Methodological Notes of the WorldRiskIndex

Edition 2020

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Section 1: Introduction

The process of developing an index concept, which is capable of measuring risk on a global scale, has to be founded on guiding principles and quality or evaluation criteria that support the selection of statistically sound indicators and techniques. In the case of the WorldRiskIndex, the statistical indicators are chosen with four core principles in mind:

- All indicators for physical exposure have to allow for a comparison of different hazard types by using the same unit of measurement and should, if at all possible, be taken from a single data source to avoid problems of statistical inconsistency,
- all vulnerability and adaptation indicators should be generic to be relevant for multiple hazards or exposure types (multi-hazard modeling perspective),
- the index concept has to be analytically and statistically sound as well as reproducible at every level
- the index results have to be appropriate in scope and value.

Furthermore, the index and all indicators should also be understandable on a basic level, easily interpreted by laymen as well as professionals, and comparable to other measures of disaster risk exposure and vulnerability.

Section 2: Computation of the WorldRiskIndex

To calculate the risk of nations to experience a humanitarian crisis or catastrophe in the aftermath of extreme natural events like earthquakes, storm winds or floods on a global scale, several spatial data sets (e.g. population grid data, hazard frequency models, etc.) are necessary, but previously most data sources like EM-DAT only provided information on the number of hazard categories or hazard events per nation. Fortunately, several agencies of the United Nations (UNEP, UNDP/GRIP, UN/ISDR) in a joint effort with the World Bank have created the PREVIEW Global Risk Data Platform, which provides the required spatial data on the global risk of natural hazards and the exposed population based on annual population data taken from the LandScan Global Population Datasets.

As a pillar of the WorldRiskIndex, the exposure is partly based on values of the annually exposed populations to earthquakes, storms, floods and droughts provided by the PREVIEW Platform, but a novelty of the index concept is the integration of emerging risks of climate change due to a rise in sea level. Since the PREVIEW Platform has no data on the physical exposure to sea level rise, these data sets have to be derived from other global data sources. To ensure comparability to the PREVIEW Platform, all population data are taken from annually published LandScan Global Population Datasets, whereas the affected areas from a sea level rise of 1 meter were obtained from the University of Kansas Center for Remote Sensing of Ice Sheets (CRESIS). These datasets allow for an estimation of people exposed to future sea level rise.

It has to be stressed that these global data sets are mostly based on statistical models and are therefore prone to include an element of uncertainty, which has to be taken into account during all stages of computing, analyzing, presenting, and interpreting the WorldRiskIndex and its parts. For example, the physical exposure to droughts is quite high due to the input parameters and assumptions made for the calculation. Compared to other hazards, droughts differ in terms of occurrence periods and the timespan of the event itself (Peduzzi et al. 2009), which results in the previously mentioned element of uncertainty.

In contrast to the physical exposure, the calculations of the susceptibilities, the coping capacities, and the adaptive capacities of countries are largely based on several indicators provided by the global databases of the World Bank, the World Health Organization, or agencies of the United Nations. All listed indicators in this document were thoroughly evaluated and analyzed for long-term data availability as well as their plausibility and suitability concerning the methodological framework for the WorldRiskIndex. Any type of serious limitation, such as sparse data coverage, resulted in the immediate exclusion of several indicators judged highly relevant by many experts and practitioners (e.g. availability of national early warning systems).

The values for these three components are calculated by a basic aggregation method after the values of their indicators were transformed to a scale of 0 to 1. In a first step, all rescaled values were combined with equal weight to a corresponding grouping indicator, such as “Government & Authorities” for the rescaled Fragile States Index and the Corruption Perception Index. In a second step, the weighted average of all grouping indicators within the susceptibility, coping capacity, and adaptive capacity components is calculated, resulting in the final value for each of these components.

Statistical Formulas and Weights for the WorldRiskIndex

$$Susceptibility\ (SC) = \frac{2}{7}\left(\frac{A1 + A2}{2}\right) + \frac{1}{7}(C1) + \frac{2}{7}\left(\frac{D1 + D2}{2}\right) + \frac{2}{7}\left(\frac{E1 + E2}{2}\right)$$

$$Coping\ Capacity\ (CC) = \frac{4}{9}\left(\frac{A1 + A2}{2}\right) + \frac{4}{9}\left(\frac{C1 + C2}{2}\right) + \frac{1}{9}(E1)$$

$$Adaptive\ Capacity\ (AC) = \frac{1}{4}\left(\frac{A1 + A2}{2}\right) + \frac{1}{4}(B1) + \frac{1}{4}\left(\frac{C1 + C2 + C3 + AC4}{4}\right) + \frac{1}{4}\left(\frac{E1 + E2 + E3}{3}\right)$$

$$Vulnerability = \frac{SC + (1 - CC) + (1 - AC)}{3}$$

$$Exposure = \frac{A + B + C + 0.5D + 0.5E}{Total\ Population\ Number}$$

$$WorldRiskIndex = Exposure * Vulnerability$$

Within the above formulas, all letters refer to indicators of the corresponding dimension of the statistical model of the WorldRiskIndex (e.g. A1 in the equation for a nations susceptibility refers to the share of a population without access to basic sanitation services). For presentation, all results can be multiplied by a value of 100 as long as final values of the WorldRiskIndex is subsequently divided by 100 to avoid a wrong scaling.

A critical issue for every index concept is the presence of missing values within data sets as it forces researchers to either exclude the affected countries from all statistical procedures resulting in a loss of information or to implement mathematical procedures to provide valid estimations for the missing data points. While the first approach will strongly decrease the validity of a global index concept, if higher numbers of countries have to be excluded from the analyses, the latter relies in most cases on statistical models, which will introduce an element of uncertainty in index model. In any case, researchers have to carefully consider all aspects of the approaches to make a suitable choice for the methodological concept.

In contrast to previous years, a new methodological procedure for the treatment of missing values has been implemented for the WorldRiskIndex 2019, which made it possible to calculate index values for eight additional countries (Antigua and Barbuda, Democratic Republic of the Congo, the Maldives, Montenegro, the Federated States of Micronesia, St. Lucia, St. Vincent and the Grenadines, Sao Tome and Principe). In 2020, this procedure made it possible to include Dominica in the ranking of the WorldRiskIndex. Furthermore, this new procedure reduces the need for complex statistical modeling to estimate values for missing data points:

For all countries that have no value for an indicator, the procedure first triggers a search whether values for these indicators in the respective reference year can be obtained from alternative sources of equal or higher quality (e.g. Statistical Yearbooks or similar). If no values can be obtained in this way, the most up-to-date values are taken from the primary and secondary sources for a period of up to 10 years, with the rule that the most recent data is always selected, irrespective of this whether it comes from the primary or adequate secondary sources. An estimation of missing values by statistical modeling (for example, regressions) becomes necessary only if no information is found in the defined period. Thus, this procedure fits into the understanding of the model, which follows the principles of transparency and traceability by applying clear rules. Finally, it should be noted that only countries that calculate less than six values of indicators by statistical estimates are included in the calculation of the WorldRiskIndex, to minimize the index's dependence on these methods.

Exposure			
Indicator A – D Physical Exposure to Earthquakes, Storms, Floods, and Droughts			
Measuring Unit Annual average number of exposed persons			
Data Sources PREVIEW Global Risk Data Platform Website: *https://preview.grid.unep.ch*		Oak Ridge National Laboratory Website: *https://landscan.ornl.gov*	
Data Updates	Irregularly	**Data Grid**	Approx. 1 km (30”)
Relevancy of Indicator The physical exposure of populations to natural hazards (e.g. earthquakes, storms, floods and droughts) is a crucial aspect of disaster risk as the degree of exposure is directly linked to the risk profile of populations or nations. Hence, knowledge of physical exposure is vital for raising awareness as well as the development of protective capacities (e.g. suitable shelters) and emergency strategies (e.g. evacuation routes). Additionally, the share of a population with a physical exposure to various hazards provides a first insight into the risk profile of nations or populations in terms of how many people are directly exposed or might be at risk in cases of extreme natural events.			
Evaluation of Indicator This group of indicators is based on estimations of the number of people at risk in case of earthquakes, storms, floods and droughts on a national level gathered by geostatistical models of annual hazard frequencies (ex-post focus) and total population estimates in spatial units exposed to each hazard. All population estimates are provided by the Oak Ridge National Laboratory (e.g. Dobson et al. 2000) for the year 2017 with a spatial resolution of 1 km, while annual hazard frequencies with spatial resolutions of 1 or 5 km are based on multiple data sources (see Global Risk Data Platform). As these indicators are the estimation results of a geostatistical modeling approach, they are directly dependent on the accuracy and return periods of natural hazard events as well as the quality of population estimates (Peduzzi et al. 2009).			
Mathematical Transformation None			
Key Literature Dobson et al. (2000); Peduzzi et al. (2009)			

Exposure			
Indicator E Physical Exposure to Sea Level Rise of One Meter			
Measuring Unit Annual average number of exposed persons			
Data Sources Centre for Remote Sensing of Ice Sheets Website: *https://www.cresis.ku.edu*		Oak Ridge National Laboratory Website: *https://landscan.ornl.gov*	
Data Updates	Irregularly	**Data Grid**	Approx. 1 km (30")
Relevancy of Indicator As a result of global climate change, the sea level rise is a major hazard with particularly strong consequences for populations in coastal regions. In direct comparison to sudden-onset hazards like floods or earthquakes, a rise in sea level is a creeping process with irreversible changes – a population might be able to return to a flood-, storm- or earthquake-prone area, but regions covered by sea water will be unusable for housing or agriculture for longer periods.			
Evaluation of Indicator The physical exposure to a sea level rise of one meter is a vital measure for the assessment of impacts climate change might have on populations or nations risk profiles. A geostatistical model is applied to compute the number of people at risk to a sea level rise of one meter from a global map of inundation regions provided by the Centre for Remote Sensing of Ice Sheets and a global population grid with a spatial resolution of 1 km created by Oak Ridge National Laboratory (e.g. Dobson et al. 2000) for the year 2017. While the set of indicators for earthquakes, storm, floods and droughts are based on a frequentist modeling approach, the sea level rise is computed by a static approach as no comparable mappings of events are available for this type of exposure.			
Mathematical Transformation None			
Key Literature Dobson et al. (2000)			

Susceptibility – Public Infrastructure

Indicator A1

People without Access to Basic Sanitation Services

Measuring Unit

Share of a population without access to basic sanitation services

Data Sources

Joint Monitoring Programme of World Health Organization and United Nations Children's Fund
Website: *http://washdata.org* – Indicator: *Household – Sanitation – Total – Basic Service*

Data Updates	Annually	**Reference Year**	2017	**Data Points**	193 Countries

Relevancy of Indicator

The access of populations to basic sanitation facilities is a valid indicator of the quality of basic infrastructure, demonstrating quality-of-life and basic health conditions in a country. Furthermore, it is considered to be a human right rather than a privilege to have access to proper sanitation. Generally, sanitation refers facilities and services for the safe disposal of human urine and faeces like flush toilets, piped sewer systems, septic tanks, flush/pour flush to pit latrines, ventilated improved pit latrines, pit latrines with slab and composting toilets, which are not shared with other households.

These types of facilities and services can effectively prevent insect and animal contact, which are agents of diarrhoea, as well as reduce other non-diarrhoea related health outcomes, such as scabies and helminthiasis (Esrey & Habicht 1986). In other words, improved sanitation should improve growth rates and reduce child mortality rates. In this context, it can be concluded that people without improved sanitation are susceptible to diseases and can become more vulnerable following a hazard.

Evaluation of Indicator

This indicator has been identified as a key indicator of vulnerability on a national level (Brooks et al. 2005).

Mathematical Transformation

Rescaled Value = 1 – (Actual Value/100)

Key Literature

Brooks et al. (2005); Esrey & Habicht (1986)

Susceptibility – Public Infrastructure					
Indicator A2 People without Access to Basic Drinking Water Services					
Measuring Unit Share of a population without access to basic drinking water services					
Data Sources Joint Monitoring Programme of World Health Organization and United Nations Children's Fund Website: *http://washdata.org* – Indicator: *Household – Drinking Water – Total – Basic Service*					
Data Updates	Annually	**Reference Year**	2017	**Data Points**	193 Countries
Relevancy of Indicator A lack of access to drinking water via basic sources like vendors, tanker trucks or unprotected wells and springs is one of many causes for infections and diseases. In other words, people without at least basic water sources are vulnerable to diseases caused by unclean water and could become more vulnerable in the aftermath of a hazard, due to their existing ailments. However, basic water sources (based on the assumption they are likely to provide safer water) can significantly lower the risk of water-borne diseases, which, in turn, has in its turn a positive impact on people's health status (Esrey & Habicht 1986).					
Evaluation of Indicator This indicator is recognized as a crucial measure for susceptibility to harm from natural hazards by a great variety of researchers (e.g. Brooks et al. 2005; Bollin & Hidajat 2006). On a national scale, this indicator can be used as an overall proxy for the general quality of infrastructure and health status, but it does not consider traditional water harvesting techniques that may play a major role in some (especially developing) countries, which would overrate the susceptibility in this aspect.					
Mathematical Transformation *Rescaled Value = 1 – (Actual Value/100)*					
Key Literature Bollin & Hidajat (2006); Brooks et al. (2005); Esrey & Habicht (1986)					

Susceptibility – Nutrition

Indicator C

Prevalence of Undernourishment

Measuring Unit

Share of a population living below the minimum level of dietary energy consumption

Data Sources

World Bank Open Data Platform
Website: *https://data.worldbank.org* – Indicator: *SN.ITK.DEFC.ZS*

Data Updates	Annually	**Reference Year**	2017	**Data Points**	178 Countries

Relevancy of Indicator

In this case, malnutrition is represented by the proportion of a population living below the minimum level of dietary energy consumption. The indicator illustrates the problems of food insecurity and hunger of a population, which has serious consequences on people's physical condition and health and very negative impacts on the mental and physical development of children (see Von Grebmer et al. 2018; UNSCN 2009). A situation of malnutrition can be also the product of different circumstances having a relationship with development policies and strategies, such as agricultural measures for food availability.

Evaluation of Indicator

The prevalence of undernourishment is calculated using estimations on food available (i.e. production, trade, etc.), inequality of distribution or inaccessibility of food (i.e. household income) and the minimum dietary energy requirement. In principle, data sources are national statistics on local food production, trade, stocks and non-food uses; food consumption data from national household surveys; country anthropometric data by sex and age and country population estimates.

This evaluation could be more useful by considering geographical areas that may be particularly vulnerable (such as areas with a high probability of major variations in production or supply or areas subject to extreme natural events) and specific ethnic or social groups, as well as gender differences. Nevertheless, this kind of assessment is a sensitive issue for a country.

Mathematical Transformation

Rescaled Value = Actual Value/100

Key Literature

FAO (2008); Von Grebmer et al. (2018); UNSCN (2009)

Susceptibility – Poverty & Dependency

Indicator D1

Age Dependency Ratio

Measuring Unit

Ratio of persons younger than 15 years or older than 65 years to persons aged 16 to 64 years

Data Sources

World Bank Open Data Platform
Website: *https://data.worldbank.org* – Indicator: *SP.POP.DPND*

Data Updates	Annually	**Reference Year**	2018	**Data Points**	193 Countries

Relevancy of Indicator

A high dependency ratio can indicate, in different ways, a population's susceptibility to harm: As the ratio of the economically dependent population to the productive population, a high value increases the susceptibility to harm as more people are affected if a working person experiences harm (see Schneiderbauer 2007). On the national scale, a high dependency ratio can also mean an increase in government expenditures on social services and support schemes (pension funds, etc.).

As the proportion of children and elderly to working-age population, it can also give a more direct measure of a susceptible population as children and elderly are often limited in mobility and thus lack the capacity to individually "move out of harm's way" in case of a hazard (Cutter et al. 2003). The dependency ratio of a given population can thus indicate societal vulnerability, as dependents are more susceptible to harm from disasters.

Evaluation of Indicator

The indicator gives an insight into the number of people of non-working age, compared to the number of those of working age. A high rate of dependent population means, that those segments of the population of working-age, and the overall economy, face a greater burden in supporting both groups, namely children (age 15 and younger) and senior citizens (age 65 and older), economically and socially in stress situations and when direct and indirect losses due to hazards of natural origin occur.

The working-age is commonly 15-64 years, which gives the most reliable data that can be compared at the global scale. The factual working-age can differ from this model, however, either due to a large proportion of younger people staying longer in the educational system or also due to larger proportions of people working beyond the age of 65 years.

Mathematical Transformation

Rescaled Value = Actual Value/100; if values are higher than 1, they will be set to 1.

Key Literature

Cutter et al. (2003); Schneiderbauer (2007)

Susceptibility – Poverty & Dependency

Indicator D2

Extreme Poverty

Measuring Unit

Share of a population living on less than 1.90 USD per day at purchasing power parity

Data Sources

World Bank Open Data Platform

Website: *https://data.worldbank.org* – Indicator: *SI.POV.DDAY*

Data Updates	Annually	**Reference Year**	2018	**Data Points**	175 Countries

Relevancy of Indicator

In general, poverty is the deprivation of essential goods, services and opportunities (ADB 2004). Poor people are more susceptible to suffer from the impact of natural hazards, as they tend to live in hazard-prone areas (e.g. in unsafe buildings, on floodplains, etc.) and continuously have to cope with various shocks related to hazards, in dire conditions with limited assets (UNDP 2007). Extreme poverty thus increases the susceptibility to harm. Therefore, it is important to use this indicator to identify those people unable to meet their minimal requirements for survival.

A national poverty line of individual countries shows the level of income or consumption needed to be excluded from the poor cohort of people. However, this cannot be used as a standard measure to compare poverty across countries, as the perceived boundary between poor and non-poor increases with the average income of a country (World Bank 2008). Therefore, this approach will use the international poverty line developed by the World Bank, with regard to the definition: "international poverty line in local currency is the international lines of $1.25 and $2 a day in 2005 prices, converted to local currency using the PPP (purchasing power parities) conversion factors estimated by the international comparison program" (World Bank 2008: 22).

Evaluation of Indicator

The indicator shows the proportion of people with an income of less than 1.90 USD PPP per day, which is an indication of extreme poverty. Using an income-based indicator to identify people living under extreme poverty could be a problem, as it does not consider other assets (human, social, natural and physical) that people possess.

Mathematical Transformation

Rescaled Value = Actual Value/100

Key Literature

ADB (2004); Ravallion et al. (2008); UNDP (2007); World Bank (2008)

Susceptibility – Economic Productivity & Income Distribution					
Indicator E1 Gross Domestic Product					
Measuring Unit US Dollar per capita (Purchasing power parity)					
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *NY.GDP.PCAP.CN & PA.NUS.PPP*					
Data Updates	Annually	**Reference Year**	2018	**Data Points**	183 Countries
Relevancy of Indicator This indicator is the result of gross domestic products divided by mid-year populations converted to international dollars using the most recent purchasing power parity rates published by the World Bank. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. The gross domestic product at purchasing prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. The gross domestic product per capita at purchasing power parity has been identified as an important determinant of susceptibility and vulnerability by different authors and used in the Disaster Risk Index 2004 (Peduzzi et al. 2009, Schneiderbauer 2007, UNDP 2004) and is commonly used as an indicator for a country's economic development (e.g. Human Development Index).					
Evaluation of Indicator The gross domestic product per capita in purchasing power parity can serve as an overall measure of economic development and has often been used as an indicator of economic development and vulnerability. The determinants of vulnerability are manifold, however, and some authors have shown, that GDP per capita is not as significant a vulnerability indicator as, for example, health and literacy (Brooks et al. 2005). This might lead to a lower weighting of this indicator. It is still considered useful to estimate a population's susceptibility to harm, as limited monetary resources are seen as an important factor of vulnerability.					
Mathematical Transformation *Rescaled Value = 1 – ([Ln(Actual Value) – Ln(Min. Value)]/[Ln(Max. Value)) – Ln(Min. Value)])*					
Key Literature Brooks et al. (2005); Peduzzi et al. (2009); Schneiderbauer (2007); UNDP (2004)					

Susceptibility – Economic Productivity & Income Distribution

Indicator E2

Gini Index

Measuring Unit

Index scale from 0 to 100

Data Sources

World Bank Open Data Platform
Website: *https://data.worldbank.org* – Indicator: *SI.POV.GINI*

Data Updates	Annually	**Reference Year**	2018	**Data Points**	183 Countries

Relevancy of Indicator

Despite the fact that the gross domestic product per capita at purchasing power parity indicates a country's overall economic achievement, the Gini index is used here in order to additionally depict the wealth distribution within countries. The index gives an estimate of inequality as it measures the extent to which the actual income distribution differs from an equal distribution. The index is obtained from a hypothetical (45-degree) line of absolute equality and the Lorenz curve.

This curve is a cumulative distribution function of the empirical probability distribution of wealth, by means the cumulative percentages of total income received against the cumulative number of receivers. The ratio of the area between the line of equality and the Lorenz curve over the total area under the line is the Gini coefficient. A result of zero represents perfect equality while an index of 100 implies perfect inequality.

Evaluation of Indicator

The index relies on data reported by countries. Limitations in comparability might occur due to different average household sizes among countries and from the scale at which Gini coefficients are determined – a coefficient with percentile resolution usually results in higher values than coefficients on a quintile resolution.

Mathematical Transformation

Rescaled Value = Actual Value/100

Key Literature

Gini (1921); Anand & Segal (2008)

Section 5: Adaptive Capacity Indicators

Adaptive Capacity – Education & Research					
Indicator A1 Adult Literacy					
Measuring Unit Share of a population aged 15 years and above with basic reading and writing skills					
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *SE.ADT.LITR.ZS*					
Data Updates	Irregularly	**Reference Year**	2018	**Data Points**	174 Countries
Relevancy of Indicator This indicator is defined as the percentage of the population aged 15 years and older who can, with understanding, read and write a short, simple statement on their everyday lives (ADB 2004: 19). The adult literacy rate shows the accumulated achievement of primary education and basic literacy skills of the population crucial for economic, social and political participation and development, especially in today's knowledge societies (UNESCO 2006). Moreover, literacy could be an essential indicator, when empowering people on hazard risk reduction. Illiteracy indicates a low quality of primary education and needs for policies in organizing adult literacy programs. The proportion of persons in a country without literacy skills may have problems taking advantage of health, educational, political, economic and cultural opportunities (UNESCO 2006). Moreover, illiterate people may have difficulty in understanding warnings and access to recovery information (Cutter et al. 2003).					
Evaluation of Indicator This indicator shows the adult literacy rate per country. Some countries apply definitions and criteria different to international standards defined above, which could be a limitation (UNESCO 2008).					
Mathematical Transformation *Rescaled Value = Actual Value/100; if values are higher than 1, they will be set to 1.*					
Key Literature ADB (2004); Cutter et al. (2003); UNESCO (2006); UNESCO (2008)					

Adaptive Capacity – Education & Research

Indicator A2

Gross Education Enrolment

Measuring Unit

Share of a population enrolled in primary, secondary or tertiary education programs

Data Sources

United Nations Educational, Scientific and Cultural Organization Institute for Statistics Data Portal
Website: *http://data.uis.unesco.org* – Indicator: *GER1T8*

Data Updates	Annually	**Reference Year**	2018	**Data Points**	182 Countries

Relevancy of Indicator

A good level of educational attainment is important not only to find a secure job or climb up the ladder of social mobility to achieve higher socioeconomic status, but also to recover sooner from shocks related to natural hazards. A good level of education also improves the capacity of a society and different groups to potentially change from one economic activity (e.g. farming) to another (e.g. small-scale business).

In this context, the gross enrolment ratio is a vital indicator that captures adaptive capacity, as it measures education access and coverage. It shows the general level of participation in a given level of education and further indicates the capacity of the education system to enrol students of a particular age group (UNESCO 2008). It also provides some indication of internal efficiency of the educational system. It defines total enrolment in a specific level of education, regardless of age, expressed as a percentage of the eligible official school-age population corresponding to the same level of education in a given school year.

Evaluation of Indicator

In general, a high gross enrolment ratio indicates a high degree of participation, whether the pupils belong to the official age group or not. A gross enrolment ratio value approaching or exceeding 100 per cent indicates that a country is, in principle, able to accommodate all of its school-age population, but it does not indicate the proportion already enrolled (UNESCO 2008). The gross enrolment ratio can exceed 100 per cent, due to the inclusion of over-aged and under-aged pupils/students because of early or late entrants, and grade repetition (UNESCO 2008).

Mathematical Transformation

Rescaled Value = Actual Value/100

Key Literature

UNESCO (2008)

Adaptive Capacity – Gender Equality					
Indicator B Gender Inequality Index					
Measuring Unit Index scale from 0 to 1					
Data Sources United Nations Development Programme Human Development Reports Website: *http://hdr.undp.org/en/data*					
Data Updates	Annually	**Reference Year**	2018	**Data Points**	160 Countries
Relevancy of Indicator A great barrier to the social development of countries remains to be the inequality of genders, although progress towards gender equity has been archived since the 1990s (UNDP 2018). In addition to societal progress, gender equality is a vital part of a country's adaptive capacities. This index focuses on three major aspects of human development in order to provide a measure of gender inequality – these aspects are reproductive health (e.g. maternal mortality and adolescent births), empowerment (e.g. proportion of parliamentary seats and proportion of persons with at least secondary education for each gender) and economic status of populations (e.g. labour market participation for each gender). As part of the Human Development Statistics, this index is built on the same framework as the Human Development Index (UNDP 2018), which means a higher index value points to more disparities between females and males.					
Evaluation of Indicator This indicator yields insights into the disparities of females and males on a global scale. Furthermore, it provides data for the monitoring of societal processes toward the equality of women and men.					
Mathematical Transformation *Rescaled Value = 1 – Actual Value*					
Key Literature UNDP (2018)					

Adaptive Capacity – Ecosystem Status & Environmental Protection					
Indicator C1 Water Resources					
Measuring Unit Index scale from 0 to 100					
Data Sources Yale Center for Environmental Law & Policy/Center for International Earth Science Information Network Website: *https://epi.envirocenter.yale.edu* – Indicator: Ecosystem Vitality – *Water Resources*					
Data Updates	Biannually	**Reference Year**	2018	**Data Points**	181 countries
Relevancy of Indicator This indicator tracks how well countries treat wastewater from households and industrial sources via basic reprocessing procedures before it is released into the environment. Untreated sewage can disrupt the functioning of downstream ecosystems. In principle, wastewater is comprised of domestic grey-water (water from baths, sinks, washing machines, and kitchen appliances) and black-water (water from toilets), as well industrial wastewater that may have additional chemical contaminants. It typically contains nutrients and chemicals that pollute natural water systems, resulting in a range of impacts from algal blooms to biological endocrine disruption. In rural areas, where pit latrines or septic systems are prominent, pollutants tend to be dispersed in the environment. In urban areas, however, functioning sewage systems that collect and treat wastewater concentrate the pollutants into discrete discharges that are more easily treatable. The practice of water treatment is vital for the health of aquatic systems, provides health benefits for local residents, and ensures that clean water is available for re-use. Good wastewater management is especially relevant for areas facing more significant impacts of climate change and rapid population growth, since such areas may face more constrained water resources in the future (Hsu & Zomer 2014).					
Evaluation of Indicator This indicator assesses the proportion of wastewater that is treated for those households that are connected to the sewerage system. It measures wastewater that mostly comes from household sources, but in some cases industrial sources contribute if they share the municipal collection network. This varies on a country-by-country basis. Despite the known limitations, expert review confirms that this measure still provides a useful metric against which to judge country performance.					
Mathematical Transformation *Rescaled Value = Actual Value/100*					
Key Literature Hsu & Zomer (2014)					

Adaptive Capacity – Ecosystem Status & Environmental Protection					
Indicator C2 Biodiversity and Habitat Protection					
Measuring Unit Index scale from 0 to 100					
Data Sources Yale Center for Environmental Law & Policy/Center for International Earth Science Information Network Website: *https://epi.envirocenter.yale.edu* – Indicator: Ecosystem Vitality – *Biodiversity and Habitat*					
Data Updates	Biannually	**Reference Year**	2018	**Data Points**	181 countries
Relevancy of Indicator Humans rely on natural resources to serve the most basic of our needs — including food, water, clothing, and shelter. Yet our collective impact on the planet's ecosystems threatens the very resources that have allowed us to thrive as a species. The targets seek to protect the Earth's biological diversity and promote the sustainable use of natural resources and the equitable sharing of the benefits we derive from ecosystem services. This indicator charts each country's progress in achieving these goals (Hsu & Zomer 2014). Habitat protection is a necessary, but not sufficient condition for the conservation of biodiversity and ecosystem services that are critical to sustaining human life and well-being. The Critical Habitat Protection indicator examines the extent of protection of the last remaining habitats for endangered or critically endangered species (according to the IUCN criteria). The measurements of terrestrial and marine protected areas stem from the targets set by the Convention on Biological Diversity (CBD), which established protection goals of 17 per cent of terrestrial and inland water areas and 10 per cent of marine and coastal areas.					
Evaluation of Indicator *"The effective protected area conservation value per country-biome is based on three 1 km global spatial datasets: World Database on Protected Areas (2007), CIESIN and Wildlife Conservation Society Human Footprint (2007); and biomes from the WWF Ecoregions of the World dataset"* (Olson et al. 2001: 45). The weights for all four indicators are distributed equally according to the information and data founded (e.g. landlocked countries – no protected areas, no alliance for zero extinction sites), which means that when one of them is missing the weight of the others would be equally distributed (Emerson et al. 2010).					
Mathematical Transformation *Rescaled Value = Actual Value/100*					
Key Literature Hsu & Zomer (2014); Olson et al. (2001); Emerson et al. (2010)					

Adaptive Capacity – Ecosystem Status & Environmental Protection					
Indicator C3 Forest Management					
Measuring Unit Index scale from 0 to 100					
Data Sources Yale Center for Environmental Law & Policy/Center for International Earth Science Information Network Website: *https://epi.envirocenter.yale.edu* – Indicator: Ecosystem Vitality – *Forests*					
Data Updates	Biannually	**Reference Year**	2018	**Data Points**	181 countries
Relevancy of Indicator This indicator factors in areas of deforestation (forest loss), reforestation (forest restoration or replanting) and afforestation (conversion of bare or cultivated land into forests). Reduction in the extent of forest cover has significant negative implications for ecosystem services and habitat protection, as forests are dynamic ecosystems vital to sustaining natural life cycles, biodiversity, and the prosperity of humankind. Forests play a critical role in mitigating the effects of climate change and providing integral ecosystem services and products. As scientists place greater emphasis on the role of forests as carbon sinks to combat global climate change and in regulating the hydrological system, policymakers increasingly acknowledge the significance of forest ecosystems.					
Evaluation of Indicator The Hansen et al. (2013) satellite-based mapping system of global forest change would benefit from differentiating between forest use practices to properly measuring global forest change. It is possible, however, that no satellite will ever be able to fully capture such practical, grounded realities. As for the previous environmental indicators all weights are equally distributed and in case one of the two is missing the other one will have a full weight.					
Mathematical Transformation *Rescaled Value = Actual Value/100*					
Key Literature Hansen et al. (2013); Hsu & Zomer (2014)					

Adaptive Capacity – Ecosystem Status & Environmental Protection		
Indicator C4 Agriculture Management		
Measuring Unit Index scale from 0 to 100		
Data Sources Yale Center for Environmental Law & Policy/Center for International Earth Science Information Network Website: *https://epi.envirocenter.yale.edu* – Indicator: Ecosystem Vitality – *Agriculture*		
Data Updates Biannually	**Reference Year** 2018	**Data Points** 181 countries
Relevancy of Indicator Agriculture is an economic activity that causes strong impacts on ecosystems. The pressure over water and land as well as the use of pesticides are some of them. The agriculture indicator gives an idea of this situation. Agricultural Subsidies is a proxy measure for the degree of environmental pressure exerted by subsidizing agricultural inputs. Pesticide Regulation assesses the status of countries' legislation regarding the use of chemicals listed under the Stockholm Convention on Persistent Organic Pollutants (POPs). Pesticide Regulation also scores the degree to which these countries have followed through on limiting or outlawing these chemicals. According to the OECD, public subsidies for agricultural protection and agrochemical inputs exacerbate environmental pressures through the intensification of chemical use, the expansion of farmland into sensitive areas, and the overexploitation of resources like water and soil nutrients. Pesticides are a significant source of pollution in the environment. They kill beneficial insects, pollinators, and fauna, and human exposure to pesticides has been linked to increased rates of neurological and reproductive disorders, endocrine disruption, and cancer.		
Evaluation of Indicator Unfortunately, neither indicator in this category is a direct measurement of agricultural environmental performance. Instead, they are both proxies related to policy intent. Globally comparable measures to assess agricultural sustainability or impacts simply do not exist. Measures of soil quality and erosion, agricultural water-use intensity, and desertification are all important issues related to agricultural sustainability. The weights for the three indicators was defined using the Principal Component Analysis, which gives a 50 per cent weight to the pesticide regulation, then 30 per cent to the agricultural subsidies and finally 20 per cent to the water intensity (Emerson et al. 2010). In the case of agriculture subsidies, for all other missing values, it was assumed a zero.		
Mathematical Transformation *Rescaled Value = Actual Value/100*		
Key Literature Hsu & Zomer (2014); Emerson et al. (2010); OECD (2004)		

Adaptive Capacity – Investments

Indicator E1

Public Health Expenditure

Measuring Unit

US Dollar per capita (Purchasing power parity)

Data Sources

World Bank Open Data Platform
Website: *https://data.worldbank.org* – Indicator: *SH.XPD.GHED.PP.CD*

Data Updates	Annually	**Reference Year**	2016	**Data Points**	193 Countries

Relevancy of Indicator

High government expenditure on health is understood to be an indicator of the quality of the health system, which is an important factor of adaptive capacity as medical services represent important sources of post-disaster relief. The lack of proximate medical services will lengthen immediate relief and longer-term recovery from disasters (Cutter et al. 2003). In our understanding, a lack of medical services is not only expressed by direct capacities as hospital beds and physicians, which are responsible for coping, but also by a lack of access to these services, which are provided by health systems. While private expenditures measure equality of this access within a country, per capita government expenditure on health at purchasing power parity gives a measure on the amount and cost of the health expenditures and thus allows the comparison of the quality of the health system among countries.

The indicator comprises the following types of expenditure: *"The sum of outlays for health maintenance, restoration or enhancement paid for in cash or supplied in kind [...] by government entities, such as the Ministry of Health, other ministries, parastatal organizations or social security agencies (without double counting government transfers to social security and extrabudgetary funds). It includes all expenditure made by these entities, regardless of the source, so includes any donor funding passing through them. It includes transfer payments to households to offset medical care costs and extrabudgetary funds to finance health services and goods"* (WHO 2010: 95).

Evaluation of Indicator

The usefulness of the indicator relies largely on the quality and accuracy of input data. According to the indicator compendium of WHO *"[t]he most comprehensive and consistent data on health financing is generated from national health accounts. Not all countries have or update national health accounts and in these instances, data is obtained through technical contacts in-country or from publicly-available documents and reports. Missing values are estimated using various accounting techniques depending on the data available for each country"* (WHO 2010: 213).

Mathematical Transformation

Rescaled Value = [Ln(Actual Value) – Ln(Min. Value)]/[Ln(Max. Value)) – Ln(Min. Value)]

Key Literature

Brooks et al. (2005); Cutter et al. (2003); UNDP (2007); WHO (2010)

Adaptive Capacity – Investments					
Indicator E2 Life Expectancy at Birth					
Measuring Unit Number of Years					
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *SP.DYN.LE00.IN*					
Data Updates	Annually	**Reference Year**	2017	**Data Points**	193 Countries
Relevancy of Indicator In general, continuous hazards have a tendency to lower life expectancy. Nevertheless, life expectancy at birth, the average number of years a newborn is expected to live if current age-specific mortality rates continue to apply over the lifespan of newborns, reflects the overall mortality level of a population. It summarises the mortality pattern that prevails across all age groups – children and adolescents, adults and the elderly (WHOSIS 2007). This indicator also reveals the general health standards of a country, therefore, vital to include it.					
Evaluation of Indicator Life expectancy can indicate general health and overall living conditions in a country (WHO 2008).					
Mathematical Transformation *Rescaled Value = -0.25 * Ln(Ln(85/Actual Value)); if values are higher than 1, they will be set to 1.*					
Key Literature UNDP (2010); WHO (2008); WHOSIS (2007)					

Adaptive Capacity – Investments		
Indicator E3 Private Health Expenditure		
Measuring Unit US Dollar per capita (Purchasing power parity)		
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *SH.XPD.OOPC.PP.CD*		
Data Updates Annually	**Reference Year** 2016	**Data Points** 193 Countries

Relevancy of Indicator

The proportion of private expenditures on health can be used as an indicator of the general structure of a countries health system and determines whether equal access to health services is granted. It is presumed that high proportions of private expenditure per capita at purchasing power parity on health indicate a lack of a reliable public health system and thus determine the adaptive capacity.

Equal access to health services would be very important when it comes to the recovery from hazard impacts as people might not only suffer from the actual impact but also be restrained economically if they have to cover medical expenses with private means. A lack of access to adequate health services would thus lead to a large proportion of people with poor health who are not able to adapt to the risk of a novel hazard impact.

The indicator comprises the following types of expenditure: *"The sum of outlays for health by private entities, such as commercial or mutual health insurance, non-profit institutions serving households, resident corporations and quasi-corporations not controlled by government with a health services delivery or financing, and households"* (WHO 2010).

Evaluation of Indicator

The usefulness of the indicator relies largely on the quality and accuracy of input data. According to the indicator compendium of WHO *"[t]he most comprehensive and consistent data on health financing is generated from national health accounts. Not all countries have or update national health accounts and, in these instances "data is obtained through technical contacts in-country or from publicly-available documents and reports. Missing values are estimated using various accounting techniques depending on the data available for each country"*(WHO 2010: 213).

Mathematical Transformation

Rescaled Value = [Ln(Actual Value) – Ln(Min. Value)]/[Ln(Max. Value)) – Ln(Min. Value)]

Key Literature

Brooks et al. (2005); Cutter et al. (2003); UNDP (2007); WHO (2010)

Section 6: Coping Capacity Indicators

Coping Capacity – Government & Authorities					
Indicator A1 Corruption Perception Index					
Measuring Unit Index scale from 0 to 100					
Data Sources Transparency International Website: *https://www.transparency.org*					
Data Updates	Annually	**Reference Year**	2019	**Data Points**	181 Countries
Relevancy of Indicator This indicator measures the perceived level of corruption of national governments using 13 different sources. In addition to the results, a confidence range is given: it is larger if there are fewer source indicators available for calculation. People living in countries with a higher level of corruption are thought to have more difficulties recovering from natural hazard impacts, due to limited governmental support reaching the affected population compared to states with a lower level of corruption. Corruption can further be of particular importance when it comes to the distribution of and access to emergency relief resources. The following sources have been used to construct CPI 2008: Asian Development Bank, African Development Bank, Bertelsmann Transformation Index, Country Policy and Institutional Assessment, Economist Intelligence Unit, Freedom House, Global Insight and Merchant International Group. Additional sources are resident business leaders evaluating their own country; in the CPI 2008, this consists of the following sources: IMD, Political and Economic Risk Consultancy, and the World Economic Forum.					
Evaluation of Indicator The CPI assesses the level of corruption using qualitative surveys, as there is no general quantitative data available. The CPI uses different sources for different countries due to data limitations. As a result, the confidence intervals for countries with few data sources are very large. For countries with intervals overlapping more than 29 per cent, this means the corruption level is indistinguishable. The general reliability of the data is demonstrated, however, in the high correlation between sources, as well as in the use of different independent sources and expert interviews.					
Mathematical Transformation *Rescaled Value = Actual Value/100*					
Key Literature Transparency International (2017)					

Coping Capacity – Government & Authorities		
Indicator A2 Fragile States Index		
Measuring Unit Index scale from 0 to 120		
Data Sources Fund for Peace Website: *http://fundforpeace.org*		
Data Updates Annually	**Reference Year** 2020	**Data Points** 178 Countries

Relevancy of Indicator

The Fragile States Index is a crucial measure to assess states vulnerability to conflict or collapse based on 12 variables, which cover and monitor a wide range of social, economic and political dynamics on a national scale. As fragile states may have difficulties to recover from extreme natural events impact due to their structural characteristics, the index is a vital indicator for the assessment of global risk. The following indicators are used to compute the index for all countries:

Cohesion Sphere	Economic Sphere	Political Sphere
C1 Security Apparatus	E1 Economic Decline	P1 State Legitimacy
C2 Factionalized Elites	E2 Uneven Economic Development	P2 Public Services
C3 Group Grievance	E3 Human Flight and Brain Drain	P3 Human Rights and Rule of Law

Social	Cross-Cutting
S1 Demographic Pressure	X1 External Intervention
S2 Refugees and IDPs	

Evaluation of Indicator

The Fragile States Index is based on the Conflict Assessment System Tool (Clark et al. 2006), a methodological framework developed by the Fund for Peace for assessing a countries vulnerability to situations of conflict or collapse. In a first step, the raw index is calculated on the basis of public data, before local expert opinions are surveyed for validation of the raw values. All expert surveys are conducted separately. In cases of significant deviations in the opinions of the experts, further experts are randomly selected and surveyed for analytical adjustment of the raw index of a country.

Mathematical Transformation

Rescaled Value = (Actual Value – 120)/(0 – 120)

Key Literature

Clark et al. (2006); Fund for Peace (2017)

Coping Capacity – Medical Services					
Indicator C1 Number of Physicians					
Measuring Unit Number of physicians per 1,000 persons					
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *SN.MED.PHYS.ZS*					
Data Updates	Annually	**Reference Year**	2018	**Data Points**	193 Countries
Relevancy of Indicator The number of practicing physicians qualified from medical schools allows the international comparison of available health care systems, which is a crucial coping measure in the aftermath of a disaster. The general assumption is that those regions, which have a significantly lower ratio of practicing physicians to the general population, are also those that might face higher difficulties in coping with extreme events and emergencies. Overall, the indicator can be used to estimate the capacity of a health care system of a country.					
Evaluation of Indicator The physicians-patient ratio can serve as a general measure of a health care system.					
Mathematical Transformation *Rescaled Value = Actual Value/10*					
Key Literature IDEA (2005)					

Coping Capacity – Medical Services		
Indicator C2 Number of Hospital Beds		
Measuring Unit Number of hospital beds per 1,000 persons		
Data Sources World Bank Open Data Platform Website: *https://data.worldbank.org* – Indicator: *SN.MED.BEDS.ZS*		
Data Updates Annually	**Reference Year** 2015	**Data Points** 190 Countries
Relevancy of Indicator The number of hospital beds is a valid indicator for the capacity of the medical care infrastructure to help or support societies in the case of a mass emergency and disaster with respective treatment. Hospital beds in private, general and specialized hospitals, medical and rehabilitation centers are included. Although hospital beds do not provide any information about the standard of these hospitals and their treatment, the general comparison of the capacities of hospital beds per 10,000 people provides an overview of those regions where this infrastructure is significantly lower than in others.		
Evaluation of Indicator Overall, some experts argue that the number of hospital beds is rather weak since it solely provides information on health care capacity. Therefore, this indicator should be supported by an appropriate mix of staff and equipment indicators as well (McKee 2004). Since this information is not available in global datasets, the respective extension of the assessment of hospital capacities could not be made in this proposal.		
Mathematical Transformation *Rescaled Value = Actual Value/20*		
Key Literature McKee (2004)		

Coping Capacity – Material Coverage		
Indicator E Insurance Coverage		
Measuring Unit Average value of ratios of insured to overall losses		
Data Sources Munich Re NatCatSERVICE Website: *https://natcatservice.munichre.com*		
Data Updates Annually	**Reference Year** 2017	**Data Points** 190 Countries

Relevancy of Indicator

The degree of non-life insurance coverage is considered as valid indicator for disaster risk transfer, particularly in the *Hyogo Framework for Action 2005-2015*, which includes insurance and reinsurance as part of the social and economic development practices for the reduction of underlying risk factors: *"Promote the development of financial risk-sharing mechanisms, particularly insurance and reinsurance against disasters"* (UNISDR 2005).

Previously, the level of property and non-life health insurance has been part of several programs for disaster risk assessment, such as the *Americas Indicator Program* for the *Prevalent Vulnerability Index*. Here, insurance coverage is measured by averaging annual ratios of insured to overall losses in a country from the last 15 years, only taking into account ratios of years in which a natural event (e.g. earthquakes, storms, floods and droughts) has occurred. Due to the long period of observation, it is possible to 1.) map the insurance coverage in a robust way despite the high variability in the annual ratios and 2.) obtain values for countries, which are rarely confronted with extreme natural events.

Evaluation of Indicator

Although this statistical approach provides a way to measure insurance coverages of countries with respect to property and non-life insurances, it is not possible to analyze countries and differences between countries on a more detailed level.

Mathematical Transformation

Rescaled Value = [Actual Value – Min. Value]/[Max. Value – Min. Value]

Key Literature

UNISDR 2005

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