main welfare indicators used are:

• Human Development Index (HDI), which measures the average achievement in three key dimensions of human development: healthy life, being knowledgeable and obtaining a decent standard of living. The HDI is the geometric mean of normalized catalogs for each of the three dimensions. The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. Gross national income measures the standard of living dimension per capita. The HDI uses the logarithm of income, to reflect the diminishing importance of income with increasing GNI. The scores for the three HDI dimension catalogs are then aggregated into a composite index using geometric mean (Jahan 2017).
• World Happiness Index (WHR) is based on individuals lives for a sample of 1000 individual for more than 150 countries, that uses people's actual life evaluations by asking questions and surveys, rather than some index of factors that imply the well-being of a certain society. The variables for the index vary from GDP per capita, social support, healthy life expectancy, social freedom, generosity, and absence of corruption. The first world happiness report was published in 2012, in support of the UN high level meeting on happiness and well-being (Helliwell, Layard et al. 2017).
• The Organization for Economic Co-operation and Development (OECD) Better Life Initiative devised a method to quantify welfare, named Better Life Index (BLI). It is based on three pillars: Material conditions, quality of life, and sustainability. The material condition assesses the consumption and economic resources distributed among the people. The quality of life ranges from economic resources to health status, human contact, education, jobs, environmental quality, civic engagement, governance, security, and free time. The sustainability section concentrates on four types of resources, which are economic, natural, human and social capital. (Gurria 2013).
• The Logistic Performance Index(LPI), is an interactive benchmarking tool created to help countries identify the challenges and opportunities facing their performance on trade logistics.
• ICT Development Index (IDI) is published by the United Nations International Telecommunication Union based on internationally agreed information and communication technologies (ICT) indicators. The IDI is a standard tool that measures the digital division and compare ICT performance within and across

countries. The ICT Development Index is based on 11 indicators, grouped in three clusters: access, use and skills.

• Environment Performance Index (EPI) is developed from the Pilot Environmental Performance Index and designed with changing variables to supplement the environmental targets set forth in the United Nations Millennium Development Goals.

Other indicators such as: Legatum prosperity Index, includes 9 pillars as references to calculate the total prosperity of any country, which are economic quality, business environment, governance, education, health, safety & security, personal freedom, social capital, and natural environment. Leisure satisfaction indicator (LI) focuses on the satisfaction obtained by individuals when participating in any leisure activity, which will reflect back into life satisfaction and positive feelings and thus, well-being occurs (Weismayer, Ponocny et al. 2017). Legatum Prosperity index (LPI) is an index conducted by the Legatum institute based in London. The index includes 149 countries with 9 pillars of the index that are Economic Quality, Business Environment, Governance, Education, Health, Safety & Security, Personal Freedom, Social Capital, and Natural Environment(Lind 2014). Infrastructure Index is founded by researchers from Kiel Institute for the World Economy in Germany, used for ranking infrastructure based on transportation, supply and disposal and finance. The indicator shows the rank based on the most developed country, where rank number 1 shows that it's the best globally and so on. (Donaubauer, Meyer et al. 2016).

Indicator	*Aspects of welfare*
Human Development Index (HDI)	Education, live expectancy, income
World Happiness Report (WHR)	Education, live expectance, housing, income, environment, communication, security
Legatum prosperity Index	Education, income, leisure, Health, Safety & Security, Personal Freedom, Social Capital, and Natural Environment
OECD Better Life Index (BLI)	Personal relationships, social network support, civic engagement, and trust
Leisure satisfaction (LI)	Satisfied with their leisure experiences and activities
Infrastructure index	Comprehensive and comparable index on the most relevant components of infrastructure
Human Economic Welfare Index (HEWI)	Focuses on the economic dimension of human welfare
Energy Total Wellbeing Index (ETWI)	Integrates human welfare and resource sustainability by minimizing the percent of non-renewable resources and maximizing
Logistic Performance Index(LPI)	Allows for infrastructure comparison between nations
ICT Development Index (IDI)	Tool for benchmarking communication and telecommunication methods across the world
Environmental Performance Index (EPI)	Method of quantifying and numerically marking the environmental performance of a state's

Table 1: Welfare indicators

The indicators written in bold in table 1, will be used in the results to show the level of welfare in accordance to material stock for the countries.

Anthropogenic Stocks

The quantification of anthropogenic stock will account for the built environment. This quantification will contribute to better understanding of welfare status, by linking welfare activities to a group of stock. Figure 1 below, shows the two segments of stocks based on the static or dynamic nature of the stock. Mobile stock includes vehicles, electronic devices and machinery. On the other hand, non-mobile stock are buildings and infrastructure. Each of the stock subdivision will have further segments as the following:

Mobile stock:

- Vehicles: include all motor-powered transportation methods, whether it is ground, air or water transportation vehicles (cars, planes and boats).
- Machinery & equipment: includes all sorts of apparatuses and mechanisms used in the medical, agricultural, manufacturing and construction fields. The last segment in the equipment is the electrical or electronic devises open to the public use, such as interactive boards or screens used for advertisements, broadcasting or communication that are owned by public facilities.
- Durables: contains two segments, personal use devices such as computers, laptops and other devices that fall in that realm. The second segment accounts for the household appliances such as kitchen appliances, house furniture and appliances that are shared by the inhabitants.
- Solid waste: waste is no longer viewed as worthless materials; therefore, they account for secondary material sources and proper disposal play a key role in the environmental indicators. This segment is composed of municipal and hazardous waste.
- Containers and packaging: this represents the shipping containers and packaging for international trade and commerce. However, this segment is not countified in this thesis report.

Non-mobile stock:

- Buildings: this segment has two subcategories: residential and non-residential buildings. The residential buildings accounts for multi-family houses, single family and other types of dwellings. While, non-residential buildings accounts for seven types of buildings based on their functionality. Essentially, they are buildings not used for housing purposes, rather they are facilities used for Healthcare, education, recreation and industries.
- Transportation: this segment includes the infrastructure used for transportation as roads, railways, subway network, airports and ports.
- Supply and disposal: this segment accounts for the underground infrastructure used in sewage and clean water systems, pipelines for oil and gas transportation, also it accounts for the main supply cables for telecommunication and information technology.
- Energy: this segment is focused on the energy generation, transmission and the main cables used for distribution.

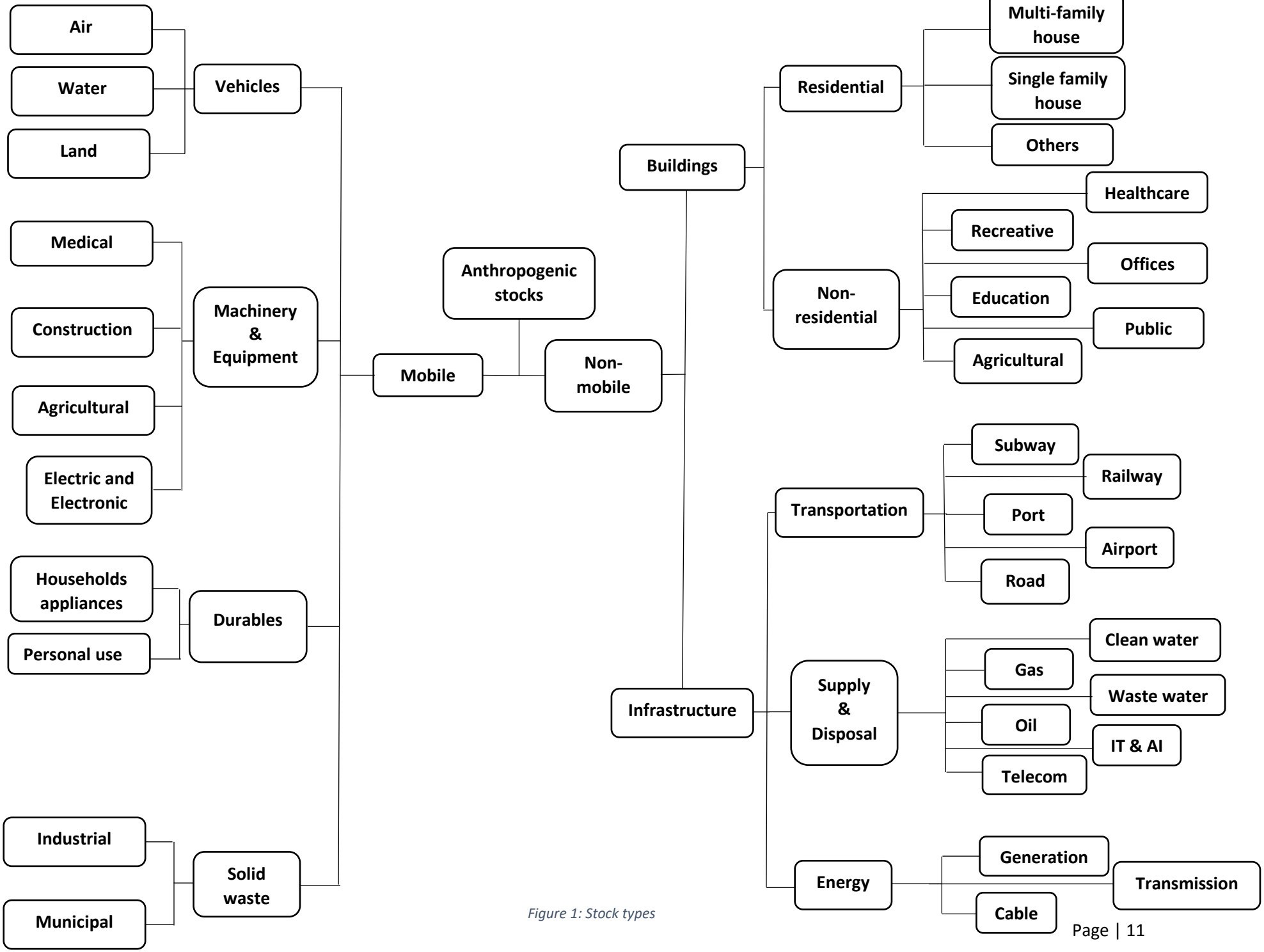

Figure 1: Stock types

African leapfrog

This segment accounts for the population growth of Africa for 2030, which is used to account for the required increase in stock to accommodate the future population. This assists to indicate future energy and transportation requirements for Africa and accompanied CO_2 emissions.

The additional stock demand is calculated by finding the total increment of population by 2030, and then multiplied by the average industrial countries stocks per capita. The CO_2 is estimated for the usage period, older studies and reports are utilized to estimate the CO_2 emissions for a single unit, the total emission is found by multiplying the single unit emission by the total number of units. This will provide a rough estimation for the environmental impact.

2030 additional stock demand = 2030 population addition X Average stock per capita (industrialized countries)

Total CO_2 emission = emission per single unit X total number of units

As for the African leapfrog, the average anthropogenic stock of the industrialized countries is normalized and adjusted for the 2030 African population. Which is used to indicate the future African stock ratios. The equation below illustrates the method used to calculate the total emission per year from transportation.

$$\textit{African leapfrog transportation emissions per year} = \left[\textit{Tailpipe emissions } X \frac{\textit{Total distance covered}}{\textit{Distance covered a year}}\right] X \textit{ Number of total car stock}$$

Conceptual framework

This section investigates the linkages between the SDGs and material stock. This is done by developing a conceptual framework that ties the SDG indicators to their respective stock need.

The framework divides the SDGs to three different scopes based on the purpose of the goals to social realm, natural environment and built environment. The break-down of these goals improves the ability to find links to the material stock in a more concise way.

The social realm includes all the goals that are dedicated for enhancing human rights. The natural environment embraces all the goals that target the protection of the environment and habitats of all species. The built environment marks the goals that pursue manufactured systems or concepts made by human.

Linkages between indicators and stock are further characterized to direct and indirect links. The direct link conveys the straight dependency of SDG to material stocks, in other words, it represents the human built environment goals. The indirect link shows the distant dependency on stock, this can be in terms of services provided based on stock, such as access to electricity, which is not a stock in itself, but requires stocks for its production and distribution. The figure below visualizes the framework used to find the linkages.

Figure 2 describes the three segments of the SDGs along with the indicators placement. The overlapping of the three different scopes shows the nature of indicator link to stocks. The direct link encompasses the indicators that fall in the built environment, while the indirect link contains the indicators that fall in the

overlapping between the built environment and the other scopes. As for the overlapping of social aspects and natural environment, the linkages are irrelevant due to their distant requirement of stock.

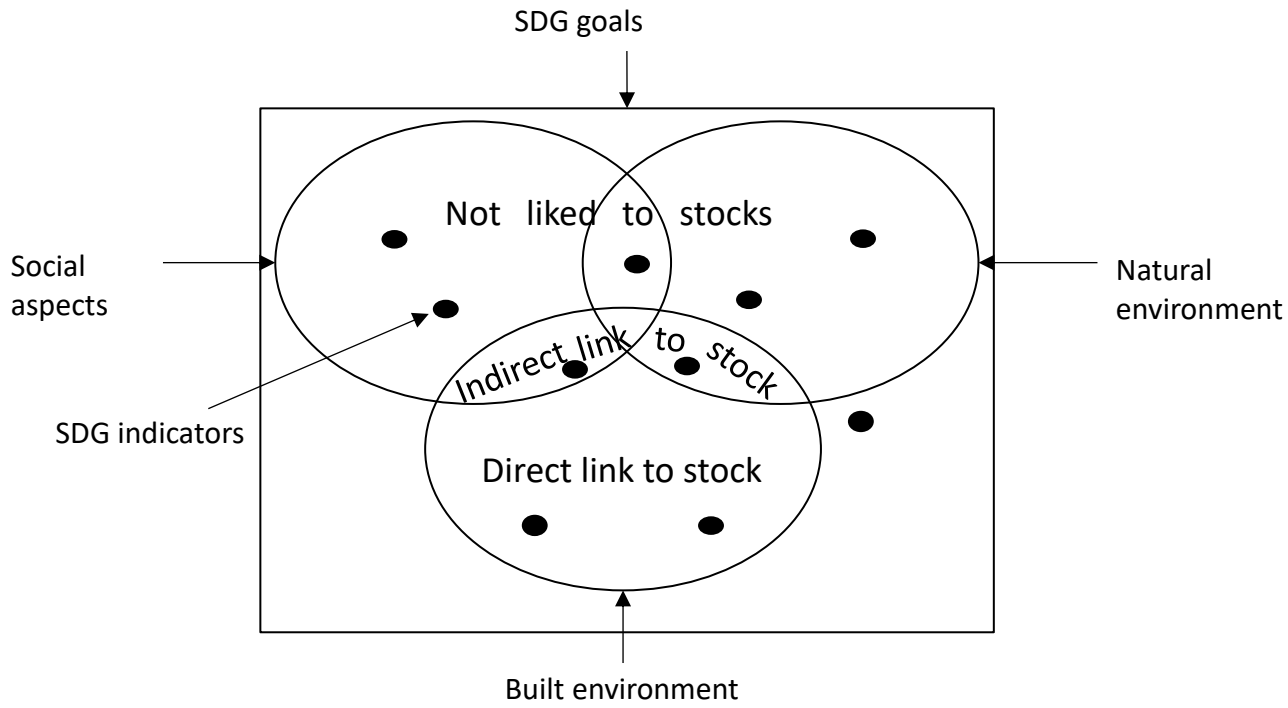

Figure 2: Direct and indirect linkages between the SDG indicators and stock

The second segment of the framework is to quantify the different stocks with welfare indicators, where the thesis inspects the mobile and non-mobile anthropogenic stocks that relate to human wellbeing. Historical data is used to show the stock trends through a particular period and then linking it with the welfare indicator in that timeframe. This analyzes the role stocks play in daily human activities and wellbeing. Furthermore, a comparison between countries is conducted for better understanding of the relationship between the stocks and the overall wellbeing of the citizens. Figure 3 illustrates the different correlations between welfare indicators, activities and material stock. The human wellbeing indicators interpret the quality of services provided by the stocks. Therefore, the quality and quantity of stocks affect the wellbeing indicators.

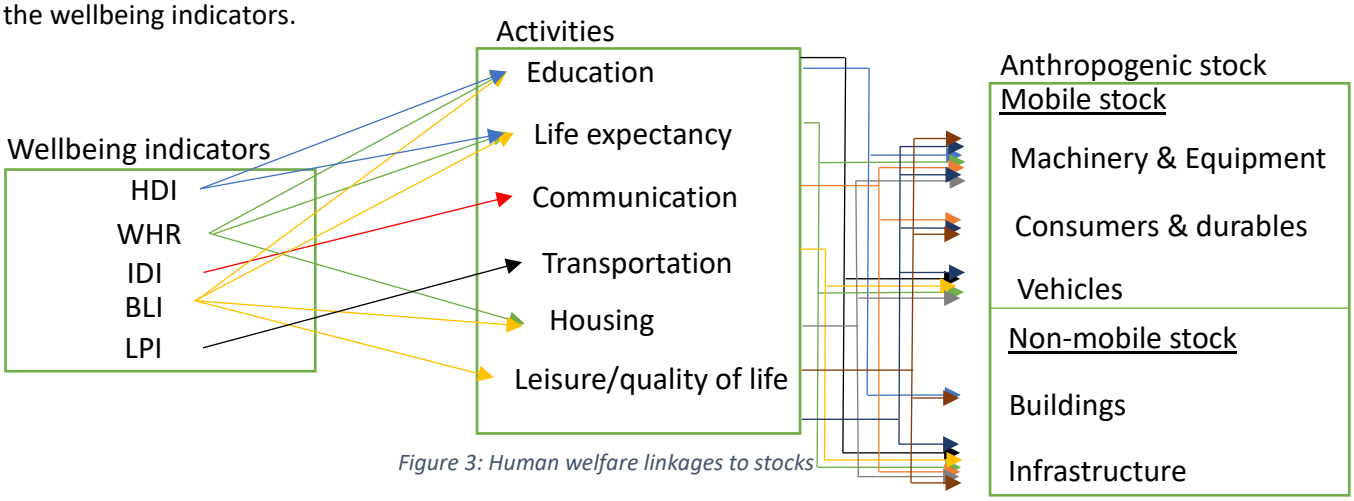

Figure 3: Human welfare linkages to stocks

Data

The report utilized multiple databases and sources. The data required will be derived from global reports and databases such as the world bank, stat bank, and the annual reports of the different welfare indicators. The data containing global information is collected from the United Nation database that covers all the different agencies under the UN umbrella. Also, the world bank database contained some of the needed information on a global level. As for the historical dwelling information, the European Commission only covered the EU countries, therefore, the global dwelling stock took a bottom up approach to map the major countries from UK, USA, China, South Africa, India and some of the EU countries not represented in the European Commission. The table below provides description of the data type, country or region, the unit of quantification and the source of the data. For more information regarding the data sources and reports, refer to the footnotes.

Due to some limitations in data availability for some countries, the scope of the report is narrowed down. It proved difficult to find detailed building stock data regarding most of the African and Asian countries. This attributed to linguistic barrier in finding specific data, where translation requires time. However, South Africa, China and India had official statistical reports in English. The historical dwelling data for India comprises of three different reports by two different agencies using different housing classification. This might cause some double count of data, therefore, only the total number of houses per year are accounted for in this report. For the data collection methods used by the data bases, refer to the links found in the footnote to retrieve the methodology from the respective agencies. As for the road and railroad data, there are several types of systems used based on dimensions and purpose, therefore the total length of network is accounted for, rather than signifying whether if they are dual or single carriage ways. The fiber optics accounts for the total weight of the products rather than length. This helps to combine all the different types of optics into one category that is easily visualized.

Stock type	Country/region	Units	Years	Source
Telecommunication	Global	Per 100 inhabitants, million users	2005-2017	ICT Indicators Database[1]
Fiber optics	Global	Metric tonnes	1995-2015	Industrial Commodity Statistics Database[2]
Cellular telephone subscriptions	Global	Subscriptions per 100 inhabitants	1960-2014	ICT Indicators Database[3]
Passenger cars	Global	Per 1000 inhabitants	2000-2016	UNECE database[4]
Roads	Global	Total length km	2000-2016	UNECE transport division database[5]
Municipal waste	Global	1000 tonnes	2000-2016	Environment Statistics Database[6]

Hazardous waste generated	Global	1000 tonnes	1990-2016	Environment Statistics Database[7]
Medical equipment	Global	Value in USD	2000-2015	Industrial Commodity Statistics Database[8]
Power grid capacity	Global	1000 kilowatts	1990-2016	Energy Statistics Database[9]
Electrical consumption	Global	KWh/cap	1960-2013	World Development Indicators, World Bank[10]
Hospitals beds	Global	Bed per 10,000 and 1000 inhabitants	1990-2012	WHO database[11]
House furniture	Global	Number of enterprises or establishments	2007-2011	INDSTAT[12]
Electric generating sets and rotary converters	Global	1000 units	1995-2015	Industrial Commodity Statistics Database[13]
Dwelling, retail, hotels, healthcare, education	EU	Average floor area m^2, 1000 units	2011-2015	European commission[14]
Housing stock and area	EU	M^2, 1000 unit, M^2/person	1980-2009	Housing Statistics in the European Union[15]
Area of building stock	Denmark	1000m^2, unit	1900-2015	Statsbank Denmark[16]
Dwelling stock	Czech	M^2, unit	1950-2011	Czech Demographic Handbook 2015[17]
	Germany	1000 Units, m^2/capita	1995-2016	Statistisches bundesamt[18]
	Sweden	1000 Units	1990-2016	Statistiska centralbyran[19]
	Finland	Floor area per dwelling, units	1960-2016	Statistics Finland[20]
	Austria	Floor area, 1000 units	1951-2016	Statistic Austria[21]
	Croatia	Units, m^2	1981-2014	Croatia bureau of statistics[22]
	Estonia	Units, m^2	1910-2017	Statistics Estonia[23]

	Latvia	Million, thousand m^2	1980-2016	Centrala statistaks pravalde[24]
	Sweden	Unit	1990-2016	Statistics Sweden[25]
	UK	Unit	1980-2016	GOV.UK[26]
	USA	1000 units	2000-2017	Federal Reserve Economic Data[27]
	China	Units	1980-2015 (intervals)	National Bureau of Statistics of China[28]
	South Africa	1000 units	2002-2016	Statistics South Africa[29]
	India	Units	1971-2015 (intervals)	Ministry of Home Affairs, India[30]
Population	Global	1000 capita	1950-2030	World Population Prospects[31]
HDI	Global	Points	1990-2016	United Nation Development Program, Human Development Report[32]
WHR	Global	Points	2005-2017	World Happiness Report[33]
Logistics Performance Index	Global	Points	2007-2016	World Bank Data base[34]
ICT Development Index (IDI)	Regional	Ranking, points	2005-20017	ITU World Telecommunication[35]
Environmental Performance Index (EPI)	Global	Score, ranking	2002-2014	Yale Center for Environmental Law and Policy[36]
OECD Better Life Index(BLI)	Global	Ranking	2017	OECD stat[37]

Table 2: Data type and source

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Results

SDGs linkages

The SDG targets and indicators at first seem overwhelming and baffling, a total of 244 indicators in a group of 169 targets. To assist in categorizing the SDG indicators; connection to anthropogenic stock is made to assist in understanding and future implementation.

The indicators that fits the stock categorization are shown in table 3 below. The SDG are broken down to individual targets and further dismantled to indicators. From there, the indicators are segmented to direct and indirect linkages to stocks. From figure 2, the direct link shows the need of the built environment. As for the indirect link, it shows that the indicators are based indirectly on the built environment in order of achievement.

Table 3 shows that the SDG No.1 (end poverty) has a total of 12 indirect links to the material stock. Goal No. 2 (end hunger) has a total of 30 linkages to stock, two links being direct and 28 indirect. Indicator 2.A.2, specifies the need of more flows to the agricultural sector, hence the solid ties to human made devices and machinery along with farms, transportation and supply and disposal facilities.

Goal No.3 (ensure health and welling) contains the second biggest linkages to material stock with 23 direct and 21 indirect linkages. This is due to the healthcare focus of the goal, where both buildings and transportation infrastructure is needed to provide a sanitized environment for proper medical procedures, Furthermore the goal also requires non-mobile stock as in medical devices and vehicles.
Goal No.4 (ensure quality education) contains the third largest linkages to stock with a total of 39. This goal requires buildings, infrastructure along with devices and energy.
Goal No.5 considers gender equality, which is another social welfare goal that requires less linkages to material stock, with only one indirect link.

Goal No.6 (sustainable management of water and sanitation) falls under the natural and built environment, with 5 direct and 15 indirect linkages. These linkages are with supply and disposal stocks through clean and waste water facilities along with the waste system.
Goal No.7 focuses on providing affordable and reliable energy sources for all, there for it depends on the energy infrastructure. The goal has a total of 27 linkages to the material stock.
Goal No.8 is concerned about economic growth, therefore it falls under the social categories. Hence the low linkages, with one direct and five indirect links to stock.

SDG No.9 has the biggest share of linkage to the material stock, this is due to the nature of the goal which is directed to the human built environment. The goal promotes building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation. The goal has 31 direct and 26 indirect linkages that are represented in transportation infrastructure, buildings and the energy sector. SDG No. 13 to 16 have two indirect links each.
Goal No. 11 encourages adapting human settlements to be more inclusive, safe and resilient. The goal has a total of 36 linkages to stock, 29 of them are direct due to the attention to buildings and infrastructure.

Goal No.12 focuses on sustainable consumption and production patterns, with a total of 12 linkages to stock.
Goal No. 17 falls in the social realm of goals that encourages different businesses and governmental bodies to work together to achieve all goals. The goal has 14 indirect linkages and one direct link to material stock. The linkages are represented in communication devices and services.

Not all 17 SDG fit into the categorizing system. Goal number 10 that reads, "Progress in reducing inequality within and among countries'' is non-categorizable in this theme, due to the lack of direct or indirect linkages to the material stocks. Similarly, some of the targets and indicators have no link to material stocks. Such indicators describe statistical quantification (proportion of people under poverty line, number of missing people, participation rates), or they describe financial aid, expenditures or costs and some of the indicators address the level of cooperation and assistance within different bodies. To view the excel table containing all the linkages, refer to the appendix page FF.

SDG	Target	Indicator	Direct link to stock	Indirect link to stock	Total direct stock links	Total indirect stock links	Total
1/ End poverty	1.4	1.4.1	1	3	1	12	12
		1.4.2	0	1			
	1.5	1.5.3	0	1			
	1.A	1.A.2	0	7			
2/ End hunger	2.1	2.1.2	0	4	2	28	30
	2.2	2.2.1	0	1			
		2.2.2	0	2			
	2.3	2.3.1	0	1			
	2.4	2.4.1	0	3			
	2.5	2.5.1	0	2			
	2.A	2.A.2	2	15			
3/ Ensure healthy lives	3.1	3.1.2	0	2	23	21	44
	3.2	3.2.2	4	0			
	3.3	3.3.2	0	1			
	3.4	3.4.1	2	0			
		3.4.2	0	1			
	3.5	3.5.1	4	0			
	3.6	3.6.1	2	1			
	3.7	3.7.1	3	0			
	3.8	3.8.1	1	4			
	3.9	3.9.1	4	0			
		3.9.2	3	5			
	3.B	3.B.1	0	3			
		3.B.2	0	2			
	3.C	3.C.1	0	2			
4/ Ensure inclusive and equitable learning	4.1	4.1.1	0	2			
	4.2	4.2.1	0	3			
	4.3	4.3.1	1	1			
	4.4	4.4.1	2	1			

	4.6	4.6.1	0	2	28	11	39
	4.7	4.7.1	0	1			
	4.A	4.A.1(a)	6	0			
		4.A.1(b)	3	0			
		4.A.1(c)	3	0			
		4.A.1(d)	4	0			
		4.A.1(e)	3	0			
		4.A.1(f)	3	0			
		4.A.1(g)	3	0			
	4.C	4.C.1	0	1			
5/ Achieve gender equality	5.B	5.B.1	1	0	1	0	1
6/ Ensure sustainable management of water	6.1	6.1.1	1	0	5	15	20
	6.2	6.2.1	2	0			
	6.3	6.3.1	0	3			
		6.3.2	0	1			
	6.4	6.4.1	0	4			
		6.4.2	0	1			
	6.6	6.6.1	2	0			
	6.A	6.A.1	0	4			
	6.B	6.B.1	0	2			
7/ Ensure access to modern energy	7.1	7.1.1	5	0	20	7	27
		7.1.2	3	0			
	7.2	7.2.1	3	0			
	7.3	7.3.1	2	3			
	7.A	7.A.1	0	4			
	7.B	7.B.1	7	0			
8/ Promote inclusive economic growth	8.6	8.6.1	0	2	1	5	6
	8.9	8.9.2	0	2			
	8.10	8.10.1	1	0			
	8.B	8.B.1	0	1			
9/ Build resilient infrastructure	9.1	9.1.1	1	0	31	26	57
		9.1.2	9	0			
	9.2	9.2.2	0	4			
	9.4	9.4.1	1	15			
	9.5	9.5.1	0	3			
	9.A	9.A.1	16	1			
	9.B	9.B.1	0	3			
	9.C	9.C.1	4	0			
11/ Make cities inclusive, safe, resilient and sustainable	11.1	11.1.1	3	4	29	7	36
	11.2	11.2.1	9	0			
	11.4	11.4.1	0	1			
	11.6	11.6.1	2	1			
	11.7	11.7.1	2	0			
	11.C	11.C.1	13	1			

12/ Ensure sustainable consumption and production	12.4	12.4.1	0	1	1	11	12
		12.4.2	0	2			
	12.5	12.5.1	0	6			
	12.8	12.8.1	1	0			
	12.A	12.A.1	0	2			
13/ Combat climate change	13.3	13.3.2	0	2	0	2	2
14 Conserve and sustainably use the oceans and seas	14.3	14.3.1	0	1	0	2	2
	14.A	14.A.1	0	1			
15/ Protect and manage forests	15.1	15.1.2	0	1	0	2	2
	15.5	15.5.1	0	1			
16/ Provide access to justice for all	16.1	16.1.1	0	2	0	2	2
17/ Strengthen global partnership	17.6	17.6.2	4	0	14	1	15
	17.7	17.7.2	6	0			
		17.2.2	0	1			
	17.8	17.8.1	4	0			

Table 3: SDG direct and indirect linkages to stock

Tables 4, 5 and 6 are follow-ups for the previous table, interpretation for the linkages between the SDG indicators and stocks. They provide an in-depth look at the stock rather than the indicators. This assists in providing a complete mapping of the linkages. Table 4 shows the mobile anthropogenic stocks in detail, while table 5 and 6 show the non-mobile stock.

In table 4, the machinery & equipment segment accounts for the highest mobile stock linkages with a total of 37 linkages, 19 of them make direct links and 18 are indirect. The majority of the linkages (14 direct links and 4 indirect) are with SDG No.4 (Ensure inclusive and equitable learning). This is due to the devices and equipment needed in regard to achieving the goal. The waste services have the second highest linkages for the non-mobile stock with 10 direct and 14 indirect linkages, nine of the total linkages are with SDG No. 6 (sustainable management of water bodies). Vehicles and consumer durables have 18 and 12 linkages respectively. Table 5 shows the non-mobile building stock in both of their sub-categories, where the non-residential buildings have the largest amount of linkages of all the anthropogenic stock, with 21 direct and 47 indirect linkages.

The educational buildings account to 26 linkages followed by 11 linkages for the healthcare buildings. The residential buildings account to 15 linkages, the 'other' in this segment refers to slums and similar types of unorganized dwellings. Table 6 is a continuation for table 5, it shows the non-mobile stock infrastructure. The tables show the different sub-categories represented in transportation, supply and disposal, energy and other. The transportation segment accounts to 26 linkages, where 16 linkages are direct and 10 indirect. The supply and disposal segment have the second highest count of linkages at 54, where 28 are direct and 26 indirect linkages. With the largest sub-category being the telecommunication segment with 10 linkages. The energy segment has 10 linkages to the SDG indicators. The last category under infrastructure is others that refers to empty plots of land that is left untouched by humans. This segment has six linkages, two direct and four indirect linkages to the SDG indicator. Further information is available in the appendix page FF.

Mobile anthropogenic stock											
	Vehicles			Machineries & Equipment				Consumer durables		Waste services	
	Air	Water	Land	Medical	Construction	Electronic & Electrical	Agriculture	Household	Personal	Municipal	Industrial
Direct link	3	3	3	4	5	9	1	6	6	5	5
Indirect link	2	3	4	5	3	6	4	0	0	7	7
Total direct links to SDG	9			19				12		10	
Total indirect links to SDG	9			18				0		14	
Total links to SDG	18			37				12		24	

Table 4: Mobile stock linkages with SDG

Non-mobile stock										
	Buildings									
	Residential			Non-residential						
	MF	SF	Other	Healthcare	Educational	Public Service offices	Office/Industries	Events & Cultural	Agriculture	Recreational
Direct link	2	2	2	5	5	2	2	4	1	2
Indirect link	3	3	3	6	21	5	8	3	3	1
Total direct links to SDG	6			21						
Total indirect links to SDG	9			47						
Total links to SDG	15			68						

Table 5: Non-mobile stock (buildings) linkages with SDG

Non-mobile															
	Infrastructure														
	Transportation					Supply & Disposal						Energy			Other
	Airport	Port	Railway	Subway	Road	Clean water	Waste water	Gas	Oil	IT/AI	Telecom	Generation	Transmission	Cables	Land
Direct link	3	3	3	3	4	6	2	3	6	3	8	7	7	7	2
Indirect link	2	2	2	2	2	8	6	2	2	6	2	5	5	5	4
Total direct links	16					28						21		2	
Total indirect links	10					26						15		4	
Total links	26					54						36		6	

Table 6: Non-mobile stock (infrastructure) linkages with SDG

Anthropogenic stocks and human welfare

It is well known that some countries or regions have better welfare statuses than others. This comes down to numerous reasons, from governmental regulation and laws, resources and output capacities represented by GDP, or it can come down to the intensity of infrastructure and services provided. This segment of the results interpreted the role of anthropogenic stock and compare their actual usability between different countries and regions. This comparison is important since stocks are not the end goal; rather they help facilitate the desired services. As an example, commuting to work is not essentially the end goal, rather, it is to be present at a certain time in the office. Some people walk or cycle to work, rendering all the commuting requirements of no use to them. These commuting requirements are represented by a plethora of anthropogenic stocks from roads, vehicles, source of energy (electricity, oil, gas) and the list can go on depending on the observational scope (cut-off criteria). That is why it is essential to show the impact of stocks in daily activities.

Building stock

Dwellings:

Figure 4 below shows the dwelling stock from the 1990 to 2015 per thousand capita. As shown, most of the European countries and USA fall between the 400-500 dwelling per 1000 capita range throughout the period. On the other hand, China has a large increase of dwellings, around 800 dwellings per 1000 cap in 2015. This might be due to the economic boom that china has been undergoing. The Indian dwelling stock also increased in this period. However, the data regarding the Indian dwelling only accounts for permitted residences which does not include all type of slums, therefore this might not indicate the actual numbers of dwellings. South African dwellings did not count for slums. Therefore, the dwelling stocks seem smaller in comparison to the other countries with an average of 300 dwelling per one thousand inhabitants in 2015.

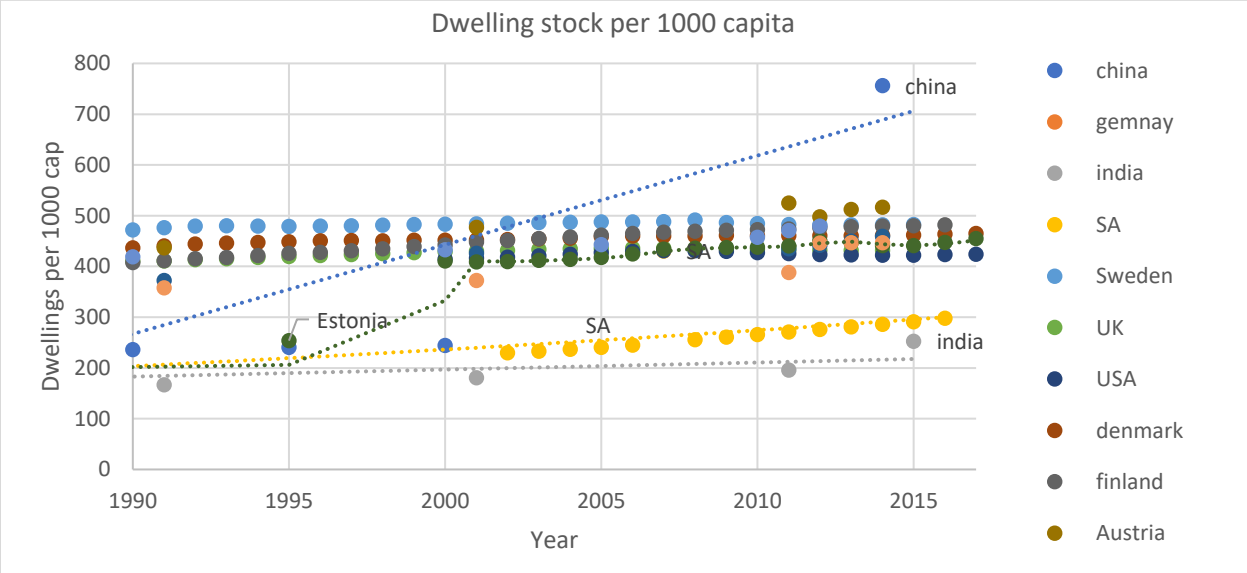

Figure 4: Dwelling stock per thousand inhabitants from 1990-2015

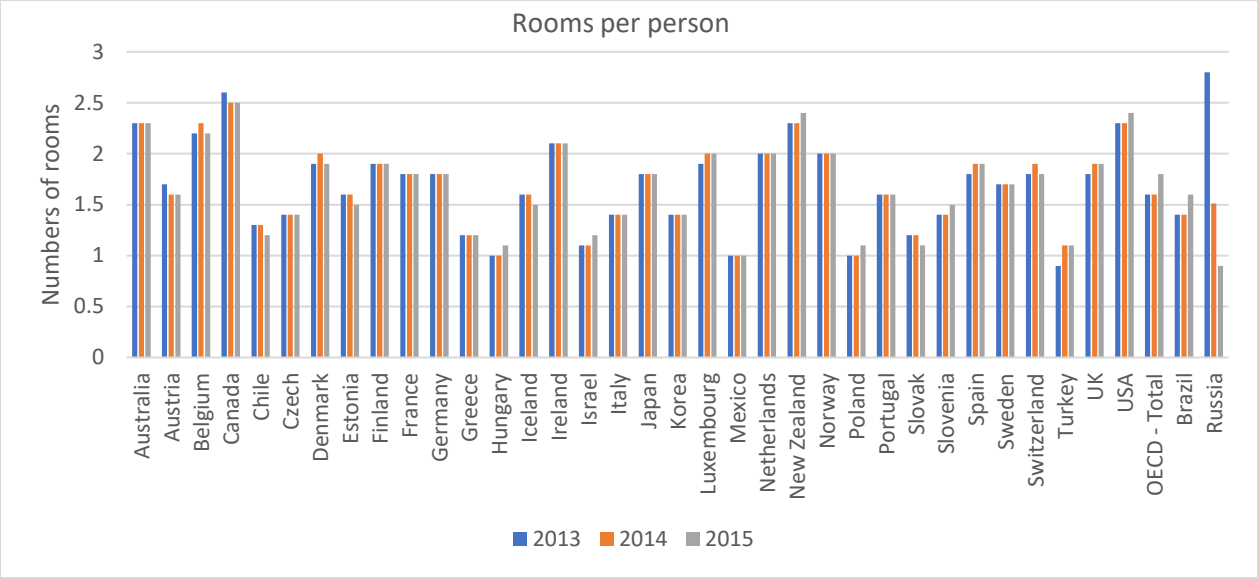

Figure 5: BLI, rooms per dwelling

To see the efficiency of the dwelling stock; a more detailed scope is adapted in figure 5 that considers the number of rooms per person within the dwelling from 2013-2015. This helps convey the level of comfort in dwellings. Despite Denmark, Sweden, Germany, UK, Finland and Austria having a similar dwelling stock, the rooms per person ratio differs between them. Denmark seems to have more rooms per person at 2, 1.7, 1.8, 1.9, 1.9 and 1.6 respectively. Aside from the EU, Russia has the largest value reaching 2.8 rooms per person in 2013, but quickly drops below one room in 2015. The BLI association does not specify any reasons for this drastic drop. Canada hold the second place globally with 2.5 rooms, followed by USA and Australia with 2.25 rooms per person each. The average number of rooms for the OECD countries is around 1.7 per person.

USA ranked number one for housing in 2017 in the Better Life Index with a score of 8.7/10 whereas Norway came second place with a score of 8.6. This comes to show that stock plays a significant role to a certain extent. The living conditions inside of the households come into play to boost the welfare of the residence. The golden ratio of stock to welfare seems to be around 450 dwelling per 1000 capita with two rooms per person in a single household.

Healthcare

The three next figures below 6,7 and 8 inspect mobile and non-mobile anthropogenic stock related to healthcare, then plots the stock against the world happiness index to evaluate its practicality in ensuring better healthy life. Figure 6 shows the number of hospital beds per thousand people by world regions. In the past 20 years the numbers of beds in Europe have dropped from 8 to 5 beds per inhabitant. This decline in hospital beds also accrued in North America from 5 to 3 beds. Whereas, the Middle East and North Africa have a steady number of beds throughout this period with slight fluctuation between 1.8-1.6 beds per thousand capita. On the other hand, East Asia and Pacific countries increased hospital beds from 1.8 beds in 1990 to 3.5 beds per 1000 capita in 2011. Figure 7 provide insight on the medical equipment expenditure. This contributes in the overall assessment of healthcare quality levels. As seen in the graph, the US, Japan and Germany have the biggest healthcare budgets with immense dissimilarity of

expenditures between them. the US spent 24 billion United State Dollars in 2014, followed by japan at 7.4 billion and Germany at 905 million USD at the end of 2014.

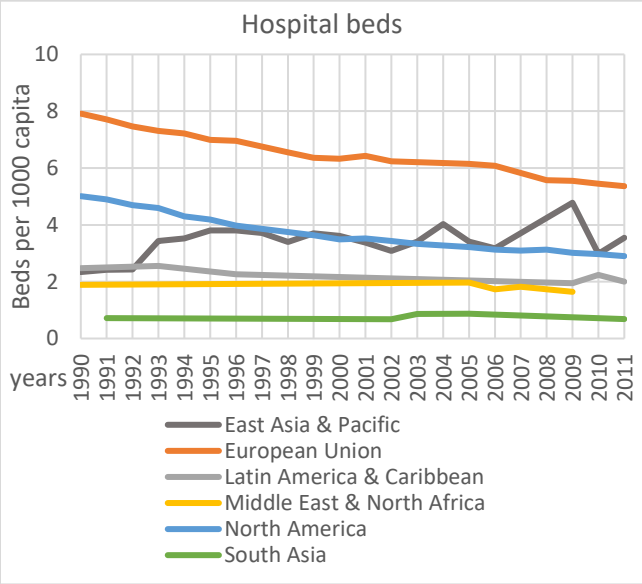

Figure 6: Hospital beds per 1000cap from 1990-2011

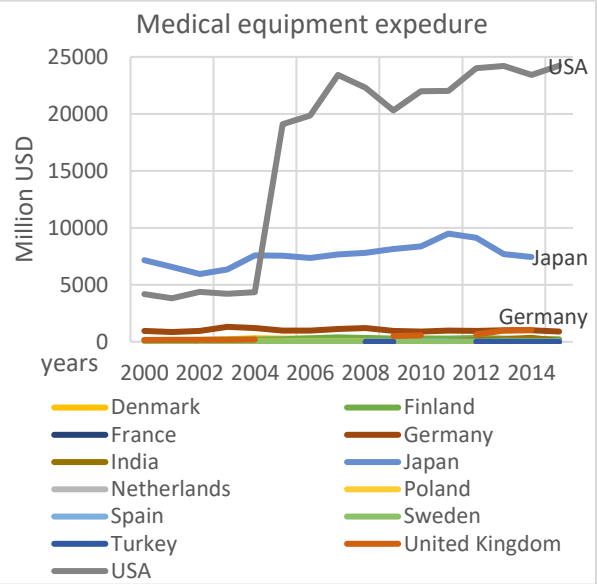

Figure 7: Medical equipment expenditure

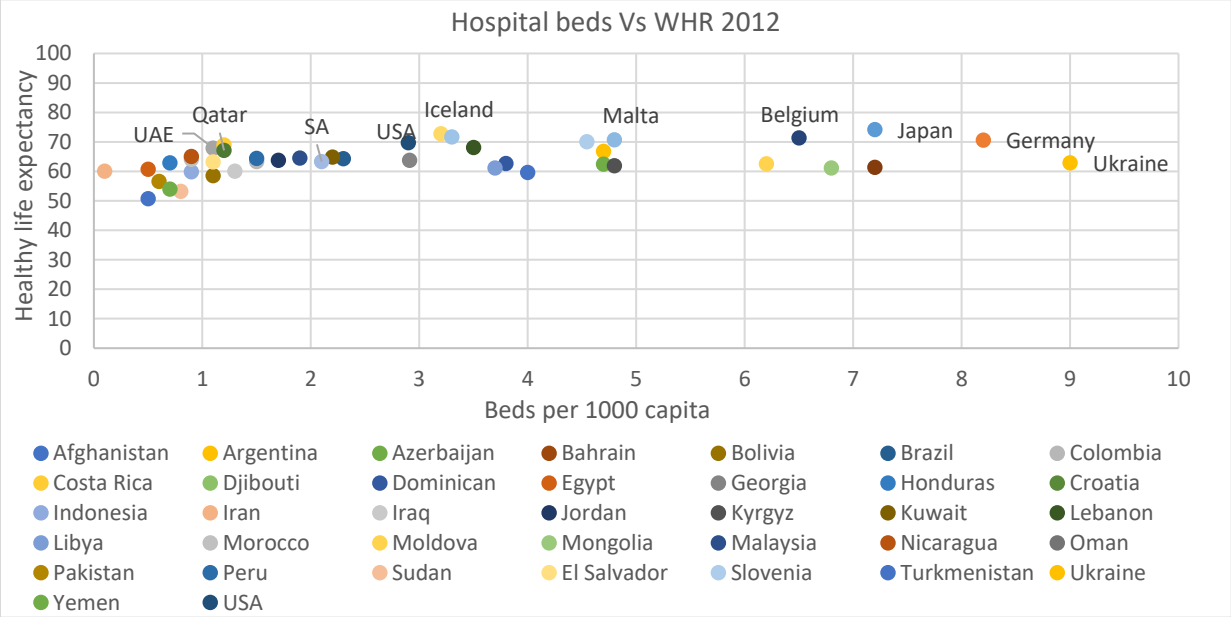

Figure 8: Hospital beds Vs WHR 2012

Figure 8 shows the plotting result of hospital beds against the healthy life expectancy (World Happiness Report, 2012). Despite the US spending more on healthcare and having considerable amount of beds, it ranked at 7th place in the WHR. While Japan and Germany ranked 1st and 5th in life expectancy segment. This shows that anthropogenic stock is partially responsible for ensuring proper healthcare services. However, the medical staff and other factors (governmental regulation and incentives) also play a vital role. Therefore, using material stocks alone to evaluate the health sector is inconclusive.

Transportation stock

This segment focuses on evaluating the services provided by two stocks of transportation (infrastructure and vehicles). In figure 9, the total road network (highway, communal and streets) is visualized from 2000 to 2015. The overall trend in the graph is flat, indicating that the road network is not significantly increasing as in the last decades. The United States of America has the largest road network that exceeds 5 million km length in 2008. A big majority of the EU countries fall below one million km of road network with France having the largest road network at 0.7 million km, followed by the UK at 0.3 million km. Russia has the third largest road network globally, with 0.57 million km. Keep in mind that the graph only accounts for the major roads. Therefore, the ranking does not consider non-asphalt roads, gravel roads and dust roads.

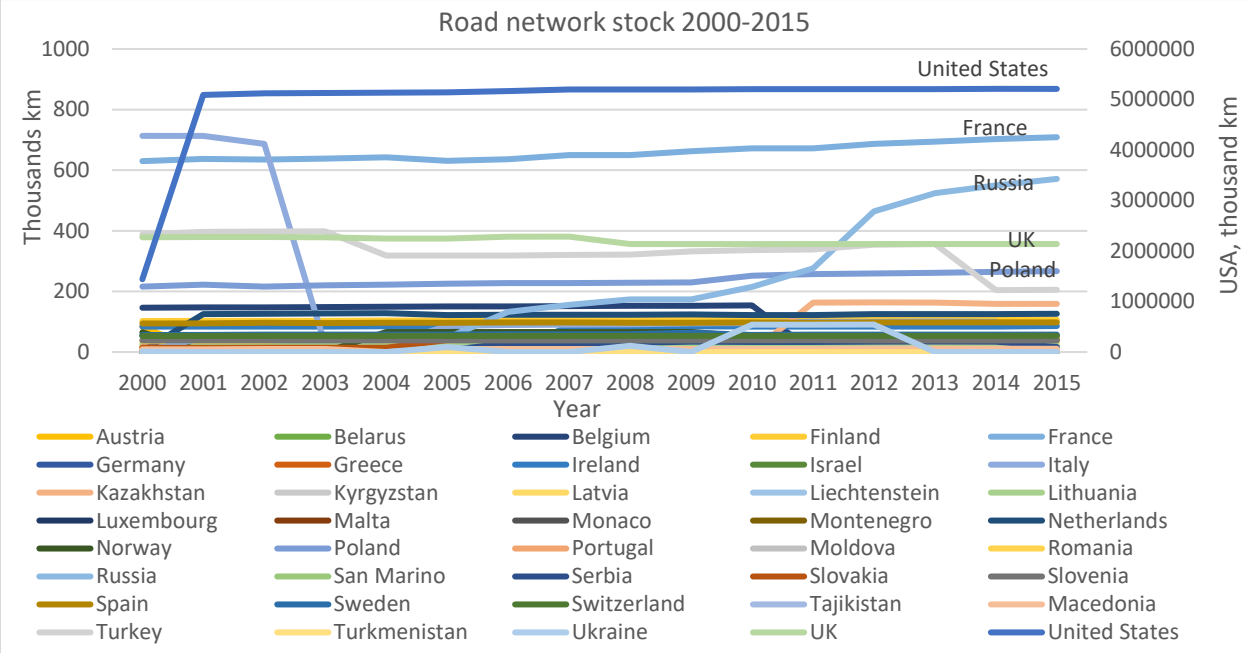

Figure 9: Road stock from 2000-2015

Figure 10 plots the road stock to the Infrastructure Logistics Performance Index (LPI) that accounts for the transportation infrastructures of countries. This aids to convey the practicality and usability of the roads in terms of structural integrity and the provided services for the community. In the graph below, the United States of America is not shown due to the scale ratios that will render the graph unusable. USA scored an average of 4.15 out of 5 throughout the seven-year period, ranking it in fifth place globally, which makes it amongst the best countries in terms of infrastructure. Russia seems to have an increment in road network length along with an increment in LPI scores from 2.23 to 2.59 in this period. The leading countries in this indicator are Germany, Netherlands, Norway and Switzerland with a score of 4.34, 4.29, 4,22 and 4.14 respectfully. When comparing the stock to the index, it is important to keep in mind that the area of the country plays a big role in stock accumulation. Bigger countries have more physical space for larger road networks and vice versa. It is noticed that the three countries with the largest road networks don't make top 5 in the LPI index, this indicates, either the road network coverage is not the only factor that plays a role in transportation and coordination.

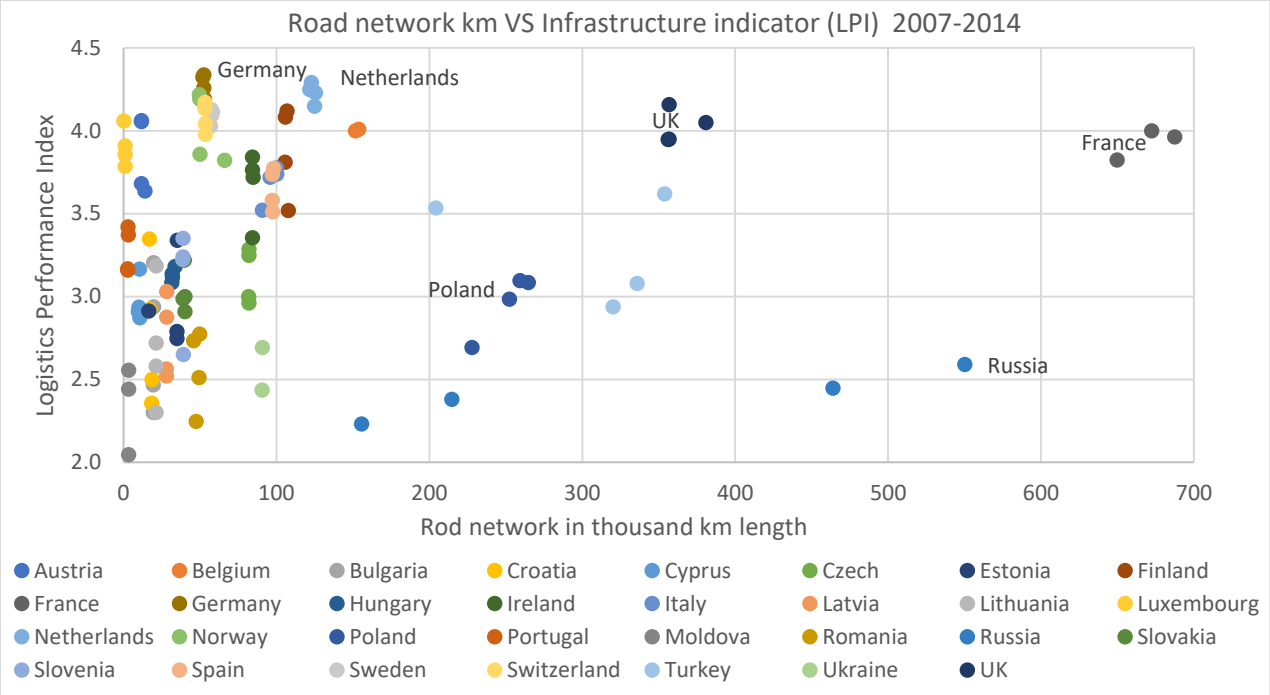

Figure 10: Roads Vs LPI from 2007-2014

After observing the road networks, it important to link it with the vehicle stock to give a more comprehensive idea of how two different types of material stock work together to facilitate one service. Therefore, figure 11 below investigates the passenger car stock for different countries for 2014. The car stock seems to have significant increment globally through the 10-year period. Iceland has the largest amount of passenger car at 684 vehicles per 1000 capita followed by Luxembourg then Canada and Finland with 669, 616 and 590 vehicles per thousand capita respectfully for 2015. The average amount of passenger cars seems to be around 400 to 500 per thousand inhabitants for the industries countries.

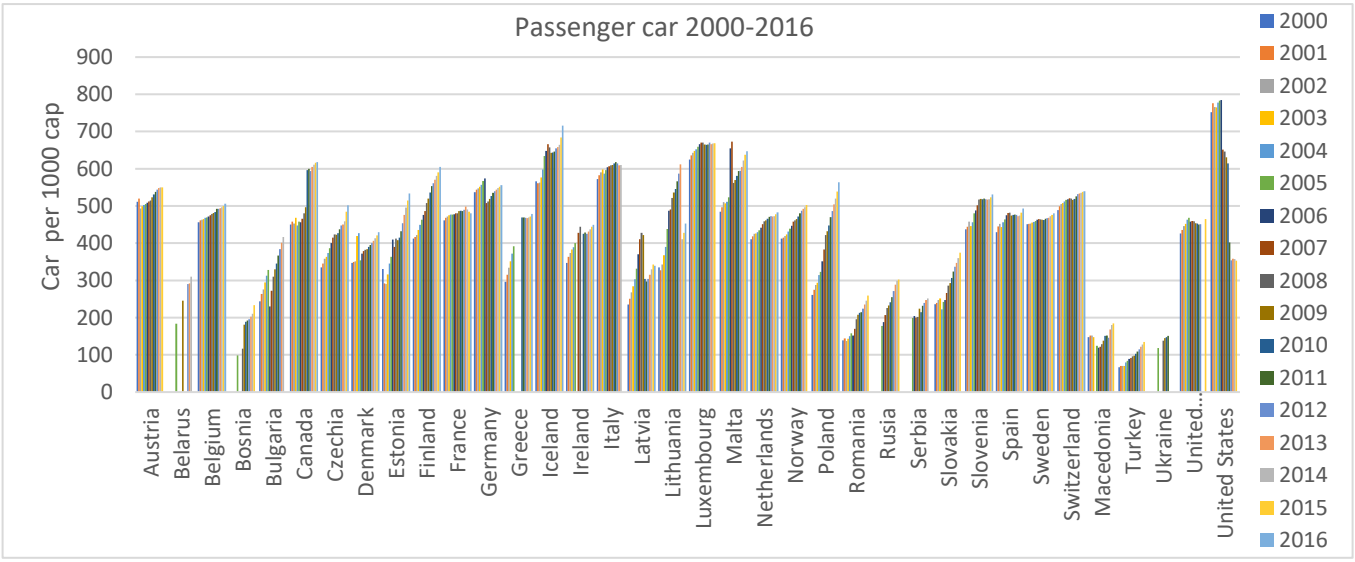

Figure 11: Passenger car stock 2000-2016

Figure 12 below shows the passenger cars against the LPI score from 2007 till 2016, providing insight to how the car stock will affect the overall Logistics Performance Index of the countries. The red circle specifies the industrialized countries which happen to have the highest LPI scores. Further noticed, that they fall between 350 to 550 cars per thousand capita, this indicates the optimal number of cars per capita to achieve the best score. Germany leads the LPI score with 4.23 out of 5. Sweden has the second highest score of 4.20 with less car ratio to Germany. The blue circle represents the developing countries, the passenger car ratio is similar to the industrialized countries, however with lower LPI scores. This indicates that the industrialized countries might have a superior transportation infrastructure (roads), car stock alone is inadequate enough to achieve better welfare for the inhabitants. The least developed countries at the left lower corner have the least amount of passenger cars and the lowest LPI ranking.

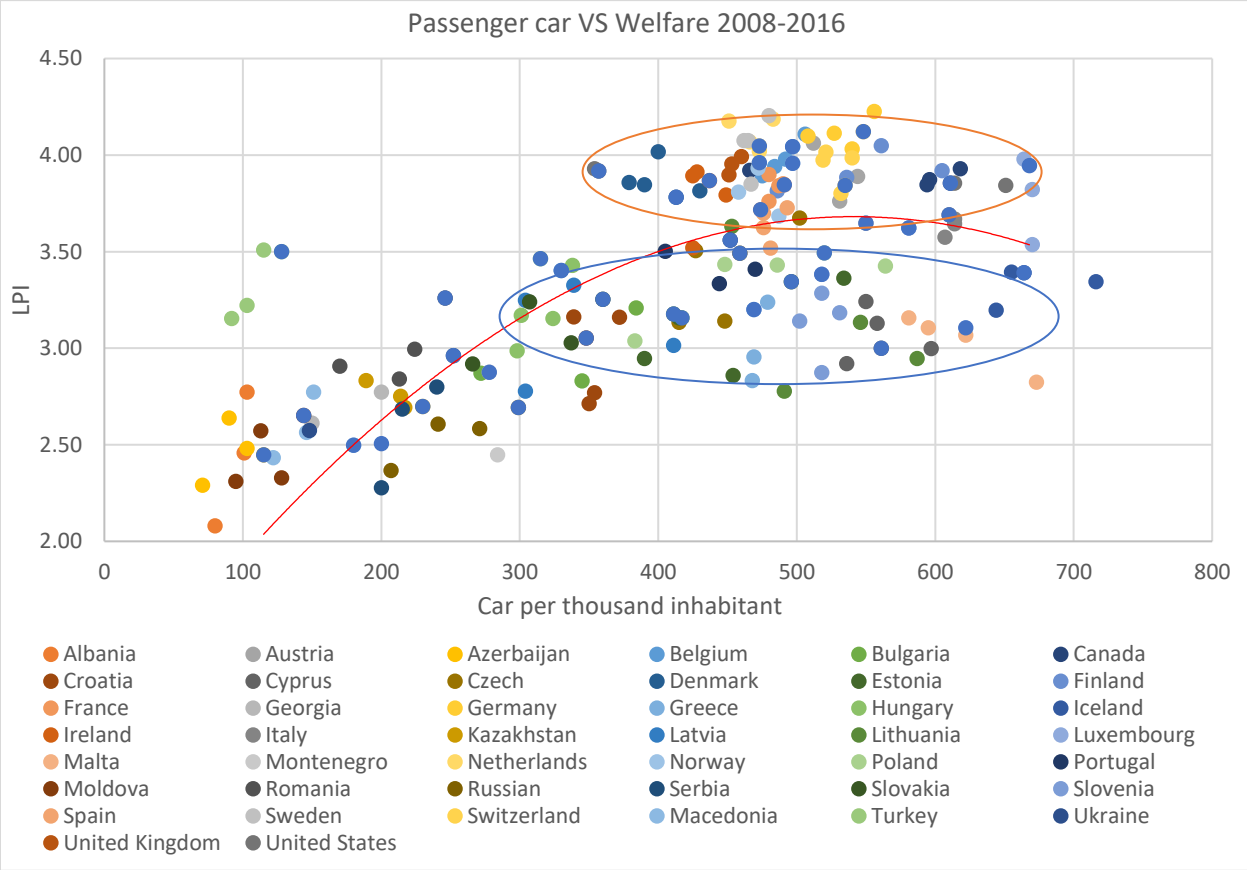

Figure 12: Passenger car stock Vs LPI

By combining the different anthropogenic stocks of transportation (roads and vehicles) and plotting them againset the Logistics Proformance Index, it became clear that the transportation welfare depends on multiple stocks rather than just one. The road network has a fundamental role, however the countries with a larg transportation infrastructure stock did not nececerly rank high in the infrastructure LPI, but when the vihcles are plotted against the overall LPI score, the countries with larg road networks ranked higher than they did previously, dispite having a simliar vehicle ratio per capita. This comes to show that the combination of different stock together delivers different interpretations for the level of service provided.

Energy stock

The electrical grid capacity describes the amount of electricity that the grid can generate and maintain within the network without any damage or blackouts. Graph 13 demonstration the electrical grid capacity from 2000 to 2016. Chain leads the global energy consumption surpassing USA in 2014, with a gird capacity of 1657 GW in 2015. The US has the second largest grid capacity at 1072 GW, Japan has the third largest grid capacity at 323.9 GW followed by India at 287.1 GW in 2015. Germany, Canada and brazil grid capacity are between 100-200 GW ranking number 4th, 5th and 6th place globally, respectively.

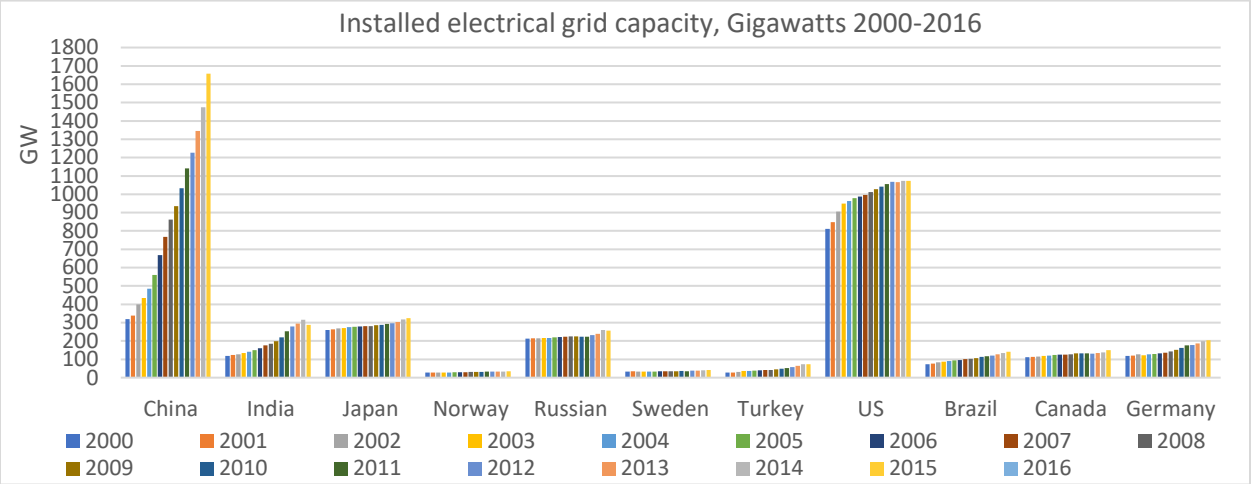

Figure 13: Total grid capacity 2000-2016

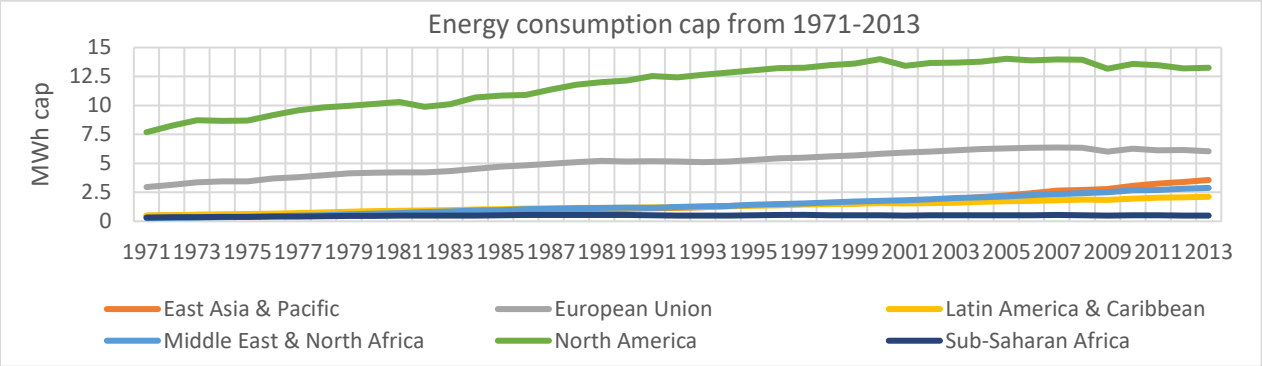

Figure 14: Energy consumption cap by region

Figure 14 above, illustrates the electrical consumption per capita from 1971 to 2013 by regions. The electrical consumption has risen in all the regions with North America (US and Canada) having the highest consumption rate at 13.2 MWh cap in 2013 followed by the EU at 6 MWh/cap. As for sub-Saharan Africa, the growth in electrical consumption did not have a noticeable increase as in the other regions. It started at 0.3 MWh/cap in 1971 and climbed to 0.48MWh/cap in 2013. This is further plotted in graph 15 showing the average per capita consumption of energy plotted against the Human Development Index. for 2013. Norway has the largest per capita consumption at 23 MWh, almost 5 MWh more than the second highest country Bahrain at 18 MWh. Despite China having the world largest electrical grid capacity, its average consumption is 3.7 MWh per capita. While USA consumption is around 13 MWh/cap.

Furthermore, figure 15 shows the level of development by the consumption trend of the countries, where the African countries at the bottom left corner indicating the lower level of human development and electrical consumption. The South Asian countries are situated in the mid left side of the graph indicating low electrical consumption along with mediocre human development. As for the European countries, they are scattered across the graph with clusters indicated in the blue circle representing good human development and intermediate electrical consumption.

Despite India and China obtaining one of the world's largest installed electrical grid capacity, their per capita consumption is low, this might be attributed to their large population of 1.27 and 1.3 billion respectfully, or it might be attributed to the large electrical consumption of the industrial sector rather than personal or household use.

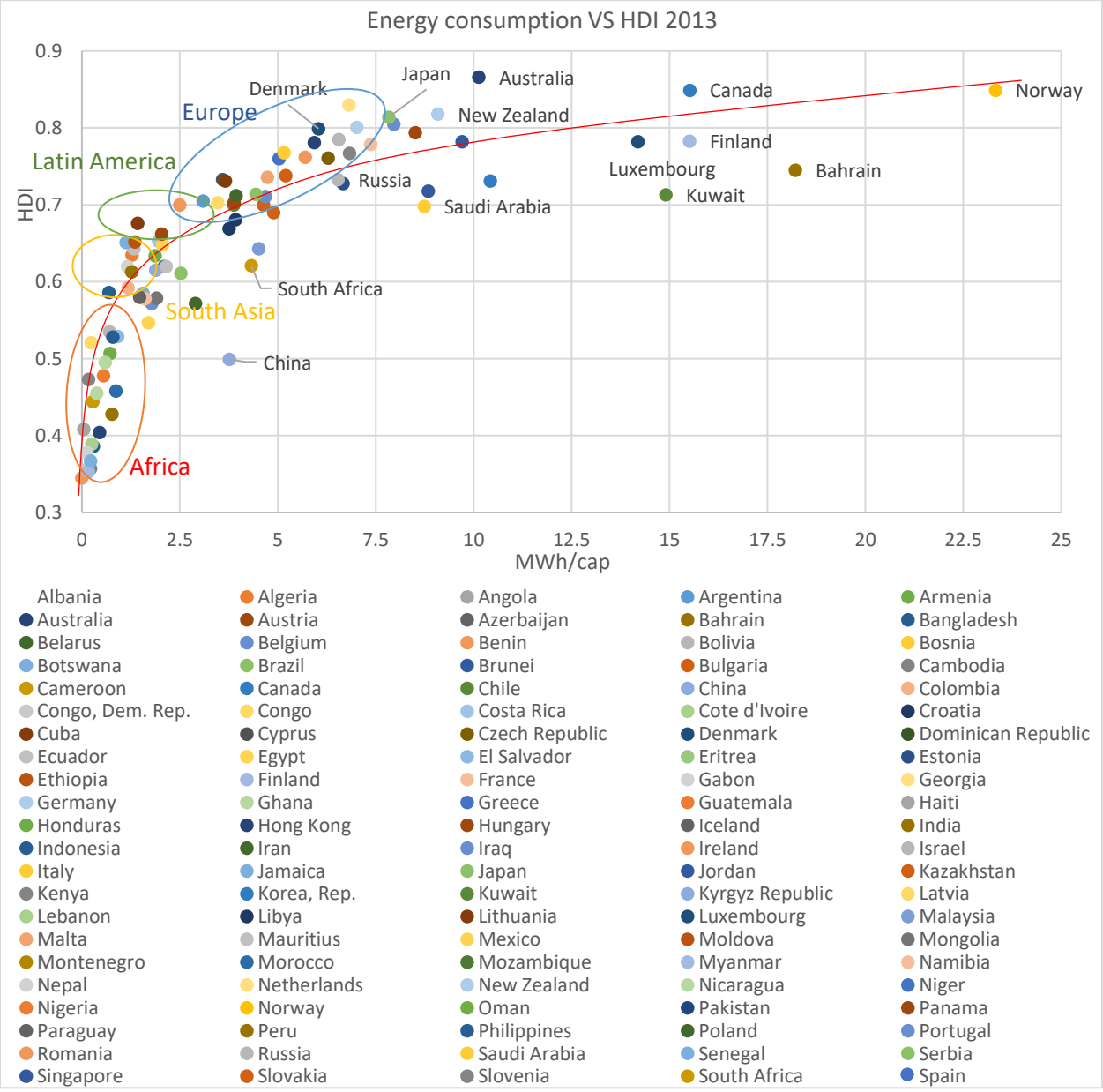

Figure 15: Energy consumption per capita Vs HDI

Communication stock

The two figures below 15 and 16 give a description of the growth and development of connectivity via phones, devices and the internet. The overall number of subscribers and users are steadily rising globally. In 2017 the Asia and Pacific countries had the biggest share of users followed by the Americas and the EU countries. The difference between the user ratio and overall subscribers can be attributed to the population difference and economies in these regions.

The ICT index for 2017 concluded that the EU countries have a better complete service in terms of network capacity and broadband speeds along with individual skills and knowledge, hence the score of 7.5 out of 10. Asia and the Arab states scored 4.8, meanwhile the African region came in last place with a score of 2.6 and the lowest number of subscribers at 155 per thousand inhabitants. The communication stock is further discussed in the discussion chapter page 43.

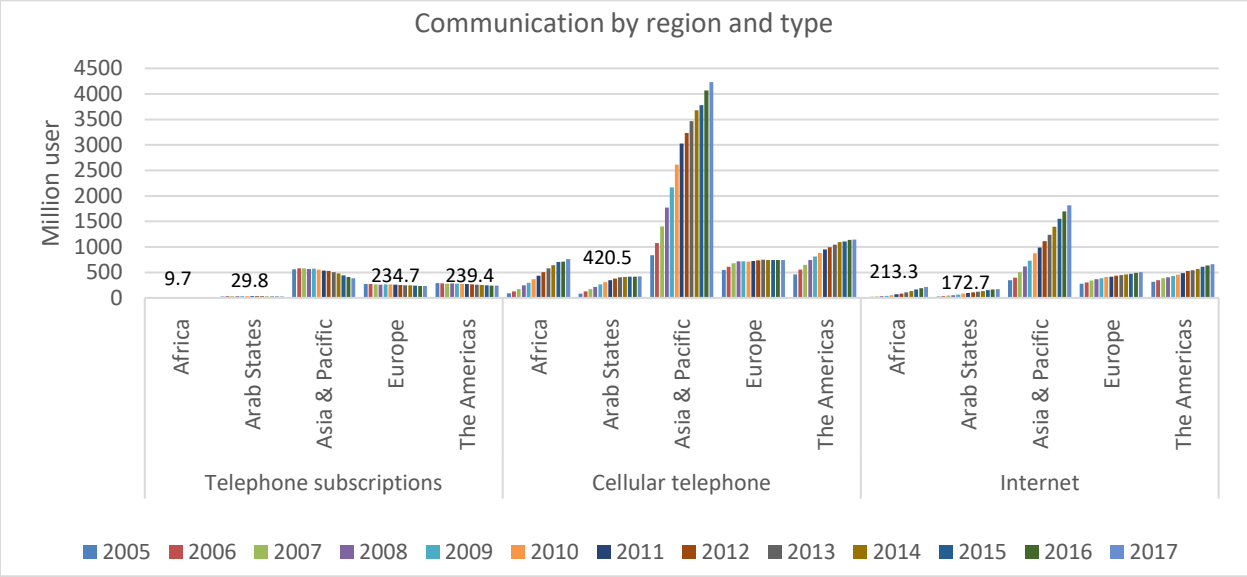

Figure 16: Telecommunication subscribers 2005-2017

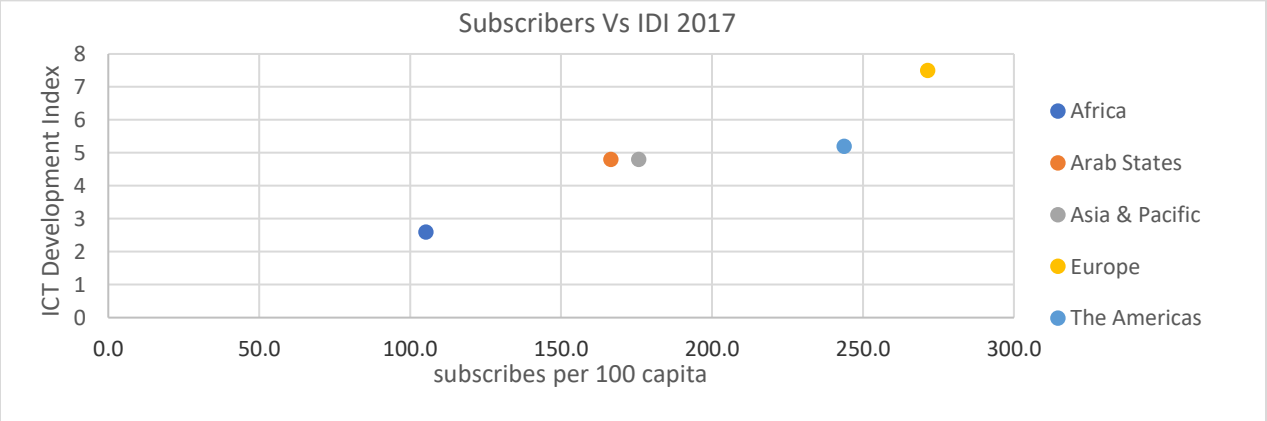

Figure 17: Telecommunication subscribers Vs IDI

Municipal waste stock

Figure 18 shows the amounts of generated municipal waste from 2000 to 2015. Some of the countries had a drop in the amounts generated like Brazil, Japan and Spain while other countries like China, Singapore and Mexico are having annual increment. Usually the economic status of the country triggers the increment or decrement of waste. This is apparent below, that the major economies have the largest amounts of generated municipal waste. Another factor of waste generation is the population numbers, therefore, in many of the countries with an increasing number of people have greater waste generation, where china, USA and brazil have the largest waste amounts. Furthermore, the waste generation depends on the laws and regulation of the countries alongside the public awareness. In figure 19, it is apparent that the amount of waste does not insinuate poor environmental performance. Germany, Italy, Japan and the USA ranked 6, 22, 26 and 33 on the Environmental Performance Index scale. Nonetheless, the countries with moderate amount of generated waste like Australia, Denmark and Netherlands ranked 3rd, 8th and 13th place respectively. China on the other hand came in 113th place with a score of 43/100. There is no direct correlation between the generated waste and the Environmental Performance Index, but rather, the implications of mismanagement of waste in terms of air quality, water and sanitation, biodiversity and human impact, additional information is presented in the discussion segment.

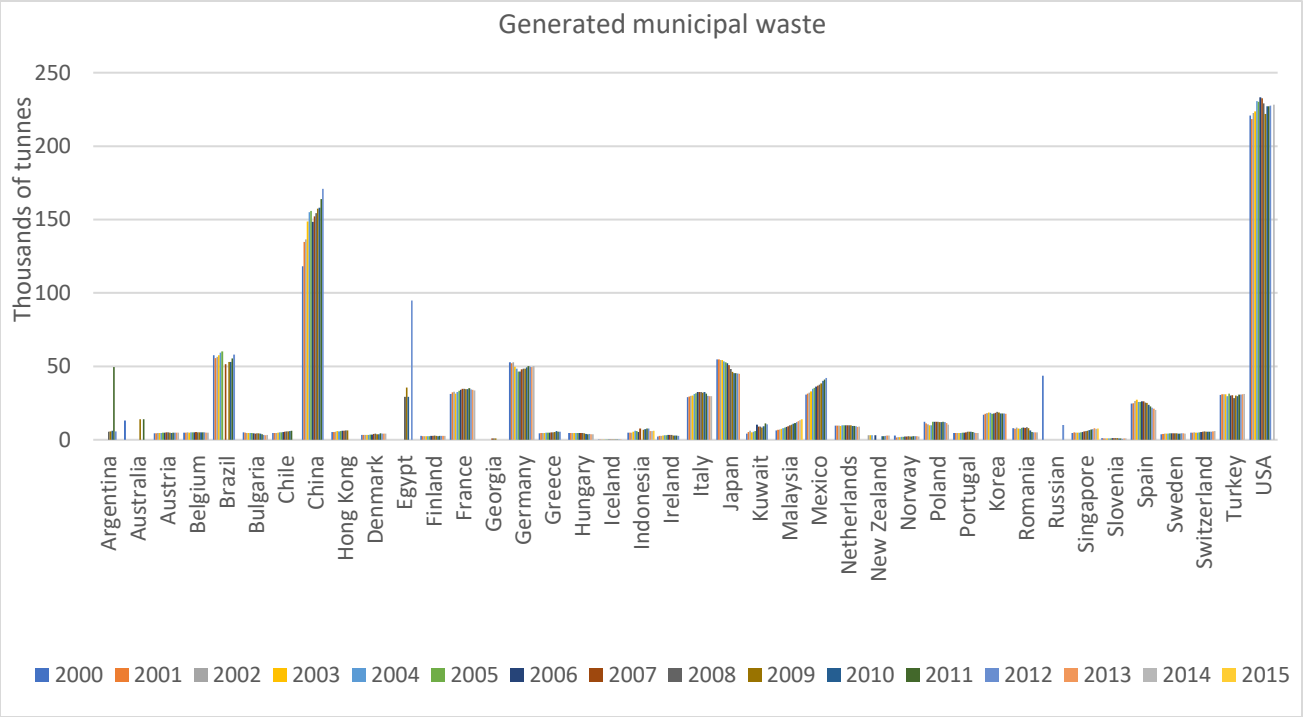

Figure 18: Generated municipal waste 2000-2015

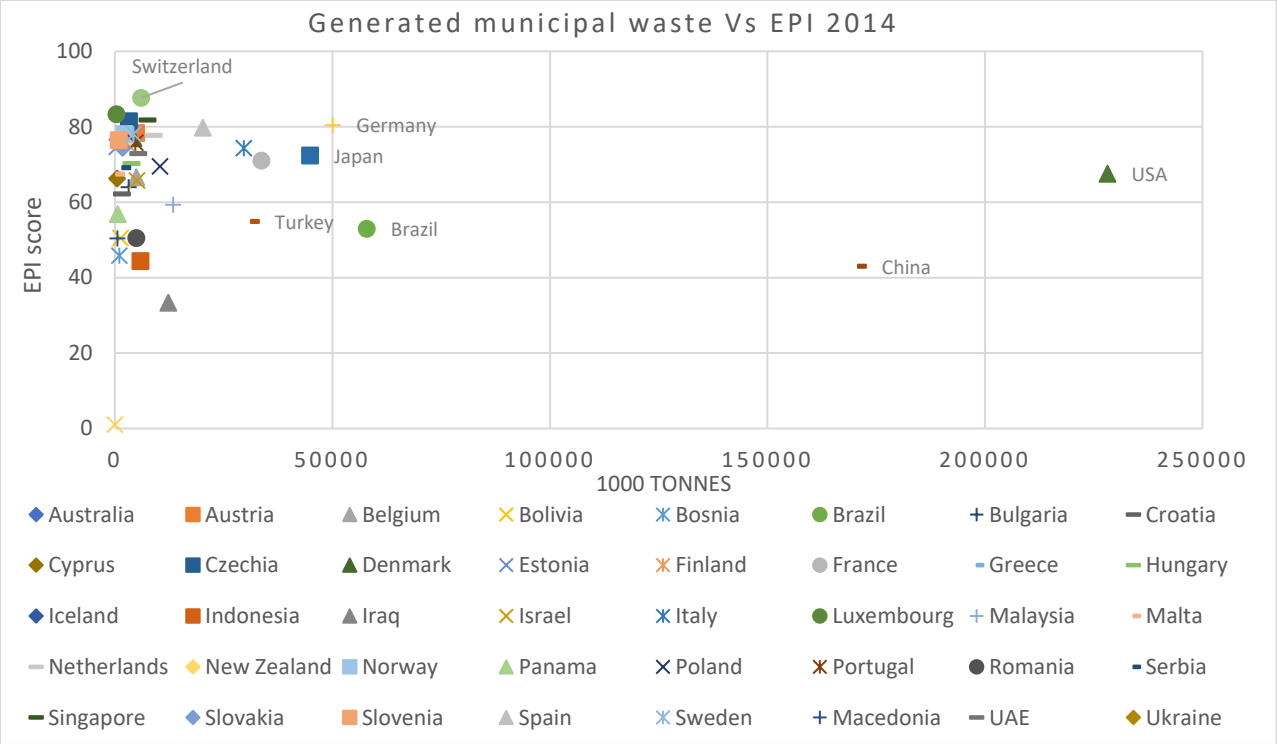

Figure 19: Municipal waste Vs HPI, 2014

Maslow's hierarchy stock requirement

The world we live in today is comprised of various components and disciplines that come together to form one cohesive structure we call communities or countries. These communities along with natural materials and resources dictate a certain level of welfare. For centuries humans have altered materials to increase living standards on a singular or global level. The graph below illustrates the different levels and components of welfare by using Maslow's hierarchy, communal interaction and the anthropogenic stock.

Maslow's hierarchy of needs is a concept in psychology proposed by Abraham Maslow in his paper "A Theory of Human Motivation" published in 1943(Maslow 1943). The concept subsequently corresponds with many other theories of human developmental psychology. Maslow used the terms "physiological", "safety", "belonging and love", "esteem", "self-actualization", and "self-transcendence" to describe the pattern that human motivations generally move through. The order of the hierarchy describes the development stages to on individuals need. The physiological needs are represented in food and shelter. Once the basic physiological needs are met, the individual starts a quest of finding a group of people to fit in or to seek an individual to belong with. The third level of Maslow's hierarchy is the need of self-esteem or recognition from peers, colleges or even from oneself. The last level is self-actualization, where one is aware of its full potential and capabilities.

Maslow's hierarchy is based on a functional society that can offer the needed attributes. Functional communities are built on administrative, financial, cultural, social and judicial systems. They interact amongst each other to offer fertile grounds in which humans can strive in pursuit of happiness. All these different systems require physical material to carry out their duties. Activities like transportation,

nourishment and communication necessitate electricity, water and food. Therefore, facilities are erected to provide these essential requirements as power stations, dams, roads, telecommunication towers.

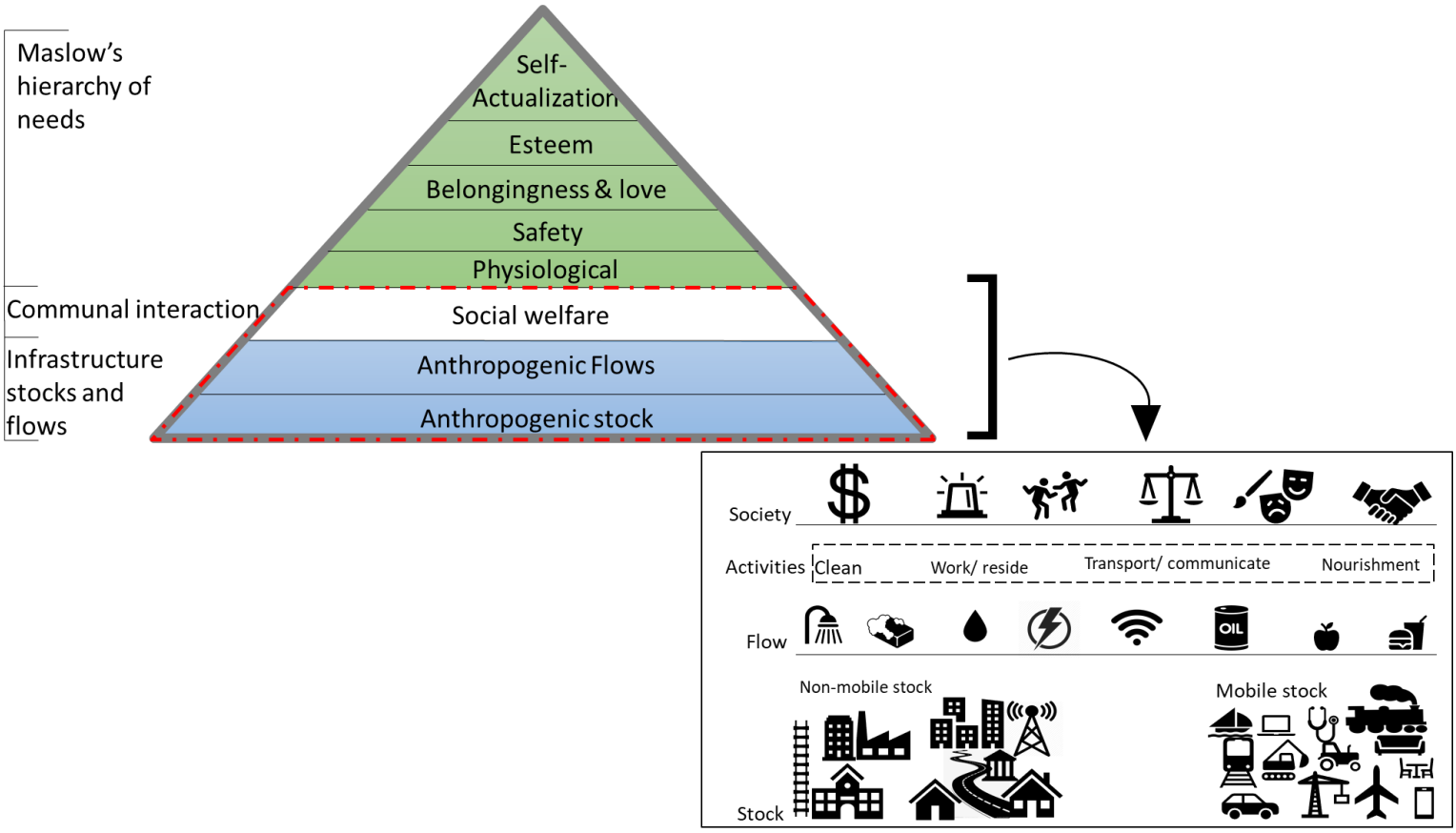

Figure 20: Fundamental needs of welfare

Humans can strive on a personal level to achieve their desired goals. But to get to this position, other aspects need to be developed and established. The red border line in graph 20 represents the foundations on which one can strive, this red border line is considered the bases on which communities and countries build upon. The anthropogenic stocks can be described as the infrastructure upon the countries rise on (roads, bridges, buildings, sewage system and energy grids). The anthropogenic flow are services provided by the stocks, flow as electricity, clean water, oil and food that are directly consumed by the population to carry out daily activities like transportation, communication, residing or working, nourishment and cleaning. The society is comprised of a large number of different activities, these activities have different fields of specialty such as artistic activities, commercial activities, commerce, judicial or even group of people socializing parties. From there, one can pursue self-actualization and personal goals.

African leapfrog affects for 2030

The term ‘’Human development’’ has various meanings depending on when and where the question is asked. In the industrialized countries, human development might be related to eco-friendly products or services, where as in developing countries, the term might indicate achieving gender equality or other social goals, but in the least developing countries human development is represented in basic need as shelter or nourishment. Therefore, regions like Africa consider fundamental necessities as welfare.

Makhtar Diop, Vice-president for Africa, World Bank Group, commented on China Daily when asked about African leapfrog. He said: ‘’ There is no doubt that technology and innovation are transforming Africa. Across Sub-Saharan Africa, phones now act as banks for millions of Africans who cannot even dream of opening a traditional bank account’’. For Africa to leapfrog further into the future, several circumstances must be met, as well as investment in infrastructure. Having the correct monitoring environment for new business models and paying thoughtful consideration to science and technology. Mr. Akhtar continued to say ‘’ China —Africa's largest economic partner— invests a considerable amount of money in skills development and infrastructure, and is working with Africa to boost technology adoption, according to one recent survey one-third of Chinese firms operating in Africa have introduced a new technology’’(Africa. 2017-10-11).

However, someday soon, the African countries will reach the current welfare state of industrialized countries. To assess the African leapfrog for 2030, it is important to estimate the population for that year. This provides insight to the additional anthropogenic stock required to accommodate the population growth. According to the UN’s World Population Prospect report for 2017, the population will increase from 7.5 billion to 8.5 billion people in 2030(Nations 2017). Based on the population increment percentages, the material stocks should rise to maintain the current level of welfare for future population. The table below gives more insight to the current and future population projection by regions.

Region	**Population (millions)**		**Increment %**
	2017	**2030**	**2017-2030**
World	7,550	8,551	13.2
Africa	1,256	1,704	35.6
Asia	4,504	4,947	9.8
Europe	742	739	-0.4
Latin America & Caribbean	646	718	9.7
North America	361	395	9.4
Oceania	41	48	17

Table 7: 2030 population projection

Table 7 shows that the African population will experience the largest global growth of 35% by 2030 with total population at 1.7 billion people.

Table 8 and 9 investigates African future stock demand for 2030. By assessing the optimal current material stock, and then matching it to the African population for 2030. Table 8 shows the optimal stock workability

from the ''Anthropogenic and human welfare'' segment. Table 9 estimates the 2030 stock demand by units, by multiplying the optimal stock to the population number.

Activities	Anthropogenic stock	Unit	Optimal mounts
Residing	Dwelling	Dwelling per thousand capita	400-500
		Rooms per person	2
	Electrical consumption	MWh per capita	5
Healthcare	Hospital beds	Bed per thousand capita	3
Transportation	Vehicles	Passenger car per 1000 capita	400-500
Communication	Connectivity	Subscribes per 100 capita	270

Table 8: Current optimum stock workability

Anthropogenic stock	Future stock demands 2030
Dwelling	852000 units
Electrical grid capacity for domestic use	8520 MWh
Hospital beds	568000 beds
Vehicles	852000 units

Table 9: 2030 African stock demand

Africa is the second-largest and second most populous continent with 54 recognized sovereign states and countries, 9 territories and 2 de facto independent states with very little recognition(Nations 2017). The African nations are made-up of such a diverse set of demographic components that it is impossible to list them in full. Therefore, predicting the Green House Gas (GHG) emissions without any studies is near to impossible. However, this segment uses passenger vehicles to roughly estimate the future GHG emission related to transportation of people. From table 9, the African continent requires 852 thousand vehicles to reach the current welfare status of industrialized countries.

Evaluating a vehicle's GHG emissions through its life cycle is not as straight forward, many parameters come into effect, such as date and place of manufacture, engine capacity, fuel source and type, number of passengers, distance covered and driving behaviors from operators. Many Life Cycle Assessments (LCA) are done with different parameters. Due to time limitations, this report discards the manufacturing emissions and focuses on the usage emissions. The Environmental Protection Agency (EPA), estimates the annual CO_2 tail pipe emission is 130 g/km(Arbor 2018 March). The life span for the passenger vehicles according to the EPA passenger vehicles have an average use of 200,000 km until they are retired, by assuming the lifespan to be at 10 years, the annual distance crossed will be around 20,000km. Consequently, the CO_2 emissions is estimated at 2.21 Mt a year.

To provide Africans with 5MWh per capita, the continent needs to enhance the current power grid. This requires establishing different infrastructures from electrical generation to distribution. However, in this report, the emissions generated from mining and construction are disregarded and the focus will be on the operational CO_2 emissions. According to a research made by the British Energy & Industrial Strategy, the generation of 1KWh by using coal equates to 0.351 kg of CO_2 (Department for Business 4 August 2017).

If the renewable energy sources are neglected, the African continent is estimated to produce 1.75 tonnes of CO_2 per capita to provide the 5MWh, this equates to 2990.5 Mt per year for the entirety of Africa.

The above rough estimations for emissions, show the magnitude of Africa's leapfrog effect, therefore, it is imperative to concede the adaptation of new technologies to help in decreasing the emission levels. The use of Photovoltaic (PV) panels for electrical generation can reduce the emissions considerably, Morocco is undergoing a project named ''Noor'' in the Saharan desert, that is estimated to generate 600MW of clean electricity by the end of 2018 and 2000MW by 2020 for 1.1 million people, helping the country to cut back hundreds of thousands of carbon emissions a year(ORG 2013, May 10).

African leapfrog is a multifaceted vision with huge complexities arranging from human development rights and environmental protection goals. The carbon budget defines the maximum quantity of carbon that humans discharge in the atmosphere while retaining worldwide temperatures under an increase of 2 degrees Celsius(Agreement 2015). Some researchers think that this might limit the chance that African countries have to prosper, whereas the industrial countries managed to develop and emit huge quantities of CO_2 ever since the industrial revolution, while other researchers as RJ Millar and ten other researches from Oxford University think that the carbon budget set is much higher than they have anticipated and state that global warming can be kept under the 2 degrees target even with current global emissions for the next 20 year(Millar, Fuglestvedt et al. 2017). This controversial topic has researchers on both sides debating.

Through providing clean energy sources, the developing countries avoid exceeding the carbon budget by implementing the use of electrical vehicles and reducing transportation emissions. Therefore, the Africa's leapfrog is comprised of several elements that are interlinked with one. Statistical data accompanied with research and new technology will pave the way for future advancement in the African continent.

Discussion

From the result section, it is apparent that the UN SDGs are closely related to the anthropogenic stocks and these stocks also play a fundamental role in human welfare and development. Therefore, the SDGs and Human welfare are strongly linked and influenced by the same stocks. Some of the stock has reached a steady amount and others are steadily increasing, depending on the region at scope. Also observed from the results, that different types of anthropogenic stock are utilized in one activity. Therefore, some of the SDG indicators will fulfil other indicators and other human welfare indexes. This segment will discuss the findings from the results.

United Nation Sustainable Development Goals

The method used to categorize the SDGs (natural or human built environment and social aspects) aided in find two levels of linkages to material stocks (direct or indirect linkages). However, the method does not account for all of UN SDG indicators that are not related directly or indirectly to the built environment, which might lead to loss of linkages and dependencies. This occurred in goal number 10 (reduction of inequality) which is not linked to any of the anthropogenic stocks, because of the nature of the goal that encourages adoption and implementation of laws and regulations, thus, no correlation to stocks are rooted with the indicators. This applied method might limit the prospective of linkages to a narrow field and discount for certain material stocks such as manufacturing Machineries, packages and containers that are utilized in the background to achieve certain targets. Yet, the method provides a details and oriented approach to categorize and quantify the interactions that fit the description. SDGs goals have 307 linkages to different anthropogenic stocks, 155 of which are direct and 152 are indirect linkages. These linkages covered 71 targets and 82 indicators out of 169 targets and 244 indicators. The non-residential buildings had the largest amount of linkages to material stock with 43 different indicators followed by equipment's and supply and disposal. The table below show the interaction between the Anthropogenic stocks and the number of indicators.

Anthropogenic stocks	*Type of stock*	*Number of indicators*
Non-mobile	Non-residential buildings	43
	Residential buildings	5
	Transportation infrastructure	6
	Supply and disposal	31
	Energy infrastructure	12
	Others	6
Mobile	Vehicles	7
	Machineries & equipment's	37
	Consumer durables	8
	Waste services	12

Table 10: Anthropogenic stock and indicators

For future systematic implementation of the UN SDG, it is advised to place added attention on the non-residential buildings, since they have the greatest interaction with the indicators. It is imperative to take a profounder look into this stock segment and analyze the different types of non-residential building. From the results gathered in this report, the educational and research buildings had the major share of non-residential buildings with 26 linkages to indicators followed by healthcare at 11 and the industrial

sectors at 10 indicators. It is also advised to investigate the electronic and electrical equipment stock since they are closely related to healthcare and educational purposes amongst other important uses.

Anthropogenic stocks and human welfare

This segment discusses the impact of stocks on human welfare. Noticed from the results, that high ranking countries or regions tend to have greater stocks. However, in many cases the country with the largest material stock does not necessarily rank number 1, this is attributed to other factors depending on the services provided by the anthropogenic stocks. This will be discussed below by grouping different elements of material stocks that serve one function (activity).

Reside;

From graph 4, the dwelling stock has been stable for most of the developed and developing countries at approximately 450 dwelling per 1000cap. However, some of the developing countries and China have a different stock trend, China has around 750 dwelling per 1000 capita in 2014 and expected to rise further in the future. Graph 5 inspects the living area of dwelling in terms of rooms per person, the developed countries (OECD countries) have an average of 1.8 rooms per person, North America has the biggest number of rooms per person at 2.5 for Canada and 2.4 in the US. New Zealand and Australia have 2.4 and 2.3 rooms respectfully. After covering the dwelling stock and rooms it is important to evaluate the electrical consumption since it is deeply rooted to residing activities and welfare in households. Norway had the largest consumption at 23.3 MWh per capita, Canada's consumption is 15.5 MWh, USA 10.9 MWh, Australia 10.1, New Zeeland 9.8MWh and china at 3.7MWh per capita. By combining these three elements (dwelling stock, rooms and electrical consumption) into one prospective, it will enable a detailed evaluation of household well-being. According to the Better Life Index 2017, the top five ranking countries for housing are US followed by Norway, Australia, Canada and New Zealand.

BLI Rank	Country	Number of rooms per person	Electrical consumption MWh
1	USA	2.4	12.9
2	Norway	2	23.3
3	Australia	2.3	10.1
4	Canada	2.5	15.5
5	New Zealand	2.4	9

Table 11: BLI housing ranking and electrical consumption

This comes to show that different anthropogenic stock and services attributed from these stocks have a considerable effect on the quality of the household life. Therefore, using singular stock as an indicator for human development will give an incomplete evaluation.

As seen in table 11 above, Norway has the lowest number of rooms per person, therefore is should not be ranked in the top countries, but by considering its electrical consumption that depends on other anthropogenic stocks, Norway ranked number 2 in the BLI housing index. Therefore, it is of paramount importance to evaluate different stocks alongside services to represent welfare status.

Healthcare;

Considering that the European Union has the largest share of hospital beds at 5.3 beds per 1000 capita in 2011, this corresponds to the European Union having the highest scores when it came to the world happiness report that considers and life expectancy where Iceland, Malta, Belgium, Slovenia and Germany amongst other countries all score above 70/100.

North America had 2.9 hospital beds per 1000 capita in 2011, the United States has the highest expenditure in medical equipment's from 2004 up until today and in 2015 the US paid over 24 billion USD. However, in the world happiness report for 2012 the scored 70 out of 100 in the healthy life expectancy index putting it in the same region as the European unions despite it having lower amount of beds. The Middle East and Africa region had a steady number of hospital beds from the 1990s up until today at 1.6 beds per 1000 capita and scored in the World Happiness Report the Arabic countries score between 60 to 70 out of 100.

This shows that the healthcare industry depends on multiple elements like the level healthcare personnel training and education alongside material stock represented in facilities and medical equipment.

Therefore, the healthcare industry is a multi-disciplinary field where the material stock, human resources and financial funding all combine to provide the services needed. It is also arguable that the human resources in this industry require educational, ambulances and devices to carry out therefore they are dependent on educational material stocks and vehicles. However, this is needed in all fields and not just the medical department.

Transportation;

Transportation activities are comprised of different material stocks, roads and vehicles along with energy source that supplies the mechanical motion. Figure 9, 10, 11 and 12 from the results chapter, show the different components related to transportation. Roads are the median that the vehicles use, therefore, the road network plays a fundamental role. The road stock depends on the geographical area and the economic status of the country. Focusing on the roads stocks, US, France and Russia have the largest road networks at 5211, 709 and 571 thousand-kilometer length respectively. According to the infrastructure Logistic Performance Index for 2014, the US scored 4.18 out of 5, France and Russia scored 4 and 2.59 respectively. While countries with lower road stocks ranked higher like Netherland, Germany, Norway and UK. The infrastructure LPI considers the roads, ports and airports in ranking and scoring, therefore some discrepancies in results are present by using this index to rank just roads.

The vehicle stocks (mobile stock) only accounts for passenger cars, motorbikes and busses, not goods transportation vehicles. The results from figure 12 show the number of vehicles alone does not provide a clear welfare state, countries with passenger car ownership between 400 and 500 cars per 1000 capita have varying score from low as 2.78 for Lithuania and as high as 4.23 for Germany. However, a trend line occurred (graph 12) when plotting the passenger cars against LPI, the trendline has an incline until it hits a score of 3.6 around 550 vehicles per 1000 cap then it starts to decline.

Comparing and ranking countries based on road networks or vehicles alone is impractical for displaying the usability of the stocks to provide the transportation service. However, by combining both mobile and non-mobile transportation stocks; the comparison is improved and provides validated results that enhances the comparison amongst countries.

Communication and connectivity;

The telecommunication subscribers and users are increasing on a global level with Asian and Pacific countries having the largest number of subscribers due to their large population numbers. Accounting for the communication stock by the number of users gives insight to the mobile stock represented in cellular mobile phones and other devices used for communication. However, the stock accumulation does not assist to analyze the provided welfare status (functionality of stock). That is why, figure 16 accounts for the subscribers per 100 capita to ease comparison between regions, the subscription accounts for mobile telephone subscription, fixed and mobile broadband subscription. These three subscriptions cover modern day connectivity, the fix broadband relates to WIFI routers that are fixed in certain location like houses, universities, shops and cafes, the mobile broadband are mobile devices used to connect to the internet such as mobile routers and smart phones. Services like faxing and telegraph are somewhat outdated currently therefore they are disregarded in this report.

Despite Asian and Pacific countries having the largest number of subscribers, they are ranked third place with 175 subscriptions per 100 capita. Europe ranked in first place with 270 subscriptions per 100 capita and scored 7.5 out of 10 in the IDI. This proves that the number of users does not give accurate results for service satisfaction, the telecommunication sector depends on various elements like broadband speed, bandwidth capacity alongside tariffs to indicate the level of satisfaction of the services.

The ICT Development Index accounts for 11 indicators, 5 of them account for the infrastructure and access, 3 of the 11 relate to usage indicators and 2 indicators relate to skill indicators that focused on the number of years that use computers for education. The skill indicators in this report are not accounted for due to the complexity of data gathering in this period. Therefore, the region scores might not be fully accurate.

Electrical energy stock;

Despite China having the world's largest installed electrical grid capacity, the energy consumption per capita is around 3.7MWh with HDI score of 0.7/1. When compared to the US which has the second largest grid capacity, the consumption per capita is approximately 12.9 MWh and a score of 0.91 on the HDI. China has a significant lower consumption per capita, therefore, using electrical material stocks alone to indicate a certain level of welfare is impractical. Take Norway for an example, its electrical grid capacity is relatively small compared to China and US, but the consumption per capita is the world's highest at 23.3MWh. This gap between the grid capacity and personal consumption is attributed to industrial nature of the countries where considerable amounts of the generated energy are used by the industrial and commerce sectors to boost the economy that will reflect in the GDP of the countries.

Waste stock;

The EPI focuses on environmental health and the ecosystem vitality that are affected from human activities, even though, if municipal waste is not handled correctly, it can affect air quality, surrounding water bodies and harm biodiversity. These three elements affected by inappropriate waste management are analyzed by the EPI. No correlation between the generated municipal waste and Environmental Performance Index are found.

African leapfrog;

Any leapfrog process requires fundamental changes in technologies and behaviors to be achieved along with statistical data and investment in both infrastructure and new technologies. Investment in infrastructure and technology will assist in developing the society in such a way that does not harm the environment and exceed the carbon budget.

Due to time constraints in this thesis, a full evaluation of African leapfrog is impossible. Therefore, only two aspects of African leapfrog are accounted for. The CO_2 emission from transportation and electrical household consumption. These calculations provide a rough estimation of the environmental impact for when the African counties reach the welfare level of industrialized countries using conventional fossil fuel passenger cars and electricity generated by coal. However, with renewable energy sources; the CO_2 can be reduced to a lower level.

To summarize the discussion, human welfare is a system comprised of multiple activities that rely on several anthropogenic stocks at once. Material stocks as an absolute value is not accurate enough to evaluate the usage of stock in everyday activities for human welfare. The proper approach for evaluation is through normalizing the material stocks per capita, this will deduct the population ratio different between nations.

Even after normalizing the material stock, it is important to consider other elements that contribute to certain service, as an example, the passenger car per 1000 inhabitants is not precise enough to show quality of transportation, therefore considering the road network in the evaluation will provide a clearer picture of transportation activities.

Data gaps and limitations

Multiple data limitation occurred while preparing the report. These data limitations shrunk the number of analyzed countries and material stocks. Also, data gaps for certain stocks and years compromised the overall comparison due to some assumption made. A detailed description of data limitations and solutions are shown below. For supplementary information regarding the data simulation and plotting refer to the appendix page GG and accompanied excel files.

Dwelling;

The dwelling data is gathered from the bottom up, different databases and references are used to compile a historical dwelling stock for 12 countries. Dwelling data for China faced lingual barriers due to the use of Mandarin in some of the reports, therefore, the data is gathered in intervals from available reports written in English. Indian dwelling stock also contained reports written in Hindi, therefore, the results are also gathered in intervals from different reports and data bases. Then the dwelling amounts is divided by the population corresponding to the specific country and year. This allowed to compare different country's dwellings stock amongst each other. This accumulation of dwelling stock might show some discrepancies in the methodology used by each of the countries in quantifying their dwelling stock, for example, India and south Africa did not account for uncertified dwellings (slums) but they did account for dwellings in poor neighborhoods that are certified and qualified as slums. The BLI is used to assess the number of rooms per person per dwelling which gives an insight to the comfort levels within the

households rather than accounting for the numbers of households. The initial scope of dwelling investigation was intended to portray a collection of five countries from each continent to assist in developing a continental scheme. However, due to time and data limitation, the scheme is not adopted. Additional information available in the appendix.

Medical equipment cost;
Numerous data gaps across the years for most of the countries. Plotting the graph covered the gaps by using a trend line. Only 20 countries are reported for by the industrial commodity database, therefore, a regional approach is impractical to display group trends in expenditures. Furthermore, the lack of countries limited the range of investigation. Therefore, only a few countries are visualized in the results, this also affected the evaluation of the healthcare sector, where hospital beds along with the medical equipment and the human resource play a fundamental role.

Hospital beds;
Data gaps limited the scope of countries and years presented in the graphs. Furthermore, the number of beds for USA for 2012 is assumed based on the last known year (2011). For the regional plotting, the African countries have been aggregated by taking the average numbers of beds for each year. This limits the quality of data and the results since not all the African countries are accounted for.

Passenger cars;
Data sources had some data gaps for the global passenger car fleet. In some of the countries motorbikes and busses are accounted, and in other countries they were neglected. This might cause inconsistencies in the overall amount of passenger cars reported.

Road stock;
The three different types of roads (motorway, communal and street) are combined to show the total road network for each country from a period of 2000 to 2015. Some data gaps are present for the individual roads resulting in discrepancies and inaccurate road stocks. Some assumptions are made to portray a somewhat accurate road stock. The US road network had incomplete data, therefore an assumption was made for the state and communal roads from 2009-2014 (shown in yellow cells in the excel data sheets). The assumption used the last known length of road for the last remaining 7 years. Refer to table 13 in the appendix (page GG) for more information regarding the data gaps and how they are dealt.
The road network is plotted against the LPI infrastructure index. The LPI index was first published in 2007 and then in 2010,2012, 2014 and 2016. Due to incomplete road network data for 2016 the LPI for 2016 is not used to convey the welfare status.

Telecommunication;
Multiple subscription and user data regarding telecommunication and connectivity are aggregated into one category to fit with the IDI indicator. This combined data is formulated from cellular telephone, mobile and fixed broadband. This selection of services covers the telecommunication market from calls, text and internet connectivity through a plethora of electronic devises. The data source used for this report accounted for regions rather than individual countries. Therefore, the data is visualized accordingly. The

regional grouping of countries disregarded the different financial and economical statuses of the countries which will conceive poor results, by portraying data sets for both North and South Americas as an aggregated group. The results will be inconclusive due to the vast difference in population and economic statuses of the countries.

Electrical grid capacity;
Data limitation restricted the scope to only 19 countries, where the different types of electrical facilities (electric power plants, self-producer combustible fuels, nuclear, hydro, solar and other sources) are aggregated into one encompassing national grid. The data gaps into the generated amounts per facility, affect the total grid capacity of the countries. Therefore, the results have a fair share of uncertainty. For further information refer to the accompanied excel sheet named 'Energy'.

Municipal waste;
Some waste generation data is missing for different years and countries. Some assumptions are made for China and Japan for 2014, the assumption used the last known generation amount in 2011 or 2012 to represent 2014, therefore some inconsistencies might be present in the graphs and results.
The limitation of data forced to use only the 2014 EPI index rather than the newer 2016 or 2017 editions. For more information regarding the data acquisition and preparation, refer to the appendix and attached excel sheets, where more description regarding calculations and setups are disclosed.

African leapfrog;
Insufficient data regarding African material stock limited the investigation scope in CO_2 emissions alongside the future material stock demand by 2030. The tail pipe emissions estimation is based for 5-seater sedan passenger car type; therefore, some inconsistency might occur when using the emission ratios for larger or smaller passenger vehicles or the fuel type used for combustions. The electrical generation emissions are assigned for coal based powerplants, once again, this might introduce incorrect estimations for fuel or renewable energy generation. Due to all these factors; the estimates are rough and do not reflect realistic bases.

Future research possibilities

Future studies could build on the method used for finding the SDG links to anthropogenic stocks, by increasing the stock categories to incorporate a larger plethora of materials to map out more of the linkages. Future studies may also alter the method to target specific sectors of material stock to increase the linkages depth with that certain material stock. They might take a different approach by linking the SDGs to other elements within the societies such as services or flows.
This report recognizes that SDGs have greater links to non-residential building particularly the Healthcare and educational facilities, therefore future studies should incorporate this aspect into their enquiries.

Future research possibilities can account for the practical usability of the anthropogenic stocks in daily human activities to increase the efficiency of stocks and enhance welfare. Through this quantification, fine adjustments to the material stocks can be done to increase the quality of provided services. Moreover, this will help to reduce the redundant amounts of future stocks and bring down the ecological footprint.

By combining these two different aspects (material stocks and welfare) with a solid data sets in a single research; it is possible to obtain a different understanding to how we view and interact with our surrounding material stocks. Only by fully understanding the level of welfare desired form mobile and non-mobile stocks, we can properly plan and invasion the future that we seek to acquire. Moreover, by understanding the role that stocks play in human welfare; the leapfrog for developing countries can be implemented in a swift and efficient way. Additionally, the results and findings may be used in political outlines alongside urban planning to tailor our communities in meeting the SDGs within the predetermined timeframe. After all, the end goal of things is to increase welfare and life quality for all.

Conclusion

The terms ‘’human development and human welfare” have vastly complex meanings that can change in definition depending on the approach or the point of view of the research. The progression in development is complicated and does not necessarily trail one specific path that has already been mapped out by other countries. Some countries think that welfare and development are achieved by education and healthcare, while other countries link welfare to economic activities. That is why the UN placed a complex road map to human development to be followed by all countries. The Sustainable Development goals can be traced back to material needs to fulfill their requirements. Depending on the methodology used in this report, the non-mobile stock had the largest amount of linkages to the SDGs indicators with 21 direct and 47 indirect linkages. The educational buildings account to 26 linkages followed by 11 linkages for the healthcare buildings. The equipment segment accounts for the highest mobile stock linkages to the SDG indicators with 37 total linkages, 19 of them make direct links and 18 are indirect. As for the transportation anthropogenic stocks, 26 linkages are found, where 16 linkages are direct and 10 indirect. The supply and disposal segment have the second highest count of linkages in material stocks at 54, where 28 are direct and 26 indirect linkages

Additional research is required to understand the full role of anthropogenic stocks especially for the non-residential buildings in achieving human welfare. Despite the limitation of data in the report, it became clear that the linkages between human welfare and material stocks require additional indicators acting as a middle ground for comparison. These indicators have a specific goal in mind like health, education or communication that can show the quality of service in comparison to the stocks. These indicators assist in quantifying the peak in stocks to welfare ratio. This was evident in the dwelling stock where the high-ranking countries had a stock of 450 dwellings per 1000 capita, and the optimum number of rooms per person is set at 2. Therefore, through proper use of indicators; the realization of stock worth can be obtained. Other correlations arose when plotting the passenger cars stock to the Logistics Performance Index, where the LPI welfare increased with the addition of vehicle stock then it dropped. This indicated that a stock of 500 passenger cars per 1000 capita is the threshold for LPI welfare. Another correlation arose between the electrical consumption per capita and the HDI, were the HDI raised with the electrical consumption. The threshold is not indicated in the graph, however from 7.5 to 25 MWh/capita, the HDI only increases by one point, indicating reduced effect from electrical consumption at this point.

The difficulties that faced this report are represented in data limitations and gaps. The initial scope of the report was to encompass 5 countries in each content to provide a fair global evaluation of the current status. However, the African country’s data bases are either lacking statistical material stock accounts or are reported in their local languages. This was also the issue for China and India, however Mandarin and Hindi are easily translated using certain internet browsers even though the accuracy of translation is not optimal for such researches. Therefore, the data gathered are from official reports published in English.

In research like this, data is fundamental in assessing the overall productivity of anthropogenic stocks and how they translate into human development of human welfare. A global reliable dataset that is consistent and acompasses all the anthropogenic stock can provide soiled results and trustworthy interoperation of current status, Additionally, this will impower and guide future plans to achieve the UN SDG and other desirable living conditions for all.

This report is not conclusive in any way; however, the findings can be used to encourage educational and research institutes to pursue future research and obtain more specific findings that can be introduced to law makers and politicians for national adoption. As mentioned before, human development is a multi-disciplinary cooperation, thus, the additional different organizations working on it; the better the success rate. After all this is goal number 17 in the Sustainable Development Goals.

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Appendix

SDGs targets and indicators

Target	Indicator
1.1 By 2030, eradicate extreme poverty for all people everywhere	1.1.1 Proportion of population below the international poverty line, by sex, age, employment status and geographical location (urban/rural)
1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty	1.2.1 Proportion of population living below the national poverty line, by sex and age 1.2.2 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	1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons
1.4 Ensure that all men and women, in particular the poor and the vulnerable.	1.4.1 Proportion of population living in households with access to basic services 1.4.2 Proportion of total adult population with secure tenure rights to land, with legally recognized documentation and who perceive their rights to land as secure, by sex and by type of tenure
1.5 By 2030, build the resilience of the	1.5.1 Number of deaths, missing persons and persons affected by disaster per 100,000 people 1.5.2 Direct disaster economic loss in relation to global gross domestic product (GDP)a 1.5.3 Number of countries with national and local disaster risk reduction strategies
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.	1.A.1 Proportion of resources allocated by the government directly to poverty reduction programmes 1.A.2 Proportion of total government spending on essential services (education, health and social protection

SUSTAINABLE DEVELOPMENT GOAL 2

End hunger, achieve food security and improved nutrition and promote sustainable agriculture

Target	Indicator
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round	2.1.1 Prevalence of undernourishment 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons	2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organization (WHO) Child Growth Standards) among children under 5 years of age 2.2.2 Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities	2.3.1 Volume of production per labor unit by classes of farming/pastoral/forestry enterprise size 2.3.2 Average income of small-scale food producers, by sex and indigenous status
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality	2.4.1 Proportion of agricultural area under productive and sustainable agriculture
2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote	2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities 2.5.2 Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction

2.A Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries	2.A.1 The agriculture orientation index for government expenditures 2.A.2 Total official flows (official development assistance plus other official flows) to the agriculture sector
2.B Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round	2.B.1 Producer Support Estimate 2.B.2 Agricultural export subsidies
2.C Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility	2.C.1 Indicator of food price anomalies

SUSTAINABLE DEVELOPMENT GOAL 3

Ensure healthy lives and promote well-being for all at all ages

Target	Indicator
3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births	3.1.1 Maternal mortality ratio 3.1.2 Proportion of births attended by skilled health personnel
3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births	3.2.1 Under-five mortality rate 3.2.2 Neonatal mortality rate
3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases	3.3.1 Number of new HIV infections per 1,000 uninfected population, by sex, age and key populations 3.3.2 Tuberculosis incidence per 1,000 population 3.3.3 Malaria incidence per 1,000 population 3.3.4 Hepatitis B incidence per 100,000 population 3.3.5 Number of people requiring interventions against neglected tropical diseases
3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being	3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease 3.4.2 Suicide mortality rate
3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol	3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders 3.5.2 Harmful use of alcohol defined according to the national context as alcohol per capita consumption (aged 15 years and older) within a calendar year in liters of pure alcohol
3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents	3.6.1 Death rate due to road traffic injuries
3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programs	3.7.1 Proportion of women of reproductive age (aged 15-49 years) who have their need for family planning satisfied with modern methods 3.7.2 Adolescent birth rate (aged 10-14 years; aged 15-19 years) per 1,000 women in that age group
3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all	

3.9 By 2030, substantially reduce the number of deaths

3.A Strengthen the implementation of the World Health Organization Framework Convention on Tobacco Control in all countries, as appropriate

3.B Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all

3.C Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States

3.D Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks

3.8.1 Coverage of essential health services (defined as the average coverage of essential services based on tracer interventions that include reproductive, maternal, newborn and child health, infectious diseases, non-communicable diseases among the general and the most disadvantaged population)
3.8.2 Number of people covered by health insurance or a public health system per 1,000 population

3.9.1 Mortality rate attributed to household and ambient air pollution
3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
3.9.3 Mortality rate attributed to unintentional poisoning

3.A.1 Age-standardized prevalence of current tobacco use among persons aged 15 years and older

3.B.1 Proportion of the population with access to affordable medicines and vaccines on a sustainable basis
3.B.2 Total net official development assistance to medical research and basic health sectors

3.C.1 Health worker density and distribution

3.D.1 International Health Regulations (IHR) capacity and health emergency preparedness

SUSTAINABLE DEVELOPMENT GOAL 4

Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all

Target	Indicator
4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes	4.1.1 Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex
4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education	4.2.1 Proportion of children under 5 years of age who are developmentally on track in health, learning and psychosocial well-being, by sex 4.2.2 Participation rate in organized learning (one year before the official primary entry age), by sex
4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university	4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex
4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship	4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill
4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations	4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated
4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy	4.6.1 Percentage of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex
4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development	4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development, including gender equality and human rights, are mainstreamed at all levels in: (a) national education policies, (b) curricula, (c) teacher education and (d) student assessment

4.A Build and upgrade education facilities that are child, disability and gender sensitive and

4.B By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries

4.C By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States

4.A.1 Proportion of schools with access to: (a) electricity; (b) the Internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapted infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions)

4.B.1 Volume of official development assistance flows for scholarships by sector and type of study

4.C.1 Proportion of teachers in: (a) pre-primary; (b) primary; (c) lower secondary; and (d) upper secondary education who have received at least the minimum organized teacher training (e.g. pedagogical training) pre-service or in-service required for teaching at the relevant level in a given country

SUSTAINABLE DEVELOPMENT GOAL 5

Achieve gender equality and empower all women and girls

Target	Indicator
5.1 End all forms of discrimination against all women and girls everywhere	5.1.1 Whether or not legal frameworks are in place to promote, enforce and monitor equality and nondiscrimination on the basis of sex
5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation	5.2.1 Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age 5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence
5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation	5.3.1 Proportion of women aged 20-24 years who were married or in a union before age 18 5.3.2 Proportion of girls and women aged 15-49 years who have undergone female genital mutilation
5.4 Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate	5.4.1 Proportion of time spent on unpaid domestic and care work, by sex, age and location
5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life	5.5.1 Proportion of seats held by women in national parliaments and local governments 5.5.2 Proportion of women in managerial positions
5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences	5.6.1 Proportion of women aged 15-49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care 5.6.2 Number of countries with laws and regulations that guarantee women aged 15-49 years access to sexual and reproductive health care, information and education
5.A Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws	
5.B Enhance the use of enabling technology, in particular information and communications	

5.C Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all Levels	5.A.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure 5.A.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control 5.B.1 Proportion of individuals who own a mobile telephone, by sex 5.C.1 Proportion of countries with systems to rack and make public allocations for gender equality and women's empowerment

SUSTAINABLE DEVELOPMENT GOAL 6

Ensure availability and sustainable management of water and sanitation for all

Target	Indicator
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water	6.1.1 Proportion of population using safely managed drinking water services
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	6.2.1 Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally	6.3.1 Proportion of wastewater safely treated 6.3.2 Proportion of bodies of water with good ambient water quality
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity	6.4.1 Change in water-use efficiency over time 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate	6.5.1 Degree of integrated water resources management implementation (0-100) 6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	6.6.1 Change in the extent of water-related ecosystems over time
6.A By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies	6.A.1 Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.B Support and strengthen the participation of local communities in improving water and sanitation management	6.B.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

SUSTAINABLE DEVELOPMENT GOAL 7

Ensure access to affordable, reliable, sustainable and modern energy for all

Target	Indicator
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services	7.1.1 Proportion of population with access to electricity
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.1.2 Proportion of population with primary reliance on clean fuels and technology
7.3 By 2030, double the global rate of improvement in energy efficiency	7.2.1 Renewable energy share in the total final energy consumption
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	7.3.1 Energy intensity measured in terms of primary energy and GDP
	7.A.1 Mobilized amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
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	7.B.1 Investments in energy efficiency as a percentage of GDP and the amount of foreign direct investment in financial transfer for infrastructure and technology to sustainable development services

SUSTAINABLE DEVELOPMENT GOAL 8

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all

Target	Indicator
8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	8.1.1 Annual growth rate of real GDP per capita
8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors	8.2.1 Annual growth rate of real GDP per employed person
8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services	8.3.1 Proportion of informal employment in non-agriculture employment, by sex
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-year framework of programmes on sustainable consumption and production, with developed countries taking the lead	8.4.1 Material footprint, material footprint per capita, and material footprint per GDP 8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value	8.5.1 Average hourly earnings of female and male employees, by occupation, age and persons with disabilities 8.5.2 Unemployment rate, by sex, age and persons with disabilities
8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training	8.6.1 Proportion of youth (aged 15-24 years) not in education, employment or training
	8.7.1 Proportion and number of children aged 5-17 years engaged in child labour, by sex and age
	8.8.1 Frequency rates of fatal and non-fatal occupational injuries, by sex and migrant status 8.8.2 Increase in national compliance of labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status

8.7 Take immediate and effective measures to Eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms

8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment

8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products

8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all

8.A Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-Related Technical Assistance to Least Developed Countries

8.B By 2020, develop and operationalize a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organization

8.9.1 Tourism direct GDP as a proportion of total GDP and in growth rate
8.9.2 Number of jobs in tourism industries as a proportion of total jobs and growth rate of jobs, by sex

8.10.1 Number of commercial bank branches and automated teller machines (ATMs) per 100,000 adults
8.10.2 Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider

8.A.1 Aid for Trade commitments and disbursements

8.B.1 Total government spending in social protection and employment programmes as a proportion of the national budgets and GDP

SUSTAINABLE DEVELOPMENT GOAL 9

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Target	Indicator
9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all	9.1.1 Proportion of the rural population who live within 2 km of an all-season road 9.1.2 Passenger and freight volumes, by mode of transport
9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances	9.2.1 Manufacturing value added as a proportion of GDP and per capita 9.2.2 Manufacturing employment as a proportion of total employment
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value markets	9.3.1 Proportion of small-scale industries in total industry value added 9.3.2 Proportion of small-scale industries with a loan or line of credit
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities	9.4.1 CO2 emission per unit of value added
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending	9.5.1 Research and development expenditure as a proportion of GDP 9.5.2 Researchers (in full-time equivalent) per million inhabitants
9.A Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States	9.A.1 Total official international support (official development assistance plus other official flows) to infrastructure
	9.B.1 Proportion of medium and high-tech industry value added in total value added
	9.C.1 Proportion of population covered by a mobile network, by technology

9.B Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities

9.C Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020

SUSTAINABLE DEVELOPMENT GOAL 10

Reduce inequality within and among countries

Target	Indicator
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	10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population
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	10.2.1 Proportion of people living below 50 per cent of median income, by age, sex and persons with disabilities
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	10.3.1 Proportion of the population reporting having personally felt discriminated against or harassed within the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality	10.4.1 Labour share of GDP, comprising wages and social protection transfers
10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations	10.5.1 Financial Soundness Indicators
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	10.6.1 Proportion of members and voting rights of developing countries in international organizations
10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies	10.7.1 Recruitment cost borne by employee as a proportion of yearly income earned in country of destination 10.7.2 Number of countries that have implemented 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.A.1 Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff

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	10.B.1 Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows)
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	10.C.1 Remittance costs as a proportion of the amount remitted countries, in accordance with their national plans and programmes

SUSTAINABLE DEVELOPMENT GOAL 11

Make cities and human settlements inclusive, safe, resilient and sustainable

Target	Indicator
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate 11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and persons affected by disaster per 100,000 people 11.5.2 Direct disaster economic loss in relation to global GDP, including disaster damage to critical infrastructure and disruption of basic services
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	

11.A Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning

11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and

11.C Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months

11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

11.7.2 adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels

11.A.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city

11.B.1 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030a

11.B.2 Number of countries with national and local disaster risk reduction strategies

11.C.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials

SUSTAINABLE DEVELOPMENT GOAL 12

Ensure sustainable consumption and production patterns

Target	Indicator
12.1 Implement the 10-year framework of programmes on sustainable consumption and production, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries	12.1.1 Number of countries with sustainable consumption and production (SCP) national action plans or SCP mainstreamed as a priority or a target into national policies
12.2 By 2030, achieve the sustainable management and efficient use of natural resources	12.2.1 Material footprint, material footprint per capita, and material footprint per GDP 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses	12.3.1 Global food loss index
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment	12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement 12.4.2 Hazardous waste generated per capita and proportion of hazardous waste treated, by type of treatment
12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse	12.5.1 National recycling rate, tons of material recycled
12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle	12.6.1 Number of companies publishing sustainability reports
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities	12.7.1 Number of countries implementing sustainable public procurement policies and action plans
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development (including climate change education) are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment

12.A Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production	12.A.1 Amount of support to developing countries on research and development for sustainable consumption and production and environmentally sound technologies
12.B Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products	12.B.1 Number of sustainable tourism strategies or policies and implemented action plans with agreed monitoring and evaluation tools
12.C Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities	12.C.1 Amount of fossil -fuel subsidies per unit of GDP (production and consumption) and as a proportion of total national expenditure on fossil fuels

SUSTAINABLE DEVELOPMENT GOAL 13

Take urgent action to combat climate change and its impacts*

Target	Indicator
13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	13.1.1 Number of countries with national and local disaster risk reduction strategies 13.1.2 Number of deaths, missing persons and persons affected by disaster per 100,000 people
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other)
13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	13.3.1 Number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula 13.3.2 Number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions
13.A Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	13.A.1 Mobilized amount of United States dollars per year starting in 2020 accountable towards the $100 billion commitment
13.B Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities	13.B.1 Number of least developed countries and small island developing States that are receiving specialized support, and amount of support, including finance, technology and capacity-building, for mechanisms for raising capacities for effective climate change-related planning and management, including focusing on women, youth and local and marginalized communities

* Acknowledging that the United Nations Framework Convention on Climate Change is the primary international, intergovernmental forum for negotiating the global response to climate change.

SUSTAINABLE DEVELOPMENT GOAL 14

Conserve and sustainably use the oceans, seas and marine resources for sustainable development

Target	Indicator
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels	14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	14.4.1 Proportion of fish stocks within biologically sustainable levels
14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information	14.5.1 Coverage of protected areas in relation to marine areas
14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognizing that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organization fisheries subsidies negotiation	14.6.1 Progress by countries in the degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing
	14.7.1 Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries
	14.A.1 Proportion of total research budget allocated to research in the field of marine technology
	14.B.1 Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and protects access rights for small-scale fisheries
	14.C.1Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

14.7 By 2030, increase the economic benefits to Small Island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism

14.A Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries

14.B Provide access for small-scale artisanal fishers to marine resources and markets

14.C Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in UNCLOS, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of The Future We Want

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

Target	Indicator
15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements	15.1.1 Forest area as a proportion of total land area 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type
15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally	15.2.1 Progress towards sustainable forest management
15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	15.3.1 Proportion of land that is degraded over total land area
15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development	15.4.1 Coverage by protected areas of important sites for mountain biodiversity 15.4.2 Mountain Green Cover Index
15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species	15.5.1 Red List Index
15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed	15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits
15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products	15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked
	15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species
	15.9.1 Progress towards national targets established in accordance with Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011-2020
	15.A.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems

15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

15.A Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems

15.B Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation

15.C Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities

15.B.1 Official development assistance and public expenditure on conservation and sustainable use of biodiversity and ecosystems

15.C.1 Proportion of traded wildlife that was poached or illicitly trafficked

SUSTAINABLE DEVELOPMENT 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

Target	Indicator
16.1 Significantly reduce all forms of violence and related death rates everywhere	16.1.1 Number of victims of intentional homicide per 100,000 population, by sex and age 16.1.2 Conflict-related deaths per 100,000 population, by sex, age and cause 16.1.3 Proportion of population subjected to physical, psychological or sexual violence in the previous 12 months 16.1.4 Proportion of population that feel safe walking alone around the area they live
16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children	16.2.1 Proportion of children aged 1-17 years who experienced any physical punishment and/or psychological aggression by caregivers in the past month 16.2.2 Number of victims of human trafficking per 100,000 population, by sex, age and form of exploitation 16.2.3 Proportion of young women and men aged 18?29 years who experienced sexual violence by age 18
16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all	16.3.1 Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognized conflict resolution mechanisms 16.3.2 Unsentenced detainees as a proportion of overall prison population
16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organized crime	16.4.1 Total value of inward and outward illicit financial flows (in current United States dollars) 16.4.2 Proportion of seized small arms and light weapons that are recorded and traced, in accordance with international standards and legal instruments
16.5 Substantially reduce corruption and bribery in all their forms	16.5.1 Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months
16.6 Develop effective, accountable and transparent institutions at all levels	
16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels	
16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance	
16.9 By 2030, provide legal identity for all, including birth registration	
16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements	
16.A Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime	

16.B Promote and enforce non-discriminatory laws and policies for sustainable development	16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official during the previous 12 months 16.6.1 Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar) 16.6.2 Proportion of the population satisfied with their last experience of public services 6.7.1 Proportions of positions (by sex, age, persons with disabilities and population groups) in public institutions (national and local legislatures, public service, and judiciary) compared to national distributions 16.7.2 Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group 16.8.1 Proportion of members and voting rights of developing countries in international organizations 16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age 16.10.1 Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months 16.10.2 Number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information 16.A.1 Existence of independent national human rights institutions in compliance with the Paris Principles 16.B.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law

SUSTAINABLE DEVELOPMENT GOAL 17

Strengthen the means of implementation and revitalize the global partnership for sustainable development

Target	Indicator
17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection	17.1.1 Total government revenue as a proportion of GDP, by source 17.1.2 Proportion of domestic budget funded by domestic taxes
17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed	17.2.1 Net official development assistance, total and to least developed countries, as a proportion of the Organization for Economic Cooperation and Development (OECD) Development Assistance Committee donors' gross national income (GNI)
17.3 Mobilize additional financial resources for developing countries from multiple sources	17.3.1 Foreign direct investments (FDI), official development assistance and South-South Cooperation as a proportion of total domestic budget 17.3.2 Volume of remittances (in United States dollars) as a proportion of total GDP
17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress	17.4.1 Debt service as a proportion of exports of goods and services
17.5 Adopt and implement investment promotion regimes for least developed countries	17.5.1 Number of countries that adopt and implement investment promotion regimes for least developed countries
17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism	17.6.1 Number of science and/or technology cooperation agreements and programmes between countries, by type of cooperation 17.6.2 Fixed Internet broadband subscriptions per 100 inhabitants, by speed
17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on	17.7.1 Total amount of approved funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies

17.8 Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology

17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North-South, South-South and triangular cooperation

17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organization, including through the conclusion of negotiations under its Doha Development Agenda

17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020

17.12 Realize timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organization decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access

17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence

17.14 Enhance policy coherence for sustainable development

17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development

17.8.1 Proportion of individuals using the Internet

17.9.1 Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries

17.10.1 Worldwide weighted tariff-average favorable terms, including on concessional and preferential terms, as mutually agreed

17.11.1 Developing countries' and least developed countries' share of global exports

17.12.1 Average tariffs faced by developing countries, least developed countries and small island developing States

17.13.1 Macroeconomic Dashboard

17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development

17.15.1 Extent of use of country-owned results frameworks and planning tools by providers of development cooperation

17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the sustainable development goals

17.17.1 Amount of United States dollars committed to public-private and civil society partnerships

17.16 Enhance the global partnership for sustainable development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the sustainable development goals in all countries, in particular developing countries

17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships

17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries

17.18.1 Proportion of sustainable development indicators produced at the national level with full disaggregation when relevant to the target, in accordance with the Fundamental Principles of Official Statistics
17.18.2 Number of countries that have national statistical legislation that complies with the Fundamental Principles of Official Statistics
17.18.3 Number of countries with a national statistical plan that is fully funded and under implementation, by source of funding

17.19.1 Dollar value of all resources made available to strengthen statistical capacity in developing countries
17.19.2Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration

*SDG information retrieved from Sustainable Development Knowledge Platform (https://sustainabledevelopment.un.org/topics/sustainabledevelopmentgoals)

X = Direct linkages
O = Indirect linkages

SDG	Target	Indicator	Non-mobile stock																								Mobile stock															
			Buildings										Infrastructure														Others															
			Residential Buildings			Non-residential							Transportation					Supply & Disposal						Energy			Land	Vehicles			Machineries & equipment				Consumer durables		Waste services						
SDG	Target	Indicator	Multi family	Single family	Other(slums)	Healthcare	Education &	Public service c	Offices/ Indu	Events & cultu	Agriculture	Recreational	Airports	Ports	Railways	Subway	Roads	Clean wat	Waste wa	Gas	Oil	IT, AI	Telecomm	Generation	Transmissior	Cables		Air	Water	Land	Medical	Construction	Electronic	Agriculture(	Household	Personal	Municipal	Industrial	Direct link	Indirect li	Total direc	Total indi	Total linka
	1.4	1.4.1	O	O	O																														X				1	3			
		1.4.2																									O												0	1			
	1.5	1.5.3					O																																0	1			
1	1.A	1.A.2				O	O	O																							O		O				O	O	0	7	1	12	13
	2.1	2.1.2									O																		O	O				O					0	4			
	2.2	2.2.1																																O					0	1			
		2.2.2							O		O																												0	2			
	2.3	2.3.1																																O					0	1			
	2.4	2.4.1									O							O																O					0	3			
	2.5	2.5.1					O			O																													0	2			
2	2.A	2.A.2					O						O	O	O	O	O	O	O	O	O	O	O	O	O	O							X	X					2	15	2	28	30
	3.1	3.1.2				O																									O								0	2			
	3.2	3.2.2																										X	X	X	X								4	0			
	3.3	3.3.2																													O								0	1			
	3.4	3.4.1				X																									X								2	0			
		3.4.2						O																															0	1			
	3.5	3.5.1				X		X		X																					X								4	0			
	3.6	3.6.1															X															O	X						2	1			
	3.7	3.7.1				X	X			X																													3	0			
	3.8	3.8.1				X																						O	O	O	O								1	4			
	3.9	3.9.1	X	X	X																						X												4	0			
		3.9.2																O	O									O	O	O	X						X	X	3	5			
	3.B	3.B.1				O	O		O																														0	3			
		3.B.2				O	O																																0	2			
3	3.C	3.C.1				O	O																																0	2	23	21	44
	4.1	4.1.1					O																										O						0	2			
	4.2	4.2.1				O	O																										O						0	3			
	4.3	4.3.1					X																										O						1	1			
	4.4	4.4.1					O															X	X																2	1			
	4.6	4.6.1					O																										O						0	2			
	4.7	4.7.1					O																																0	1			
	4.A	4.A.1(a)																			X			X	X	X						X	X						6	0			
		4.A.1(b)																					X									X	X						3	0			
		4.A.1(c)																					X									X	X						3	0			
		4.A.1(d)					X																X									X	X						4	0			
		4.A.1(e)																X														X	X						3	0			
		4.A.1(f)																X														X	X						3	0			
		4.A.1(g)																X														X	X						3	0			
4	4.C	4.C.1					O																																0	1	28	11	39
5	5.B	5.B.1																																		X			1	0	1	0	1
	6.1	6.1.1																X																					1	0			
	6.2	6.2.1																X	X																				2	0			
	6.3	6.3.1																	O																		O	O	0	3			
		6.3.2																O																					0	1			
	6.4	6.4.1																O	O																		O	O	0	4			
		6.4.2																O																					0	1			
	6.6	6.6.1																																			X	X	2	0			
	6.A	6.A.1																O	O																		O	O	0	4			
6	6.B	6.B.1																																			O	O	0	2	5	15	20
	7.1	7.1.1																		X	X			X	X	X													5	0			
		7.1.2																						X	X	X													3	0			
	7.2	7.2.1																						X	X	X													3	0			
	7.3	7.3.1																						O	O	O						X	X						2	3			
	7.A	7.A.1					O																	O	O	O													0	4			
7	7.B	7.B.1																		X	X			X	X	X						X	X						7	0	20	7	27
	8.6	8.6.1					O		O																														0	2			
	8.9	8.9.2								O		O																											0	2			
	8.10	8.10.1							X																														1	0			
8	8.B	8.B.1						O																															0	1	1	5	6
	9.1	9.1.1																														X							1	0			
		9.1.2											X	X	X	X	X				X			X	X	X													9	0			
	9.2	9.2.2							O															O	O	O													0	4			
	9.4	9.4.1							O				O	O	O	O	O	O	O	O	O	O	O	O	O	O						X							1	15			
	9.5	9.5.1					O															O											O						0	3			
	9.A	9.A.1											X	X	X	X	X	X	X	X	X	X	X	X	X	X						O			X	X			16	1			
	9.B	9.B.1					O		O													O																	0	3			
9	9.C	9.C.1																				X	X										X			X			4	0	31	26	57
	11.1	11.1.1	O	O	O																						O								X		X	X	3	4			
	11.2	11.2.1											X	X	X	X	X				X							X	X	X									9	0			
	11.4	11.4.1								O																													0	1			
	11.6	11.6.1						O																													X	X	2	1			
	11.7	11.7.1								X		X																											2	0			
11	11.C	11.C.1	X	X	X	X	X	X	X	X	X	X															X					O					X	X	13	1	29	7	36
	12.4	12.4.1						O																															0	1			
		12.4.2																																			O	O	0	2			
	12.5	12.5.1	O	O	O				O																												O	O	0	6			
	12.8	12.8.1					X																																1	0			
12	12.A	12.A.1					O															O																	0	2	1	11	12
13	13.3	13.3.2					O		O																														0	2	0	2	2
	14.3	14.3.1					O																																0	1			
14	14.A	14.A.1					O																																0	1	0	2	2
	15.1	15.1.2																									O												0	1			
15	15.5	15.5.1																									O												0	1	0	2	2
16	16.1	16.1.1																												O	O								0	2	0	2	2
	17.6	17.6.2																					X										X		X	X			4	0			
	17.7	17.7.1																										X	X	X			X		X	X			6	0			
		17.7.2																				O																	0	1			
17	17.8	17.8.1																					X										X		X	X			4	0	14	1	15
Indicators directly linked to stocks			2	2	2	5	5	2	2	4	1	2	3	3	3	3	4	6	2	3	6	3	8	7	7	7	2	3	3	3	4	5	9	1	6	6	5	5					
Indicators indirectly linked to stocks			3	3	3	6	21	5	8	3	3	1	2	2	2	2	2	8	6	2	2	6	2	5	5	5	4	2	3	4	5	3	6	4	0	0	7	7					
Total count of direct links			6			21							16					28						21			2	9			19				12		10						
Total count of indirect links			9			47							10					26						15			4	9			18				0		14						
Total			15			68							26					54						36			6	18			37				12		24						

Table 12: Comprehensive SDG and Stock linkages

Data plotting clarifications

Section	Stock type	Source	Country	Units	Years	Adaptations
Communication	Cellular telephone subscriptions	ICT Indicators Database	Global	Subscription per 100 capita	1960-2014	-Accumulation of regional subscribers for IDI, shown green cells in excel sheet.
Transportation	Passenger cars	UNECE database	Global	Per 1000 capita	2000-2016	-Missing data that are not represented in the graphs peach cells.
	Roads	UNECE transport division database	Global	Total length km	2000-2016	-Uncomplete or missing data peach cells. -The different road types are accumulated to cover the entire road network green cells. -Assumptions for the US network made for 2007 to 2014. Shown yellow cells.
Waste	Municipal waste	Environment Statistics Database	Global	1000 tonnes	2000-2016	-Assumptions for China and Japan for year 2014 are done based on the last known municipal waste generation amounts show in yellow cells in excel sheets. -Missing data regarding the amounts for various years, shown in peach cells.
Energy stock and welfare	Power grid capacity	Energy Statistics Database	Global	1000 KW	1990-2016	-Different types of electrical grids are aggregated into one national grid for each of the countries. -Some gaps are present in the electrical network throughout different years, represented in peach cells.
	Electrical consumption	World Development Indicators, World Bank	Global	KWh/cap	1950-2013	-Few gaps in consumption data missing for certain year and countries shown in peach cells in the excel sheets. The latest data update is in 2013.
Healthcare	Hospitals beds	WHO database World bank	Global	Bed per 10,000 and	1990-2012	-Data gaps throughout the years, shown in peach cells.

				1000 habitants		-Assumption for USA hospital beds for 2012. Where the last known count for 2011 is used for 2012, shown in yellow cells in the data table sheet.
	Medical equipment	Industrial Commodity Statistics Database	Global	Value in USD	2000-2015	-Data gaps for all the countries in some years, shown in peach cells in the data table sheet in excel. -Data is plotted on a time series where the gaps are filled in by the trend line.
Residential buildings	Area of building stock	Statsbank Denmark	Denmark	1000m^2, unit	1900-2015	-Population data missing from 1930 t0 1949, shown in peach cells in the excel sheet.
	dwelling stock	Czech Demographic Handbook 2015	Czech	M^2, unit	1950-2011	-Data is gathered from multiple reports. Therefore, some data gaps are present, plus the data is gathered in interval years.
		Statistisches bundesamt	Germany	1000 Units, m^2/capita	1995-2016	-Some years of the residential establishments are missing, shown in peach cells in the excel sheets.
		Statistics Finland	Finland	Floor area per dwelling, units	1960-2016	-Data is gathered every 10 years from 1960 to 1970, and then every 5 years from 1975 to 1985, and from then it accounts for every year.
	Dwelling stock	Statistic Austria	Austria	Floor area, 1000 units	1951-2014	-Data is accumulated in intervals of 10 years from 1951 until 2011 then on annual bases until 2014.
		Croatia bureau of statistics	Croatia	Units, m^2	1981-2011	-Data is accumulated in intervals of 10 years from 1981 until 2011 then on annual bases until 2014.
		Statistics Estonia	Estonia	Units, m^2	1980-2017	-Data is accumulated in 10 or 5 years intervals from 1980 until 2010 then on annual bases until 2017.
		Centrala statistaks pravalde	Latvia	Million, thousand m^2	1980-2014	-Data is accumulated in 10 years intervals from 1980 until 2010 then on annual bases until 2014.
		Statistics Sweden	Sweden	Unit	1990-2016	-Some missing data specified by Statistiska centralbyran in columns (excel sheets). -Missing data affects the overall numbers of dwelling.

		GOV.UK	UK	Unit	1980-2016	-Data missing from 1891-1980 and 2015 to 2016, shown in peach cells in excel sheets.
		National Bureau of Statistics of China	China	Units	1980-2015	-Data is accumulated from different reports and data bases. -Some data gaps are indicated in peach highlighted cells in excel sheets.
		Statistics South Africa	South Africa	1000 units	2002-2016	-Data is gathered from reports published by the bureau of census. -Data for 2001 and 2002 had significantly larger dwelling amounts, consequently it is disregarded in this report.
		Ministry of Home Affairs, India	India	Units	1971-2015	-Data gaps for several years shown in peach cells in excel.
Welfare indicators	Logistics Performance Index (LPI)	World Bank Data base	Global	points	2007-2016	-The report is published every other year starting from 2007.
	ICT Development Index (IDI)	ITU World Telecommunication	Regional	Ranking, points	2005-20017	-The data is gathered from the 2017 ITC report. (No data base is found). Referee to data table 2 (data type and source) in methodology for the published report

Table 13: Data plotting clarifications

Human welfare indicators

- OECD Better Live Index, rooms per person

An indicator refers to the number of rooms (excluding kitchenette, scullery/utility room, bathroom, toilet, garage, consulting rooms, office, shop) in a dwelling divided by the number of persons living in the dwelling.

- Logistics Performance Index, infrastructure

The infrastructure index accounts for the coverage and state of the transportation infrastructure (roads, ports, airports and trains). Scores are used to evaluate the infrastructure, on a scale of 1 (low) to 5 (high). The Logistics Performance Index uses a structured online survey of logistics professionals at multinational freight companies and main express carriers which was administered to nearly 1,000 respondents at international logistics companies in 143 countries.

- ICT Development Index

An index published by the United Nations International Telecommunication Union based on international information and communication technologies (ICT) indicators. The index investigates infrastructure and access, intensity and usage, and skills. The scoring scale starts at 1 to 10 (10 being the highest score), the scores are derived from these indicators:

Infrastructure and access:
Fixed-telephone subscriptions per 100 inhabitants, mobile-cellular telephone subscriptions per 100 inhabitants, international Internet bandwidth (bits/s) per user, percentage of households with a computer, and percentage of households with Internet access

Intensity and usage:
Percentage of individuals using the Internet, fixed (wired)-broadband subscriptions per 100 inhabitants, and wireless broadband subscriptions per 100 inhabitants (includes satellite, terrestrial fixed, and active mobile with a minimum download of 256 Kbit/s)

Skills:
Adult literacy rate (percentage of population whom are 15 and older who can read and write simple statements with understanding and do simple arithmetic calculations), gross enrollment ratio secondary level (total enrollment in a specific level of education as a percentage of all eligible), and gross enrollment ratio tertiary level