**Methodological note: Social vulnerability to climate transition impacts index**

**Index Construction**

The second social vulnerability index aims to consider workers’ vulnerability to skills and occupations change due to the net-zero transition (rise in sustainable industries and falling fossil fuel industry). Climate change poses numerous risks for the global workers [1]. Two of the main factors that influence a just transition for workers in the face of climate change a flexible and highly mobile workforce and a strong income support system [2]. Fundamental programs to enable a transition that leaves no one behind are a trade adjustment assistance and income support [3], programs which may have large costs that will mostly be born by governments. An ageing workforce has less flexibility and mobility is a hindering mechanisms. Technical innovation and governmental support for new industries are important to avoid sunk investments in industries that no longer are compatible with a future affected by climate change [4].

Economic sectors can be affected by physical risks due to extreme weather events [5] or to transition risks, due to economic changes in markets [6] [7]. Industries where workers will most be affected by physical risks are Agriculture [8] and Construction [9], while Energy, Fossil fuel extraction [10], Manufacturing [11], and Mining [12] are most at risk from transition factors. Other industries, like tourism, may exhibit a loss of income source and physical damages in the case of dwindling ecosystems and sea level rise.

The transition vulnerability index aims to consider factors at a personal and structural scale that enable and hinder a just transition for workers. Additionally, the proportion of workers in industries affected by physical and transitional risks will be compared to the general social vulnerability index to transition risks. It is important to also compare workers exposed to physical risks with climate change exposure.

The construction of the climate transition vulnerability index is similar to the physical impacts vulnerability index. It is composed by six categories: workforce age, education, inequality, research and development, government debt. and gender. Each category is represented by one variable. For each category, a country is assigned a grade from 0 (least vulnerable) to 10 (most vulnerable) according to its corresponding rank percentile (a generalization of the classical statistical percentile that allows for repeated values). The final vulnerability index is calculated by averaging the five categories and normalizing the result to have a value of 0 for the least vulnerable country and 10 for the most vulnerable one.

For the workforce age, the selected variable is theratio of population 20-39 years old to the population 40-65 years old, using data from the World Bank’s Population Estimates and Projections [13]. This category measures a personal component of vulnerability; the variable is relevant since an older workforce is more at risk of having their skills become obsolete, and companies will likely be less interested in investing in their reskilling. The variable for the education category is mean years of schooling, reported as a component of the HDI by UNPD [14]. This variable also measures a personal component of vulnerability, and it is relevant since there is evidence “*the net-zero transition is creating […] good-quality jobs […] in high-skill occupations and represent an opportunity for highly educated [workers] […] for low-skilled workers, green driven occupations may not be a sufficiently attractive alternative to jobs […]”* [15]. While it would be more directly useful to measure continuing education as measured by UNESCO (Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months), but it is a variable for which several countries have no data. Inequalityis measured by the Gini index, using data from the World Bank [16] and the CIA [17]. This category of vulnerability is part of structural components; in more unequal economies, a just transition will be harder to achieve, with the wealthier workforce having the means and support to reskill and the opportunities to find new jobs in growing industries, while less well-off workers will more likely be locked in sunk industries and be left behind. Research and development by Scientific and technical journal articles per million inhabitants. As a structural component of vulnerability, this variable is aimed at measuring an individual country’s ability at creating new jobs and industries and leading the economic transition. Government debt is measured both by total debt service as % of GNI (reported mostly for global south countries, includes the interest payment), and Central Government debt as % of GDP (reported mostly for global north countries), obtained from the World Bank [18]. This variable measures a structural component of vulnerability; it is relevant since world governments might be in need to offer buyouts, early retirement packages or otherwise bear the brunt of reskilling costs in order to ensure a just transition for all. This will further increase debt burdens. The last category, gender, is measured using UNDP’s GII, the Gender Inequality Index [3], measuring female reproductive health and contrasting male and female empowerment and labour market participation. As a personal and structural component of vulnerability, it relates to women’s agency and the opportunities they have in the labour market and the government. A more inclusive workforce can be more easily diversified and retrained, and households with more sources of income are less vulnerable to job losses.

**Index Results**

Figure 1 represents the Social vulnerability index to climate transition impacts. The 10 most vulnerable countries are Papua New Guinea (Index value: 10), Angola (9.8), Mozambique (9.7), South Sudan (9.5), Nicaragua (9.2), Lesotho (8.9), Cambodia (8.9), Congo (8.8), Martinique (8.8), and Bermuda (8.7).

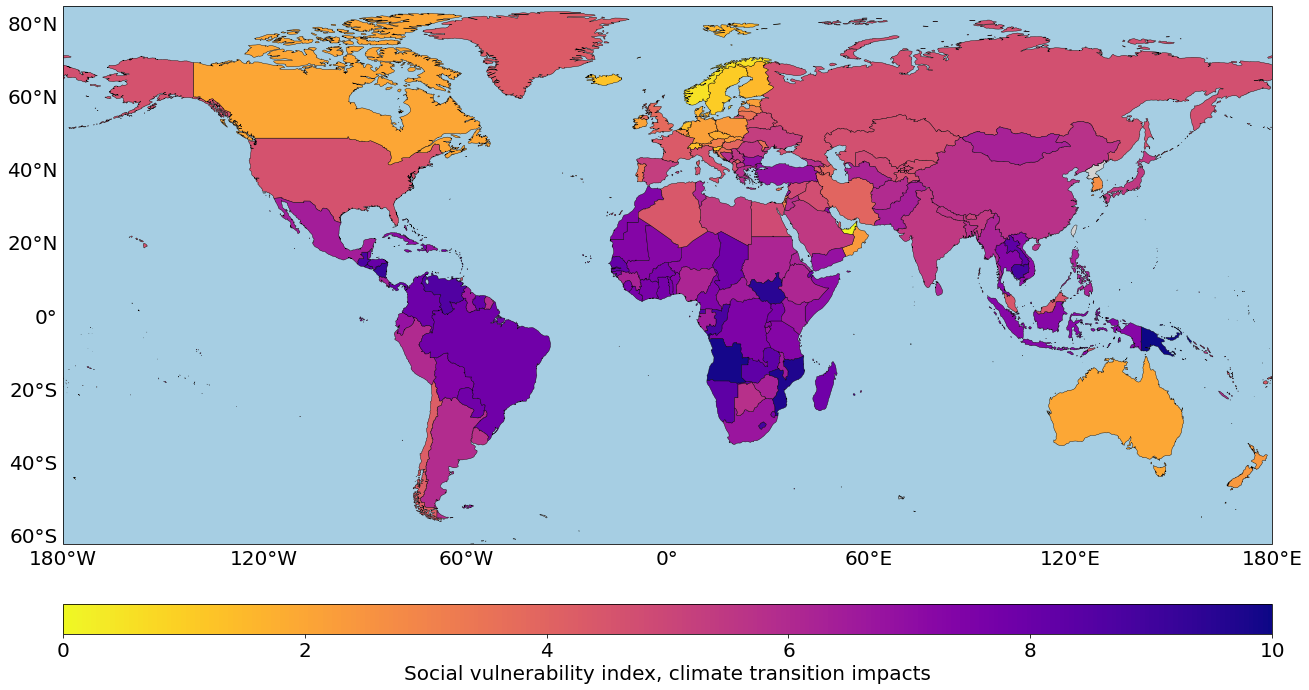


Figure 1. Social vulnerability to climate transition impacts

**Workers in vulnerable industries**

As mentioned before, industries like Agriculture and Construction, where most workers work outdoors, will be heavily impacted by extreme weather events, particularly by heat stress [19]. It has short-term impacts, such as heat stroke, and can cause chronic diseases relating to the cardiovascular, respiratory and renal systems. The most vulnerable persons are migrant and informal workers, women and pregnant workers, older workers, and workers with disabilities.

Other industries, like Energy, Manufacturing, and Mining will be deeply changed, requiring new skillsets from workers, as their production is oriented towards a net-zero economy. Defining green jobs is a complex matter, especially since some occupations may not exist yet; there are top-down approaches which consider industries affected by the climate transition, and bottom-up approaches that consider occupations that will most likely change [15]. On a global scale, workforce data per industry has more availability than occupation data, so a top-down approach has been selected.

Workers have been group into three categories: Workers in sectors subject to physical climate vulnerability (including Agriculture and Construction), workers in sectors subject to transitional climate vulnerability (including Manufacturing, Mining and quarrying, and Electricity, gas, and water supply), and other sectors less vulnerable to climate change (mainly in the service sector, such as Accommodation and Food, and Public Administration). Workers have also been demographically group into total workers, female, above 65 years old, and above 45 years old. The percentage of the total workforce in sectors subject to physical vulnerability has been compared with the extreme temperature exposure index explained in the climate exposure vulnerability index methodological note.

The countries with the largest % of workers in sectors subject to transitional climate vulnerability are Nepal (45.5% workers, transition vulnerability index: 5.5), Czechia (29.1%, vulnerability 1.8), and Lesotho (27.2%, vulnerability 8.9), with Nepal and Lesotho being highly vulnerable. Ordered by social vulnerability: Papua New Guinea (3.7%, vulnerability 10.0), Angola (3.5%, vulnerability 9.9), and Mozambique (4.7%, vulnerability 9.7); these countries have a small population at risk that will however be exceptionally vulnerable. Regarding the female workforce, the countries with largest workforce at risk are Lesotho (16.1% of total workforce is female and at risk, vulnerability 2.3), Tonga (16.1%, vulnerability 3.9), and Nepal (12.3%, vulnerability 5.5); Tonga and Lesotho’s workforce at risk is primarily female.

The countries with the largest % of workers in sectors subject to physical climate vulnerability are Burundi (86.4% workers, physical vulnerability index: 9.4, extreme temperature exposure index: 0.13), Mozambique (75.1%, vulnerability 8.9, exposure 6.1), and Lao People’s Democratic Republic (73.0%, vulnerability 6.7, exposure, 6.7), with Mozambique and Lao being highly vulnerable and exposed. Ordered by social vulnerability: Chad (71.9%, vulnerability 10.0, exposure 9.1), Niger (33.1%, vulnerability 9.9, exposure 9.3), and Somalia (29.7%, vulnerability 9.6, exposure 8.6); these countries have a large workforce that will be exceptionally vulnerable. Ordered by extreme temperature exposure: Cambodia (46.3%, vulnerability 7.04, exposure 9.9), Burkina Faso (30.5%, vulnerability 9.2, exposure 9.9), and Senegal (37.8%, vulnerability 7.8, exposure 9.8); these countries a large workforce that will be exceptionally exposed to extreme temperatures. Regarding the female workforce, the countries with largest workforce at risk are Burundi (51.1% of total workforce is female and at risk, vulnerability: 9.4, exposure: 0.1), Mozambique (43.2%, vulnerability: 8.9, exposure: 6.2), and Uganda (35.2%, vulnerability: 8.9, exposure: 3.2); while Burundi and Uganda aren’t highly exposed, the majority of the exposed workforce is female.

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**Annex A: Climate transition vulnerability categories**

Figure A.1 represents the education category, measured by the mean years of schooling. The 10 countries with years of schooling, are Niger (1.3 years), Mali (1.6), Somalia (1.9), Burkina Faso (2.3), Chad (2.3), Guinea (2.4), Ethiopia (2.4), Afghanistan (2.5), Yemen (2.8), and Senegal (2.9).

Figure A.2 represents the research and development category, measured by scientific and technical journal articles per million inhabitants. The 10 countries with the lowest scientific production are Chad (0.88 articles per million inhabitants), Turkmenistan (0.93), Equatorial Guinea (1.25), South Sudan (1.29), Angola (1.43), Democratic Republic of the Congo (1.98), Liberia (2.44), El Salvador (2.63), Niger (2.73), and Burundi (2.89).

Figure A.3 represents the young workforce category, measured by ratio of population 20-44 to 45-64 years old. The 10 countries with the oldest workforce are Sin Maarten (0.55 young workers per older worker), San Marino (0.66), Northern Mariana Islands (0.71), Bermuda (0.72), Saint Martin (0.72), Kuwait (0.73), Italy (0.74), Ukraine (0.74), U.S. Virgin Islands (0.77), and Spain (0.78).

Figure A.4 represents the gender category, measured by the Gender Inequality Index (GII). The 10 countries with the largest GII are Yemen (0.820), Nigeria (0.677), Somalia (0.674), Chad (0.671), Afghanistan (0.665), Liberia (0.656), Benin (0.649), Guinea-Bissau (0.631), Haiti (0.621), and Sierra Leone (0.613).

Figure A.5 represents government debt, measured by total debt service as % of GNI. The 10 countries with largest debt service are Mozambique (35.6% of GNI), Kazakhstan (22.1%), Mongolia (21.55%), Lebanon (20.9%), Nicaragua (16.6%), Panama (16.4%), Angola (15.9%), Montenegro (15.8%), Papua New Guinea (14.9%), and Georgia (13.9%).

Figure A.6 represents government debt, measured by central government debt as % of GDP. The 10 countries with largest central debt are Japan (216%), Greece (203%), Singapore (150%), Barbados (146%), United Kingdom (142%), Namibia (118%), Bahrain (116%), Spain (111%), United States (110%), and France (99%).

Figure A.7 represents inequality, measured by the Gini index. The 10 countries with largest Gini index are Bermuda (63.0), South Africa (6.03), Bahrain (59.0), Namibia (59.1), Bahamas (57.5), Colombia (54.8), Kingdom of Eswatini (54.6), Belize (53.3), Botswana (53.3), and Martinique (53.0).

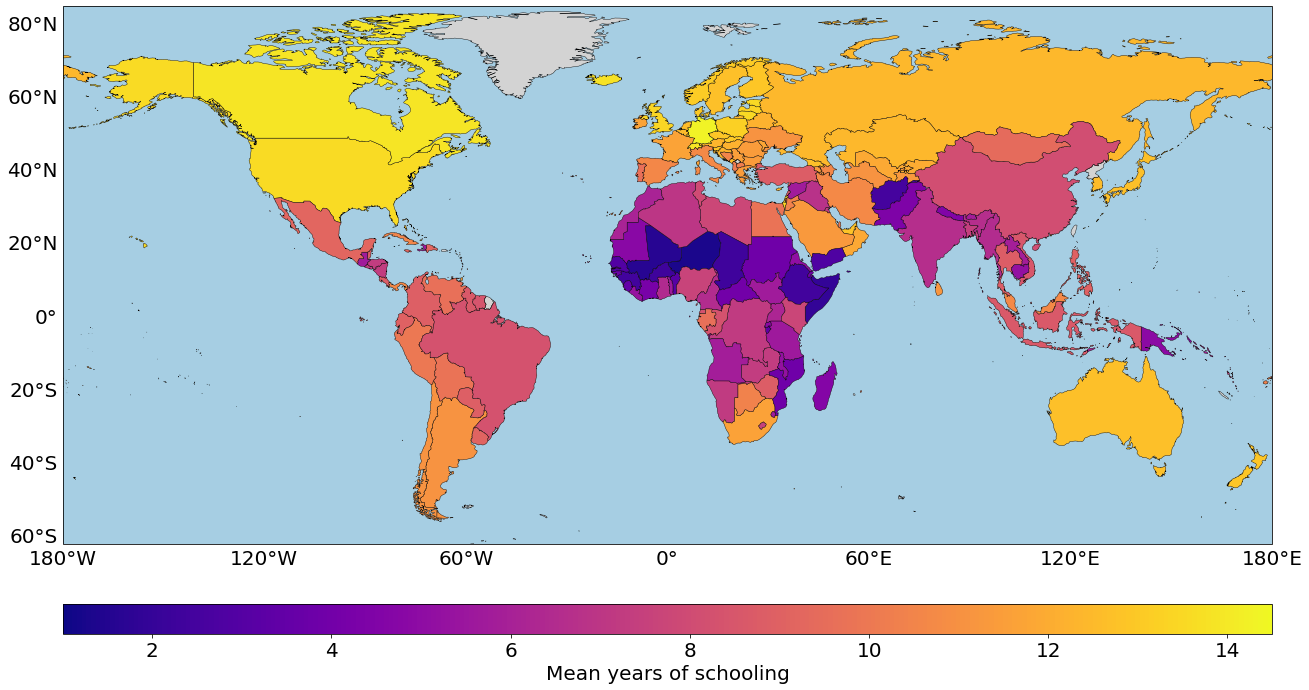


Figure A.1. Mean years of schooling

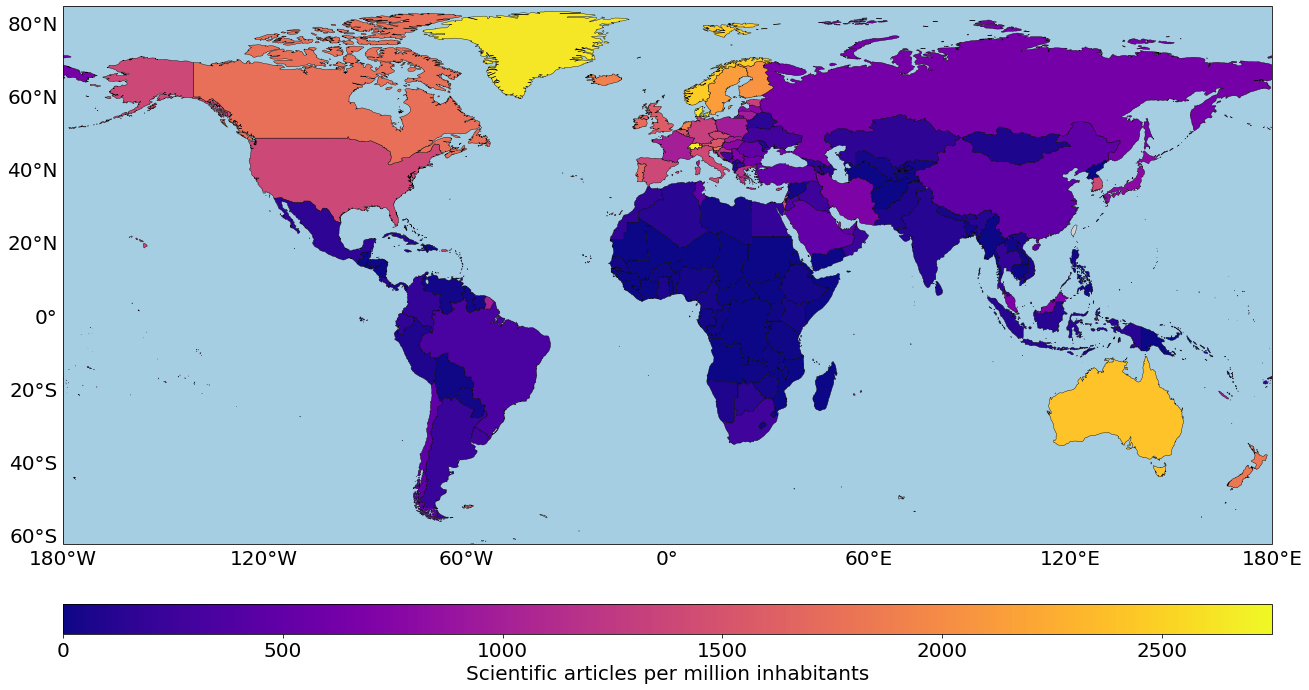


Figure A.2. Scientific and technical journal articles per million inhabitants

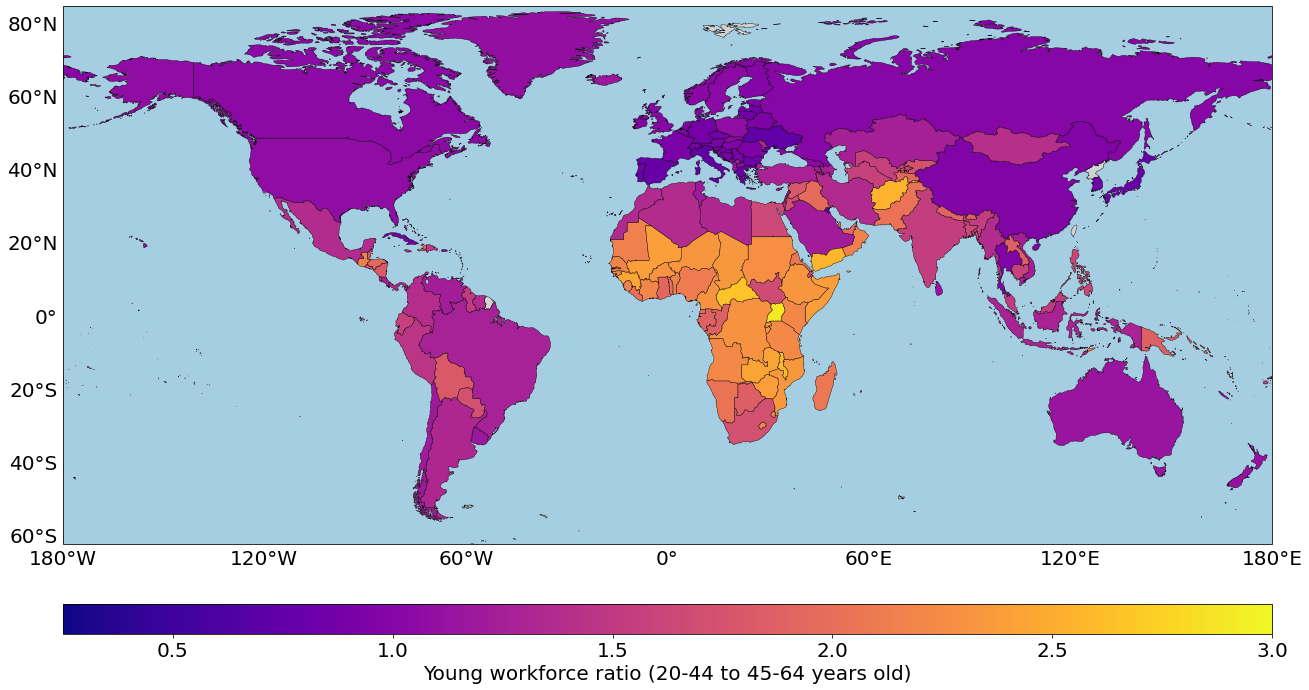


Figure A.3. Young workforce ratio

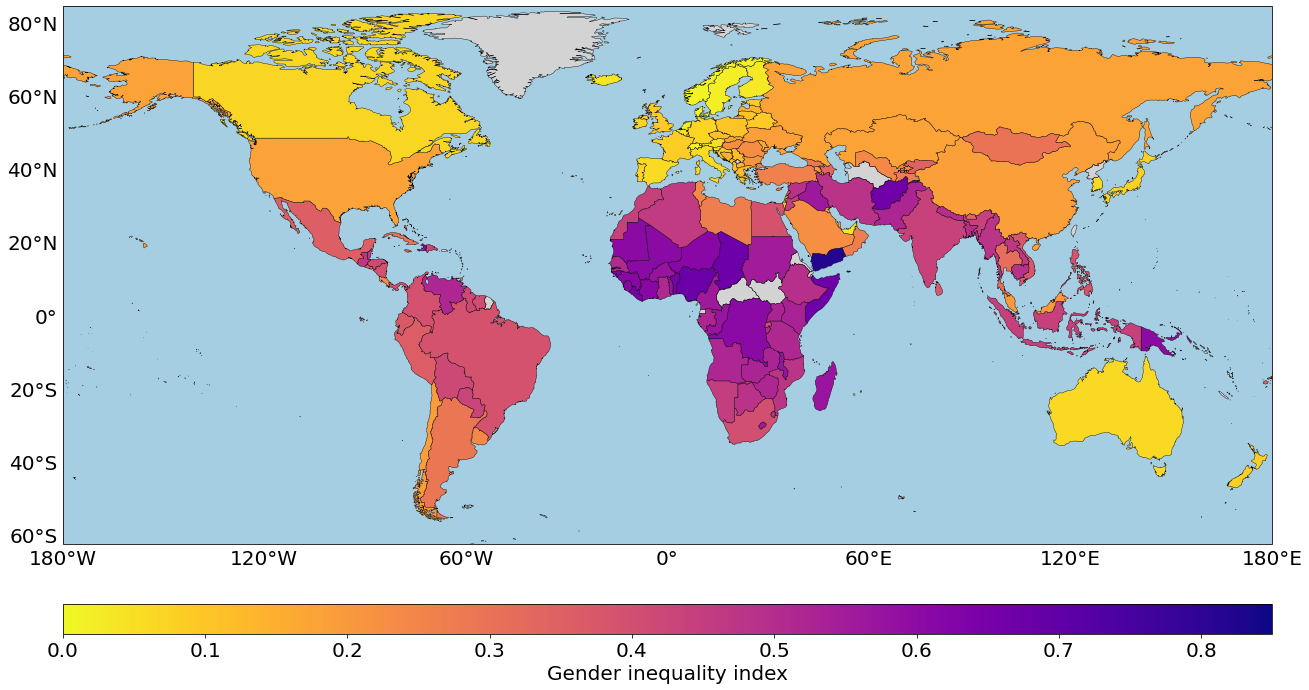
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Figure A.4. Gender Inequality Index

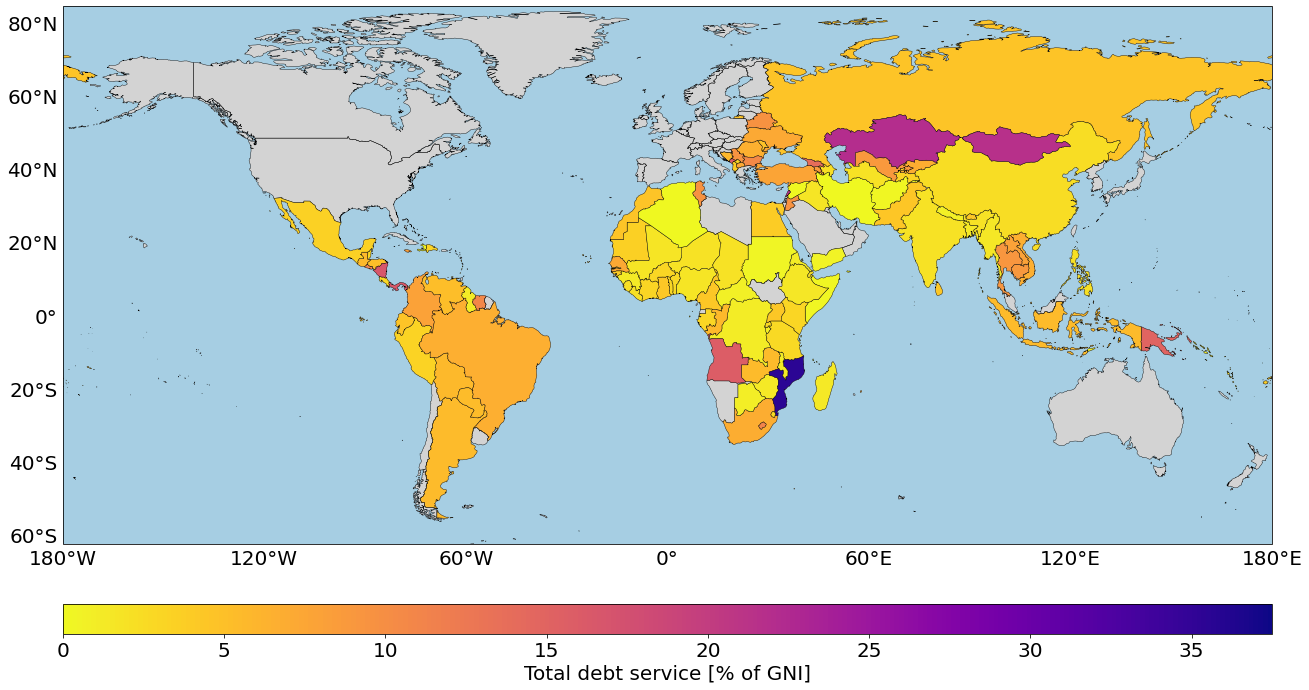
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Figure A.5. Total debt service

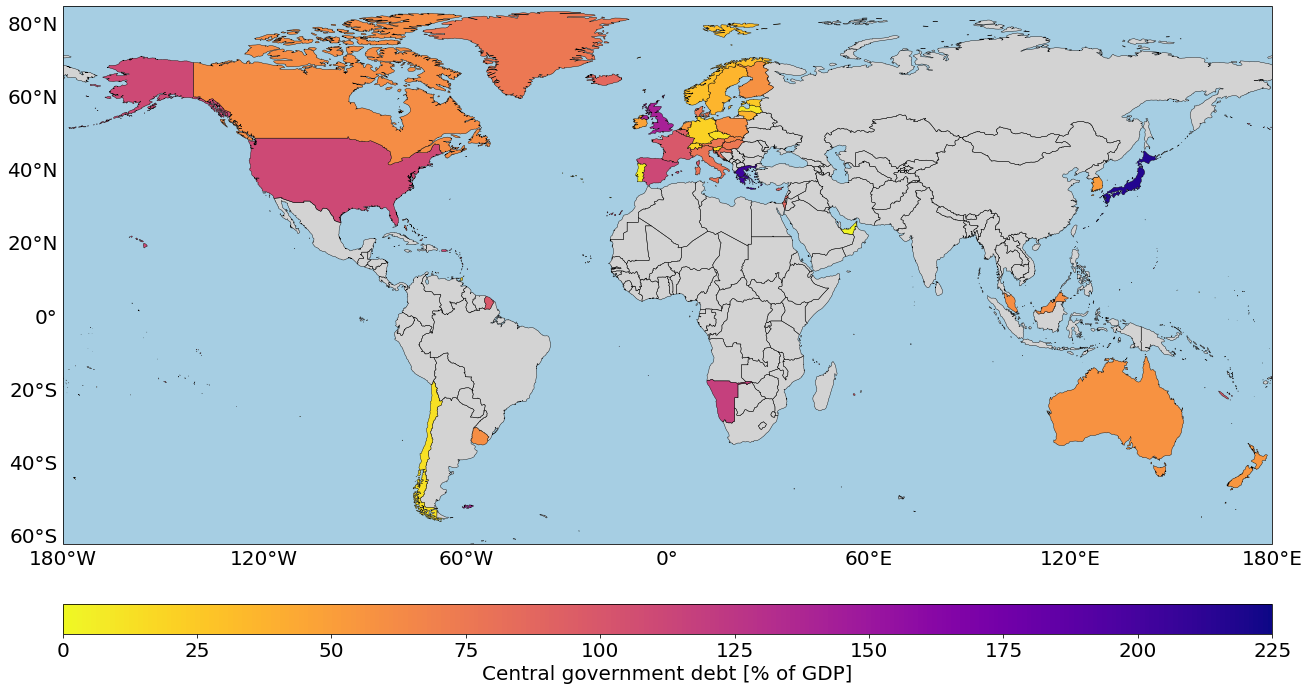
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Figure A.6. Central government debt

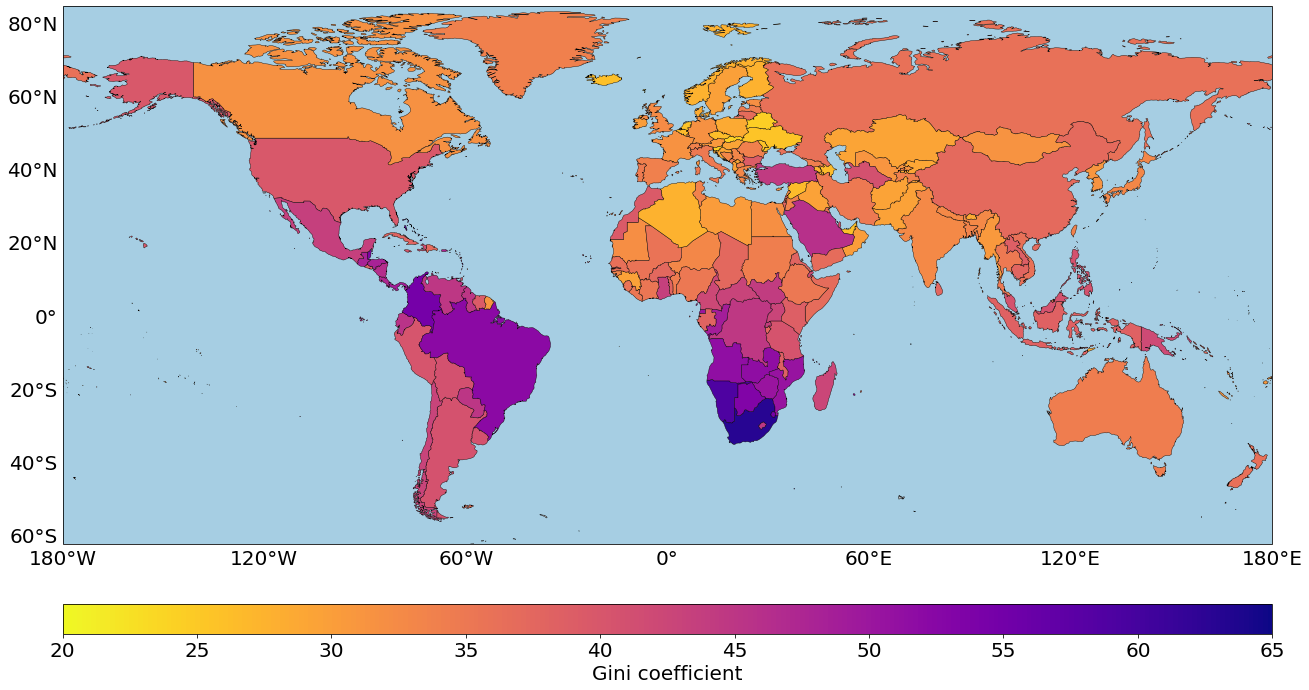
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Figure A.7. Gini Index

**Annex B: Index values for a given country**

As an example, the vulnerability values for Nicaragua are shown:

* Social vulnerability index, climate transition impacts: 9.2
* Mean years of schooling: 7.3
* Scientific articles per million inhabitants: 5.76
* Young workforce ration (20-44 to 45-64 years old): 1.52
* Gender inequality index: 0.397
* Total debt service (% of GNI): 16.6%
* Central government debt (% of GDP): no data
* Gini index: 46.2