Analysis on Impact of Global Trade and Poverty on Carbon Footprints

Team Members:
20BCE2661 (Mylie Mudaliyar)
20BCE2692 (Amrit Akshay Acharya)
20BCE0563 (Boggavarapu Ch N V Shivani)

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Professor: Dr. Ilanthenral Kandasamy

Vellore Institute of Technology
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1. Introduction:

In recent years, the world has been grappling with a complex set of interrelated challenges, including global trade, poverty, and carbon footprints. These issues are inextricably linked, and addressing one without considering the others is likely to be insufficient in achieving sustainable development. This project aims to examine the relationship between these variables and understand their impact on each other.

Carbon footprints refer to the total amount of greenhouse gas emissions that are produced as a result of human activities. As the global economy has grown, so too it has the demand for goods and services, leading to increased carbon emissions and contributing to climate change. Global trade has been a key driver of this economic growth, with trade flows increasing rapidly in recent decades. However, trade has also had a profound impact on poverty, both in developed and developing countries. In many cases, the benefits of trade have been distributed unevenly, leading to rising income inequality and poverty.

Given the interdependence between global trade, poverty, and carbon footprints, this project aims to examine the current state of the world's trade, poverty, and carbon emissions and explore how these trends are likely to shape our future. Furthermore, we will examine the effectiveness of current initiatives aimed at reducing poverty and mitigating climate change and discuss the potential for further actions to help achieve a more sustainable future. The project will also examine the links between poverty and trade, and the impact of these relationships on carbon footprints.

2. Literature Review Summary Table

	Authors and Year (Reference)	Title (Study)	Concept / Theoretical model/ Framework	Methodology used/ Implementation	Dataset details/ Analysis	Relevant Finding	Limitations/ Future Research/ Gaps identified
1.	Edgar G. ertwich, Anglen . Peters Published on: lay 12, 2009	Carbon ootprint of ations: A ilobal, rade-Linked nalysis	The study rovides cross-ountry analysis of ie carbon footprint f consumption as a ınction of per apita expenditure nd grouped by ontinent. The uthors also iscuss the need for global trade-nked methodology correctly attribute ie IPCC emission ources to onsumption ctivities.	The ethodology sed was a ılly coupled ultiregional iput-output MRIO) model onstructed sing the ilobal Trade nalysis roject GTAP) atabase upplemented ith data on O2 missions and on-CO2 reenhouse as emissions.	A multiregional iput-output iodel was used analyze missions data. he model used ie GTAP atabase, which ontains input-utput tables nd bilateral ade statistics r 57 sectors nd 87 regions. dditional data n greenhouse as emission tensity in each ector was also sed.	The major nding of the aper was that the otprint is strongly orrelated with per apita consumption xpenditure and cludes both CO2 nd non-CO2 reenhouse gases. utrition is the most nportant onsumption ategory, followed y shelter and iobility. The arbon footprint of ood is dominant in oor countries, hile mobility is iore important in ch countries	The study iggests that iture analysis iould focus n physical uantities and uality escriptors of hat is onsumed.

2.	Benedikt Bruckner, Klaus Hubacek, Yuli Shan, Honglin Zhong Kuishuang Feng 14 February 2022	Impacts of poverty alleviation on national and global carbon emissions	Wealth and income are disproportionately distributed among the global population. This has direct consequences on consumption patterns and consumption-based carbon footprints, resulting in carbon inequality. Due to persistent inequality, millions of people still live in poverty today. On the basis of global expenditure data, we compute country- and expenditure-specific per capita carbon footprints with unprecedented details.	To analyse global carbon inequality, Et.al computed country- and expenditure-specific carbon footprints using detailed expenditure data linked with an EEMRIO analysis. Subsequently, Et.al applied multiple poverty alleviation scenarios to determine impacts on carbon emissions. The EEMRIO approach uses an MRIO table, which consists of the inter-regional trade between m sectors in n countries. The data are collected in matrix Z((mn)×(mn))	This research is based on a detailed expenditure dataset for the year 2011. The dataset was constructed by the World Bank from expenditure survey raw data and contains 116 countries and almost 90% of the global population.	To ensure global progress on poverty alleviation without overshooting climate targets, high-emitting countries need to reduce their emissions substantially.	Emissions from firewood and biomass are missing from the database and, thus, not included in the analysis

3.	Klaus Hubacek, Giovanni Baiocchi, Kuishuang Feng, Raúl Muñoz Castillo, Laixiang Sun Jinjun Xue	Global carbon inequality	Global climate change and inequality are linked both in terms of who contributes climate change and who suffers the consequences. Et.al explored the global carbon inequality between and within countries and the carbon implications of poverty alleviation by combining detailed consumer expenditure surveys for different income categories for a wide range of countries.	To compute household carbon footprints, Et.al use multi-regional input–output (MRIO) analysis. The MRIO-based approach enables us to calculate emissions and resource use along global supply chains .MRIO is based on national economic input–output tables depicting flows of money and embodied resources to and from sectors within and between countries.	The compiled dataset allowed Et.al to assess some important questions such as what are the carbon implications of moving the poorest people on the planet out of poverty. When looking specifically at India and China, we find that the global carbon emissions would increase by 7 and 4%, respectively.	While looking at poor countries, Et.al tend to find larger disparities between the carbon footprints of the rich versus the poor reflecting larger income inequalities in those countries.	Given the huge level of carbon inequality, critical discussion of undifferentiated income growth and current carbon-intensive lifestyles and consumption patterns need to enter the climate discourse to a larger extent.

4.	Waqas Kamran ,Najia Saqib, Yushan Jianhua Zhang Published on: 22 June 2022	An Empirical Study on the Impact of Energy Poverty on Carbon Intensity of the Construction Industry: Moderating Role of Technological Innovation	Energy has brought convenience to human production and life. However, the traditional energy development model also brings energy exhaustion, climate change, and other problems. This article analyzes the influence of energy poverty on carbon intensity of the construction industry and constructs the influence model of carbon intensity of the construction industry.	The regression model is used to test the mediating effect and the moderating effect of the technology level and the marketization degree on the influence mechanism of energy poverty on carbon emissions from the construction industry through energy consumption structure.	Limited by the availability of data, annual data of 30 Chinese provinces from 2004 to 2016 were selected. The carbon emission data and energy consumption of the construction industry are from the China Carbon Emission database.	The carbon intensity of the construction industry increases by 1.683 units per unit increase of energy poverty, showing a positive impact. Energy consumption structure has a mediating effect on the impact of energy poverty on carbon intensity of the construction industry. Energy consumption structure has a mediating effect on the impact of energy poverty on carbon intensity of the construction industry.	The improvement of marketization degree of the construction industry enables construction enterprises to strive to improve their core competitiveness in the market close to perfect competition, including but not limited to the use of green technology innovation to improve energy utilization efficiency, development of carbon capture, carbon sequestration, carbon secondary utilization, and other technologies to reduce carbon dioxide emissions.

5.	Salim Khan , Wang Yahong , Asma Zeeshan Published on:November 2022	Impact of poverty and income inequality on the ecological footprint in Asian developing economies: Assessment of Sustainable Development Goals	To control Environmental Degradation along with poverty and income inequality arise as a major concern and for researchers, particularly, after the "United Nations (UN) conferences on "Environment and Development". Increasing environmental degradation is a big constraint in the path of sustainable development, poverty alleviation, and controlling income inequality as well.	D–K standard error approach handles the problems of serial correlation, heteroscedasticity, and the most common problem of cross-sectional dependency. In addition, the D–K standard error approach ensured and handles the most common issues of missing values while it is suitable for balanced as well as for unbalanced panel series.	Et.al have employed the panel data of 18 Asian developing countries from 2006–2017.The data for targeted variables have been collected from World Development Indicators (WDI), and other databases. The data for mostly variables such as poverty, Gini, GDP, FDI, Pop, AE, FA, INF, and IND are collected from WDI while the data for EFP was collected from GFN.	Income inequality has a detrimental and harmful effect on the environment in Asian developing countries. The higher economic growth and industrialization process for alleviation of extreme poverty may negatively affect the quality of the environment.	Failed to find the causality among the variables of the study due to the unavailability of the extended dataset, therefore, it could be better and more interesting to emphasize this limitation in the future.

6.	Jiangfeng Hu,Haoming Shi,Qinghua Huang,Yalan Luo Published on: 18 Dec 2020	The Impacts of Freight Trade on Carbon Emission Efficiency: Evidence from the Countries along the “Belt and Road”	There is a lack of research on the carbon emissions efficiency of the countries along the “Belt and Road,” especially regarding the impact of freight trade. To address this research gap, this paper first employs a meta frontier non radial directional distance function to measure the carbon emission efficiency of 32 countries along the “Belt and Road”	This paper takes the GDP of each country as the desired output variable, CO2 as the undesired output, the average annual employment as labor input, and the total energy consumption as energy input.	There are 70 countries along the “Belt and Road.” Due to the availability of relevant data and the fact that the dataset for measuring carbon emission efficiency needs to be balanced panel data, this paper selected the dataset of 32 countries from 1990 to 2014 as the research samples.	The carbon emission efficiency of the countries along the “Belt and Road” is generally low. Freight trade promotes carbon emission efficiency, but it will aggravate the gap between the contemporaneous technology and the group technology. (FDI) has a significant negative effect on a host country’s group-frontier carbon emission efficiency(ITCEI) and meta frontier carbon emission efficiency	A country’s government can set an appropriate upper limit on the emission from freight trade in accordance with its economic and social development goals. A country can improve its national energy consumption structure and introduce relevant policies to improve its transportation infrastructure and technological innovation.

7.	Shuaib Lwasa a, Frank Mugagga a, Bolanle Wahab b, David Simon c, John Connors d, Corrie Griffith e	Urban and peri-urban agriculture and forestry: Transcending poverty alleviation to climate change mitigation and adaptation	Urban and peri-urban agriculture (UPAF) studies have traditionally focused on issues such as livelihoods, poverty reduction, and environmental pollution. However, recent research has emphasized the ecological importance of UPAF and the potential for it to provide ecosystem services, support adaptation and mitigation of climate change, and alleviate food	Systematic review included 213 papers using an ecosystem services framework. Peer-reviewed literature used Web of Science and Google Scholar. Fieldwork conducted in Kampala and Ibadan with key informant interviews.	A total of four UPAF sites were examined in detail in Ibadan and four in Kampala. Data on production scales, nutrient recovery, mitigation potential and evidence of adaptive UPAF were collected during fieldwork. As part of fieldwork, we also interviewed policy makers in four focus group discussion workshops organized in Ibadan and Kampala.	This study finds that urban and peri-urban agriculture (UPAF) is an important strategy for sub-Saharan African urban livelihoods, food security, and mitigation of and adaptation to climate change. Well-managed UPAF systems can absorb greenhouse gases, reduce urban heat island effects, and promote urban food security. To build urban resilience, it is necessary to address the development deficit, reform institutional architecture	Urban agriculture (UPAF) faces limitations related to production and distribution systems, including land competition, biological and chemical contamination, and infrastructure challenges like water accessibility and transportation. Non-recognition of UPAF as a distinct urban land-use component and its non-integration in land-use and urban and regional planning policies is a major limitation. The economic value of urban agriculture remains an emerging issue, and the

			security and poverty. The framework for this research considers UPAF as an approach to mitigate greenhouse gas emissions and maintain a balance of food supply, livelihoods, and ecosystem services along the urban-rural gradient.			and policy, and share knowledge and resources to scale out best practices.	indirect costs associated with ecosystem services that city authorities and managers require to promote UPAF are less known.

8.	Mairéad Connolly1, Yuli Shan4,1,2, Benedikt Bruckner1, Ruoqi Li1,3 and Klaus Hubacek4, 1	Published 15 July 2022 2022 The Author(s). Published by IOP Publishing	This study examines household carbon footprints in urban and rural areas across 90 developing countries, finding large inequalities and high per capita carbon footprints in urban areas. Electricity consumption and transport are the largest contributors to total carbon footprints, with high-income rural households having the highest per capita footprint.	The EEMRIO framework is used to calculate interregional trade and total output of sectors. Technical coefficients are calculated with the A-matrix, and final demand is calculated using the Leontief inverse matrix. CO2 coefficients are used to calculate consumption-based carbon emissions.	This study uses two datasets: WBGCD and GTAP 10 MRIO, and matching them requires dividing the aggregate region into the relevant country size, inflating consumer price indices, and bridging the 25 sectors of WBGCD with the 65 sectors of the final demand vector in GTAP.	The EEMRIO framework is used to calculate interregional trade and total output of sectors. Technical coefficients are calculated with the A-matrix, and final demand is calculated using the Leontief inverse matrix. CO2 coefficients are used to calculate consumption-based carbon emissions.	Household surveys taken at different times and the exclusion of unmarketed energy sources affect the accuracy of carbon footprint data. Some low-income countries and missing data also impact results. The use of older data may introduce uncertainties.

9.	Glen P. Peters* and Edgar G. Hertwich	CO2 Embodied in International Trade with Implications for Global Climate Policy	Globally over 5 Gt of CO2 are embodied in international trade and this has strong implications for the participation in and effectiveness of post-Kyoto climate policy.	EET's relevance to climate policy is examined through direct analysis of environmental separation, carbon leakage, and trade-adjusted GHG emission inventories to understand pollution shifting and potential emission mitigation through trade.	Data for multiregional IOA is available, but it requires significant effort to convert country-level data into a consistent global data set. The GTAP has created data for CGE modeling with extensive coverage, but consistency and accuracy must be ensured due to voluntary data submissions.	International trade involves significant flows of anthropogenic carbon, with over 5.3 Gt of CO2 emissions embodied in trade flows. Annex B countries are net importers of CO2 emissions, and EET varies depending on country characteristics. High EET can negatively affect competitiveness and participation in emission reductions. Carbon leakage is a challenge for global climate policy, and encouraging coalition formation may be a	The main limitation of the dataset is the considerable task of converting country data to a consistent global dataset. However, the Global Trade Analysis Project has constructed a dataset for multiregional IOA that covers 87 countries and 57 industry sectors.

						way to reduce trade impacts on individual countries. Regional approaches may be more effective in designing a global framework.	

10.	Jemyung Lee, Oliver Taherzadeh, Keiichiro Kanemoto	The scale and drivers of carbon footprints in households, cities and regions across India	This study discusses the development of the first district-level carbon footprint accounts for India using micro consumption data from 203,313 households and 623 districts. District-level assessments are crucial for better distinguishing carbon emissions related to different consumers, households and social groups. However, the development of such accounts remains limited.	The two main approaches to district-level carbon footprint assessment are areal CF and Personal CF. Areal CF aggregates total expenditure within a given area, while Personal CF focuses solely on residential spending, allowing for a more detailed examination of individual consumption habits. This study uses a Personal CF approach to map the carbon footprint of Indian households.	The study used the Consumer Expenditure Survey (CES) data from the National Sample Survey Organisation (NSSO) of India in the year 2011 and 2012, which captured household expenditure on food, energy, consumable goods, and services. The study also linked the CES data to the Eora multi-regional input-output (MRIO) database developed by Lenzen	A carbon footprint database linking micro and macro data shows the districts, activities, and groups responsible for carbon emissions in India. The database is available online and is discussed in the following sections.	This study has several limitations, including data availability and quality, methodological assumptions, and scope limitations. It is also limited by the large size of India's informal economy, the self-reported nature of household survey data, and the coarse sectoral and spatial resolution of the Eora database. In addition, the study is based on data from 2011-2012 and certain assumptions were made in calculating household and individual carbon footprints.

					et al. (2012, 2013) to enable a global supply chain-wide carbon footprint assessment. The Eora database provides detailed information for 116 commodities, including food products and consumable goods.		

3. Objective of the project:

This project aims to investigate the relationship between variables such as global trade, poverty, and carbon footprints and understand their impact on each other. The analysis done in this project will provide insights into the current state of the world's trade, poverty, and carbon emissions and explore how these trends are likely to shape our future. Furthermore, through these analyses of datasets, the project would look upon several hypotheses on the relationships between each variable and suggest actions policymakers can take to help achieve a more sustainable future.

4. Innovation component in the project:

Most of the works available are done either in poverty or trade alone. We are trying to combine both Global trade and poverty and try to analyze how they impact the carbon footprint.As HDI(Human Development Index) increases the carbon footprint increases. In our project, we try to find such mappings between countries and carbon emissions. We map poverty with carbon footprint and trade with carbon footprint and try to find relations between them.So, for mapping these we try to merge 3 different datasets(MPI, Carbon footprint, and trade datasets) to achieve the required result.

5. Work done and implementation

a. Methodology adapted:

Our whole project would involve plotting attributes and correlating the relationships between each different variable, factor, and attribute. This would involve representations of carbon footprints in developing vs developed countries, GDP per capita, and population; Human Development Index(HDI), exports, and imports between continents and how each of them impacts carbon footprint. Through these plots, we would accordingly develop hypotheses and look out for answers for more sustainability.

b. Dataset or Data collection:

For this project, the dataset used is a combination of 3 different datasets.

- ➔ Global Ecological Footprint,
- ➔ Global Commodity Trade Statistics,
- ➔ Multidimensional Poverty Measures

All of these datasets are obtained from a crowd-sourced platform named Kaggle.

We will merge all these 3 datasets into 1 for fulfilling the objective of this project..

Global Ecological Footprint dataset contains columns such as:

- Country: Country Name
- Region: Continent Name
- Population: Population Count in millions
- HDI: Human Development Index
- GDP: Gross Domestic Produce per capita
- Cropland Footprint: Amount of land used for crop production
- Grazing Footprint: Amount of land required for production of feed for livestock

- Carbon Footprint: Amount of greenhouse gas emitted
- Fish Footprint: Total area of marine habitats needed for fishing

Global Commodity Trade Statistics dataset contains columns such as:

- Country or Area: Country name of record
- Year: Year in which the trade has taken place
- Customs Code: It comprises about 5,000 commodity groups; each identified by a six digit code, arranged in a legal and logical structure
- Commodity: The description of a particular commodity code, i.e. "Horses, live pure-bred breeding"
- Flow: Flow of trade i.e. Export, Import
- Trade Value: Value of the trade in USD
- Weight: Weight of the commodity in Kilograms
- Quantity Name: A description of the quantity measurement type given the type of item (i.e. Number of Items, Weight in Kilograms, etc.)
- Quantity: Count of the quantity of a given item based on the Quantity Name
- Category: Category to identify commodity

Multidimensional Poverty Measures dataset contains columns such as:

- ISO: Unique ID for country
- Country: country name
- MPI Urban: Multi-dimensional poverty index for urban areas within the country
- Headcount Ratio Urban: Poverty headcount ratio (% of population listed as poor) within urban areas within the country
- Intensity of Deprivation Urban: Average distance below the poverty line of those listed as poor in urban areas
- MPI Rural: Multi-dimensional poverty index for rural areas within the country
- Headcount Ratio Rural: Poverty headcount ratio (% of population listed as poor) within rural areas within the country
- Intensity of Deprivation Rural: Average distance below the poverty line of those listed as poor in rural areas

c. Tools used:

Jupyter Notebook: This is a popular open-source web application for data analysis and visualization. It offers an interactive environment for writing and running code, visualizing data, and creating documents. It supports multiple programming languages, making it versatile for performing different tasks. It is also easily shareable, allowing for collaboration and dissemination of results. Thus, this environment seemed the most appropriate for our project.

Python Libraries:

Numpy: This library provides support for arrays and matrices, allowing for efficient operations on large datasets. It includes functions for linear algebra, random number generation, and signal processing, making it a comprehensive tool for data analysis and scientific computing.

Pandas: It allows for data manipulation and analysis with functions like groupby, merge, and pivot tables, and also integrates well with other popular libraries such as NumPy and Matplotlib.It provides fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive.

Plotly: An python library for creating interactive, web-based visualizations. It provides a wide range of chart types and customization options, allowing us to create sophisticated visualizations with ease. All visualizations in this project were plotted using this library.

Math: This library includes functions for basic mathematical operations like square roots and logarithms, as well as more advanced functions such as trigonometry, hyperbolic functions, and special functions. Some of our analyses will involve some math functions, thus needing us to use this library.

d. Screenshot and Demo along with Visualization: (Pre-processing)

1. Initial Data Loading:

MPI Dataset:

[3]:

```
countries = pd.read_csv("../input/mpi/MPI_national.csv")
print(countries.shape)
countries.head()
```

```
(102, 8)
```

	ISO	Country	MPI Urban	Headcount Ratio Urban	Intensity of Deprivation Urban	MPI Rural	Headcount Ratio Rural	Intensity of Deprivation Rural
0	KAZ	Kazakhstan	0.000	0.0	33.3	0.000	0.09	33.3
1	SRB	Serbia	0.000	0.1	41.4	0.002	0.50	40.3
2	KGZ	Kyrgyzstan	0.000	0.1	40.2	0.003	0.70	37.1
3	TUN	Tunisia	0.000	0.1	35.6	0.012	3.18	38.7
4	ARM	Armenia	0.001	0.2	33.3	0.001	0.39	36.9

Carbon Footprint Dataset:

[4]:

```
footprint = pd.read_csv("../input/ecological-footprint/countries.csv")
print(footprint.shape)
footprint.head()
```

(188, 21)

[4]:

	Country	Region	Population (millions)	HDI	GDP per Capita	Cropland Footprint	Grazing Footprint	Forest Footprint	Carbon Footprint	Fish Footprint	Total Ecological Footprint	Cropland	Gra L
0	Afghanistan	Middle East/Central Asia	29.82	0.46	$614.66	0.30	0.20	0.08	0.18	0.00	0.79	0.24	
1	Albania	Northern/Eastern Europe	3.16	0.73	$4,534.37	0.78	0.22	0.25	0.87	0.02	2.21	0.55	
2	Algeria	Africa	38.48	0.73	$5,430.57	0.60	0.16	0.17	1.14	0.01	2.12	0.24	
3	Angola	Africa	20.82	0.52	$4,665.91	0.33	0.15	0.12	0.20	0.09	0.93	0.20	
4	Antigua and Barbuda	Latin America	0.09	0.78	$13,205.10	NaN	NaN	NaN	NaN	NaN	5.38	NaN	

Global Trade Dataset:

[5]:

```
trade = pd.read_csv("../input/global-commodity-trade-statistics/commodity_trade_statistics_data.csv"
trade = trade.rename(columns={'country_or_area': 'Country'})
print(trade.shape)
trade.head()
```

[5]:

	Country	year	comm_code	commodity	flow	trade_usd	weight_kg	quantity_name	quantity	category
0	Afghanistan	2016	10410	Sheep, live	Export	6088	2339.0	Number of items	51.0	01_live_animals
1	Afghanistan	2016	10420	Goats, live	Export	3958	984.0	Number of items	53.0	01_live_animals
2	Afghanistan	2008	10210	Bovine animals, live pure-bred breeding	Import	1026804	272.0	Number of items	3769.0	01_live_animals
3	Albania	2016	10290	Bovine animals, live, except pure-bred breeding	Import	2414533	1114023.0	Number of items	6853.0	01_live_animals
4	Albania	2016	10392	Swine, live except pure-bred breeding > 50 kg	Import	14265937	9484953.0	Number of items	96040.0	01_live_animals

Since in the dataset, at different timestamps, each country's trade is noted separately. Thus to get the total trade we Consolidated the total trade in USD and the type of flow (export/ import/ re-import) among all the counties using a python function given below.

```
[6]:
# recode levels
def recode(levels):
    if levels == 'Re-Export':
        return 'Export'
    else:
        return levels

trade['flow'] = trade['flow'].apply(recode)
country_trade = trade.groupby(["Country","flow"])["trade_usd"].sum().reset_index()
print(country_trade['flow'].value_counts())
# just query the exports leave out the imports
country_exptrade = country_trade.loc[(country_trade['flow'] == 'Export')].reset_index()
country_exptrade.head()
```

```
Import       208
Export       206
Re-Import    102
Name: flow, dtype: int64
```

[6]:

	index	Country	flow	trade_usd
0	0	Afghanistan	Export	8780222349
1	2	Albania	Export	47544871187
2	5	Algeria	Export	1764159930121
3	8	Andorra	Export	3644090536
4	11	Angola	Export	868304901687

2. Merging Data

Since we have 3 different datasets of our attributes, we merged all of them into a single dataset for our further analysis.A snippet of code is given below:

[8]:
```python
MERGE = footprint.merge(countries, how="outer", on="Country")
print(MERGE.shape)
MERGE
```

(196, 28)

[8]:

Country	Region	Population (millions)	HDI	GDP per Capita	Cropland Footprint	Grazing Footprint	Forest Footprint	Carbon Footprint	Fish Footprint	Total Ecological Footprint	C
Afghanistan	Middle East/Central Asia	29.820	0.460000	$614.66	0.30	0.20	0.08	0.18	0.00	0.79	
Albania	Northern/Eastern Europe	3.160	0.730000	$4,534.37	0.78	0.22	0.25	0.87	0.02	2.21	
Algeria	Africa	38.480	0.730000	$5,430.57	0.60	0.16	0.17	1.14	0.01	2.12	
Angola	Africa	20.820	0.520000	$4,665.91	0.33	0.15	0.12	0.20	0.09	0.93	
Antigua and Barbuda	Latin America	0.090	0.780000	$13,205.10	NaN	NaN	NaN	NaN	NaN	5.38	
Argentina	Latin America	41.090	0.830000	$13,540.00	0.78	0.79	0.29	1.08	0.10	3.14	
Armenia	Middle East/Central Asia	2.970	0.730000	$3,426.39	0.74	0.18	0.34	0.89	0.01	2.23	
Aruba	Latin America	0.100	NaN	NaN	NaN	NaN	NaN	NaN	NaN	11.88	
Australia	Asia-Pacific	23.050	0.930000	$66,604.20	2.68	0.63	0.89	4.85	0.11	9.31	
Austria	European Union	8.460	0.880000	$51,274.10	0.82	0.27	0.63	4.14	0.06	6.06	

[9]:
```python
MERGE2 = MERGE.merge(country_exptrade, how="outer", on="Country")
MERGE2 = MERGE2.drop(columns=['index', 'flow'])
MERGE2 = MERGE2.sort_values(['Country'], ascending=[True])
print(MERGE2.shape)
MERGE2.head()
```

(223, 29)

[9]:

	Country	Region	Population (millions)	HDI	GDP per Capita	Cropland Footprint	Grazing Footprint	Forest Footprint	Carbon Footprint	Fish Footprint	Total Ecological Footprint	Cr
0	Afghanistan	Middle East/Central Asia	29.82	0.46	$614.66	0.30	0.20	0.08	0.18	0.00	0.79	
1	Albania	Northern/Eastern Europe	3.16	0.73	$4,534.37	0.78	0.22	0.25	0.87	0.02	2.21	
2	Algeria	Africa	38.48	0.73	$5,430.57	0.60	0.16	0.17	1.14	0.01	2.12	
199	Andorra	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	
3	Angola	Africa	20.82	0.52	$4,665.91	0.33	0.15	0.12	0.20	0.09	0.93	

3. Preprocessing/ Analysis:

Getting Carbon Footprint Dataset Description:

```
[11]: MERGE2['ExpTrade_Mill'] = MERGE2['trade_usd']/1000000
      MERGE2.columns
      MERGE2['Carbon Footprint'].describe()
```

```
[11]: count    177.000000
      mean       1.798927
      std        1.887528
      min        0.000000
      25%        0.420000
      50%        1.140000
      75%        2.600000
      max       12.650000
      Name: Carbon Footprint, dtype: float64
```

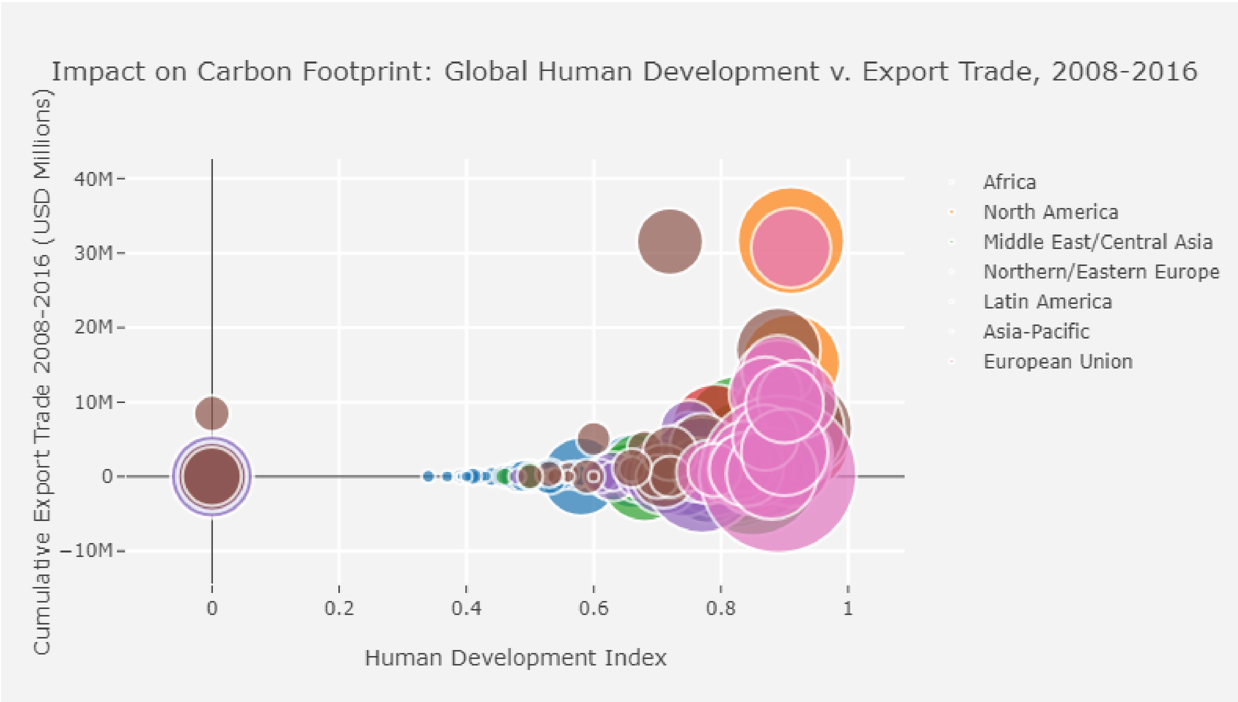
A series of operations to fill missing values:

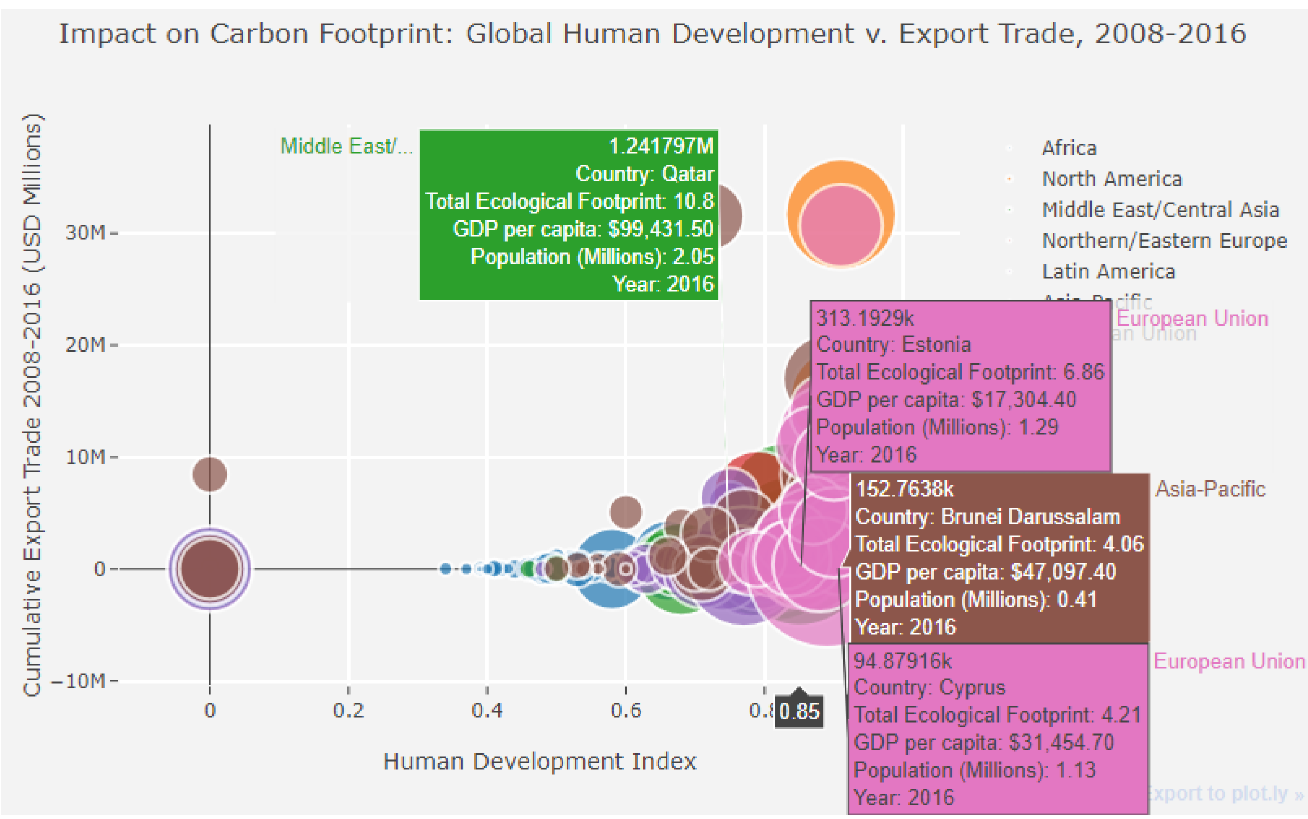
```
df_2007 = MERGE2
df_2007['HDI'].fillna(0, inplace=True)
df_2007['ExpTrade_Mill'].fillna(0, inplace=True)
df_2007['Total Ecological Footprint'].fillna(0, inplace=True)
df_2007['GDP per Capita'].fillna(0, inplace=True)
df_2007["Population (millions)"].fillna(0, inplace=True)
df_2007["Carbon Footprint"].fillna(0, inplace=True)
```

4. Visualizations

<u>Note: the size of the bubble represents a particular country's Carbon Footprint</u>

1. Global Human Development VS Export Trade





- The scatter plot visualizes the relationship between two variables: "Human Development Index (HDI)" and "Exported Trade (Millions)" for different regions of the world.

- There are five Scatter traces, one for each of the following regions: Africa, North America, Middle East/Central Asia, Northern/Eastern Europe, and Latin America/Caribbean. Each trace consists of the x and y values (HDI and Exported Trade (Millions)) for each country in the region, along with the marker size (based on Carbon Footprint).

Insights drawn from this plot:

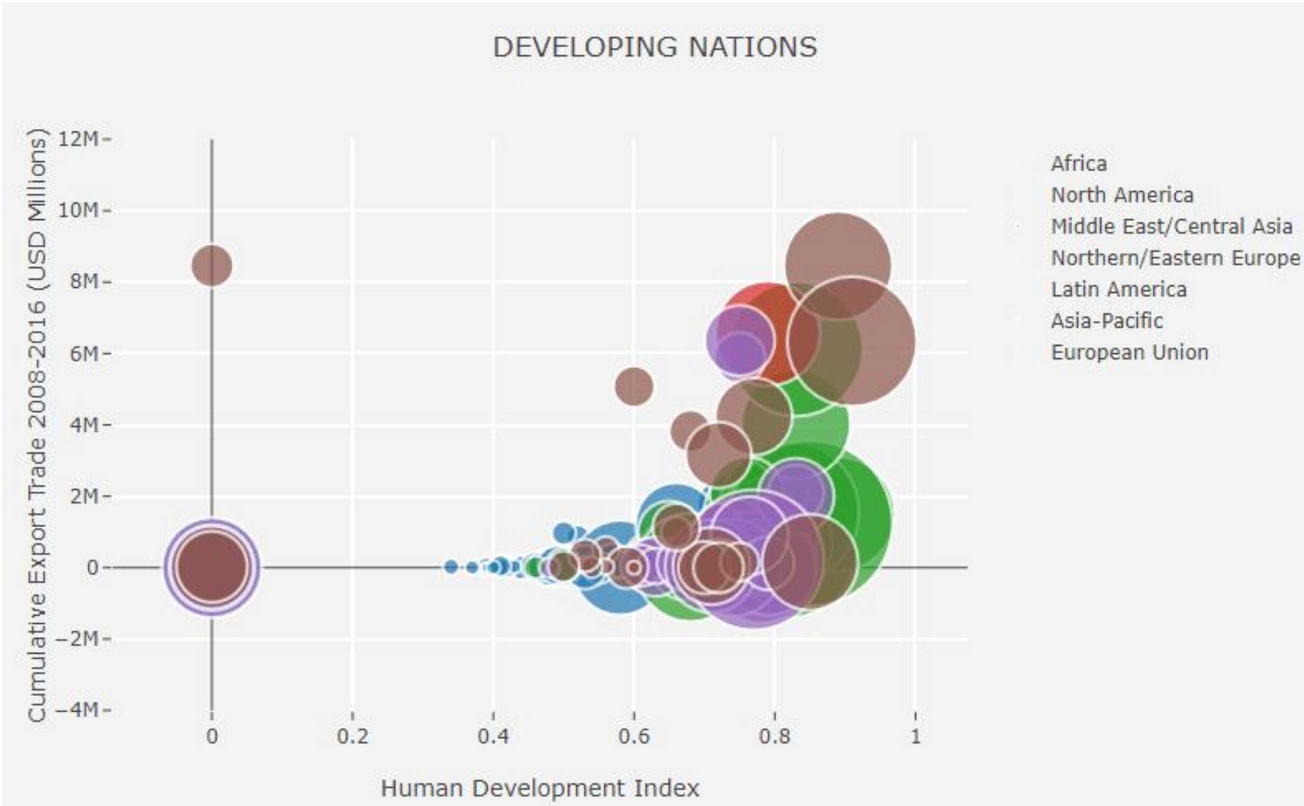
Let's start with African countries by filtering out all other regions:

- Carbon Footprint: bubbles are relatively small comparing to other regions, indicating that African countries are not the main contributors to carbon emissions
- HDI: African countries have relatively lower Human Development Index (HDI), however as HDI increases, the bubbles size increases, inferring that as quality of living and development increases, carbon footprint also increases
- Trade: most of the African countries don't trade as much (under 5MM), and interesting observation is that countries that have higher HDI trade more, indicating that there is a positive relationship between trade and HDI.

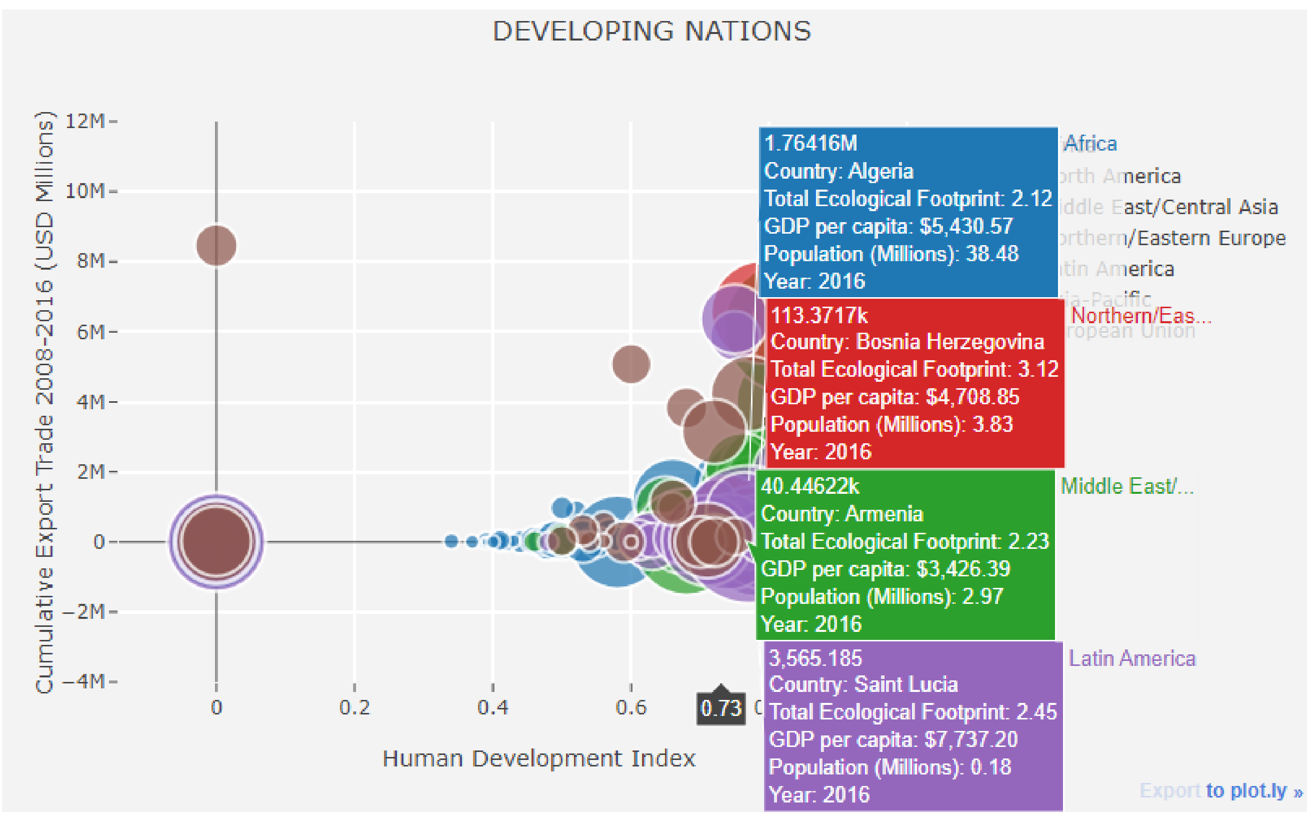
Next contrasting with First-World Countries: EU and North America

- Carbon Footprint: bubbles are relatively large comparing to Africa and other developing regions, indicating that First-world countries are the main contributors to carbon emissions.
- HDI: EU and NA countries have relatively higher HDI (> 0.8).
- Trade: most of the developed countries trade more.

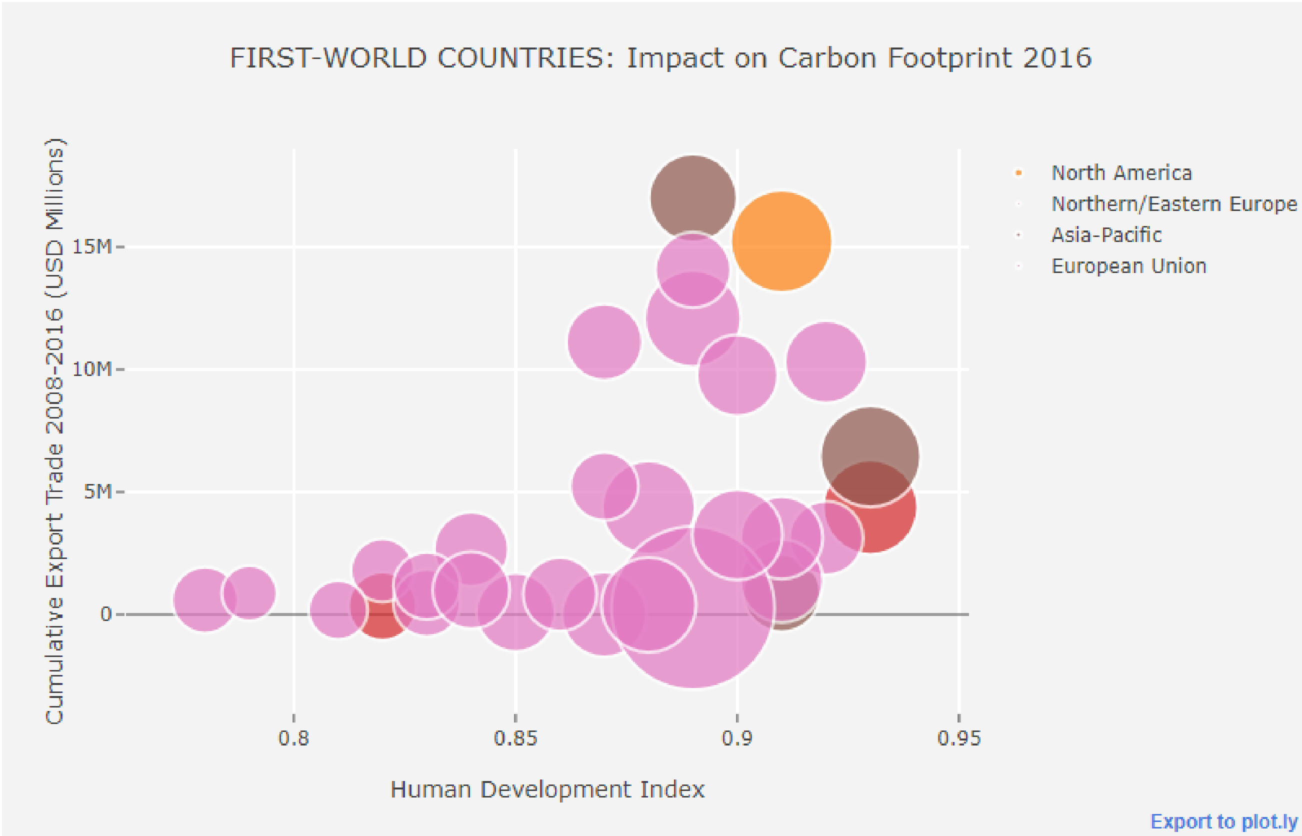
2. Developing vs First World Countries Impact on Carbon Footprints



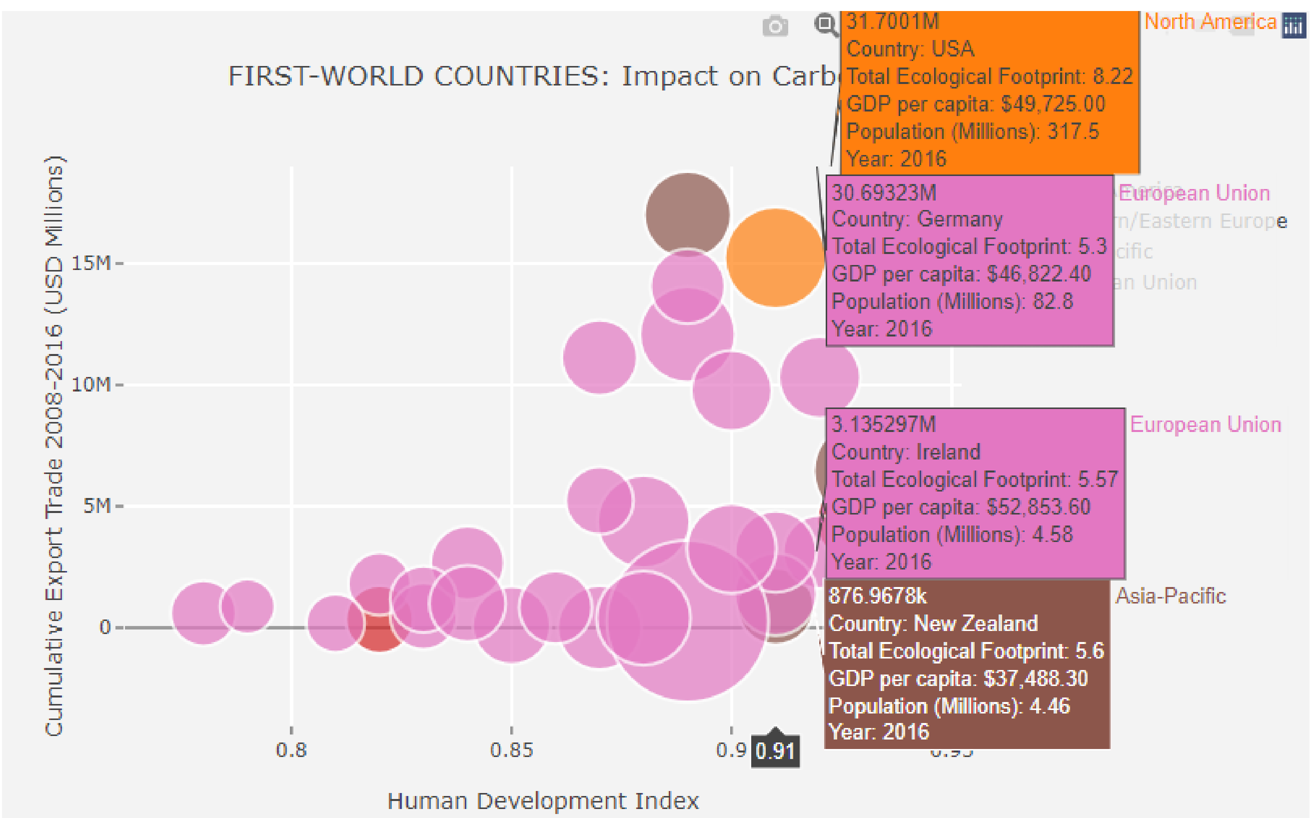
DEVELOPING NATIONS
Cumulative Export Trade 2008-2016 (USD Millions)
12M
10M
8M
6M
4M
2M
0
−2M
−4M
0
0.2
0.4
0.6
0.8
1
Human Development Index
Africa
North America
Middle East/Central Asia
Northern/Eastern Europe
Latin America
Asia-Pacific
European Union



DEVELOPING NATIONS
Cumulative Export Trade 2008-2016 (USD Millions)
12M
10M
8M
6M
4M
2M
0
−2M
−4M
0
0.2
0.4
0.6
0.73
Human Development Index
1.76416M
Country: Algeria
Total Ecological Footprint: 2.12
GDP per capita: $5,430.57
Population (Millions): 38.48
Year: 2016
Africa
113.3717k
Country: Bosnia Herzegovina
Total Ecological Footprint: 3.12
GDP per capita: $4,708.85
Population (Millions): 3.83
Year: 2016
Northern/Eas...
40.44622k
Country: Armenia
Total Ecological Footprint: 2.23
GDP per capita: $3,426.39
Population (Millions): 2.97
Year: 2016
Middle East/...
3,565.185
Country: Saint Lucia
Total Ecological Footprint: 2.45
GDP per capita: $7,737.20
Population (Millions): 0.18
Year: 2016
Latin America
Export to plot.ly »



FIRST-WORLD COUNTRIES: Impact on Carbon Footprint 2016
Cumulative Export Trade 2008-2016 (USD Millions)
15M
10M
5M
0
0.8
0.85
0.9
0.95
Human Development Index
North America
Northern/Eastern Europe
Asia-Pacific
European Union
Export to plot.ly



FIRST-WORLD COUNTRIES: Impact on Carb
Cumulative Export Trade 2008-2016 (USD Millions)
15M
10M
5M
0
0.8
0.85
0.9
0.91
Human Development Index
31.7001M
Country: USA
Total Ecological Footprint: 8.22
GDP per capita: $49,725.00
Population (Millions): 317.5
Year: 2016
North America
30.69323M
Country: Germany
Total Ecological Footprint: 5.3
GDP per capita: $46,822.40
Population (Millions): 82.8
Year: 2016
European Union
3.135297M
Country: Ireland
Total Ecological Footprint: 5.57
GDP per capita: $52,853.60
Population (Millions): 4.58
Year: 2016
European Union
876.9678k
Country: New Zealand
Total Ecological Footprint: 5.6
GDP per capita: $37,488.30
Population (Millions): 4.46
Year: 2016
Asia-Pacific

HYPOTHESIS 1:

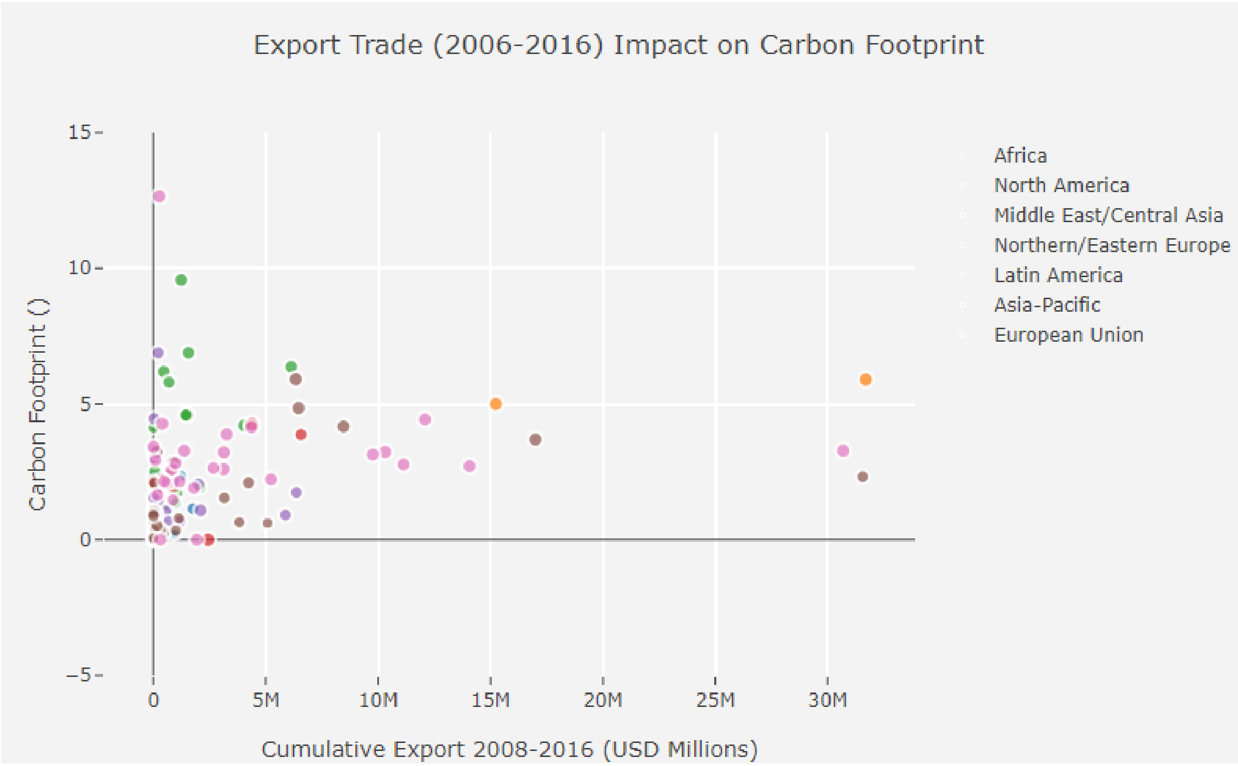
<u>More a country trades, the more carbon footprint</u>

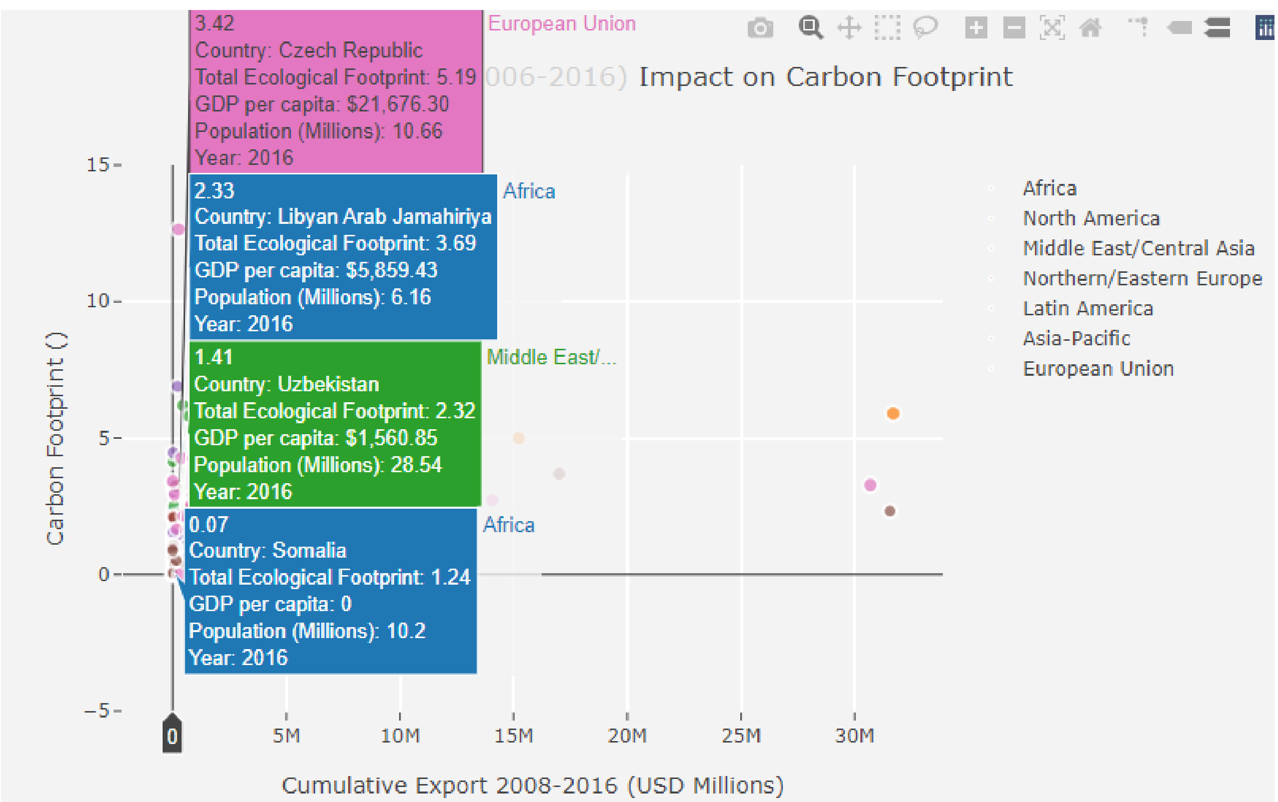
This suggests that there is a positive correlation between a country's level of trade and its carbon footprint. This hypothesis is based on the idea that increased trade results in increased economic activity, which in turn leads to greater energy consumption and greenhouse gas emissions.

In general, developing nations tend to have lower levels of trade and economic activity compared to first-world nations. As a result, they may have a lower carbon footprint per capita. However, as these nations continue to develop and increase their levels of trade and economic activity, their carbon footprint may also increase. This is because as their industries grow, they require more energy and resources, leading to higher greenhouse gas emissions.

On the other hand, first-world nations typically have higher levels of trade and economic activity, which can result in a larger carbon footprint per capita compared to developing nations. However, due to their advanced technology and infrastructure, they may also be more efficient in their energy use and have implemented more environmentally friendly policies.

3. EXPORT TRADE IMPACT ON CARBON FOOTPRINT





Insights drawn from this plot:

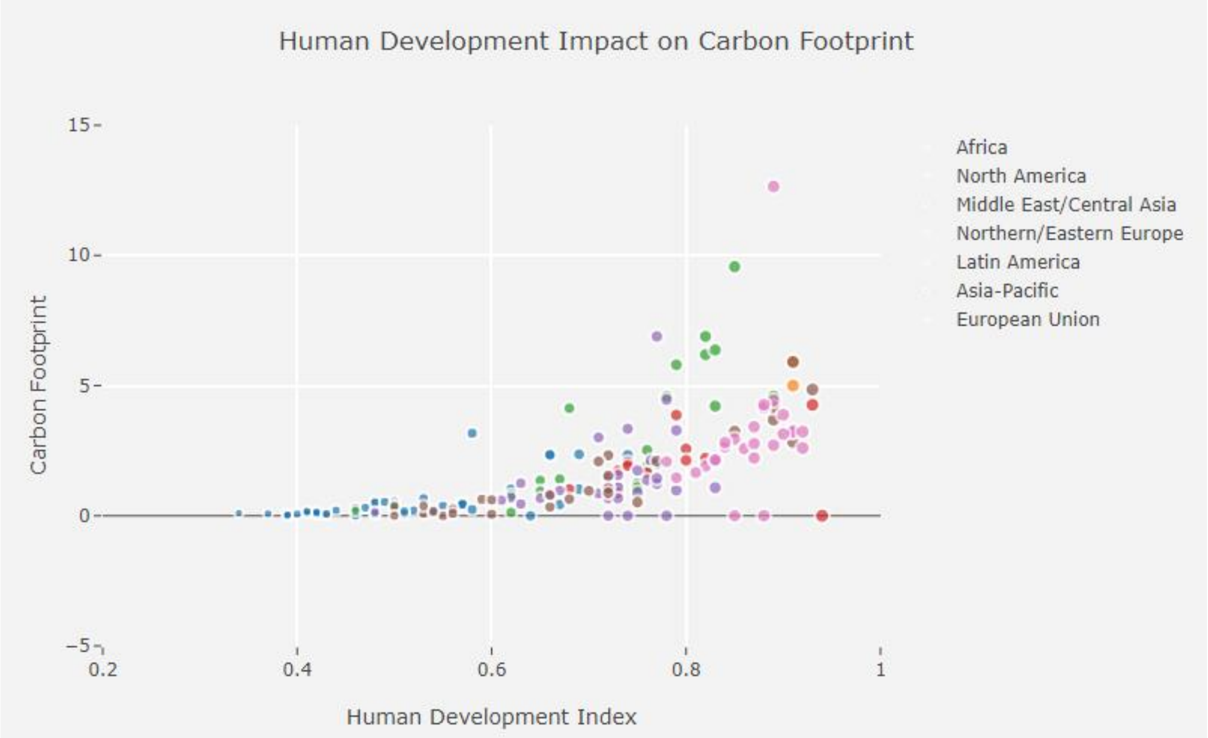
- There is an obvious postive relationship as Cumulative Export size increases, carbon footprint also increases, but variation also increases as export increases, suggesting there is a case of heteroscedacity.

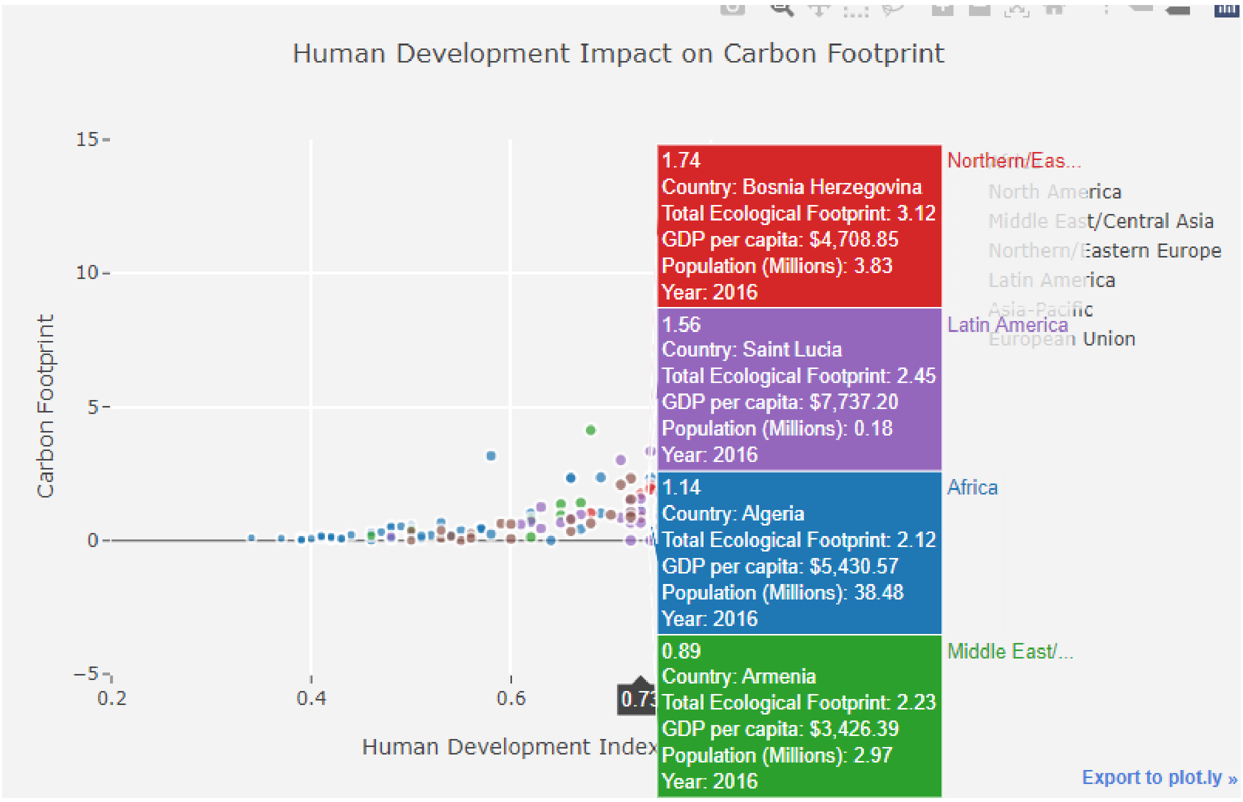
Hypothesis 2:

<u>More Poverty a country has, the more carbon footprint</u>

The relationship between poverty and carbon footprint is complex and influenced by other factors such as trade and economic development. Poverty alone may not necessarily lead to a larger carbon footprint. Developing nations with widespread poverty may rely on traditional and inefficient energy production methods, while developed nations with less poverty may have high levels of consumption and energy use. Exporting natural resources and engaging in high levels of trade can also contribute to a country's carbon footprint.

4. HUMAN DEVELOPMENT IMPACT ON CARBON FOOTPRINT





Insights drawn from this plot:

- One can infer that once a country reaches a certain standard of living (HDI = 0.6), it will accelerate its carbon emission output.
- At HDI = 0.6, carbon footprint has exponential growth; perhaps analyzing these countries can reveal kind of standards of living developing countries have.
- Countries that have HDI close to 0.6 can be considered as “critical” countries. Once they adopt existing infrastructure, raw materials, technology, and supply chain to move out of poverty, subsequently they will follow the same pattern of development and pollution that the current first-world nations went through.
- One can infer that export trading also increases as a market mechanism to increase standards of living by providing products that serves the next level of human development.
- For the Policy Makers and Supply Producers How do we:
  - Rethinking Manufacturing and Logistics for Developing Nations
  - Renegotiate Political Trade Agreements and allow Developing Nations Take the Lead

6. Final Conclusions

- Energy consumption structure has a mediating effect on the impact of energy poverty on carbon intensity.
- The higher economic growth and industrialization process for alleviation of extreme poverty may negatively affect the quality of the environment.
- Estimates indicate that by 2030 more than 100 million people could fall back into extreme poverty due to climate change, while over 200 million people could be displaced due to more frequent and severe climatic disasters.
- The threshold effect analysis shows that foreign trade has a significant dual-threshold impact on carbon emissions in different countries, depending on their economic development level.
- This leads to the identification of three threshold intervals, which reflect distinct stages of economic development.
- In the relationship between Export and Carbon Footprint shows that there is a threshold for which a country can be considered either developing or developed. This can be inferred from the sudden drop in the carbon footprint when the exports increase after around 5M.

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