Health Adaptive Capacity: Methods for Developing Indicators of Countries' Health Preparedness to Climate Change

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Abstract

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This study builds scientific understanding of adaptive capacity and health preparedness to construct an index of health adaptive capacity that is applied globally at the country-level. Understanding effective climate change adaptation approaches is increasingly important as the health impacts of climate change continue to grow. Yet, in public health research there is a gap in understanding health adaptive capacity.[1,2] Therefore, this study built an index on health adaptive capacity based on the World Health Organization's Operational Framework[3] and the general determinants of adaptive capacity to build an index of health-specific determinants of adaptive capacity. This index will help provide clearer understanding of countries' ability to adapt, potential vulnerabilities, and gaps in data and assessments. This study is a first step in facilitating resilience to the health risks of climate change, that further research will help clarify.

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To my family and friends, you have been such a constant support and I cannot thank you enough. You have emboldened me to achieve more, show me your love for me daily, and remind me of the goodness of this life. Gratias ago Deo meo in omni memoria vestri.

List of Abbreviations and Terminology

IPCC – Intergovernmental Panel on Climate Change

WHO – World Health Organization

Measures of Health Adaptive Capacity – Quantifiable actions that strengthen health adaptive capacity, both ideal and proxy measures. Feeds into Determinants.

Determinants of Health Adaptive Capacity – Range of factors for adaptive capacity: Economic Resources, Infrastructure, Information and Skills, Technology, Governance/Institutions, and Equity. Feeds into Components and Health Adaptive Capacity Overall.

Components of Health Adaptive Capacity – Awareness, Ability, and Action as key stages and components of Health Adaptive Capacity. Determinants feed into Components.

Operational Framework – 'Operational Framework for building climate resilient health systems' a publication by WHO.[3]

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INTRODUCTION

Anthropogenic warming leads to a wide range of negative health outcomes. As the climate warms, heatwaves and wildfires lead to increased mortality, vector-borne diseases spread geographically and seasonally, mental health is harmed, changes to local environments leads to displacement and so on.[4] Many aspects of climate change are known to impact human health and more are anticipated. These health impacts are not inevitable. Decreasing morbidity and mortality from climate change requires mitigation of emissions of greenhouse gases and the simultaneous adaptation of human systems to manage climatic change.[4,5] This research focuses on how health systems can adapt to lessen the burden caused by climate change. This study focuses on determining health adaptive capacity, a commonly referenced concept, for each country.

Defining Adaptive Capacity

There is a tendency in health literature to use adaptive capacity as a theoretical measure of the limits or lack thereof that a country faces to adaptation.[6] This likely stems from the lack of consistent definition of adaptive capacity, as the term relates to climate change, in public health research. Two basic elements of the capacity to address climate change are coping capacity and adaptive capacity. Coping capacity measures more immediate resource availability and societal potential to adapt to climate shocks and stresses.[7] Adaptive capacity is more complex, referring to the long-term ability to adapt to ongoing climate change. The Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as "the ability of systems, institutions,

humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences {of climate change.}"[8]

Health Applications

Across adaptive capacity literature, very little is written relating to public health, leaving a knowledge gap on a standardized method of measuring health adaptive capacity across regions and countries.[1] This study aims to initiate work on understanding countries' adaptive capacity as it relates to their health systems. This work will help provide clearer understanding of countries' ability to adapt, potential vulnerabilities,[9] and gaps in data and assessments. This work is done with the aim of initiating further research and anticipates limitations.

While various efforts have been taken to aid country-level health preparedness to climate change, these typically aim to address single issues and are rarely comprehensive. An exception is the 'Operational Framework for building climate resilient health systems,' developed by the World Health Organization to provide guidance on how health systems can comprehensively address climate vulnerability and health challenges.[3] Its elements are depicted in Figure 1. There are several mechanisms for evaluating countries' climate change and health programs, but none explicitly utilize the Operational Framework; many of the recommended adaptation action are difficult to quantify across countries or to use to evaluate adaptive capacity globally.[10] Therefore, this work aimed to align with the Operational Framework and assess how countries are adapting and preparing for further health adaptation.

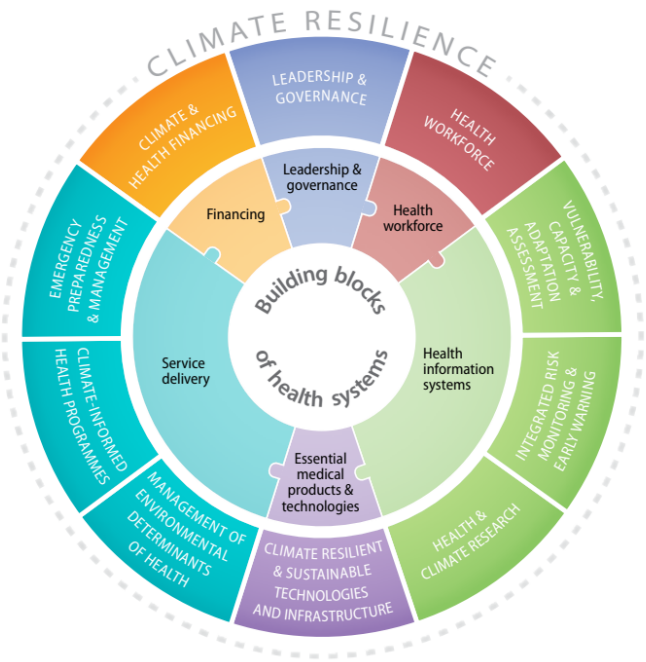

Figure 1 Operational Framework Components

METHODS

Conceptual Framework Development

An initial literature review provided guidance on adaptive capacity determinants within and outside of the public health context. The determinants of adaptive capacity include: economic resources, technology, information and skills, infrastructure, governance, and equity[11] as they relate to climate adaptation. The determinants of adaptive capacity are widely accepted in climate change literature. These determinants are also present in the health literature.[11] Most literature focuses on adaptive capacity, and often vulnerability, as a theoretical measure.

However, there is a branch of research, primarily through WHO, focusing on how countries can most effectively adapt to climate change from the health systems and public health context. This research has been done through the Operational Framework[3]. The Operational

Framework provides health-relevant recommendations for climate resilience. These recommendations fall into the broad categories of: "Leadership and Governance, Health Workforce, Health information systems, Essential medical products and technologies, Service Deliveries, and Finances." Notably, many of the determinants of adaptive capacity mentioned above relate to the building blocks of the Operational Framework, such as Economic Resources and Financing.

Therefore, in an effort to align the public health knowledge with the climate science understanding of adaptive capacity, determinants of adaptive capacity identified in the literature review were overlaid with the 10 health components of the Operational Framework. This process was not a direct matching but required expert evaluation, leading to the Frameworks' components being placed within the broader determinants as ideal adaptive capacity measures (see Table 1). In this paper these ideal aforementioned factors and ways of measuring health adaptative capacity are referred to as *determinants of health adaptive capacity*.

The determinants' definitions are as follows, based on the IPCC's definitions with relevant health application.[12] Economic Resources refers to [capital resources allocated to adaptation efforts with established health benefits and an absence of widespread poverty that expands health vulnerabilities]. Technology is defined as [use of technology and ability to expand technological understanding to address climate change health impacts]. Information and skills describe [clear scientific understanding of the health burden from climate change that aids in developing solutions, community involvement; and trained and skilled personnel to implement adaptation]. Infrastructure is defined as [ability of the most vulnerable to access needed infrastructure and ability of leaders to use infrastructure resources to assign in abnormal situations]. Governance/institutions includes two words, given the different terminology across

literature. In this study it is expressed as [clearly defined social institutions that lend themselves to the betterment of the public's health and improved adaptation through strong communal and sociocultural bonds]. Finally, Equity is defined as [distribution of resources, assets, infrastructure and social capital to communities most in need to limit health vulnerabilities while addressing adaptation effectively]. Notably the economic quantification of equality is like this definition of equity. The term Equity was kept, recognizing the importance of distributing resources to those most in need rather than evenly across the population.

Within each of the determinants of health adaptive capacity there are health specific measures, based on the Operational Framework. These health measures capture both the mechanisms to improve health adaptive capacity and the elements needed to develop indicators that could be used to quantify health adaptive capacity. At the country level, however, this is not currently feasible, hence proxy measures were used to assess the current health adaptive capacity for countries.

These proxy measures are meant to be reflections of the ideal measures of determinants rooted in literature. The selection of proxy measures was restricted by globally available country-level data from the last five years. Each of the proxy measures was then standardized and scored from 0 to 100, with 0 being the least adaptive. For each of the proxy measures additional information is provided on the methods used to standardize (see Table 2, appendix).

Table 1 Index of Health Adaptive Capacity Measures; Including Proxy Measures Used in this Study

Determinants of Adaptive Capacity	**Ideal Measures**	**Proxy measures**
Economic Resources	Funding within departments of environment for health-specific outcomes, and funding within health departments towards addressing climate specific drivers	Out-of-pocket expenditure as percentage of current health expenditure (CHE) (%)[13]
		Domestic government health expenditure as percentage of GDP (%)[13,14]
Technology	Innovative approaches to health and climate solutions	Meteorological systems informing health systems[15]
	Collaboration across meteorological, health, and other sectors	
Information and skills	Climate education incorporated in medical and public health training	Secondary female education[16]
	Research on health adaptation measures relevant to policy	Resident population patent applications[17–19]
Infrastructure	Climate resilient WASH, food, and health systems	Safe Sanitation and Drinking Water[20]
	High accessibility of healthcare providers	Medical doctors per 10,000 people[21,22]
	Sustainably built environments providing access to health facilities	Rural Accessibility Index[23]
Institutions | Governance	Relational communities with climate change and health awareness and government engagement	Corruption Perception Index[24]
		Vaccinations for children under 2[25]
Equity	Health vulnerability and capacity assessments	Gini Coefficient[26,27]

Components of Adaptive Capacity

The initial literature review identified various concurrent levels or stages of adaptation. The IPCC definition of adaptive capacity specifies ability as a key component to effective adaptation.[8] Other studies distinguish between the initial awareness of climate change adaptation needs, followed by the ability to begin adaptation efforts, culminating in action through implementing adaptation measures.[28] In the health literature, Yohe and Ebi discussed the theory of linking adaptive capacity to a public health understanding, noting that in public health, a range of abilities are needed to address health problems:

> "1 an awareness that a problem exists;
>
> 2 a sense that the problem matters;
>
> 3 understanding of what causes the problem;
>
> 4 capability to influence; and
>
> 5 political will to influence the problem.[11]"

Therefore, to link the IPCC understanding of adaptive capacity to the public health understanding, this paper chose to group the determinants into three different levels or what will be referred to as *components*: 'awareness', 'ability' and 'action'.[28–31] Awareness is defined as [perception of health risks and possible adaptation measures with clear support through institutional, governance, and healthcare structures]. Ability is defined within the health context as [countries' preparedness for addressing the health vulnerabilities through policy, plans, and/or financial backing]. Separately, action is an additional level of adaptive capacity that is defined as [countries' implementation of evidence-based health actions to minimize key climate and health vulnerabilities]. The levels of adaptation recognize countries' planning and preparedness as well

as implementation. The levels are referred to as *components* of health adaptive capacity, which are fed into by the determinants previously mentioned.

This resulted in the need to determine a weighting mechanism to result in 4 different scores, one for overall health adaptive capacity and one for each of the three components. For each of the determinants of health adaptive capacity (i.e., economic resources, infrastructure), the proxy measures were equally weighted. The process of determining the weightings of the determinants into the components was more complex. Other studies used similar conceptual frameworks of adaptive capacity broken into 'awareness', 'ability', and 'action', but only placed determinants under one subcomponent.[28,29, 30,31] To create a more complex understanding, it was decided that the determinants do not feed solely into a singular level or subcomponent, such as measures of equity only impacting 'awareness'. Instead, determinants were weighted based to represent their relative contributions to each of the components. These weights were initially determined based on an assessment of the papers using the three components within their index and which determinants were placed under which components.

This initial literature weighting scheme was then used as a baseline weighting from which authors devised the following weighting (see Figure 2 or Table 2, appendix). This is meant to capture the flows of each of the determinants into different components, awareness, ability, and action. For each determinant a percentage flows into each component, such as economic resources with 60% into action and 40% into ability. These accumulate in the components to then create the totals for each component. It provides a more complex understanding of the nature of these components, or stages of health adaptive capacity. These different weightings do then make it appear that the ability component appears to score highest, which should be noted when interpreting scores.

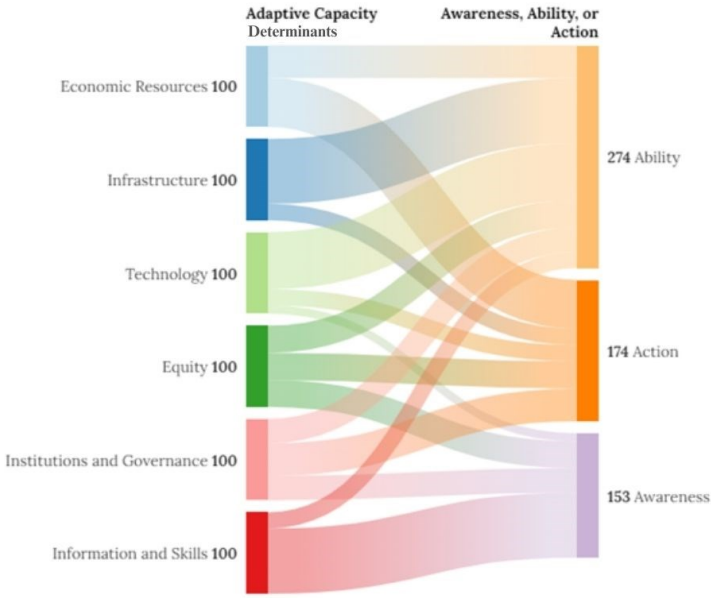

Figure 2 Flowchart Displaying Weightings into 'Action', 'Ability', and 'Awareness' [28,29,31,32]

RESULTS

The resulting scores for each country were broken into 4 categories: ‘Awareness’, ‘Ability’, ‘Action’, and ‘Overall Health Adaptive Capacity’ score. Countries that did not have relevant data for each of the proxy measures were not included. This resulted in 125 countries receiving scores. Countries were further grouped by Lancet Countdown (LCD) regions and 2021 Human Development Index.[32] According to these groupings, 34 countries from LCD Europe were captured, 27 from LCD Asia, 12 countries from LCD Small Island Developing States (SIDS), 35 countries from Africa, 13 from South and Central America, and 2 countries from both LCD North America and from LCD Oceania. The full scores can be seen in the Appendix, Table 3.

The resulting scores are mapped below by category. The first map of ‘Awareness’ scores (see Figure 3) highlight the range of scores from 49 to a possible 153. When averaged by LCD

region, Africa scores the lowest average of 65.6 out of 153. This is followed by the SIDS region, with an average of 73.2. At the country-level Papua New Guinea scored lowest, followed by Liberia, Guinea, Uganda, and Guatemala. The highest scoring region on average was North America (the United States and Canada) at an average of 120.3. Highest scoring countries were Switzerland, followed by France, the United Kingdom, Germany, and the Republic of Korea.

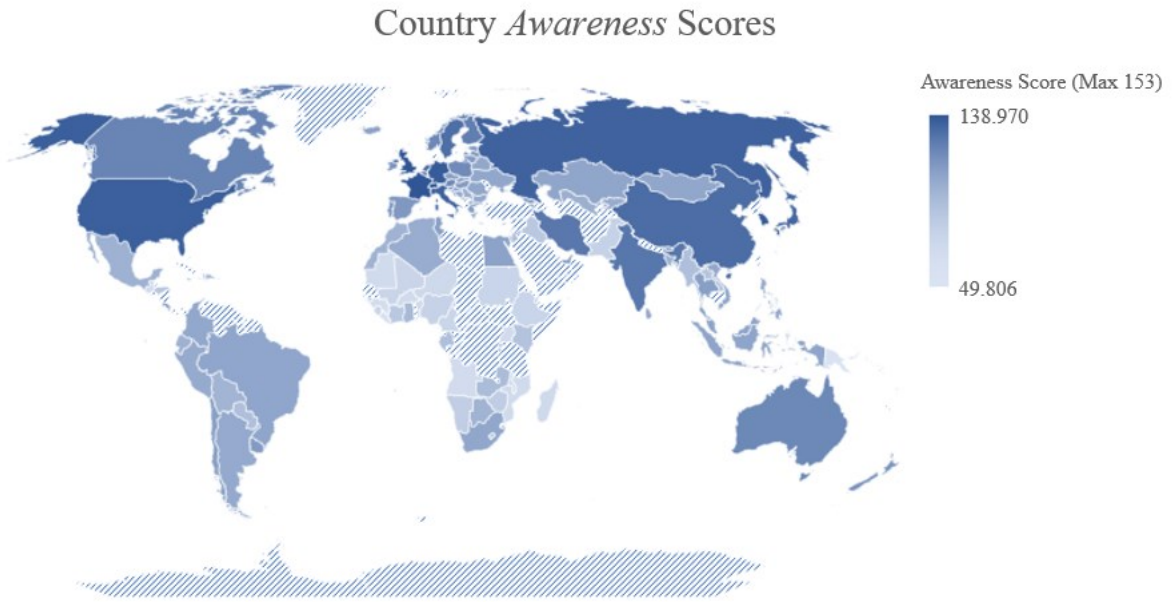

Figure 3 Country-level Awareness Scores mapped globally with darker blue representing higher scores and stripes representing countries without relevant data

The 'Ability' scores saw similar trends, with LCD Africa region scoring lowest on average at 133.8 of a much higher possible score of 274. The lowest scoring countries were Benin, with Mauritania, Liberia, Sudan, and Comoros with incrementally higher scores. The highest scoring LCD region was Australia (comprised of Australia and New Zealand) with an average score of 238. The highest scoring countries were France followed by United Kingdom, Switzerland, Sweden, and Finland.

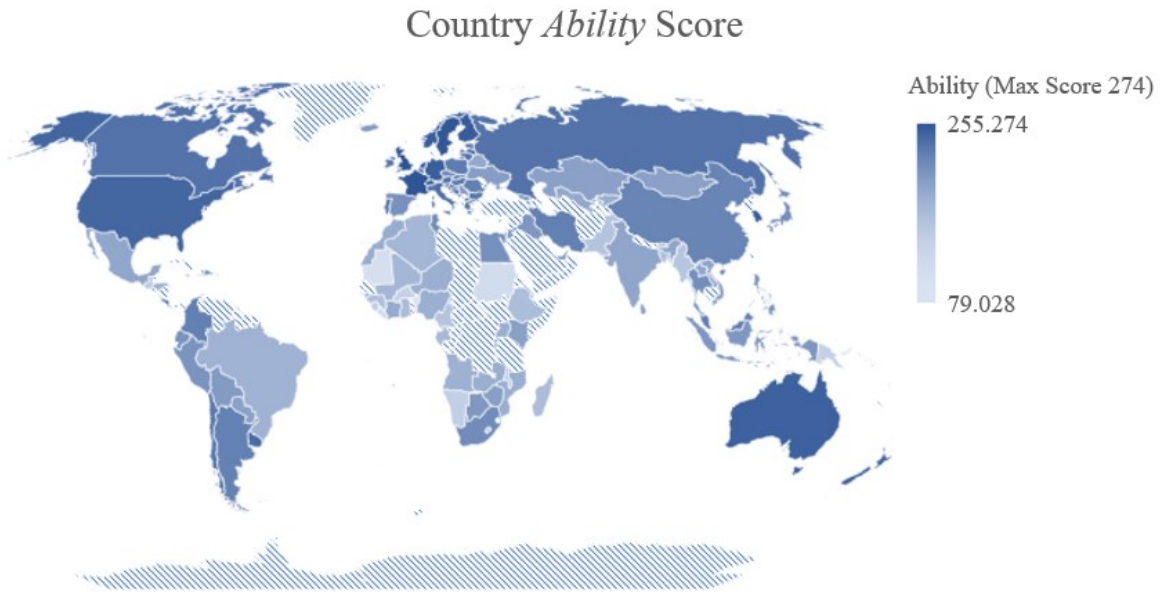

Figure 4 Country-level Ability Scores mapped globally with darker blue representing higher scores and stripes representing countries without the relevant data

The 'Action' score distributions were slightly different, with the LCD African region ranking again the lowest average score of 97.0. The lowest scoring countries started with Benin, then increasing to Comoros, Mauritania, Cameroon, and Sudan. The highest scoring LCD region on average was again Oceania with an average score of 150.3. The highest-ranking countries were Sweden, followed by Norway, France, the Netherlands, and the United Kingdom.

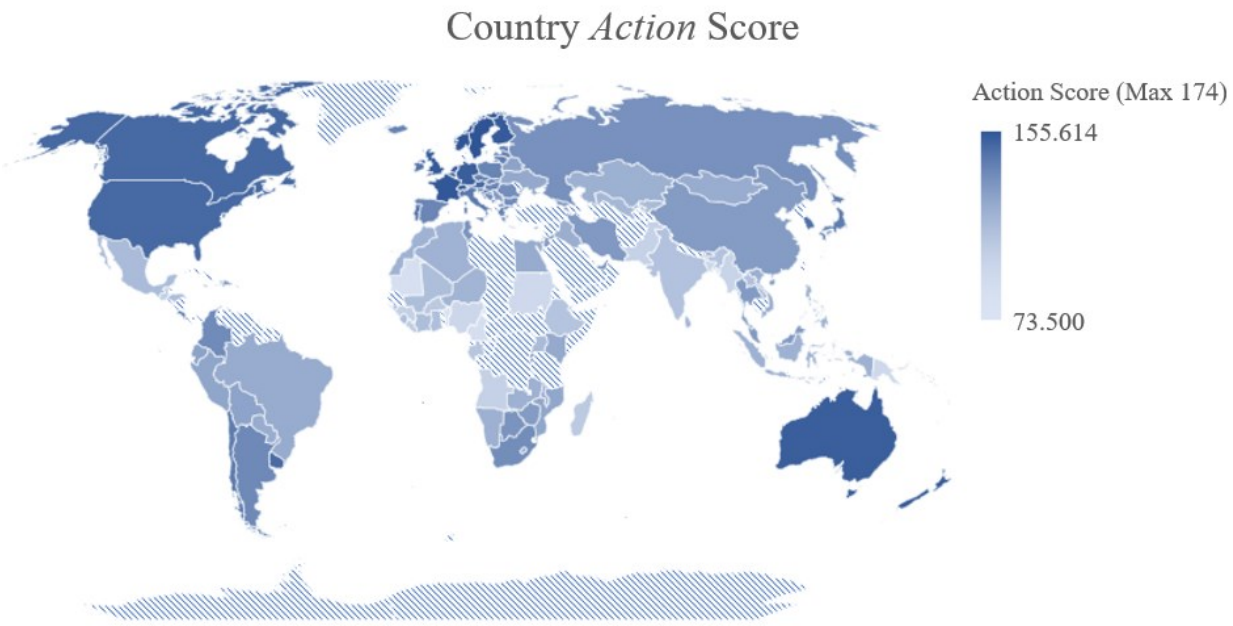

Figure 5 Country-level Action Scores mapped globally with darker blue representing higher scores and stripes representing countries without the relevant data

Finally, the overall score represents countries' cumulative health adaptive capacity score from 0 to 100 with 100 being the highest capacity. The lowest ranking LCD region overall was Africa with an average score of 49.4. The lowest ranking countries were Benin, followed closely by Mauritania, Liberia, Sudan, and Papua New Guinea. The highest overall scoring LCD region was Australia with an average of 81.8, almost tied with North America, which had an overall averaged score of 81.4. The highest scoring countries overall were France followed by United Kingdom, Switzerland, Sweden, and Germany.

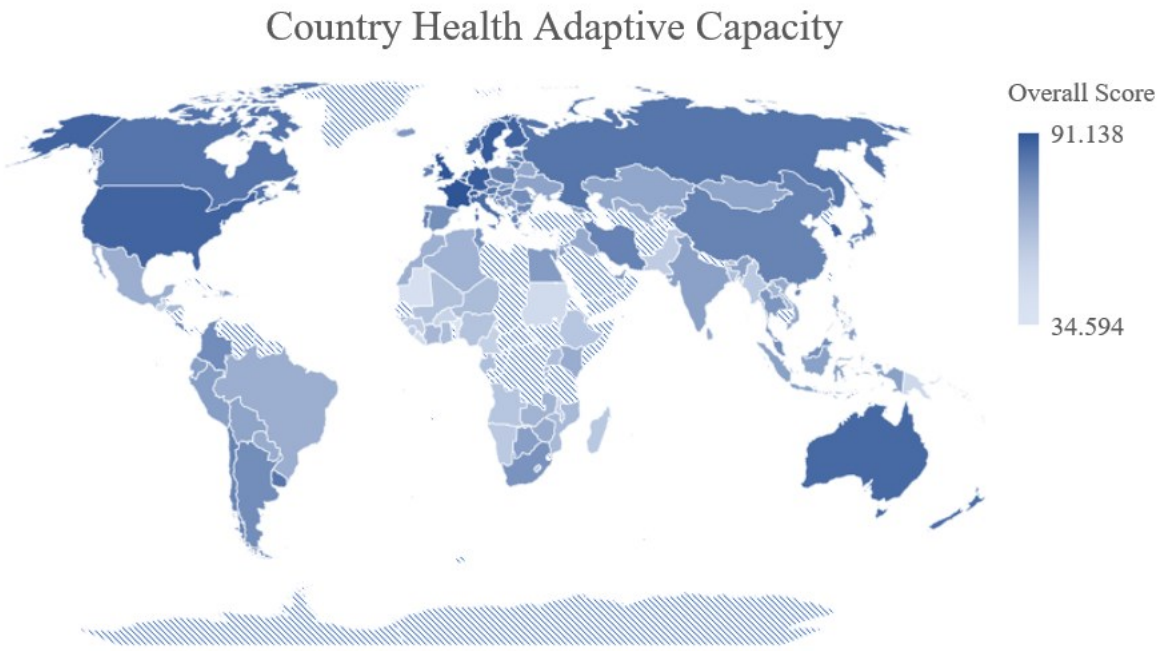

Figure 6 Country-level Overall Health Adaptive Capacity Scores mapped globally with darker blue representing higher scores and stripes representing countries without the relevant data

DISCUSSION

This study created an index investigating the components of adaptive capacity specific to health. The health determinants were transferred into the matrix of the general components of adaptive capacity. This yielded 4 key scores, the 'Awareness' of countries to the health impacts of climate change; the 'Ability' of countries to enact health-focused climate action measures; the 'Action' of countries governments, health systems, and industries to address the health burden of climate change; and the final 'Overall Health Adaptive Capacity' of countries to "adjust to potential damage, to take advantage of opportunities, or to respond to consequences of climate change{on health}."[12]

These scores had some general trends within different regions, notably that African countries consistently scored the lowest. In all four scores, Africa ranked lowest on average with

African countries as the majority of lowest scoring countries African. Regionally this was followed by Small Island Developing States (SIDS), with Papua New Guinea, Comoros, and Mauritania being in these lowest scoring countries. On the other end of the spectrum, Australia and North America consistently ranked highest. However, this could be tied to the smaller country count of these regions. In the Countdown regional groupings Mexico is not considered part of North America. However, if Mexico is incorporated in North America, the scores decrease by roughly 20 points for each component, from 81.4 without Mexico to 72.6 overall if Mexico is included.

At the country-level, France, Sweden, Switzerland, and the United Kingdom were consistently among the highest scoring countries. This highlights the distribution of scores for regions with more countries such as Europe, Asia, or South and Central America.

Implications for Health Adaptive Capacity on Vulnerability

These scores are relevant to the scientific understanding of adaptation as a component of risk. Health adaptive capacity decreases health vulnerabilities of a region or population group. The higher the adaptation, the lower the vulnerability. This has a cascading effect on risk, which is a function of the probability of hazard(s), exposure, and vulnerability.[8,33] In the most recent IPCC assessment, risk was defined as "the potential for adverse consequences," with risk being considered both as the impacts and the responses to climate change.[34] Therefore these scores reflect increased health vulnerabilities and risk to climate change in Africa and SIDS. This conclusion is supported by literature, which points to high health vulnerabilities throughout Africa as well as SIDS.[35,36]

It is also worth noting that, while health is generally scientifically understood to worsen from climate change, there are some regions that will see improved health. This includes through decreased mortality from cold-related injuries, illnesses, and death.[37] Some may therefore argued that improved health adaptation is not necessary in these regions. That would discount that many of the elements of health adaptation are grounded in improving health systems generally. For example, improved accessibility of healthcare providers would aid in countries without high climate vulnerabilities.

Role of Economics

Finally, the scores are linked to economic resources. The scores were highly correlated with gross domestic product (GDP) per capita with a correlation coefficient of 0.75. This reflects the advantage countries with higher incomes have for improving Economic Resources, Technology, and occasionally Infrastructure. It also reflects the historic advantage many countries have in implementing effective Governance/Institutions. Although all countries should strive for improved adaptive capacity, there are hard and soft limits to adaptation. These include biophysical limits, such as how often extreme events occur, economic limits, like livelihoods, and socio-cultural limits, such as beliefs and social support.[38] For health-specific limits, economic resources is one of four constraints to adaptation, with information as the largest constraint.[38] As economic limits are a major consideration, it is somewhat reflective that lower income countries rank lower on this scale of health adaptive capacity.

This is not to say that lower income countries that score lower in this index cannot improve their health adaptive capacity. There are many actions that can be achieved without depending upon financial resources. These include undergoing health-specific adaptation plans

and vulnerability assessments, prioritizing equity, improving population and health vulnerability specific research, improving communication methods for health-related disasters and climate change caused migration, etc.[39,40] Additionally, it is key that actions to prioritize health adaptation occur at all levels, from local adaptation efforts to international governance.[11] While there are many actions that low-income countries can take, many adaptation actions require development assistance to bolster adaptive capacity in these countries, which are more likely to be impacted than higher income states.

Components of Awareness, Ability and Action

Distinguishing between 'Awareness', 'Ability' and 'Action' of health adaptive capacity is an important step for countries and regions to recognize how the determinants feed into each other. However, in this index the scores did not differ drastically, with the same select countries and LCD regions ranking in the same or similar positions. The correlation coefficient between the 'Awareness' score and 'Overall' was 0.89, between 'Ability and 'Overall' was 0.98, and between 'Action' and 'Overall' was 0.95. Therefore, at the country-level it is likely not valuable to differentiate between these scores, but the matrix (see Figure 2) provides useful guidance for more localized or specific studies to replicate. It is also valuable that in implementation the difference between these levels is recognized.[29]

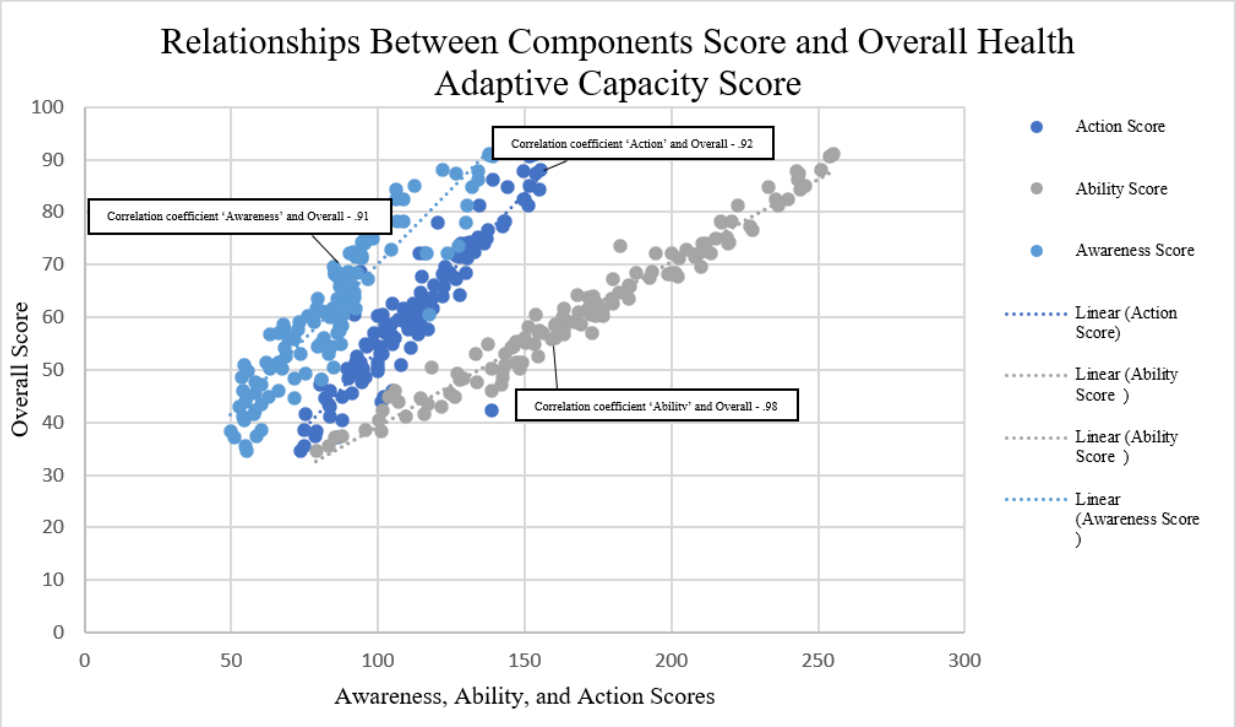

Figure 7 Correlation between Scores, with each of the Components compared to the Overall Score

Data limitations resulted in exclusion of approximately 70 countries in the final index measure. Notably this excluded many vulnerable countries, including countries in Sub-Saharan Africa and many SIDS countries more prone to sea-level rise. While it is important that data limitations be remedied, this also highlights an important consideration of whether countries are prioritizing health, policy, and general data collection. Data collection is not a component of health adaptive capacity that is factored into this index directly, but this lack of data highlights the inequitable assignment of resources globally towards health capacity building.

Limitations

Broadly this study is limited by a lack of research in the field of adaptive capacity and health. This includes a missing base of data for many of the measures that should be assessed for

adaptive capacity. This lack of research constrains the relevant references and examination into other potential methods. Additional research could also aid in validation efforts.

The primary limitation of this study is the lack of data pertaining to the determinants of adaptive capacity. This is addressed through proxy measures that lack data for approximately 70 countries. This could be better addressed through mapping trends of data for countries with data prior to the relevant year.

An additional limitation is data availability as it relates to more traditionally qualitative measures, such as governance or equity in health and climate actions. This is important to note as many of these more difficult to quantify measures tend to not be as dependent on government or individual spending. An example is improving governance through more highly connected communities that engage in climate change and health building, which is very difficult to measure let alone quantify.

Recommendations

A recommendation to refine the overall score of health adaptive capacity is to use fuzzy logic modeling to determine the overall score. This could take several different forms, including using human thought processes to quantify weightings through an if-then system.[41] This could prove useful to get a more complex understanding of how the different components feed into the overall score but was not feasible for this study.

Another recommendation for further research is to use measures such as content of Health National Adaptation Plans by country to check consistency of the current actions with scores. Comparisons could also be made with countries' responses to the COVID-19 virus and

the health adaptive capacity score. Other validation methods could also be considered with the understanding that the longevity of adaptive capacity lends itself to difficulties in validating.

A final broad recommendation is to apply the ideal measures of heath adaptive capacity to a case-specific example. This could include applying to a localized region and determining alternative proxy measures for the region. Alternatively, this could be applied by climate-related disease risk or climate-related health risk. This work could also be expanded by using the health adaptive capacity measures to guide projections to further assess adaptive capacity. An example would be using the Shared Socioeconomic Pathways to build pathways of health adaptive capacity. [42]

Conclusion

Health adaptive capacity is a complex concept that has broad implications for understanding the mechanisms of health adaptation, vulnerabilities, and risks and for supporting and expediting adaptation in countries with lower capacity. This effort is a theory-based approach to provide a conceptual framework of health adaptive capacity measures and a globally applied proxy index. Gaps in the availability of data, missing measures of ideal levers for health adaptation, and a lack of conceptual understanding of adaptive capacity in public health remain a challenge. However, there is existing literature and experience to support regions implementing measures to see improved health adaptation. The known determinants for improving current health adaptation should be addressed to create context-specific implementation for improved wellbeing paired with mitigation of existing climate change.

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Appendix

Table 2 Methods used for Standardizing Proxy Measures

Determinant of Health Adaptive Capacity	Proxy Measures Used	Standardization Methods
Economic Resources	Health expenditure as a percentage of GDP	*Data was gathered from World Health Organization Global Health Expenditure Database, from 2019* Decided to use percentage of Gross Domestic Product based on McIntrye et al.'s analysis They recommended 5% of GDP towards health spending, but as this was not solely health spending but "Estimates of current health expenditures include healthcare goods and services consumed during each year" So, this was set as double 5% with the gold standard at 10%, approximately 11% of countries were at the gold standard.
	Out of Pocket Expenditures	*Data was gathered from WHO Global Health Expenditure Database, from 2020* Country percentages were inverted so that countries where less was spent out of pocket by the individual were given a better (higher) score.
Technology	Climate Informed Health Systems	*Data was gathered from the World Meteorological Organization database, from 2022* Total of 6 elements, "Data Services", "Climate monitoring", "Climate analysis and diagnostics", "climate predictions", and "Climate projections" Each one was given a score of 16.5 if the country provided the service, if not a 0 score was given. If the country provided all 6 an extra point was given to make it 100, this also reflects the reality that if all 6 are given it is more beneficial than singular ones as they build off each other.
Information and Skills	Secondary Female School Enrollment	*Data was gathered from the United Nations Educational, Scientific and Cultural Organization (UNESCO) Institute for Statistics, from 2021* This captures the "ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown" Chose female specific education to recognize the equity and governance it takes to get females educated. Note that in the current version we took the most recent updates from 2015 on and all other countries were given the percentage of female literacy rate instead. Applicable for Bosnia and Herzegovina, Haiti, Vietnam, and Zambia
	Resident Patent Applications	*Data was gathered from the World Intellectual Property Organization (WIPO), from 2019* Initially we aimed to capture green patent filings, however on closer review it was found that WIPO only captures renewable energy PCT publications from 2019-2021. Therefore, resident patent applications by country were used. The WIPO database did not provide clear data for each country, so WIPO country profiles were individually scrapped for the relevant data. This resulted in countries with 0 resident patent applications being included. To standardize the patent applications with a high tail, the average number of resident applications was found, at 12633.79 and made the maximum score of 100, the remaining applications were divided by 126.33 and given the score out of 100. This resulted in 11 of 191 countries receiving a score of 100.
Infrastructure	Sanitation and Drinking Water	*Data gathered from the Yale Center for Environmental Law and Policy, from 2022* Gave a score out of 100, "Unsafe Sanitation (40% of issue category) We measure unsafe sanitation using the number of age-standardized disability-adjusted life-years lost per 100,000 persons (DALY rate) due to their exposure to inadequate sanitation facilities. Unsafe Drinking Water (60% of issue category)- We measure unsafe drinking water using the number of age-standardized disability adjusted life-years lost per 100,000 persons (DALY rate) due to exposure to unsafe drinking water."
	Medical Doctors per 10,000	*Data gathered from WHO Global Health Observatory database, originally sourced from the National health Workforce Accounts database, data from 2021-2020* The WHO recommendation is that there are 23 medical professionals per 10,000. This is meant to include physicians, nurses, and midwives. Accordingly, 23 doctors per 10,000 was set as the gold standard, with all other countries divided by .23 to give a score out of 100. This gave a high average of 59.975.
	Rural {Road} Access Index	*Data was gathered from the World Bank, Azavea, DRID UK, and ReCAP, from 2019* Score out of 100% for the proportion of the rural population who live within 2 km of an all-season road. Three datasets are used in this iteration: OpenStreetMap, WorldPop, GRUMP
Governance	Estimated DTP3 Vaccination Coverage for 1 year olds	*Data gathered from WHO and UNICEF, for 2021-2019* There was a high average of 85.96, so rotavirus immunizations were considered as an alternate proxy measure. However the coverage for rotavirus immunizations was far lower. Methods are listed as: "The estimate of immunization coverage is derived by dividing the total number of vaccinations [reportedly] given by the number of children in the target population, often based on census projections…The indicator is estimated as the percentage of children ages 12–23 months who received three doses of the combined diphtheria, tetanus toxoid and pertussis vaccine time before the survey."
	Corruption Perception Index	(This was included under consideration, as corruption is an illusive concept for inclusion. However, it was included to recognize the role of functioning governments in overseeing policy enactment for adaptation.) *Data was gathered from Transparency International, from 2021* Sources for the Index are from: 1. African Development Bank Country Policy and Institutional Assessment 2020 2. Bertelsmann Stiftung Sustainable Governance Indicators 2021 3. Bertelsmann Stiftung Transformation Index 2021 4. Economist Intelligence Unit Country Risk Service 2021 5. Freedom House Nations in Transit 2021 6. Global Insight Country Risk Ratings 2021 7. IMD World Competitiveness Center World Competitiveness Yearbook Executive Opinion Survey 2021 8. Political and Economic Risk Consultancy Asian Intelligence 2021 9. The PRS Group International Country Risk Guide 2021 10. World Bank Country Policy and Institutional Assessment 2021 11. World Economic Forum Executive Opinion Survey 2021 12. World Justice Project Rule of Law Index Expert Survey 2021 13. Varieties of Democracy (V-Dem v. 12) 2021
Equity	Gini Coefficient	*Data was gathered from the World Bank and World Economics database, 2021-2019* Scores were inverted so that 100 was the top score and zero was the lowest score in terms of equitably distributed resources. Any missing scores were replaced through World Economics database from 2019: Afghanistan, Albania, Bahamas, Bahrain, Bosnia and Herzegovina, Burkina Faso, Cabo Verde, Cambodia, Central African Republic, Chad, Eswatini, Guyana, Kuwait, Libya, Oman, Qatar, Moldova, Singapore, Costa Rica, Central African Republic, Republic of Korea, Dominican Republic, El Salvador, New Zealand, Lao People's Democratic Republic, North Macedonia, Papua New Guinea, and Nicaragua

Table 3 Weights of Determinants into Components

	Awareness	Ability	Action
Economic Resources_1	0	40	60
Technology_2	10	70	20
Information and Skills_3	70	30	0
Infrastructure_4	0	80	20
Institutions and Governance_5	30	30	40
Equity_6	33	33.5	33.5

Table 4 Total Scores All Countries with Scores for Each Determinant and Component

			Determinants of Health Adaptive Capacity						Components of Health Adaptive Capacity			
Country	LC Grouping	HDI Level (2021)	Governance	Information and Skills	Equity	Technology	Economic Resources	Infrastructure	Awareness Score (153)	Ability Score (274)	Action Score (174)	Overall Score (out of 100)
Benin	Africa	Low	57	21.76382	62.2	0	41.35715	25.24366	55.037056	79.027552	73.500022	34.594105
Mauritania	Africa	Medium	50	19.71379	67.4	16.5	43.22649	16.19121	54.663032	83.315322	75.053136	35.50524833
Cameroon	Africa	Medium	48	23.92419	53.4	66	33.84698	23.64586	57.761352	115.729318	75.32636	41.469505
Sudan	Africa	Low	55	23.16544	65.8	16.5	46.38783	17.99773	58.396352	87.679404	78.775244	37.47516667
Nigeria	Africa	Low	40	21.20577	64.9	100	27.7933	28.85896	60.381616	142.187142	80.189272	47.12633833
Angola	Africa	Medium	40	19.87091	48.7	100	44.0968	23.65428	53.967728	138.850826	83.503436	46.053665
Guinea	Africa	Low	36	15.36362	70.4	66	46.2645	24.32629	52.922896	121.623556	83.807958	43.05906833
Liberia	Africa	Low	47	19.6107	64.7	0	68.89029	22.58734	51.13956	85.322628	86.326142	37.13138833
Madagascar	Africa	Low	46	17.6457	57.4	82.5	51.41642	14.38978	55.10856	126.386532	87.856808	44.89198333
Burkina Faso	Africa	Low	66.5	20.4810645	45.2	33	60.00471	17.58363	54.5508516	100.3570009	87.861552	40.46156742
Gabon	Africa	High	47	38.12336	62	66	53.77681	23.82347	71.658688	129.264172	89.80078	48.45394
Ethiopia	Africa	Low	55	17.12496	65	66	49.65043	20.90414	58.249968	124.483476	90.946086	45.613255
Djibouti	Africa	Low	50	27.7727	58.4	100	45.69634	26.07855	66.49016	149.259916	92.197514	51.32459833
Ghana	Africa	Medium	68.5	38.91948	56.5	49.5	51.70794	30.61524	75.280584	127.086764	93.375312	49.29044333
Sierra Leone	Africa	Low	62.5	46.31659	64.3	16.5	65.87883	23.95529	89.697272	193.388778	94.158856	68.59542167
Cote d'Ivoire	Africa	Medium	55.5	28.1713886	51.3	100	50.49815	22.87908	66.11611088	147.9723017	94.260206	51.39143643
Mali	Africa	Low	49.5	17.44197	63.9	82.5	55.13949	17.52277	58.140576	133.568906	94.294748	47.66737167
Uganda	Africa	Low	58	11.46757	57.3	82.5	50.40112	32.27107	53.733056	142.616318	95.590386	48.65662667
Niger	Africa	Low	56	10.3669	62.7	100	56.66815	12.17516	55.78452	142.285268	99.840422	49.65170167
Algeria	Africa	High	62	51.06071	72.4	0	63.31686	68.87956	83.340568	133.496534	100.820028	52.942855
Morocco	Africa	Medium	69	42.20156	60.5	49.5	55.53226	49.23328	79.376248	145.65734	100.933512	54.32785
Malawi	Africa	Low	64.5	16.82774	61.5	16.5	77.20206	26.31791	54.757192	106.8032	101.287318	43.80795167
Zambia	Africa	Medium	58.5	42	42.9	82.5	72.15601	20.34398	73.557	143.209088	101.633902	53.066665
Namibia	Africa	Medium	71	34.98254	40.9	0	88.76503	32.78483	62.783032	103.731884	101.917484	44.73873333
Gambia	Africa	Low	61	50	61.2	82.5	57.34855	31.43414	86.746	154.638732	102.097958	57.247115
Egypt	Africa	High	63.5	48.00655	68.1	100	44.04487	51.41094	89.92824	180.21151	104.92261	62.51039333

Lesotho	Africa	Low	62.5	36.3297	55.1	0	92.725	30.04164	65.99676	105.597752	105.101828	46.11605667
Kenya	Africa	Medium	59.5	27.47209	59.2	100	60.92913	28.83886	69.363672	160.619158	105.95725	55.99001333
Mozambique	Africa	Low	52.5	18.91981	46	82.5	84.18756	21.28618	54.315848	143.39793	107.679772	50.898925
Zimbabwe	Africa	Medium	54.5	25.68474	49.7	100	83.31282	27.2554	63.298792	163.265896	113.888272	56.74216
Burundi	Africa	Low	56	26.12383	61.4	100	74.83957	33.51325	67.961064	169.340194	114.575392	58.64610833
Rwanda	Africa	Low	72	24.65327	56.3	82.5	76.87834	34.2747	68.151616	161.31225	117.142444	57.76771833
Botswana	Africa	Medium	75	38.80321	46.7	100	77.92183	30.84544	78.953568	171.750226	118.566686	61.54508
Tunisia	Africa	High	70.5	49.65948	67.2	82.5	66.5923	59.41453	91.303584	185.51244	119.050286	65.97771833
South Africa	Africa	High	64	57.1400301	37	100	92.86677	44.62959	87.12202408	185.873386	122.64098	65.93939835
Bangladesh	Asia	Medium	62	43.42951	67.6	49.5	25.41788	41.31139	80.601608	127.798166	80.859006	48.20979667
Myanmar	Asia	Medium	56	35.64877	69.3	33	37.03782	36.60603	71.488016	114.345206	81.759398	44.59877
Pakistan	Asia	Low	52.5	22.48122	70.4	33	39.17964	42.81796	60.266976	116.856468	83.255376	43.39647
India	Asia	Medium	62.5	88.35708	64.3	66	39.77573	42.10938	117.254664	153.759712	92.027814	60.50703167
Lao People's Democratic Republic	Asia	Medium	54.5	29.1694107	56.7	100	42.11262	33.15298	68.39652856	154.5458141	92.692668	52.60583512
Kyrgyzstan	Asia	Medium	57	50.34038	71	33	49.51771	65.43957	84.102304	146.211816	95.98354	54.38294333
Uzbekistan	Asia	High	61.5	47.79108	64.7	33	51.53302	71.52495	81.333864	150.615884	98.099302	55.008175
Sri Lanka	Asia	High	66.5	51.0527982	62.3	49.5	47.10898	64.92199	86.30123856	156.4622436	98.620286	56.8972947
Philippines	Asia	Medium	52	49.0269	59.3	100	47.86883	52.74535	84.39052	176.614692	99.935868	60.15684667
Bhutan	Asia	Medium	81.5	47.85506	62.6	16.5	60.32808	34.41546	85.042048	118.205612	99.95094	50.5331
Indonesia	Asia	High	57.5	50.73962	62.1	100	48.62968	43.76874	88.334696	172.668288	101.735056	60.45634
Kazakhstan	Asia	Very High	62.5	50.35621	72.2	49.5	50.19728	65.88733	87.810968	160.447018	102.382834	58.44013667
Viet Nam	Asia	High	66.5	51.71910868	63.2	49.5	56.44828	58.00804	87.13128695	155.1015657	103.142576	57.56257145
Mongolia	Asia	High	65.5	50.43141	67.3	49.5	55.31039	64.11347	87.154128	160.346714	104.654428	58.692545
Georgia	Asia	Very High	71.5	50.35621	65.8	49.5	59.86721	77.98591	88.398968	174.549854	112.060508	62.501555
China	Asia	High	72	94.00634	61.8	66	59.35639	79.64064	123.799072	194.759336	114.244962	72.133895
Jordan	Asia	High	63	36.44175	66.3	33	72.80235	82.97609	73.2324	167.000662	114.287128	59.08669833
Thailand	Asia	Very High	66	53.26719	64.9	82.5	63.6756	58.48282	92.080752	182.201434	114.543424	64.80426833
Malaysia	Asia	Very High	73	46.94845	58.8	100	51.18071	76.01823	88.86276	202.274558	114.810072	67.65789833
Armenia	Asia	High	70	45.32237	72.1	49.5	61.075	82.68469	86.000896	179.445726	115.235438	63.44701
Iran	Asia	Medium	62	85.41052	59.1	100	65.02308	60.78878	116.431416	200.12086	115.770104	72.05373
United Arab Emirates	Asia	Very High	79.5	50.2730943	74	33	65.77025	79.33013	91.788475444	171.5668229	118.518176	63.64557905
Cyprus	Asia	Very High	74.5	50.09931	68.3	33	78.04016	79.75776	88.268448	173.372634	122.056148	63.94953833
Japan	Asia	Very High	84.5	100	67.1	0	93.715	96.68756	127.493	182.664548	131.845012	73.66709333
Israel	Asia	Very High	78.5	56.30096	61.4	82.5	78.73659	93.07822	97.102768	219.086404	134.326598	75.08596167
Ireland	Asia	High	84	54.04496	70.8	66	78.14658	97.32087	98.399968	215.042322	136.870122	75.05206833
Republic of Korea	Asia	Very High	80	97.8791695	65.6	100	76.94583	95.91036	133.9513356	243.0584539	139.32557	86.05589325
Iraq	Europe	Very High	48.5	23.05341	70.5	100	49.98358	50.03069	66.257728	172.796166	103.013786	57.01128
Ukraine	Europe	High	56.5	52.66894	74.4	33	61.56301	79.79909	86.937152	163.972264	107.021624	59.65517333
Belarus	Europe	Very High	69	51.45254	75.6	0	66.9217	85.36026	86.810032	151.373396	110.151072	58.05575
Serbia	Europe	Very High	65	47.23164	65	33	75.40532	80.40654	82.035312	168.308688	115.6995	61.00725
North Macedonia	Europe	High	61.5	39.7207001	68.2	66	66.8355	78.92114	79.332560008	185.312252	116.532528	63.52955668
Russia	Europe	Very High	63	100	64	100	64.36246	76.26664	130.02	217.098296	120.510804	77.93818333

Romania	Europe	Very High	66	46.84143	65.4	82.5	69.20739	79.14254	87.105144	199.824274	122.161942	68.18189333
Bulgaria	Europe	High	66.5	44.30562	59.5	100	67.34057	80.29821	85.029496	209.91842	122.996484	69.6574
Montenegro	Europe	Very High	65	45.97084	63.2	82.5	73.37416	79.56668	85.382672	200.619176	123.609832	68.26861333
Bosnia and Herzegovina	Europe	High	54	48.70976807	65.7	82.5	80.81549	78.97446	85.09881445	201.2072176	124.393686	68.44995301
Spain	Europe	Very High	77.5	62.8948	65.1	16.5	85.85066	95.54942	96.69884	179.96726	126.72878	67.23248
Hungary	Europe	Very High	71	52.18871	70.3	82.5	68.99011	84.73996	94.499968	208.426254	126.792558	71.61979667
Poland	Europe	Very High	73	65.49117	71.2	66	72.21913	88.70079	104.388936	204.898518	127.323636	72.768515
Iceland	Europe	Very High	83.5	50.37996	73.9	0	85.6834	92.0457	89.740968	167.792412	127.97568	64.25151
Greece	Europe	Very High	74	52.35494	66.4	66	72.46943	97.35247	92.595952	207.984736	127.996152	71.42947333
Slovakia	Europe	Very High	74.5	50.45912	76.8	49.5	75.41823	89.03771	94.847296	210.636104	128.48648	74.04277167
Czechia	Europe	Very High	75.5	52.94863	73.8	33	83.40854	92.05292	92.662904	188.068478	129.978708	68.45168167
Latvia	Europe	Very High	79	50.49869	64.3	100	66.84571	83.77975	95.317952	219.102322	130.003876	74.07069167
Estonia	Europe	Very High	82.5	50.37204	69.3	66	72.85725	86.63999	94.516632	202.6948	130.457848	71.27821333
Lithuania	Europe	Very High	76	50.60951	64	100	70.68502	83.86825	94.407608	219.73051	131.024662	74.19379667
Italy	Europe	Very High	75	100	64.8	66	82.70284	99.15233	130.484	222.811	134.36017	81.27586167
Portugal	Europe	Very High	80.5	53.96185	65.3	66	83.7573	94.11845	95.46848	211.81555	136.353577	73.9396
Croatia	Europe	Very High	70.5	50.41162	70.5	100	79.66809	88.44151	94.744296	227.470268	137.306656	76.58687
Slovenia	Europe	Very High	76	20.5312004	76	66	86.38432	89.41319	58.043960302	101.4625041	138.77323	42.2775534
Austria	Europe	Very High	79.5	66.29654	70.2	66	91.6	96.15491	106.653232	220.390236	142.707982	78.29190833
Germany	Europe	Very High	85.5	97.36298	68.3	82.5	93.73	99.31768	134.329384	242.69924	149.682036	87.78511
Belgium	Europe	Very High	85	63.00166	74	82.5	91.98	97.59218	108.571328	235.506076	149.996436	82.34564
Switzerland	Europe	Very High	90	99.86623	66.9	100	89.015	98.50963	138.969984	253.79845	151.522426	90.71514333
Finland	Europe	Very High	89	64.50566	72.9	100	87.56242	95.57209	112.361528	245.505272	151.67337	84.92336167
United Kingdom	Europe	Very High	85.5	100	67.4	100	93.2	99.13668	137.892	254.818344	152.526336	90.87278
Netherlands	Europe	Very High	88	84.22782	74	82.5	95.34	99.55215	126.452256	243.563284	153.60443	87.269995
France	Europe	Very High	83.5	100	69.3	100	95.53	98.49554	137.919	255.273932	153.632608	91.13759
Norway	Europe	Very High	91	56.27325	72.3	100	93.05	92.52099	106.1776	244.011942	154.954698	84.19070667
Sweden	Europe	Very High	91	76.60097	71.1	100	93.485	96.52076	122.043776	251.049302	155.613652	88.11778833
Canada	Northern America	Very High	83	68.64165	67.5	66	93.785	89.98899	108.68832	216.946022	143.281298	78.15260667
United States of America	Northern America	Very High	80	99.7071495	60.3	82.5	95.055	91.19177	131.9147196	232.8673459	143.971854	84.79231992
Australia	Oceania	Very High	84	61.7391	65.7	100	92.66893	91.18087	106.27228	239.569588	149.447032	82.54815
New Zealand	Oceania	Very High	90	51.3061031	65.4	100	92.91588	87.74431	99.626882488	236.5320206	151.20739	81.22771552
Comoros	SIDS	Medium	53.5	30.70725	54.7	16.5	42.02652	33.77049	60.3168	95.89295	74.99451	38.53404333
Papua New Guinea	SIDS	Medium	35	20.7933502	53.7	49.5	57.1168	13.85166	49.805680 16	101.226218	78.929912	38.32696837
Haiti	SIDS	Low	35.5	29	58.9	100	50.19045	27.8032	63.287	148.50024	89.60641	50.232275
Guinea-Bissau	SIDS	Low	47.5	20.158315 52	65.2	100	59.54881	16.50862	61.892652 42	147.1500831	99.87301	51.48595759
Mauritius	SIDS	Very High	73.5	48.02016	63.2	0	60.34219	87.45403	81.322128	146.926132	104.26812	55.41939667
Cabo Verde	SIDS	Medium	75.5	46.3473341	50.9	49.5	63.06609	51.25264	81.474867 28	149.8495148	105.241682	56.09434402
Vanuatu	SIDS	Medium	61.5	27.63527	67.7	100	63.12673	26.60895	72.899216	163.194406	110.477328	57.761825
Dominican Republic	SIDS	High	56	39.5120611	59.5	82.5	67.32071	56.33013	76.294648 88	174.3773002	110.490952	60.19381685
Solomon Islands	SIDS	Medium	68.5	23.5107346	62.9	82.5	71.98812	15.62594	68.365587 68	145.3696469	111.28956	54.1707991
Jamaica	SIDS	High	70	47.75357	54.5	66	72.95242	48.31529	83.787856	162.841414	112.89201	59.92021333
Fiji	SIDS	High	77	50	69.3	66	62.25035	44.67836	92.569	163.158328	113.501382	61.53811833

Seychelles	SIDS	High	83.5	40.79388	67.9	66	68.87646	78.54312	86.692104	192.540356	126.381	67.60224333
Guatemala	South and Central America	Medium	54	23.80024	51.7	16.5	52.91305	48.22161	53.951192	109.572056	83.611652	41.18915
Honduras	South and Central America	Medium	51.5	35.13199	51.8	66	61.39959	35.31671	67.249592	138.842602	95.056096	50.19138167
Mexico	South and Central America	High	51.5	54.42096	54.6	33	57.78026	78.25254	80.304768	153.439328	95.809664	54.92562667
Paraguay	South and Central America	High	54.5	39.322	57.1	49.5	66.67905	68.15778	71.6006	159.190744	104.467486	55.87647167
Brazil	South and Central America	High	57.5	68.46751	47.1	0	86.76136	70.10627	87.567008	137.511562	104.85657	54.98919
Peru	South and Central America	High	54	50.37204	59.8	82.5	64.69534	58.3542	84.481632	176.618904	108.621044	61.62026333
Bolivia	South and Central America	Medium	49	44.86618	59.1	82.5	73.9819	45.71974	78.345944	167.390288	109.431588	59.19463667
Ecuador	South and Central America	High	53	50.13853	54.2	66	72.17623	71.59248	80.496824	176.429182	110.181234	61.18454
Colombia	South and Central America	High	63.5	51.70981	48.5	100	81.75218	64.4829	86.422848	199.926654	123.595388	68.32414833
Argentina	South and Central America	Very High	56	51.6069	58	82.5	85.44535	75.40168	85.47552	198.800864	124.677546	68.15898833
Costa Rica	South and Central America	Very High	77.5	50.0593683	51	100	76.22466	78.03178	90.12749464	213.2621617	129.426152	72.13596805
Chile	South and Central America	Very High	80	51.59107	55.1	82.5	81.97362	83.26044	91.705856	209.924514	132.79476	72.40418833
Uruguay	South and Central America	Very High	82.5	50	59.2	100	88.39916	83.51179	94.286	226.751096	142.573854	77.26849167