Measuring Global Progress in Relation to Climate Change Indicators

FINAL PROJECT

GROUP 7

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Main Goal

This project will use the Earth as a study area in order to evaluate human impact on climate change. The goal of our project is to measure the progress of each country which will be specifically dependent on the relationship between the chosen indicators. The 13 chosen indicators are classified under 4 identified measures—population, environment, world development, and education. The progress of the countries will be analyzed from a perspective that incorporates the status between its stage of development and global impact. The purpose is to develop an international index using ArcGIS software that will illustrate a ranking of the countries based on their current ability to fulfill the environmental, economic, and social needs of the population. Overall, a higher ranking shows which country has progressed more towards sustainability in that it approaches development without compromising the needs of future generations. In the end, the index measures 'good governance' of a country.

Background

The risk of large-scale climate change is one of the biggest issues facing the world today. It has erupted an increased consensus from the scientific community around the world. The conceivable negative consequences from this extreme event has provoked an international concern—more towards the reasons behind it. The complications that continue to rise often times are stimulated by human influences and products. Therefore, the responsibility for global emissions is heavily skewed by the lifestyle of human population. This project will project the indicators relative to human action.

PROBLEM STATEMENT

The problem statement is measuring the state of the world by United Nations indicators emphasizing the indicators that can often be disregarded in the process of acquiring human needs and desires. Our specific indicators correlate to matters of the environment, world development, population, and education. Environmentally, the indicators focus specifically on the emissions each country contributes to global climate change which goes hand in hand with population. Population indicators become an influential factor in the different circumstances of each country. The indicators subject to world development stress the rates of poverty and military expenditure. Climate change disrupts livelihoods, which affects families and their homes. Moreover, if a country cannot sustain itself economically or environmentally, it plays a contributing factor to the education aspect in that country. Hence, the reason to also bring attention to education indicators. All in all, the indicators will create an interdependent relationship in order to show the progress of the countries by an index—which is the goal of the project.

Scope and Characteristics

The scope of the study area was very broad—which was to use the Earth. There were no constraints on how to use the data. As a group, we chose what data we wanted to and determined how we wanted to evaluate it. As an open project, we were able to create our own composite indexes from measures and indicators. We collected data from the Geodatabase that was provided by the professor and data from State of the World United Nations Indicators, World Bank, and EDGAR database.

Based on readings, about 50% of global carbon emissions arise from the activities of around 10% of the global population, increasing to 70% of emissions from just 20% of citizens. Noting that carbon emissions are a great factor into a country's influence on climate change, we took that into account when determining the weight of each measure—making environmental indicators weigh more. World development was second, followed by education, and then population. We assessed the breakdown by also accounting for which indicators become a consequence of the effects of a main contributing indicator.

In addition, it was important to realize that there were holes in the data, which can skew the data. Also, some data sets did not include countries or countries were not given values. Hence, the accuracy of our results will not yield to 100%.

Objectives

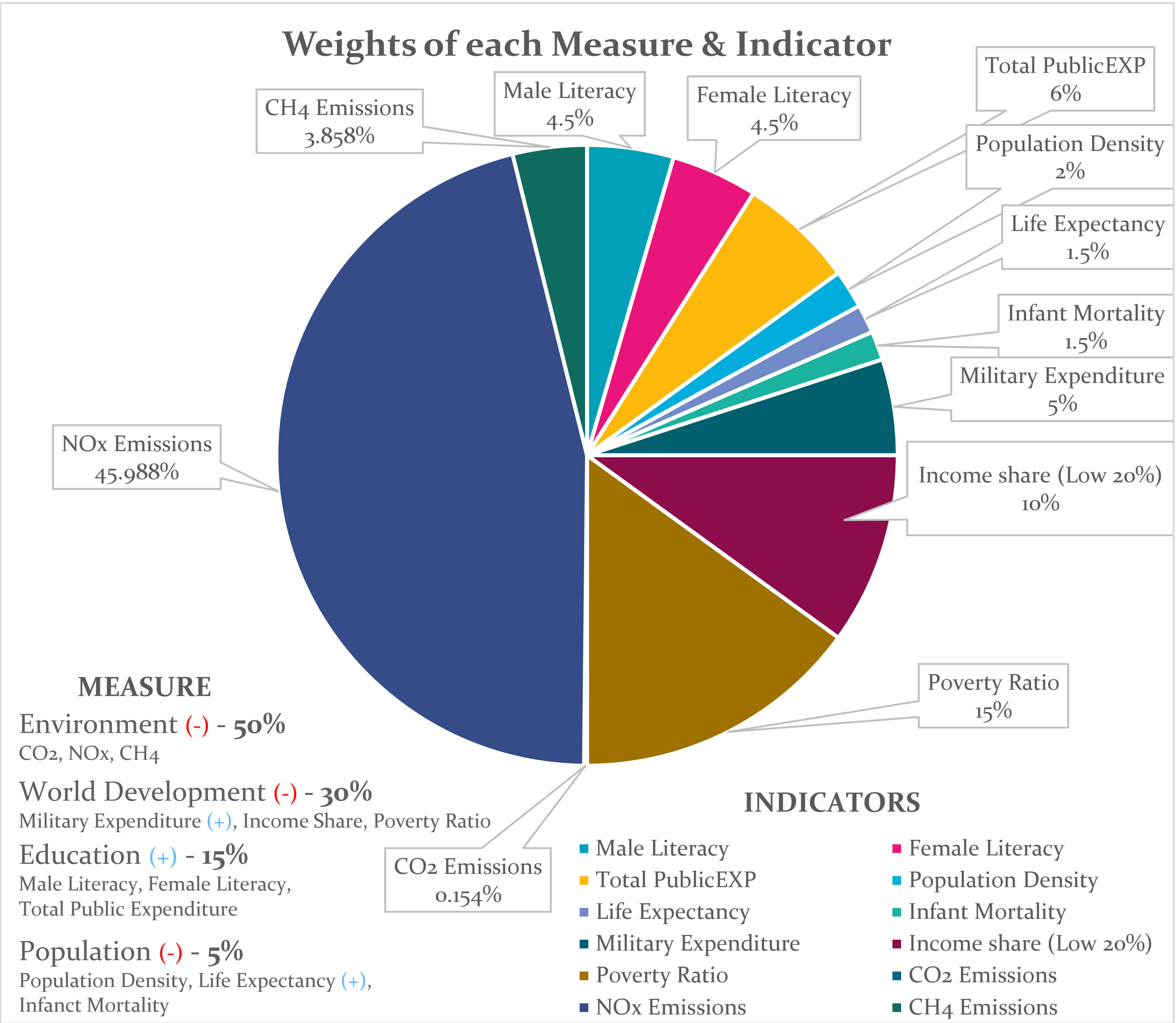
This project was designed to acknowledge the huge asymmetry between human consequences and climate change. Through ArcGIS software, we wanted to create datasets that combined the indicators expecting that there was a relationship between the indicators and the country's position on the index. More importantly, we wanted to see which indicators would overlap giving us a better understanding for the rank each individual country was given.

Our 4 measures included environment, population, world development, and education. Environment included 4 indicators: methane emission per country (per capita), CO_2 emission per country (per capita), NO_2 emission per country (per capita), Global Warming Potential per country (per capita) (weighted calculation = (co2*1) + (NOx*298) + (CH4*25)). Population included 3 indicators: Population per density, life expectancy, and infant mortality. World Development included 3 indicators: poverty percentage per population, poverty ranking by country, and percentage of GDP on military expenditures. Education included 3 indicators: female literacy, male literacy, and total expenditure on education as total of government expenditure.

Methodology

As a group, we initiated with wide ranges of indicators such as healthcare, transportation, carbon emissions, literacy rate, GDP, and human development. We realized it was important to choose data that we could connect and eventually see an interdependent relationship further in the project's research process. After eliminating different topics, we chose four measures significant to our means of research. We categorized each indicator to its respective measure displaying an understandable association.

Since some of the data came from different sources, it was in different formats. Before adding it to ArcGIS, the data had to be weighted. *[Weights of each indicator is shown in the Pie chart below.]* Weighing our indicators helped us organize our data by evaluating which indicators weighed more in our map in displaying the ranking of the countries. To weigh the indicators and measures, we created a pie chart, called Weight of Each Indicator and Measure, to show the breakdown of each sections' contribution to a country's status using a percentage system out of 100 percent.



Excel Spreadsheets allowed us to format the data so that all the data had a common denominator. Using Excel, the data for each indicator was represented as a percentage (a country's contribution to the globe) in order to combine the indicators for each measure. The weight of the indicator was calculated into each indicator's percentage. A sheet was then created to be the index for the measure where the sum of the percentages of the indicators of each individual country was calculated. A final sheet, the Country Index, summed up all of the measures' percentages to create a final number for each country—the negative indicators (-) were subtracted, and the positive indicators (+) were added. *[Note: Refer to Pie Chart for which indicators depending on the measure are positive or negative. Symbols are noted.]* In the end, a higher value signified that the country was in a better position than those with lower values. Finally, the data was added to ArcGIS to create a final map where techniques of symbology were applied to illustrate the overall country rankings basing on all four measures (including its indicators).

ENVIRONMENTAL

Our group decided that the most important metric by which to measure each country's contribution to climate change is the anthropogenic activity which is detrimental to our planet. As such, we've weighted the environment as the biggest factor, at 50%. We first wanted to research a number of related statistics, such as energy generation methods, means of transportation, methods of waste disposal, agriculture, etc. Unfortunately, we discovered that the various sources of environmentally harmful pollution span much more than the scope of this section of the project. As a result, we decided to focus on the particular harmful emissions associated with all the aforementioned sources. Carbon dioxide, methane, and nitrogen oxides make up nearly 97% of all greenhouse gases emitted by all countries.

These three greenhouse gases are not equally harmful, however. Carbon dioxide, which is mainly emitted from motor vehicles and fossil-fueled energy facilities, is by far the most common greenhouse gas (nearly 81% of all greenhouse gases by volume). Methane typically comes from natural gas and organic digestion, and accounts for 10% of the total by volume. Nitrous oxides are also emitted alongside carbon dioxide but is much more harmful to the environment. The measure by which a gas contributes to global warming is called its global warming potential (GWP).

Since carbon dioxide is the most abundant greenhouse gas and is one of the least harmful in this regard, it is set as the standard, with a GWP equal to one. Methane and nitrogen oxides on the other hand, are 25 and 298 times more harmful than carbon dioxide to climate change, their GWPs are 25 and 298, respectively. To properly account for the GWP disparities between the three gases, the methane and nitrous oxide emissions were multiplied by their GWPs. Finally, each country's emissions data was changed to a percentage of the total world's emissions of greenhouse gases per capita, so better comparisons can be observed on a person-to-person basis.

POPULATION

The population data was collected from the provided Geodatabase. The component population values were recorded and then the relative global percentage of each value was found along with a multiplier based on the assumed importance of the figure. Then, the three component global percentage values were summed to provide a final figure for the global ranking index. The first indicator was population density—this is to find the contributions from people as individuals rather than a piece of a country; it would be inappropriate to say that America and Kenya could be considered equal since there's a massive gradient in population—among other things. The second indicator was life expectancy. Life expectancy is important for the lineage aspects of global scientist contributions to climate sciences. Elder populous grow wiser and therefore are more likely to contribute to the country's scientific advances and green practices. The third indicator was infant mortality. Infant mortality was weighted in considering the state of the population because raising a child who dies at 6 years old, in comparison to a child who grows to adulthood who could contribute to society in a beneficial manner, would expend more capital/environmental resources and yield little to no benefit.

WORLD DEVELOPMENT

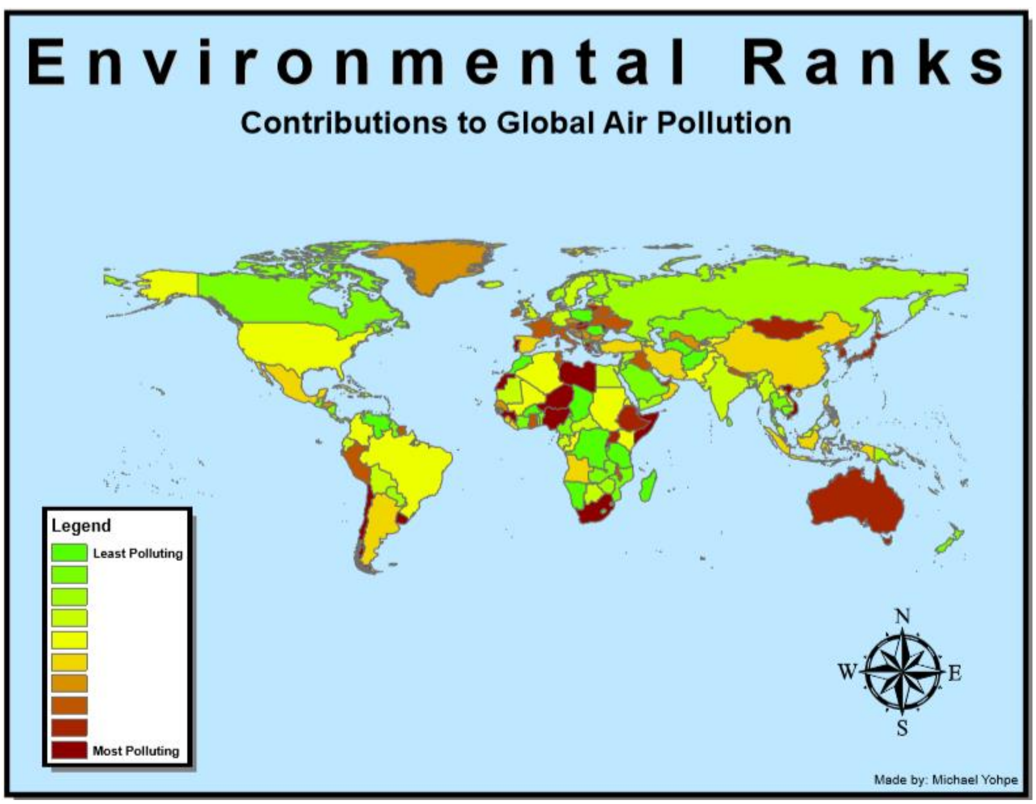
In this section of our project, we used world development and economic impact as a category with three subset indicators. The three indicators used to analyze world development and economic aspect of the current state of the world created a proportion between the country's population living in poverty, the percentage of gross domestic product spent on military expenditures, and the proportion of a country's population living on less than $1.25 a day. The total economic impact of each country contributed to 30% of the final ranking and each indicator for world development had a contribution percentage toward that total economic ranking. The percentage of GDP spent on military accounted for 5% of the total economic ranking, while the percentage of a country's population living in poverty accounted for 15%, and the percentage of a country's population living on less than $1.25 a day accounted for 10%. After analyzing our data in ArcGIS, it is very evident that the world has a large amount of economic inequality. The percentages of GDP spent on military expenditures did not contribute to a large portion of the economic ranking because countries like Germany only spent .83% of their GDP on military, however their GDP was ranked fourth out of all countries during that year. In that same time span of having the fourth highest GDP of all countries, Germany also had 15.6% of the population living in poverty which is why we used poverty as a bigger contributor towards final economic ranking.

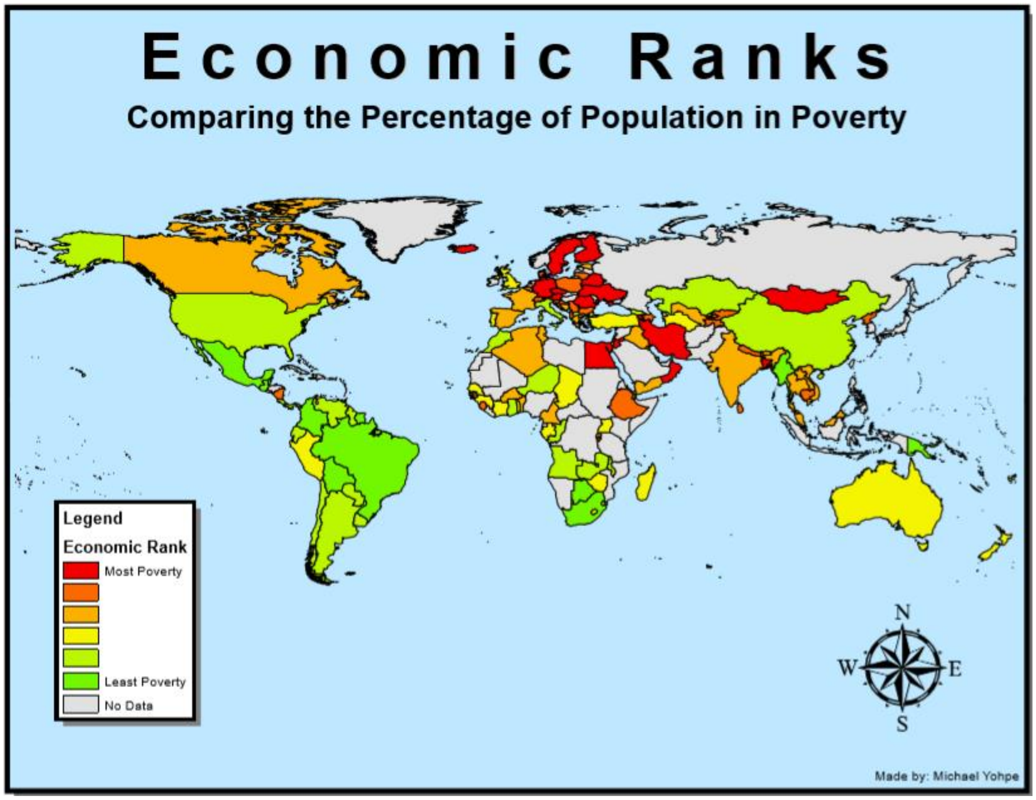
EDUCATION

The data for each indicator was obtained through the provided Geodatabase. The raw data was added to ArcGIS in order to see the data firsthand. The Female Literacy and Male Literacy indicators was the percentage of the female or male population (aged 15+) that is literate. The range of years used was 1990-2005 in order to capture the largest number of countries possible. These indicators were weighted at 4.5% each. The 3rd indicator was Total public expenditure on education as total of government expenditure—Expenditure of education as percent of the total government expenditure in 2002 (All sectors including pre-primary, primary, lower secondary, upper secondary, secondary, post-secondary). This indicator had a weight of 6%. In ArcGIS, the map was organized in order to show all three indicators (joining the indicators together). At first, different shades of color were applied to show which country had higher values. However, it was more effective to use symbols. Symbols were given for 5 different classes ranging from 0%-100% being literate. A larger symbol represented a countries higher literacy rate.

Results

The maps shown below illustrate each individual measures' rank of the countries in order of weight.




Economic Ranks
Comparing the Percentage of Population in Poverty
Legend
Economic Rank
Most Poverty
Least Poverty
No Data
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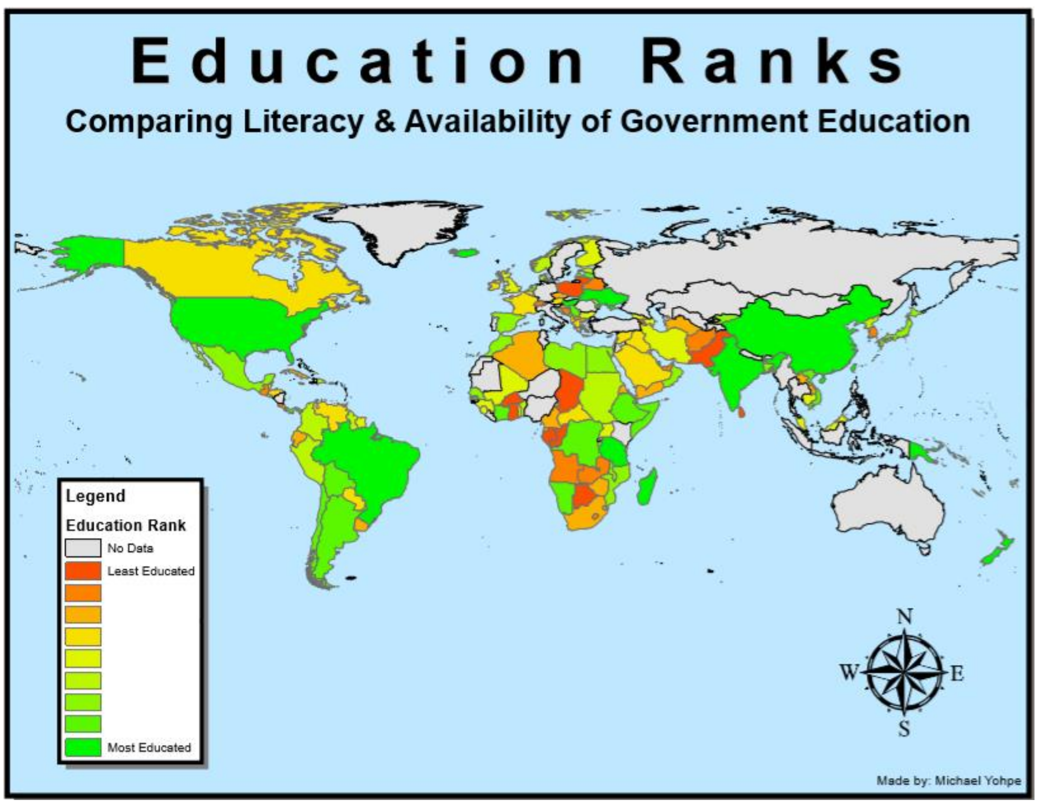
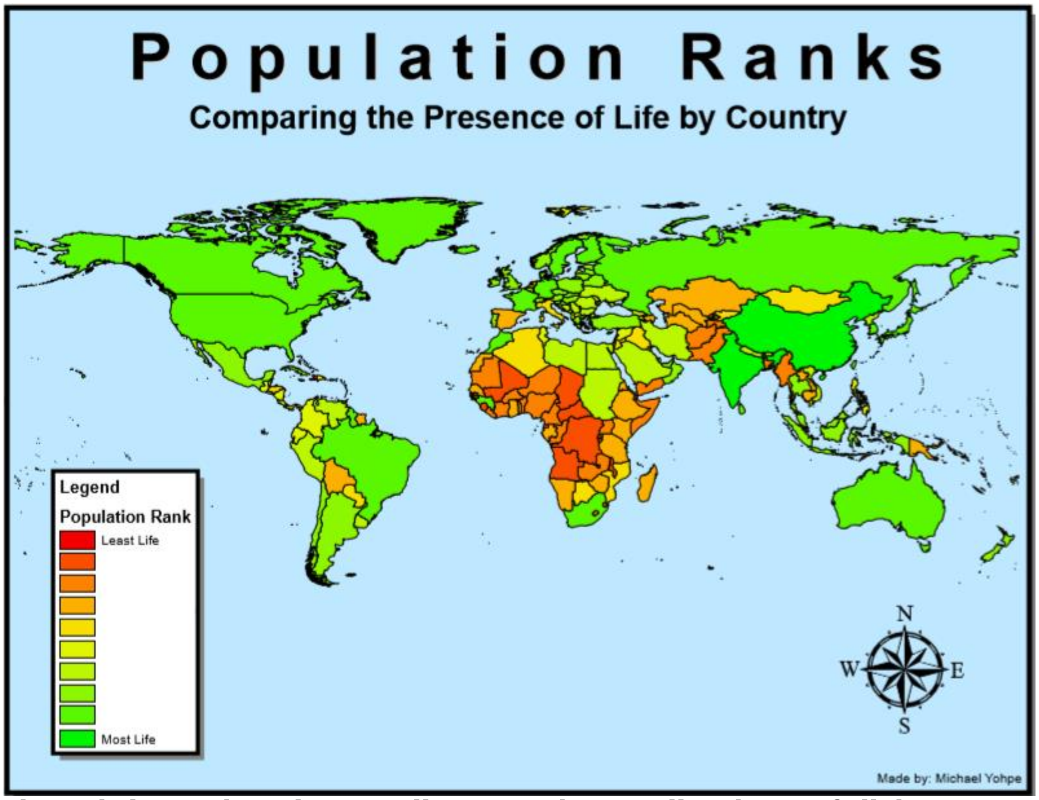
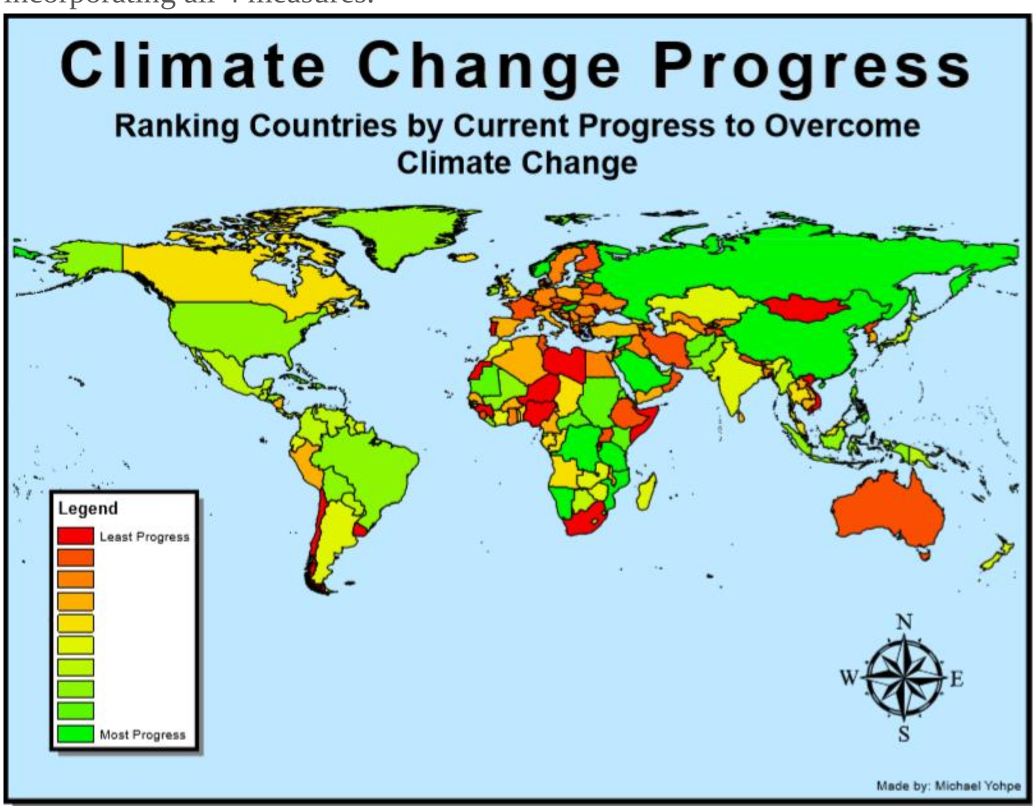

Education Ranks
Comparing Literacy & Availability of Government Education
Legend
Education Rank
No Data
Least Educated
Most Educated
N
W
E
S
Made by: Michael Yohpe



Shown below is the index map illustrating the overall rankings of all the countries incorporating all 4 measures.



DISCUSSION

Our rankings of the current state of the world was determined by creating four categories that measured economic impact, environmental impact, population, and education of every country—each with its subset of 3 to 4 indicators. For environmental impact the indicators analyzed were CO_2 emissions, CH_4 emissions, and NOX emissions. For education, the indicators measured were male literacy, female literacy, and public expenditure. For measuring population, the indicators were population density, life expectancy, and infant mortality rate. The economic impacts were measured by percentage of population living in poverty, proportion of the population living on less than $1.25 a day, and percentage of GDP spent on military expenditures.

We then took these indicators and created a percentage that we determined as a team that would contribute to the final ranking. For example, in the economic impact, the percentage of the population living in poverty was measured as 15% towards the total economic impact of 30% etc. *[Refer to Pie Chart for breakdown of percentages.]* After analyzing and ranking each category by their indicators, we combined all of the categories to create a final ranking. All indicators that were 'bad' were created as negative values, for example, a higher ranking for economic impact was 'bad' for countries because this meant more poverty. On the contrary, a high ranking for education was 'good' because this meant that more of the population is educated and literate. After the negative and positive values were assigned, we totaled all of our categories to create a final ranking of countries.

Some of the final country rankings were unexpected. We predicted to see countries like Iceland and the United States in the top ten, due to their progressive efforts in a number of subjects. However, they ended up somewhere in the middle (#131 and #67, respectively). We think this could be due to a few factors: inconsistencies in the data, ambiguous weightings of the data, and exclusions of countries from some of the data. First, not all sets of data were the same; some had more countries than others, and some referred to different years. Second, the weightings corresponding to the different subjects were estimates given by group members, and had little factual basis for actual importance. Finally, in some sets of data, many of the countries were left out, and no other data could be found. This resulted in different final ranking values than if there was actually data available. Below is tables of our top ten and bottom ten ranking countries.

TOP 10

	Country	Final Rank
1	Christmas Island	1.5014
2	China	1.0671
3	Hungary	0.4110
4	Taiwan	0.1374
5	Turks and Caicos Islands	0.1116
6	Saint Barthelemy	0.0750
7	Tanzania	0.0429
8	Namibia	0.0200
9	Mozambique	0.0195
10	Norway	0.0133

BOTTOM 10

	Country	Final Rank
228	Slovakia	-51.6227
229	South Africa	-52.4456
230	Montenegro	-63.1104
231	Western Sahara	-75.9716
232	Faroe Islands	-111.1542
233	Nigeria	-193.7905
234	Niger	-202.4017
235	Timor-Leste	-234.9798
236	Uruguay	-420.9755
237	Moldova	-1012.1774

Conclusion

Climate change impacts environment, social, and economic pillars of our society. By identifying indicators that show evidence of human consequences, we were able to study and analyze data. The purpose of this project was to use ArcGIS software in order to help us create an index relating measures and indicators that related to climate change. It emphasized how much some indicators have an impact on a country's status compared the rest of the globe. The index presented an overview of progress toward achieving the sustainability, which holds the countries accountable and aware of what we should be aiming for.

We achieved the purpose of this project by using ArcGIS software to create an index correlating measures and indicators relating to climate change.

Sources

3 datasets:

http://edgar.jrc.ec.europa.eu/overview.php?v=CO2andGHG1970-2016

https://data.worldbank.org/indicator/EN.ATM.METH.KT.CE?view=chart

https://unstats.un.org/unsd/environment/air_nox_emissions.htm

Environmental Section:

https://www.epa.gov/ghgemissions/understanding-global-warming-potentials