VISUALISING GLOBAL SOCIO-ECONOMIC TRENDS IN D3

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1 Introduction

This report presents a visualisation of an ensemble of datasets compiled by NASA's Socioeconomic Data And Applications Center (SEDAC) to visualise the correlation between socio-economic and environmental current and predicted performance based on IPCC scenarios.

The aim of this visualization is to put into perspective sustainable consideration and wealth in different countries, with an example of socio-economic impact: crop production, directly correlated to life prices and purchasing power.

Questions one might ask oneself when using this visualisation are for instance:

- How correlated is wealth to environmental concerns?
- How are emissions distributed worldwide?
- How have environmental concerns evolved?
- Are wealthy countries very likely to be impacted by food shortage?
- Are highly emitting countries very likely to be impacted by food shortage?
- What is the variation of food production depending on the emission path taken globally?

The data presented takes into account years from 1990 to 2100 on all countries of the globe. The indicators displayed are wealth per capita, greenhouse gas emissions, environmental performance indices and crop production.

The live version of our visualisations can be found at abhaydmathur.github.io/sedac-vis, while a condensed version of this documentation along with concise intructions for the former's usage can be found here.

2 Data

2.1 Gridded Emissions

We consider global gridded emissions for reactive greenhouse gases, as covered in the Intergovernmental Panel on Climate Change (IPCC) Special Report [1]. Emissions (measured in TgS) have been projected for every 10 years, beginning in 1990 to 2100. The dataset covers 6 scenarios, as explained in Table 1.

2.1.1 Preprocessing

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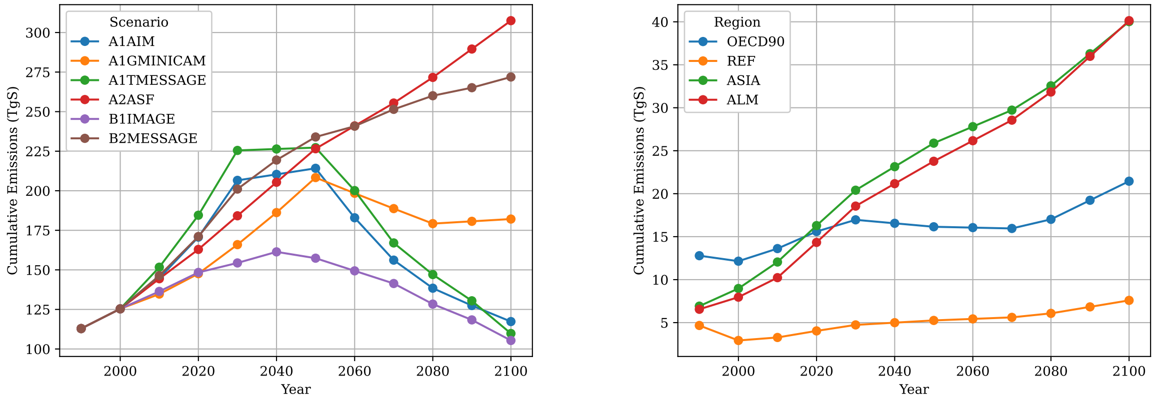
2.2 Environmental Performance Indices

The Environmental Performance Index (EPI) is a tool developed by Yale Center for Environmental Law and Policy (YCELP) and the Center for International Earth Science Information Network (CIESIN) at Columbia University [2, 3]. The EPI is designed to assess and rank the environmental performance of countries around the world. It provides a quantitative analysis of a country's environmental policies and outcomes across various indicators.



(a) CH4 Emissions in Asia

(b) NOx Emissions in Scenario A2ASF

Figure 1: A Summary Representation of the 1x1 Gridded Emissions dataset. Part (a) shows the predicted emission levels for Methane (CH_4) in Asia for all scenarios (Table 1) in consideration, while Part (b) shows the predicted emissions of Nitrogen Oxides (NO_x) in different regions (North America + Western Europe, Central & Eastern Europe, Asia and Africa & Latin America) in scenario A2ASF (High Population Growth, Regionalism, Technological Development, Regional Inequality)

The EPI is calculated based on a set of performance indicators that fall into two broad categories: environmental health and ecosystem vitality. These categories are further divided into sub-indicators, creating a comprehensive framework for evaluating a country's environmental performance. The specific indicators may vary across different editions of the EPI and may include more than 40 indexes, but common examples include:

1. Climate Change Indicators:
   - CO_2 Growth Rate
   - Black Carbon Growth Rate
   - CH_4 Growth Rate
   - F-Gas Growth Rate
2. Environmental Health Indicators:
   - Air quality
   - Water and sanitation
   - Ambient particulate matter pollution
   - Recycling Rates

Emission Scenario	**Scenario Assumptions**	**Model Parameters**
A1B-AIM	Rapid economic growth, urbanization, industrialization, balanced use of fossil fuels, biomass	economy, climate, land use
A2-ASF	Rapid economic growth, urbanization, industrialization, strong emphasis on fossil fuels	economy, energy, environment
B1-IMAGE	Moderate economic growth, urbanization industrialization, shift to clean energy sources and greater emphasis on sustainable development	atmosphere, ocean, land, human activities
B2-MESSAGE	moderate economic growth, urbanization, industrialization, focus on sustainable development	energy, climate, economy
A1G-MiniCAM	Low rate of population growth, heavy reliance on fossil fuels	atmosphere, ocean, land, ice
A1T-MESSAGE	Rapid economic and technological advancement, strong focus on sustainable development	energy, climate, economy

Table 1: Scenarios for 1x1 Gridded Reactive Gase Emissions

3. Ecosystem Vitality Indicators:
   - Biodiversity and habitat
   - Fisheries
   - Tree Cover Loss
   - Health impacts Agriculture

We have taken 4 sub-indicators with high weights in EPI and created plots that illustrates dependency between sub-indicators and GDP of the country. More information about selected sub-indicators:

1. *CDA: CO2 Growth Rate*
   The CO2 growth rate is calculated as the average annual rate of increase or decrease in raw carbon dioxide emissions over the years 1995–2022. It is then adjusted for economic trends to isolate change due to policy rather than economic fluctuation.
2. *PMD: Ambient Particulate Matter Pollution*
   Measure $\mathrm{PM}_{2.5}$ exposure using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to fine air particulate matter smaller than 2.5 micrometers ($PM_{2.5}$).
3. *TCL: Tree Cover Loss*
   Quantify tree cover loss by constructing a five-year moving average of the percentage of forest lost from the extent of forest cover in the reference year 2000. We define a forest as any land area with over 30% canopy cover.
4. *REC: Recycling Rates*
   Measure recycling rates as the proportion of post-consumer recyclable materials (glass, plastic, paper, and metal) that is recycled.

All these data available from 1995 to 2022. It is normalized with minimum value 0 and maximum value 100

2.2.1 Preprocessing

There is no need in reprocessing, all data already normalized.

2.3 Gross Domestic Product per Capita

2.4 Effects of Climate Change on Global Food Production

This dataset [4] presents the predicted productions of wheat, rice and maize under 7 Special Report on Emissions Scenarios (SRES), that describe 7 plausible futures with different emission trajectories as described below. These scenarios have been designed by considering different socio-economic and technological developments. Some of these are:

- Various speeds of carbon removal technologies developments
- Evolutions in the global energy mix
- The speed of population and economic growth
- The attention given to sustainable and social issues

all of them impacting the evolution of emissions over the 21st century and thus crop production. Some of these scenarios coincide with the ones used in the emissions display, however we have decided not to merge them in order not to mix or lose information since the hypothesis taken in each case are different.

The available information takes into account 'current' production averaged between 2000 and 2006 and gives the expected variations compared to this value for years 2020, 2050 and 2080 depending on the greenhouse gas emissions' trajectory.

2.4.1 SRES Scenarios

2.4.2 Preprocessing

In the raw data, the crop evolution is described in terms of absolute variation and percentage. The absolute value used in our visualisation has thus been computed using the current production and the absolute predicted variation. Some

Scenario	Description
AF1	"All fossil fuels" scenario. It considers a world with rapid economic and population growth, peaking mid-century and decreasing after; the rapid introduction of new and more efficient technologies; and a fossil fuel-intensive energy mix.
A2a	This scenario considers a nationally or regionally oriented development, leading to fragmented economic and technological growth as well as a steadily growing population.
A2b	Similar to A2a but considering a more rapid technological development leading to a less carbon-emitting scenario.
A2c	Similar to A2a and A2b, but with greater emphasis on social sustainability.
B1a	Considers the same population evolution as scenario A1 but a rapid economic evolution towards service and information; the development of clean technologies; and an emphasis on social sustainability.
B2a	A scenario focused on local solutions, an intermediate level of development, less rapid and more diverse technological development than previous scenarios, as well as a balanced energy mix.
B2b	Similar to B2a, but with more emphasis on social and economic sustainability.

Table 2: Scenarios used for crop predictions

country names have also been altered in order to match those used in the other datasets, for example, the emissions data uses the name 'United States of America' while the food data used 'United States'.

[5]

3 Design choices

The visualisation is composed of four sections:

- The navigation section, allowing the user to select his country and date of interest
- Greenhouse gas emissions
- Environmental Performance Indices compared to GDP per capita
- Crop production and predictions depending on the IPCC scenario

3.1 Navigation section

The aim of this section is for the user to select their country and period of interest. It does not contain data, thus allowing the use of a globe rather than a map. The selection done by the user updates the other visualisations.

3.1.1 Interactive 3D Globe

This globe allows the user to select his country of interest, by double-clicking on the interactive globe. We have decided to use this visualisation because it provides a satisfying user experience but does not hide any information, since this map in not displaying data. The selected country is highlighted in yellow.

3.1.2 Adaptative search bar

The user can also use a search bar to find a specific country by name.

The search bar proposes countries using the first letters provided by the user and once selected highlights the chose country and rotates the globe accordingly. This functionality has been added in order to allow the user to select countries that might be tricky to double-click on due to their size, or to look for countries whose location he is unaware of.

3.1.3 Timescale

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3.1.4 Technical choices

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3.2 Gridded Emissions

The aim of this visualisation is to put into perspective the localisation and amount of emissions with the wealth of countries.

3.2.1 Visualisation update

The map is updated with the use of the previous navigation section : when a country is selected, it zooms on it and displays its area colour and emissions colour in bright, helping the user focus on the region of interest and find country specific information. However, it is possible to zoom out in order to compare it with other regions of the globe.

3.2.2 GDP per capita

We have decided to colour encode the map with respect to country wealth. Since this implies that areas are encoded, the perception of the value might be influenced by the size of the country. In order to prevent this, we have decided to use normalise our data with respect to country size using GDP per capita rather than GDP to colour code the map. The encoding legend is displayed below the map.

3.2.3 Emissions

The map displays the locations and the amount of a selected gas. This is encoded with positioning and size of circles on the map, allowing the user to spot regions of maximal intensity when zooming out and to have a fine grain analysis when zooming in.

3.2.4 Selectors

The user can select the type of scenario he wishes to see, rather than displaying all the scenarios on one map. This choice has been made to prevent confusion and overflow of information. It is also possible for the user to select the type of emissions he is interested in using a scroll down menu above the map in order to have a more precise understanding. Since the scenarios considered in this dataset are not the same as those used in the crop production visualisation, we have decided not to connect them together.

3.2.5 Technical choices

The gridded emissions are visualised as a bubble map using a chloropleth with each country's GDP per capita in the backdrop.

MAYBE TO DO MORE? @Abhay

3.3 Environmental Performance Indices

These four maps display the importance given by countries to environmental concerns compared to their wealth.

3.3.1 Visualisation update

The selected country is displayed in a red fill in order to stand out from other countries using 'odd-one-out' visual technique. The information is updated using the timescale selected by the user, which allows him to follow the evolution of the indicators over time.

3.3.2 Data points

If a user wants to compare the selected country to other points, it is possible to see what the other points are by hovering over them to see their name. In this way, the user is able to know which country to select in the navigation section if he wants to have more information on a specific point of interest.

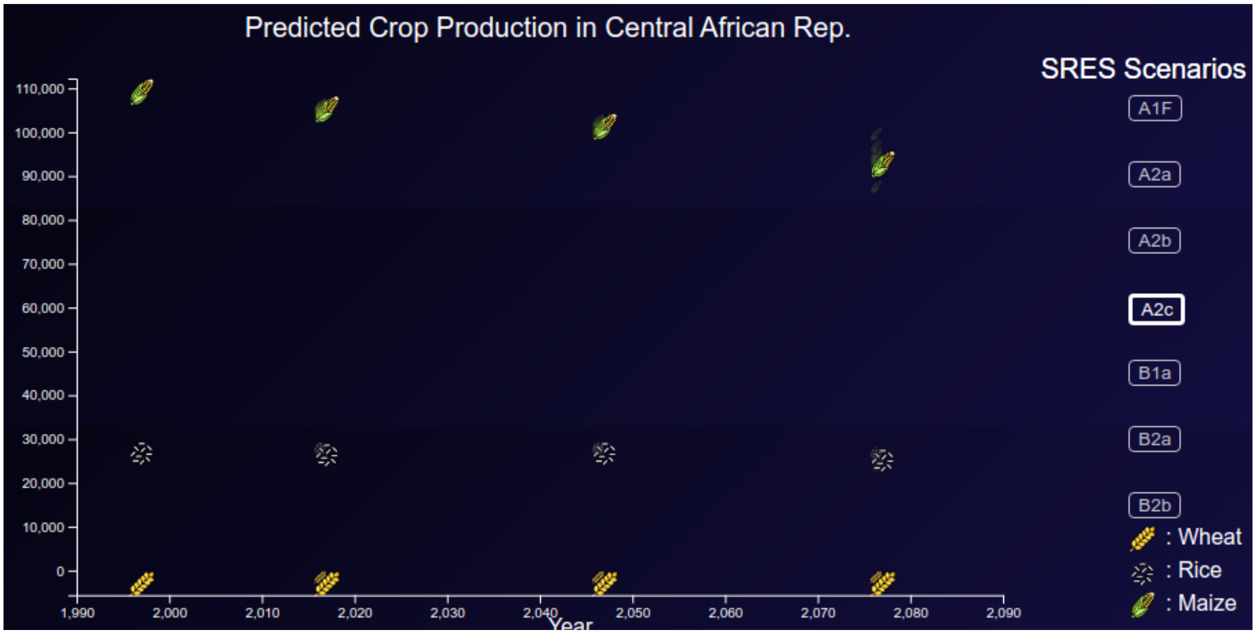

Figure 2: Crop production window

3.3.3 Data representation

In order to be in line with the information displayed on the emissions map, the wealth indicator used is also GDP per capita so that the user is not confused with the scales. We had at first envisioned to display the indicators on the same graph using different shapes and a normalised scale, however this proved to be too much information, and we have thus decided to use multiple graphs.

3.3.4 Technical choices

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3.4 Crop Production

This graph displays the current and predicted production of wheat, maize and rice in the coming years depending on the greenhouse gases emissions' trajectory.

3.4.1 Visualisation update

The graph depicts the predictions for the selected country and is updated accordingly. We have decided not to make the visualisation change with the timescale since it depicts predictions which do not vary with the date, and we only have information for 2000-2006, 2020, 2050 and 2080. The scale of production is automatically updated to the selected country so that the data points are as spread out as possible on the graph. This is helpful since countries have very different orders of magnitude in crop production but also in between crops.

3.4.2 Data representation

The graph displays data points using icons associated and representing each crop. Since the graph is not densely populated, the icons are easy to distinguish from one another and allow for a more straight forward read of the graph rather than having to use a legend.

3.4.3 SRER Scenarios

At first, all the scenarios are displayed on the graph so that the user is able to compare them. However, since the icons can are quite close together depending on the scale, it is possible to use the side buttons to select a scenario of interest.

Clicking on this bottom displays the selected production values in bigger, while the opacity of other icons fades out in order to let the user still have an idea of where the other scenarios are positioned but make the selected one stand out.

3.4.4 Technical choices

This section has been coded using d3 and the icons were selected from Flaticon. A general function creates the groups where the country data is stored, as well as the buttons and the initial graph visualisation. A dedicated function manages button usage, and another one deals with country update by emptying all the groups in the svg canvas and launching the display function again with the new country information.[6]

4 Code Architecture

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5 Conclusion

This visualization displays an ensemble of socio-economic and environmental indicators and puts them into perspective with environmental impact. It allows the user to interact with the data in order to highlight information according to his interest and to draw visual conclusions by helping him better understand the data at hand. It is designed to be user-friendly and interactive, providing a pleasurable experience.

References

[1] Intergovernmental Panel on Climate Change-IPCC,. IPCC special report on emissions scenarios (SRES) 1x1 degree gridded emissions dataset, 2000.

[2] Yale Center for Environmental Law + Policy-YCELP - Yale University, and Center for International Earth Science Information Network-CIESIN - Columbia University,. 2022 environmental performance index (EPI), 2022.

[3] M J Wolf, J W Emerson, D C Etsy, Z A Wendling, and Et al. Environmental performance index 2022. Technical report, Yale Center for Environmental Law and Policy, New Haven, CT, 2022.

[4] A Iglesias and C Rosensweig. Effects of climate change on global food production from SRES emissions and socioeconomic scenarios, 2009.

[5] M L Parrya, C Rosenzweig, A Iglesias, M Livermored, and G Fischer. Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change*, 14:53–67, 2004.

[6] FLATICON (Available: www.flaticon.com) Last Accessed December 22, 2023.