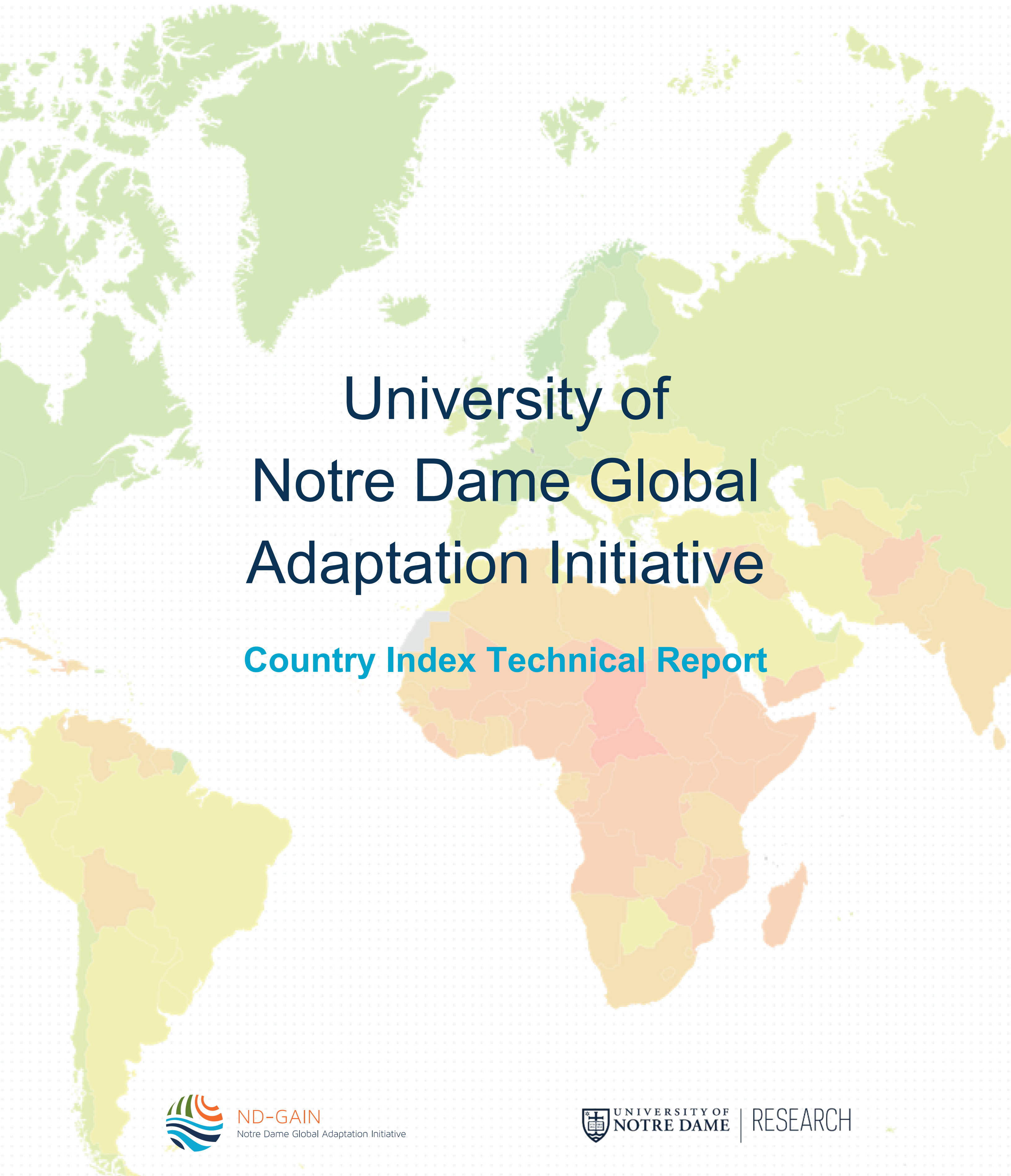

University of Notre Dame Global Adaptation Initiative

Country Index Technical Report

ND-GAIN
Notre Dame Global Adaptation Initiative

UNIVERSITY OF NOTRE DAME | RESEARCH

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ND-GAIN
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**Note: Author/Expert positions are reflective of 2015 release.

I. Introduction

The Notre Dame Global Adaptation Initiative's (ND-GAIN) Country Index is a free, open source index that shows a country's current vulnerability to climate disruptions. It also assesses a country's readiness to leverage private and public sector investment for adaptive actions. The ND-GAIN Country Index brings together more than 40 core indicators to measure vulnerability and readiness of 182 UN countries from 1995 to the present (10 countries only have readiness scores).

Corporate, NGO, government, and development decision-makers use ND-GAIN's country-level rankings and underlying data to make informed strategic operational and reputational decisions regarding supply chains, capital projects, policy changes and community engagements.

The Notre Dame Global Adaptation Initiative moved to the University of Notre Dame in April 2013. It was formerly housed in the Global Adaptation Institute in Washington, D.C. Now a program within the Notre Dame Environmental Change Initiative, ND-GAIN works to enhance the world's understanding of adaptation through knowledge, products and services that inform public and private actions, and investments in vulnerable communities.

Adaptation is an evolving concept. Our understanding of climate change and the risks it presents are constantly improving through ongoing research. At ND-GAIN, we strive to estimate adaptation risk and opportunity using the best available research outputs, data, and tools. Therefore, the Country Index is updated annually.

This technical document provides detailed information on the framework, data sources, and data compilation process used for producing the ND-GAIN Country Index.

II. ND-GAIN Country Index Overview

All countries, to different extents, are facing the challenges of adaptation. Due to geographical location or socio-economic condition, some countries are more vulnerable to the impacts of climate change than others. Further, some countries are more ready to take on adaptation actions by leveraging public and private sector investments, through government action, community awareness, and the ability to facilitate private sector responses. ND-GAIN measures both of these dimensions: vulnerability and readiness.

Terminology

ND-GAIN's framework breaks the measure of vulnerability into exposure, sensitivity and adaptive capacity, and the measure of readiness into economic, governance and social components. The construction of the ND-GAIN framework is based on published peer-reviewed material, the IPCC Review process, and feedback from corporate stakeholders, practitioners and development users. Most of the vulnerability and readiness measures (except indicators of exposure – see below) are said to be actionable, meaning that these represent actions or the result of actions taken by national governments, communities, Civil Society Organizations, Non-Government Organizations, and other stakeholders.

Vulnerability

Propensity or predisposition of human societies to be negatively impacted by climate hazards.

ND-GAIN assesses the vulnerability of a country by considering six life-supporting sectors: food, water, health, ecosystem services, human habitat and infrastructure. Each sector is in turn represented by six indicators that represent three cross-cutting components: the *exposure* of the sector to climate-related or climate-exacerbated hazards; the *sensitivity* of that sector to the impacts of the hazard and the *adaptive capacity* of the sector to cope or adapt to these impacts.

<u>Exposure:</u> The extent to which human society and its supporting sectors are stressed by the future changing climate conditions. Exposure in ND-GAIN captures the physical factors external to the system that contribute to vulnerability.

Sensitivity: The degree to which people and the sectors they depend upon are affected by climate related perturbations. The factors increasing sensitivity include the degree of dependency on sectors that are climate-sensitive and proportion of populations sensitive to climate hazard due to factors such as topography and demography.

Adaptive capacity: The ability of society and its supporting sectors to adjust to reduce potential damage and to respond to the negative consequences of climate events. In ND-GAIN adaptive capacity indicators seek to capture a collection of means, readily deployable to deal with sector-specific climate change impacts.

Readiness

Readiness to make effective use of investments for adaptation actions thanks to a safe and efficient business environment ND-GAIN measures readiness by considering a country's ability to leverage investments to adaptation actions. ND-GAIN measures overall readiness by considering three components: economic readiness, governance readiness and social readiness.

Economic Readiness: The investment climate that facilitates mobilizing capitals from private sector.

Governance Readiness: The stability of the society and institutional arrangements that contribute to the investment risks. A stable country with high governance capacity reassures investors that the invested capitals could grow under the help of responsive public services and without .

Social readiness: Social conditions that help society to make efficient and equitable use of investment and yield more benefit from the investment.

Selecting ND-GAIN Indicators

To identify indicators that reflect climate vulnerability and adaptation readiness, the ND-GAIN team surveyed the most recent literature and consulted scholars, adaptation practitioners, and global development experts. The indicators included in ND-GAIN were chosen to fit within the structure described above and to meet the following criteria:

- Focus on sectors and components that have impacts on human well-being, including biophysical impacts of climate change on a country's society, and the socioeconomic factors that either amplify or reduce such impacts.
- Indicators that represent vulnerability or readiness should be actionable for climate change adaptation. In other words, governments and private sector or communities could take actions on an issue and expect to see changes in one or more indicators over time. Exceptions are the exposure indicators, which are not actionable through adaptation, as they are mostly driven by biophysical factors and are only actionable through greenhouse gas abatement (climate change mitigation).
- Representatives of vulnerability sectors or readiness components, based on relevant literature and climate change adaptation practices (i.e. the adaptation actions taken by individuals or the adaptation programs run by country governments, bilateral or multilateral aid agencies, international organizations, NGOs, private investors and so forth).
- When possible, indicators should have the potential to be scaled down from country to sub-country level, to support the possibility of assessing climate vulnerability and adaptation readiness at finer scales.
- Two kinds of indicators are explicitly excluded from ND-GAIN. The first is Gross Domestic Product (GDP) per capita or any of its closely related measures. GDP per capita is commonly used in indices relating to development and poverty (e.g., UNDP's Human Development Index), but including it in ND-GAIN would doubly penalize many developing countries. It is well known that less developed countries also have low adaptive capacity and readiness, and high sensitivity. ND-GAIN does show a high correlation with a county's economic status; and a version of ND-GAIN that adjusts the index score using GDP per capita. Second, ND-GAIN does not include data on the impact of recent climate-related disasters. Instead, disaster data provide an independent source of information for decision-making and also for possible index validation.
- The data selected that quantifies the ND-GAIN indicators have the following features to ensure transparency, reliability and consistency:
    - Available for a high proportion of United Nations countries.
    - Time-series so that changes and trends in country vulnerability and readiness can be tracked. Indicators with data from 1995 to the present are preferred.
    - Freely accessible to the public.

- Collected and maintained by reliable and authoritative organizations that carry out quality checks on their data.
- Are transparent and conceptually clear.

Figure 1 below summarizes indicators measuring both vulnerability and readiness.

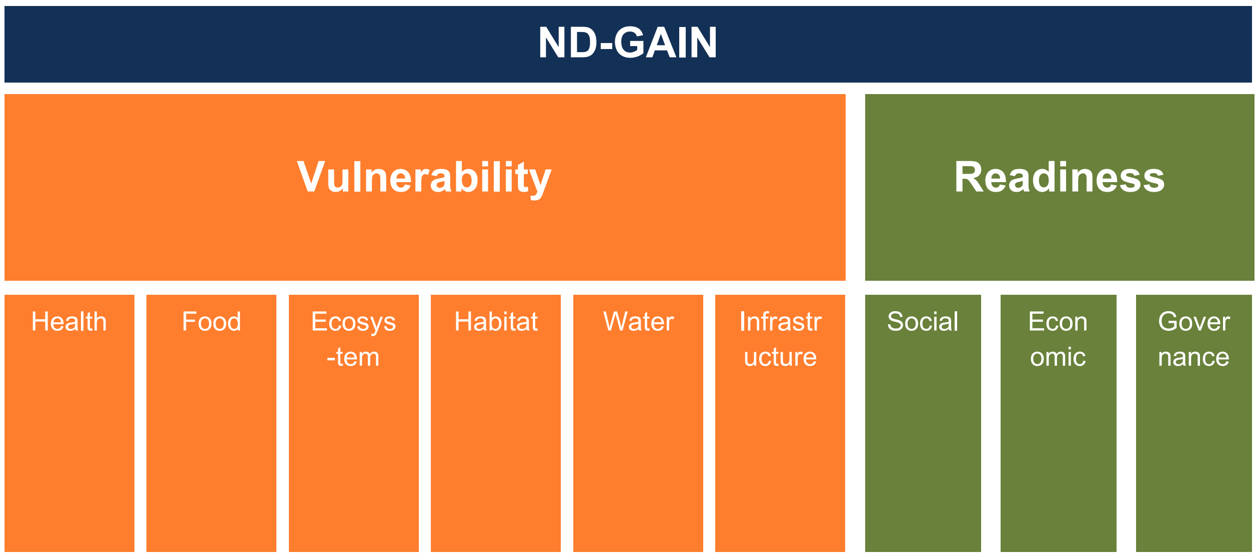

Figure 1. Summary of ND-GAIN Vulnerability and Readiness Indicators

Vulnerability is composed of 36 indicators. Each component has 12 indicators, crossed with 6 sectors. Readiness is composed of 9 indicators.

Calculating the ND-GAIN Score

There are many systematic methods for converting data into an index. For instance: scaling data into similar ranges of values, including normalizing to a common mean and standard deviation; setting base low and high values for the data (e.g. from the observed minimum to the observed maximum; or from 0 to 100% compliance etc.), and scaling data either linearly or after transformation to a prescribed range (e.g. 0 to 1; 0 to 100; -1 to +1); or converting the data to ranked values.

The 45 ND-GAIN indicators come from 74 data sources that provide 74 underlying data. 20 of the 45 indicators come directly from the sources; the rest 25 are computed by compiling underlying data. The methods used to compute these 25 indicators are detailed in Section IV of this report.

ND-GAIN follows a transparent procedure for data conversion to index. A detailed, step-wise process is described below and in Figure 2.

Step 1. Select and collect data from the sources (called “raw” data), or compute indicators from underlying data. Some data errors (i.e. tabulation errors coming from the source) are identified and corrected at this stage. If some form of transformation is needed (e.g. expressing the measure in appropriate units, log transformation to better represent the real sensitivity of the measure etc.) it happens also at this stage.

Step 2. At times some years of data could be missing for one or more countries; sometimes, all years of data are missing for a country. In the first instance, linear interpolation is adopted to make up for the missing data. In the second instance, the indicator is labeled as "missing" for that particular country, which means the indicator 6will not be considered in the averaging process. However, it is important to have most of the UN countries present in the data.

Step 3. This step can be carried out after of before Step 2 above. Select baseline minimum and maximum values for the raw data. These encompass all or most of the observed range of values across countries, but in some cases the distribution of the observed raw data is highly skewed. In this case, ND-GAIN selects the 90-percentile value if the distribution is right skewed, or 10-percentile value if the distribution is left skewed, as the baseline maximum or minimum.

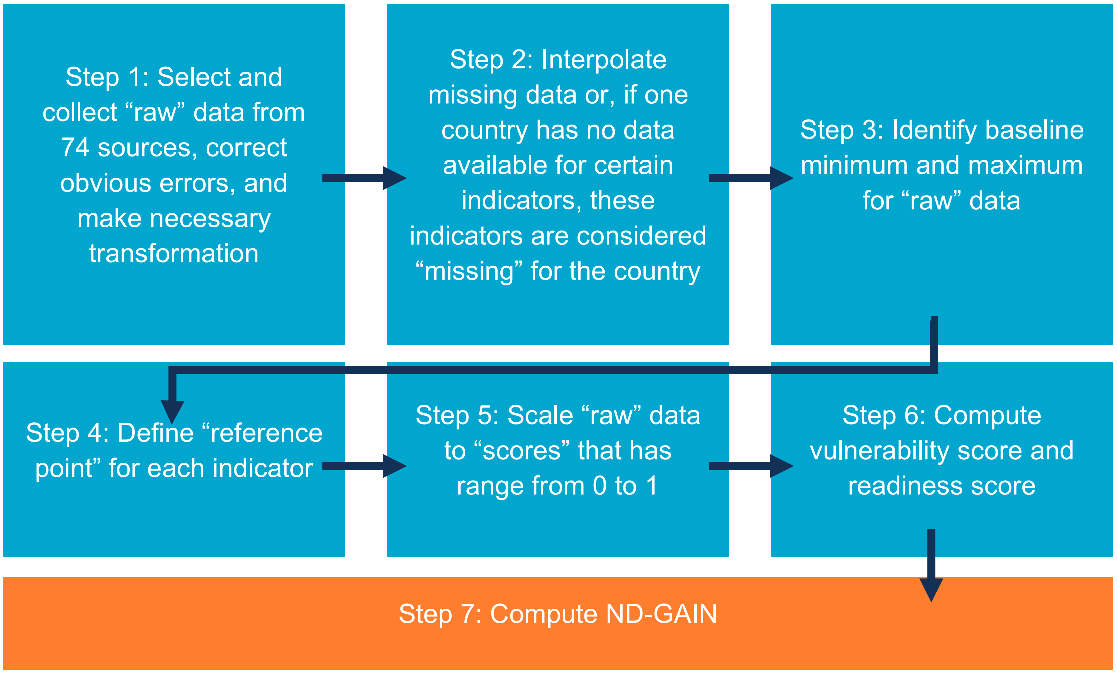

Figure 2: Steps to Creating ND-GAIN

Step 4. Whenever applicable, set proper reference data points for measures. The reference points stand for the status of perfection, i.e. the best performance that represents either zero vulnerability or full readiness. In some cases, reference points were the baseline minimum or maximum identified in Step 3. For certain measures, based on the adaptation or development practices, reference points were set by common sense. For example, the reference points for child malnutrition is 0%, for reliable drinking water is 100% and so on. If data sources have reference points by default for a measure, these are adopted. For instance, the reference point for the measure “Quality of trade and transport-related infrastructure” is 5, because the raw data are ranged from 1 to 5 with 5 being the highest score (See reference points section below).

Step 5. Scale “raw” data to “score”, ranging from 0 to 1, to facilitate the comparison among countries and the comparison to the reference points. Scaling follows the formula below:

$$\text{“score”} = |\ \text{“direction”} - \frac{\text{“raw” data} - \text{reference point}}{\text{baseline maximum} - \text{baseline minimum}}$$

The parameter of “direction” has two values, 0 when calculating score of vulnerability indicator; 1 when calculating score of readiness indicators, so that a higher vulnerability score means higher vulnerability (“worse”) and a higher readiness score means higher readiness (“better”).

Step 6. Compute the score for each sector by taking the arithmetic mean of its 6 constituent indicators (all scaled 0-1, weighted equally). Then calculate the overall vulnerability score by taking the arithmetic mean of the 6 sector scores.

Step 7. Follow the same process as Step 6 to calculate the overall readiness score.

Step 8. Compute the ND-GAIN score by subtracting the vulnerability score from the readiness score for each country, and scale the scores to give a value 0 to 100, using the formula below:

$$\text{ND-Gain score} = (\text{Readiness score} - \text{Vulnerability score} + 1) \times 50$$

THE ND-GAIN MATRIX

ND-GAIN can be represented as a scatter plot of readiness against vulnerability, that is, the ND-GAIN Matrix (Figure 3).

The Matrix provides a visual tool for quickly comparing countries and tracking their progress through time. The plot is divided into four quadrants, delineated by the median score of vulnerability across all the countries and overall years, and the median score of readiness calculated the same way. Approximately half the countries fall to the left of the readiness median and half to the right. Similarly, half fall above the vulnerability median and half below.

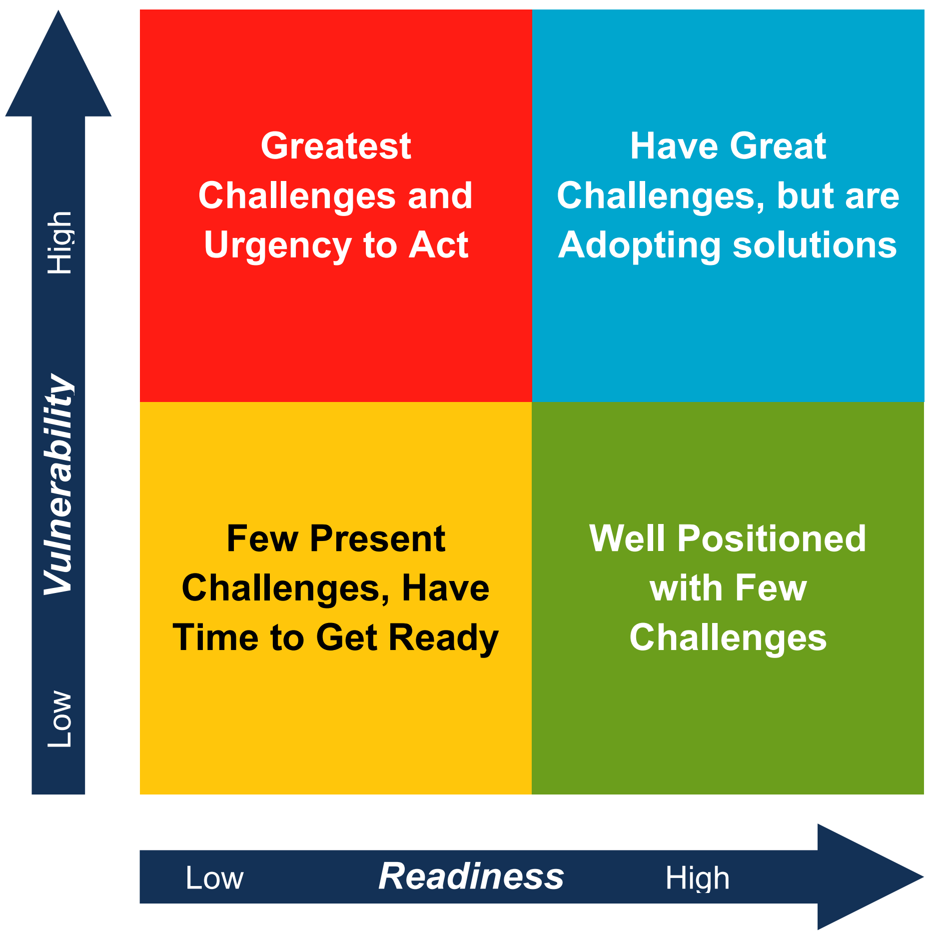

Figure 3. The ND-GAIN Matrix

Red (Upper Left) Quadrant: Countries with a high level of vulnerability to climate change but a low level of readiness. These countries have both a great need for investment to improve readiness and a great urgency for adaptation action.

Yellow (Lower Left) Quadrant: Countries with a low level of readiness but also a low level of vulnerability to climate change. Though their vulnerability may be relatively low, their adaptation may lag due to lower readiness.

Blue (Upper Right) Quadrant: Countries with a high level of vulnerability to climate change and a high level of readiness. In these countries, the need for adaptation is large, but they are ready to respond. The private sector may be more likely to participate in adaptation here than in countries with lower readiness.

Green (Lower Right) Quadrant: Countries with low level of vulnerability to climate change and a high level of readiness. Though less vulnerable, these countries still need to adapt but may be well positioned to do so.

Note: This does not mean that there will be the same number of countries in each quadrant. Highly ready, often wealthy, countries tend to have lower vulnerabilities and vice versa, so proportionately more countries fall in the green and red quadrants.

III. ND-GAIN Indicators

Table 3 and Table 4 list all the 45 indicators used in the ND-GAIN Index

Table 1: ND-GAIN Vulnerability Indicators

Sector	Exposure component	Sensitivity component	Adaptive Capacity component
Food	Projected change of cereal yields	Food import dependency	Agriculture capacity (fertilizer, irrigation, pesticide, tractor use
	Projected population change	Rural population	Child malnutrition
Water	Projected change of annual runoff	Fresh water withdrawal rate	Access to reliable drinking water
	Projected change of annual groundwater recharge	Water dependency ratio	Dam capacity
Health	Projected change of deaths from climate change induced diseases	Slum population	Medical staffs (physicians, nurses, and midwives)
	Projected Change in Vector Borne Disease	Dependency on external resource for health services	Access to improved sanitation facilities
Ecosystem services	Projected change of biome distribution	Dependency on natural capital	Protected biomes
	Projected change of marine biodiversity	Ecological footprint	Engagement in international environment conventions
Human Habitat	Projected change of warm period	Urban concentration	Quality of trade and transport-related infrastructure

	Projected change of flood hazard	Age dependency ratio	Paved roads
Infrastructure	Projected change of hydropower generation capacity	Dependency on imported energy	Electricity access
	Projected change of sea level rise impacts	Population living under 5m above sea level	Disaster preparedness

Table 2: ND-GAIN Readiness Indicators

Component	Indicators			
Economic Readiness	Doing Business[2]			
Governance Readiness	Political stability and non-violence	Control of corruption	Rule of law	Regulatory quality
Social Readiness	Social inequality	ICT infrastructure	Education	Innovation

[2] The Doing Business indicators is composed of 10 sub-indicators. See Section IV for details

IV. ND-GAIN Measure Description, Rationale, Calculation, Data

This section details ND-GAIN's indicators and is organized in the following manner:

VULNERABILITY SECTOR OR READINESS COMPONENT NAME

INDICATOR NAME

Description: Description of the indicator.

Rationale: Reasons for inclusion.

Calculation: Description of the approach followed to calculate the indicator, if data from the original source(s) need to be processed.

Data Source: Source name (hyperlinks are included on ND-GAIN web platform)

Time Series: Estimate of data reporting (Missing years are assumed with a simple linear interpolation. If the first years of data or the most recent years of data are used, constant values equal to the first or last reported datum are assumed).

Notes: Comments on indicator cautions, alternatives, or potential improvements.

Vulnerability Indicators

FOOD

EXPOSURE INDICATOR 1: Projected change of cereal yield

Description: Projected amount that climate change is predicted to change food supply by mid-century for three staples: rice, wheat and maize. The projections of the yield productions are obtained from five crop models (EPIC, GEPIC, LPJmL, pDSSAT, PEGASUS), and it assumes effect of CO2 fertilization but does not adjust for changes in farming systems or irrigation.

Rationale: Rosenzweig, et al. (2013) compared results from seven crop models against agricultural impacts of climate change expressed by yield changes through the end of the century. ND-GAIN includes the average impacts on three crops (rice, wheat and maize) as an indication of the climate impacts on agriculture sector and food supply because these three crops make up two thirds of human food consumption (FAO).

Calculation: The projected change is calculated by the percent change from the baseline projection of annual average of actual cereal yield in 1980-2009 to a future projection in 2040-2069 under the RCP 4.5 emission scenario (about RCP emission scenarios see IPCC, 2014). Data for baseline and future are the average yield productions from the five crop models. The conversion from models to an Index follows a process whose explanation is beyond the goals of this report.

Data Source: Earth System Grid Federation

Time Series: Single projection

EXPOSURE INDICATOR 2: Projected population change

Description: An indication of food demand by the mid-century. The projection data are from the World Bank Health Nutrition and Population Statistics (HNPStats) which provides country-level projection of population up to 2050.

Rationale: Population changes and shifts in consumption patterns are key determinants of food demand (Godfray et al., 2012). Diet shift, especially towards more meat/dairy consumption in emerging economies, is an important factor contributing to the food demand in the coming decades. But, uncertainties still exist as to the precise balance between opposing trends in developing and developed Countries (Alexandratos & Bruinsma, 2012). Given these uncertainties, as well as the lack of data on diet shifts, the projection of population growth is a simple approximation of food demand in the future.

Calculation: Average population growth is calculated by the percent change from the baseline population size in 2010 to the average predicted population size during the period 2020-2050, by country.

Data Source: HNPStats projection of total population

Time Series: Single projection

Notes: ND-GAIN uses population growth, since global data projecting future meat/dairy is lacking.

SENSITIVITY INDICATOR 1: Food import dependency

Description: Food comprises commodities such as food and live animals, beverages and tobacco, and animal and vegetable oils, such as fats and oil seeds, oil nuts, and oil kernels.

Rationale: Countries highly dependent on food imports are susceptible to shocks in food prices in the international market. Climate change and its impacts on the agriculture sector may accentuate price volatility (Nelson et al., 2010).

Data Source: Food imports (% of merchandise imports), World Bank

Time Series: Annual from 1995 to Present for several countries. Other countries have irregular updates.

Notes: While tobacco is included in this measure, it is not a food yet could not be disaggregated from the food dependency measure.

SENSITIVITY INDICATOR 2: Rural population

Description: The proportion of the total population living in rural areas, defined as the difference between total population and urban population according to national statistical offices.

Rationale: The vast majority of the world's poor live in rural areas (Global Monitoring Report, 2013), and agriculture is the major source of income and near-term development for the rural poor (World Bank, 2014). Therefore, a high proportion of rural population is indicative of a strong dependency on subsistence, or near subsistence, farming. Subsistence farmers are more vulnerable to climate shocks (Thorlakson et al., 2012).

Data Source: Rural population (% of total population), WDI

Time Series: Annual from 1995 to Present

ADAPTIVE CAPACITY INDICATOR 1: Agriculture capacity

Description: A combination of four indicators of agricultural technology: capacity to equip agriculture areas with irrigation, N+P205 total fertilizer use on arable and permanent crop area use, pesticide use, and tractor use. The irrigation measure obtained from FAO indicates the proportion of agriculture areas equipped with irrigation, but does not measure the amount of land that is indeed been irrigated in a specific year. Therefore, it is a capacity measure. The fertilizer and pesticide measures are the total consumption of the active ingredients (for both fertilizer and pesticide) as the reported sum divided by hectare. The tractor use measures the number of wheel and crawler tractors used in agriculture. Together, these measures are combined into an indication of the accessibility of agricultural technological inputs.

Rationale: Agricultural capacity is useful to distinguish between technological stages, especially in developing countries. This indicator is related to agricultural technologies as indicators of adaptive capacity to changing climate (Rosegrant et al., 2014). These four technologies included here are indicative of agricultural-related resources that a country can apply.

Calculation: The indicator of agricultural capacity takes the average of the two best (i.e. least vulnerable) scores of the four measures of agricultural technology described above. Using four measures allows for missing data but also for situations such as where irrigation or fertilizer is less necessary because of rainfall or good quality soils.

Data Source:

- Fertilizer use on arable and permanent crop areas, FAOSTAT
- Pesticide use on arable and permanent crop areas, FAOSTAT
- % of agriculture area/land area equipped for irrigation, FAOSTAT
- Tractor use per 100 sq. km of arable land, WDI

Time Series: Irregular data reporting for the four measures, ranging from annual update to 5-year update

Notes: In some cases, certain agricultural technologies, like pesticides and fertilizers, may be maladaptive, since the applications may either to some extent do more harm than good to crop productions or may increase greenhouse gas emissions. As an indicator of capacity, this indicator does not necessarily suggest adaptive solutions.

ADAPTIVE CAPACITY INDICATOR 2: Child malnutrition

Description: A measure of malnutrition based on the percent of under-5-year-olds with a low weight for height ratio; usually taken as a good indicator of chronic malnutrition. An assumption is taken for this indicator that OECD countries have a default child malnutrition rate of 0.

Rationale: This is presumed to be an indication of the lack of capacity to deliver basic nutritional needs to the most sensitive group in society.

Data Source: Prevalence of wasting (% of children under 5), WDI

Time Series: Irregular data reporting ranging from annually to every 5+ years

WATER

EXPOSURE INDICATOR 1: Projected change of annual runoff

Description: An indication of how climate change will bring changes to annual surface water resources by the mid of the century. Projected surface runoff data, defined as precipitation minus evapotranspiration and change in soil moisture storage, are provided by Aqueduct at the World Resource Institute. Aqueduct uses the ensemble of six global circulation models (GCMs) from Coupled Model Intercomparison Project Phase 5 (CMIP5) chosen to represent a broad diversity of models that best reproduce the mean and standard deviation of recent streamflow records in 18 large river basins (Alkama et al., 2013). The database covers 14998 catchments derived from the Global Drainage and Basin Database.

Rationale: Surface water resources are considered susceptible to climate change because of the impact of temperature and precipitation variability on rainfall, snowpack, evaporation, etc. (EPA, n.d.). The projected change of annual runoff due to climate change takes into account impacts on precipitation, evaporation, transpiration and soil moisture, which are the key factors impacting volume of runoffs (Němec & Schaake, 1982). ND-GAIN uses the projected change of annual runoff as a proxy to measure the climate impacts to surface water resources.

Calculation: The projected change is the percent change in annual runoff from the baseline projection (1980-2009) to the future projection (2040-2069) using RCP 4.5 emission scenario. Some baselines are close to zero, causing large percent changes even though the future projection is still low. To offset this effect, ND-GAIN sets all baseline flows to a set minimum value. The calculation here sets the 10th percentile to be the minimum value. Baseline and future projections are generated by averaging annual runoffs from six GCMs.

Data Source: Projected change of water risks by Aqueduct, World Resource Institute

Time Series: Single projection

Notes: (1) There are several factors that current hydrology models have not taken into consideration when projecting the future runoffs. For example, melting from snow will likely be affected by climate change, but is not included in this indicator; the topography also plays an important yet unmodeled role in this indicator. (2) Since ND-GAIN is an annual index, this indicator considers the runoff projection on an annual basis, which avoids the bigger variations in a shorter time-window (seasonal or monthly variation).

EXPOSURE INDICATOR 2: Projected change of annual groundwater recharge (GWR)

Description: An indication of how climate change will bring changes on annual groundwater resource by mid-century. GWR data are provided by Goethe University Frankfurt (Portmann et al., 2013).

Rationale: Ground water, together with surface water, is a key source of fresh water to supply drinking water and other water uses (EPA, n.d.). The projected change of groundwater recharge due to climate change takes into account the climatic impacts on the factors of total runoff, precipitation intensity, relief, soil texture, aquifer properties, and the occurrence of glaciers and permafrost. ND-GAIN uses the projected change of annual groundwater recharge as a proxy to measure the climate impacts of freshwater resources, complementing the surface runoff water indicator.

Calculation: The projected change is the percent decrease of the annual groundwater recharge from the baseline projection (1971-2000) to the future projection (2040- 2069) using RCP4.5 emission scenario. Some baselines are close to zero, causing large percent changes even though the future projection is still low. To offset this effect, ND-GAIN sets all baseline flows to a set minimum value. The calculation here sets the 10th percentile to be the minimum value. Baseline and future projections are generated by averaging annual GWR from five GCMs.

Data Source: Portmann, et al. (2013). Impact of climate change on renewable groundwater resources: assessing the benefits of avoided greenhouse gas emissions using selected CMIP5 climate projections.

Time Series: Single projection

Notes: It is commonly believed that climate change will have a large impact on freshwater supply because of the impact on GWR. However, the projection shows that under RCP4.5 emission path, the absolute change of GWR with respect to the baseline is relatively small by mid-century (2040-2069). Country values range from about - 60mm/yr to 40 mm/yr, compared with baseline GWR rates ranging up to 955 mm / yr. This implies that the impacts on freshwater supply via groundwater may be small in many countries.

SENSITIVITY INDICATOR 1: Fresh water withdrawal rate

Description: The proportion of total actual renewable water resources that is withdrawn as freshwater, to approximate the pressure on the renewable water resources, according to the FAO Aquastat database.

Rationale: Annual freshwater withdrawal out of the total renewable water resources is a proxy for countries' water stress (Oki & Kanae, 2006). Countries that already have water stress are less resistant to water scarcity exacerbated by climate change.

Data Source: Annual freshwater withdrawals, total (% of internal resources), AQUASTAT

Time Series: Countries all update the data periodically but not all countries make updates at the same time. The frequency of data reporting ranges from only once since 1995 to every 5 years.

SENSITIVITY INDICATOR 2: Water dependency ratio

Description: The proportion of the total renewable water resources originated outside the country, including the surface water and ground water entering the country or secured by treaties.

Rationale: An indication of how much renewable water resource a country has that is not exclusively controlled by the country. High dependency on foreign water resources makes a country potential susceptible to water insecurity (Bates et al., 2008; Tir & Stinnett, 2012), because climate change increases the demand for shared, transboundary water sources (Tir & Stinnett, 2012).

Data Source: Water dependency ratio, AQUASTAT

Time Series: Single estimate provided by AQUASTAT

ADAPTIVE CAPACITY INDICATOR 1: Dam capacity

Description: An indication of the capacity to adjust to the changing (temporal and geographical) distribution of freshwater resources, including changes due to climate change. It is a measure of the per capita dam storage capacities within one country, calculated by the per capita theoretical initial capacities of all dams, which does not allow for changes over time due to siltation.

Rationale: Adaptations to increase water scarcity and variability in flow could include both the establishment of an efficient water market and an increase in water storage capacity through the construction of dams (RCCCA, 2013). The construction of dams and reservoirs are an example of a country's capacity to build structural works that may reduce climate change impacts (De Loek et al., 2001). Although countries with high rainfall in theory do not need large dams under normal conditions, with climate change and the possibility of rainfall patterns changes, dams become more important. Therefore, dam capacities are an appropriate measure of the capacity to cope with changes brought by climate change regarding temporal and geographic distribution of water resources.

Data Source: Dam capacity per capita, AQUASTAT

Time Series: Irregular updates; dependent upon the country. Some have single estimates provided by AQUASTAT

Notes: (1) In some cases, increased dam construction may be maladaptive under climate change because of other negative environmental and social consequences of dam construction and maintenance (Fearnside, 2001; Tilt et al., 2009). In these cases, a country's ability to create dams could be indicative of the capacity to store water in other ways as well (e.g., wetland restoration), but does not necessarily suggest an adaptation solution. (2) The best data ND-GAIN has found so far is FAOSTAT that provides a single estimate with no variation over time. In future releases, tracking the capacity of water storage capacities with time-series data is desired.

ADAPTIVE CAPACITY INDICATOR 2: Access to reliable drinking water

Description: Commonly used indicator of the capacity to deliver reliable domestic water supplies. The drinking water sources are considered reliable if they have a household connection, public standpipe, borehole, protected well or spring, or rainwater collection.

Rationale: A country's ability to maintain high-level access to improved drinking water indicates the capacity to adapt to water shortage in general (Ivey et al., 2004). The indicator captures institutional support to manage water supplies.

Data Source: People using safely managed drinking water services (% of population), JMP

Time Series: Annual from 2000 to Present for several countries. Others have no reported data available.

HEALTH

EXPOSURE INDICATOR 1: Projected change of deaths from climate change induced diseases

Description: An indication of the climate change impacts on several types of diseases. The indicator is a model-based estimate of the quality-adjusted loss of life years under several different climate scenarios. Disability adjusted life year (DALY) due to malaria, an indication of the climate change impacts on vector borne diseases, is excluded because more specific models have been used to project such impacts and it is assessed by another ND-GAIN indicator, the projected change of length of transmission season of vector-borne diseases (see below).

Rationale: This is the only comprehensive assessment of the effects of climate change on overall health impacts.

Calculation: The projected change is the percent increase of DALYs from the historical baseline (2000) to the 2030 estimation using S550 emission scenario.

Data Source: Ebi (2008). Adaptation costs for climate change-related cases of diarrhoeal disease, malnutrition, and malaria in 2030.

Time Series: Single projection

EXPOSURE INDICATOR 2: Projected Change in Vector Borne Disease

Description: This indicator takes the projection of malaria LTS as an indication of the climate change impacts on vector-borne diseases. LTS data were taken from projections (Caminade, et al., 2014) that took the ensemble mean of malaria LTS over four malaria models and five GCMs. However, the incidence of vector-borne diseases is also strongly dependent on the quality of public health systems. In this indicator the WHO estimated number of malaria cases per 1000 population per month of current LTS is used as a measure of these services.

Rationale: The prevalence of malaria is the most researched important vector-borne disease for which projections have been made with climate impact models. The effect of public health in limiting the incidence of cases of the disease is assumed to remain at current (2010-2012) effectiveness. This is a conservative assumptions as public health measures are improving in almost all regions.

Calculation: The projected change is the absolute increase in malaria LTS from the baseline projection (1980-2010) to the future projection in 2050, using RCP 4.5 emission scenario.

Data Source: Caminade, et al. (2014). Impact of climate change on global malaria distribution. Proceedings of the National Academy of Sciences.

Time Series: Single projection

Notes: Literature shows that the transmission of many other vector-borne diseases like dengue fever yellow fever, Lyme disease, etc. will be highly impacted by climate change (Hales, et al.

2002; McMichael, et al. 2006; Lindgren, et al. 2012, etc.) but the data from modeled projections are either lacking or not accessible.

SENSITIVITY INDICATOR 1: Dependency on external resource for health services

Description: Share of current health expenditures funded from external sources. External sources compose of direct foreign transfers and foreign transfers distributed by government encompassing all financial inflows into the national health system from outside the country.

Rationale: A high dependency, usually on foreign aid, is an indicator of weakness in internal capacity and of sensitivity to climate-related health shocks.

Data Source: External health expenditure (% of current health expenditure), WHO

Time Series: Most countries have annual update from 2000 to Present

SENSITIVITY INDICATOR 2: Slum population

Description: The proportion of urban population living in slum households, defined as a group of individuals living under the same roof lacking one or more of life-supporting facilities: access to improved water, access to improved sanitation, sufficient-living area and durability of housing.

Rationale: Urban population living in slum-like conditions are vulnerable to climate change and poor health (e.g. St Louis and Hess 2008; Revi 2008) because of high population density and lack of access to basic life-supporting infrastructures, including clean drinking water and sanitation facilities. These features make slum dwellers particularly susceptible to water-borne diseases that could increase under climate change (WHO).

Data Source: Population living in slums (% of urban population), UN-HABITAT

Time Series: Biannual from 2000 to present for many countries

ADAPTIVE CAPACITY INDICATOR 1: Medical staffs

Description: Sum of the number of physicians, nurses and midwives per 1000 population in the country. Increases in physicians, nurses, or midwives will have the same effect on the indicator.

Rationale: Lack of medical staff is a major impediment to achieving good health outcomes in many poor countries. The numbers of staff in developed countries also varies significantly but may not be so directly related to health outcomes. In the index the score saturates so that this variation does not greatly affect outcomes in developed countries.

Data Source: Physicians (per 1000 people), WDI; Nurses and midwives (per 1000 people), WDI

Time Series: Countries update the data periodically but not all countries have updates at the same time.

Notes: Hospital beds are often used as an alternative measure. However, access to the beds may be difficult following extreme climate events and the hospitals may be damaged themselves. Also, the quality of a "hospital bed" and the services that go with it often vary greatly. ND-GAIN has favored a people and skills-based measure.

ADAPTIVE CAPACITY INDICATOR 2: Access to improved sanitation facilities

Description: The percentage of people using improved sanitation facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite. Improved sanitation facilities include flush/pour flush to piped sewer systems, septic tanks or pit latrines: ventilated improved pit latrines, composting toilets or pit latrines with slabs.

Rationale: Sanitation influences the incidence of infectious diseases (Tol et al., 2007). Thus, access to sanitation is particularly crucial to build up preparedness to various natural disasters exacerbated by climate change (McMichael & Woodruff, 2005; Keim, 2008).

Data Source: People using safely managed sanitation services (% of population), JMP

Time Series: Annual from 2000 to Present for several countries. Others have no reported data available.

ECOSYSTEM SERVICES

EXPOSURE INDICATOR 1: Projected change of biome distribution

Description: An indication of how climate change will impact the change of terrestrial biome biodiversity within a country by the end of the century. Data were taken from the global version of a dynamic vegetation model (MC1) (Gonzalez et al., 2010).

Rationale: The indicator captures the threat of changes in biome function. It is based on the projected impact of climate change on the area occupied by different biomes within a country.

Calculation: The projected change is the fraction of land area within a country that is projected to become a different potential biome type under future climate (2070-2100, combining three Special Report of Emission Scenarios (SRES) and three GCMs relative to baseline years 1990.

Data Source: Gonzalez, et al. (2010). Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change.

Time Series: Single projection

EXPOSURE INDICATOR 2: Projected change of marine biodiversity

Description: An indication of how climate change will impact the change of marine biodiversity in a country's exclusive economic zones by mid-century. It is a measure based on projected changes in the distribution of 1066 exploited species of marine fish and invertebrates under climate envelope scenarios based on A1B scenarios (Cheung et al., 2009).

Rationale: The indicator is a complement to the terrestrial biome diversity indicator, in order to capture the threat of changes in providing fishery or non-fishery marine resources.

Calculation: The projected change of marine biodiversity is the projected species turnover (invasion + local extinction) in 2050 relative to the 2001-2005 baseline. The Exclusive Economic Zones Boundaries map (World EEZ V8) released in 2014 from marineregions.org was used to aggregate the pixel-level (half-degree grid) species turnover data up to the country-level. All countries not adjacent to the ocean are assumed to have zero vulnerability in terms of marine biodiversity.

Data Source: Cheung, et al. (2009). Projecting global marine biodiversity impacts under climate change scenarios.

Time Series: Single projection

Notes: As a complementary indicator to the terrestrial biomes' biodiversity, marine biodiversity should ideally be considered in combination with freshwater biodiversity, especially for land-locked countries that count more on freshwater resources. So far, no model has been developed to produce such data that has global coverage.

SENSITIVITY INDICATOR 1: Natural capital dependency

Description: Based on the World Bank's Natural Capital Accounting project. This indicator of the strength of the dependency of social systems on ecosystem goods and services is based on the deployment of natural capital in national accounting, including national income and savings in the form of all assets and capital goods that are inputs to economic well-being (The World Bank, 2011). The natural capital related to ecosystem services includes: crop, pasture, forest (timber), forest (non-timber) and protected areas. Sub-surface capital such as oil, gas and mineral reserves are not Included.

Rationale: The indicator captures a country's reliance on ecosystem services, which are themselves exposed to disruption by climate change.

Calculation: The indicator is the ratio of natural capital over the total wealth of one country.

Data Source: The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium. World Bank (retired dataset)

Time Series: Three estimates: 1995, 2000, 2005

SENSITIVITY INDICATOR 2: Ecological Footprint

Description: The ecological footprint estimates the number of hectares of land and water, both within and outside the country, that are needed to meet the average demand on ecosystems services by the population's lifestyle. This is compared with the estimated capacity of a country's ecosystems to regenerate and maintain ecosystem services for either internal use or export. This indicator uses the surplus or deficit of capacity to cover the demand within each country.

Rationale: A country with a surplus (more supply than demand) has the capacity to produce more from within its boundaries and thus is likely to have more options to adapt to a changing climate.

Data Source: National Footprint and Biocapacity Accounts

Time Series: Periodic updates within data period from 1995 to Present

ADAPTIVE CAPACITY INDICATOR 1: Protected Biomes

Description: Taken directly from the Yale Environmental Performance Index (EPI), the indicator "assesses the protection of biomes weighted by the proportion of a country's territory the biome occupies." EPI defines the indicator as follows: "It measures the degree to which a country achieves the target of protecting 17% of each terrestrial biome within its borders, weighted by the domestic contribution of each terrestrial biome…all biome protection percentages were capped at 17% so that higher protection in one biome cannot be used to offset lower protection in another."

Rationale: Countries with good protection of their core ecosystem types are likely to have the capacity to implement a wider range of actions to continue to protect and manage ecosystem services under a changing climate.

Data Source: Terrestrial Protected Areas (National Biome Weights), Environmental Performance Index (retired dataset)

Time Series: Periodic updates within data period from 2007 to 2016

ADAPTIVE CAPACITY INDICATOR 2: Engagement in international environmental conventions

Description: An indicator based on the country's participation in international forums, which is an indicator of its capacity to engage in multilateral negotiations and to reach agreement on appropriate actions internally.

Rationale: Although not a direct measure of capacity, the failure to take part in such forums is usually associated with either lack of technical capacity to deal with the issues and/or lack of political ability to reach decisions over appropriate engagement.

Calculation: The indicator is the ratio of a single country's current status of convention engagement to the maximum engagement among all countries. The current status is a comprehensive measure considering dates of signing in conventions, ratification of convention participation and denunciation of treaty agreement.

Data Source: Environmental Treaties and Resource Indicators (retired dataset)

Time Series: Annual from 1995 to 2011.

Notes: Below is a description of the original rationale for this indicator. It has since gone stagnant and will be replaced in the future.

The outcome for this indicator is strongly dependent on the process of selecting the agreements to be included. ND-GAIN includes "environmental treaties" in their broadest sense while avoiding any to do with military/warfare, gross marine pollution, safety at sea, and other shipping controls. ND-GAIN also excludes treaties directly setting up International organizations such as the World Bank etc. ND-GAIN also excludes agreements with less than 20 signatories. Some agreements have a limited regional scope (e.g. dealing with Atlantic tuna). ND-GAIN could have excluded them, but this would have limited the list (16 out of 54 have clear regional scope of application), and many were signed by countries beyond the region (e.g those with fishing fleets in the Atlantic). Many (17 out of 54) also deal with the agreements on oceans and this may disadvantage land-locked countries. However, land-locked countries are sometimes signatories to such conventions (e.g. those relating to whaling). It could similarly be argued that some agreements are not relevant to many countries on other grounds (e.g. those to do with desertification). Thus ND-GAIN retains a wide set of agreements rather than culling, thereby reducing the list to only 10 to 20.

HUMAN HABITAT

EXPOSURE INDICATOR 1: Projected change of warm periods

Description: An indication of the probability of extreme heat under climate change by mid-century. This indicator uses the Warm Spell Duration Index (WSDI), which defines periods of excessive warmth using a percentile-based threshold calculated for a calendar 5-day window in the base period 1961-1990. WSDI counts the number of days in a year when daily maximum of near surface temperature exceeds the 90th percentile threshold for 6 consecutive days or longer (Alexander, et al., 2006; Sillmann, et al., 2013b).

Rationale: Human living conditions are threatened by the increased intensity and/or frequency of extreme weather, including storms, flooding, landslides and heat waves, that climate change is bringing or will bring (Satterthwaite, 2008).

Calculation: The projected change is the absolute change of WSDI from the baseline year (1960-1990) to the future projection (2040-2070), using RCP4.5 emission scenario.

Data Source:

- WSDI baseline projection (1960-1990)
- WSDI future projection (2040-2070)
- Sillmann, et al. (2013a). Climate extremes indices in the CMIP5 multimodel ensemble: Part 1. Model evaluation in the present climate.
- Sillmann, et al. (2013b). Climate extremes indices in the CMIP5 multimodel ensemble: Part 2. Future climate projections.

Time Series: Single projection

Notes: Another relevant index to measure the duration of warm spell is the Heat Wave Duration Index (HWDI), which counts the number of days when the daily maximum of near surface temperature exceeds more than 5 degree C above the mean daily maximum temperature in a calendar 5-day window in the base period 1961-1990. (Frich, et al., 2002; Sillmann, et al., 2013b). However, the 5 degree C threshold that HWDI uses is too high to detect the low variation of daily temperature, for example, in tropical areas. Therefore, an index calculated using a percentile-based threshold is more appropriate to capture various degrees of temperature variation.

EXPOSURE INDICATOR 2: Projected change of flood hazard

Description: Flood hazard is measured by the predicted, monthly maximum precipitation in 5 consecutive days (rx5day). Rx5day is defined as monthly maximum consecutive 5-day precipitation. It is a measure of precipitation extreme under climate change, a risk factor for flood hazard (Kundzewicz & Schellnhuber, 2004). The monthly rx5day data are extracted from ensemble mean of extreme indices generated by 19 GCMs (Sillmann et al., 2013a; Sillmann et al., 2013b).

Rationale: An indicator that complements the warm period projection, to capture one of the important disastrous threats to human living conditions.

Calculation: The projected change is the percent change in the flood hazard from the baseline projection (1960-1990) to the future projection (2040-2070), using RCP 4.5 emission scenario. The annual figure is derived from averaging the monthly data.

Data Source:

- rx5day baseline projection (1960-1990)
- rx5day future projection (2040-2070)
- Sillmann, et al. (2013a). Climate extremes indices in the CMIP5 multimodel ensemble: Part 1. Model evaluation in the present climate.
- Sillmann, et al. (2013b). Climate extremes indices in the CMIP5 multimodel ensemble: Part 2. Future climate projections.

Time Series: Single projection.

SENSITIVITY INDICATOR 1: Urban concentration

Description: Urban concentration measures both concentration of a country's population within cities (i.e. the degree of urbanization in general) and concentration of the urban population within a small number of large population (cities of 750,000 inhabitants or more) centers via the Herfindahl Index (Henderson, 2000; Van Eck & Koomen, 2008).

Rationale: Countries in which urban populations are concentrated in a single or a small number of urban areas are considered more sensitive to climate change (Lankao, 2008). According to this indicator, a country with a highly concentrated urban sector and a highly urbanized population is the most sensitive.

Calculation: Urban concentration is the product of Herfindahl measure of concentration of the urban population weighted by the percent of a country's population that is urbanized. The Herfindahl measure takes the sum of the squared percent of the population residing in each large city over the total population in these large cities. The total urbanized population is the proportion of urban population to the total country population. Countries that do not have cities with more than 750,000 inhabitants are considered to have zero vulnerability due to high urban concentration.

Data Source: Urban population (% of total), UN Population Division, World Urbanization Prospects

Time Series: Annual from 1995 to Present

SENSITIVITY INDICATOR 2: Age dependency ratio

Description: An indication of the size of the vulnerable population in terms of ages. This indicator considers the population under 14 or above 65 as the vulnerable group.

Rationale: Vulnerable age groups—under 14 or above 65—are susceptible to climate change impacts through direct and indirect channels. The direct effects of extreme weather may disproportionately affect the old and the young (Wolf et al., 2010), and they may be indirectly affected by climate change impacts operating through social political structures or the economy.

Data Source: Population ages 65 and above (% of total), WDI; Population ages 0-14 (% of total), WDI

Time Series: Annual from 1995 to Present

ADAPTIVE CAPACITY INDICATOR 1: Quality of trade and transport infrastructure

Description: Logistics professionals' perception of country's quality of trade and transport related infrastructure (e.g. ports, railroads, roads, information technology), on a rating ranging from 1 (very low) to 5 (very high). Scores are averaged across all respondents.

Rationale: Transportation infrastructure has been shown to be important for migration and development (Malik & Temple, 2009; Jayachandran, 2006). Migration away from challenging climates is important for improving human health over time (Deschenes & Moretti, 2009). The quality of trade and transport infrastructure shows the capacity to effectively supply and manage essential infrastructure by the public and private sectors. It is assumed here that same capacity is indicative of a capacity to sustain that infrastructure in the face of future changes, including climate change.

Data Source: Quality of trade and transport-related infrastructure, WDI

Time Series: First reported in 2007, then biennial from 2010 to 2018 for several countries. Others have no reported data available.

ADAPTIVE CAPACITY INDICATOR 2: Paved roads

Description: Roads surfaced with crushed stone (macadam) and hydrocarbon binder or bituminized agents, with concrete, or with cobblestones, as a percentage of all the country's roads, measured in length. It reflects a country's capacity to acquire and deploy transportation improvements, especially in rural areas.

Rationale: This is a measure of the sturdiness of the road system and all of the social and economic activity dependent upon it. This is also a measure to complement the first capacity indicator (which is mainly as a proxy to measure transport infrastructure between major cities). Paved roads capture a country's capacity to deploy transportation improvements, especially in rural areas.

Data Source: International Roads Federation

Time Series: 1995 to 2011 but not annually for most of the countries. The frequency of data reported ranges from only once since 1995 to annual.

INFRASTRUCTURE

EXPOSURE INDICATOR 1: Projected change of hydropower generation capacity

Description: An indication of the potential risk of hydropower generation capacity weighted by the importance of hydropower to one country, i.e. the proportion of the electricity production from hydroelectric sources. The data of the projected change are available at the sub-continental level, drawn from (Hamududu & Killingtveit, 2012).

Rationale: Due to the hydrological impact of climate change in the mid- to long- term (see the two exposure indicators in the water sector), climate change also is projected to directly impact hydropower generation capacity (Schaeffer et al., 2012).

Calculation: The projected change is the percent change in the hydropower generation capacity from the historical baseline (2005) to the future projection (2050), using the A1B emission scenario.

Data Source: Hamududu & Killingtveit (2012). Assessing Climate Change Impacts on Global Hydropower. Dependency on hydropower

Time Series: Annual from 1995 to 2015.

EXPOSURE INDICATOR 2: Projected change of sea level rise impacts

Description: An indication of how coastal infrastructure will be impacted by the combined effect of sea level rise and potential storm surge by the end of the century. The indicator considers the proportion of land areas, adjacent to the ocean, that are lower than the projected sea level rise and the average height of storm surge.

Rationale: Sea level rise due to climate change is a threat to coastal infrastructure, requiring resilient infrastructure that protects coastal areas (Lemmen& Warren, 2004; Tol, et al., 2008; Hallegatte, 2009). ND-GAIN assumes that the potential risk or damage to coastal infrastructure from sea level rise depends on the extent of coastal areas exposed to both sea level rise and potential storm surge.

Calculation: The global average of sea level rise by the end of the century under RCP 4.5 scenario is projected to be 0.32-0.63 m (IPCC, 2013). There is no consistent average height of storm surge because the factors vary tremendously. 1.5m or 2-3 m is considered to be the moderate zone (Smith et al., 2010). Taking 0.63 m of the projected change of sea level rise and 3 m of moderate height of storm surge, ND-GAIN estimates the impact to be the proportion of ocean-adjacent land areas lower than 4 m above sea level. The equal-area map projection is used to calculate land area. ND-GAIN assumes that land-locked countries do not have coastal risks.

Data Source: 1 arc-minute global relief model of Earth's surface, integrating land topography and ocean bathymetry

Time Series: Single measure

SENSITIVITY INDICATOR 1: Dependency on imported energy

Description: A measure of the percentage of total energy use that is imported and thus not fully within a country's control. According to the IEA, energy use refers to the use of primary energy before transformation to other end-use fuels, equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.

Rationale: The imported energy could increase in price or be cut off in crises. A higher proportion of imported energy implies higher sensitivity to price volatility and supply crises. Countries heavily dependent on imported energy are considered energy vulnerable (Gnansounou, 2008).

Data Source: World Energy Balances, IEA

Time Series: Updates annually from 1995 to Present. Some countries have no reported data.

SENSITIVITY INDICATOR 2: Population living under 5m above sea level

Description: The proportion of the population living in the area where elevation is 5 m or less. It is a simple measure of the population sensitive to coastal risks.

Rationale: An estimate of the population sensitive to the risks arising from seal-level rise, storm surge and similar effects, which are exacerbated by climate change.

Data Source: Population living in areas where elevation is below 5 meters (% of total population), WDI

Time Series: Updated in 2000, 2010, and 2015

Notes: (1) Generally, this indicator should be continuously changing considering that many countries are experiencing population migration to coastal cities (e.g. Adebusoye, 2006; Chan, 2013). (2) A more consistent measure should be the coastal population living in areas where elevation is 4m or less, to line up with the exposure indicator (the second exposure indicator above). The population data available from the World Development Indicators database, however, are for 5 m.

ADAPTIVE CAPACITY INDICATOR 1: Electricity access

Description: The proportion of the population with access to grid-power.

Rationale: Access to electricity enables the poor to get the most basic services and economic opportunities to improve their standard of living. Considering the potential climate risks, access to electricity provides the basics that facilitate health care, disaster relief, food storage, and social services like education and ICT infrastructures. Therefore, electricity access is indicative of the capacity to delivery energy to a country's citizen and businesses, including technology and infrastructure, personnel, and the ability to respond to disruptions in supply.

Data Source: Access to electricity (% of population), WDI

Time Series: Updated annually from 1995 to Present

ADAPTIVE CAPACITY INDICATOR 2: Disaster preparedness

Description: A measure of a nation's adoption and implementation of national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, as measured through the UN Sustainable Development Goal 13.1.2.

Rationale: Resilience of infrastructure depends on the capacity to respond to natural disasters (Cutter, et al., 2008), therefore, preparedness to natural disasters, an indication of such social capacity, is a proxy to measure the infrastructure resilience.

Data Source: United Nations Sustainable Development Goals Indicators database

Time Series: Annually from 2014 - 2019

Notes: (1) The Sendai Framework was adopted in 2015, but some countries have scores for 2014 due to previous disaster reduction plans that aligned with the Hyogo Framework for Action (2005 – 2015). (2) The self-reported data are not always comparable among countries. However, the UN SDG database still provides so far, the most comprehensive data set that monitors the progress of capacity building in terms of preparing for natural disasters.

Readiness Indicators

ECONOMIC READINESS

INDICATOR: Ease of doing business index

Description: The indicator took the World Bank Doing Business (DB) indicators as an indication of how countries are capable of attracting adaptation investment. The index assesses the investment climate in 10 topics using 40 indicators. The 10 topics are: starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency.

Rationale: The World Bank Doing Business (DB) indicators, which have been used by many studies to evaluate countries' investment climate by measuring procedures, time and cost of performing business activities through business life cycles (e.g. Commander & Svejnar, 2011; Hallward-Driemeier & Pritchett, 2011; Morris & Aziz, 2011; Collier & Duponchel, 2013). As the economic readiness in ND-GAIN seeks to capture the business conditions that attract adaptation investment, a description of the general investment climate is a good proxy for the economic component of readiness.

Calculation: There are 40 indicators in total provided by the DB database, available since 2003. But the overall DB scores have only been reported since 2012 by the World Bank. ND-GAIN recreated scores of the DB index for 2003-2020 using raw data and following the DB methodology. Countries are ranked by percentile on each topic, and the overall DB scores are obtained by averaging the percentile rankings of all 10 topics.

Data Source: Doing Business Index (retired as of 2022)

Time Series: Annually from 2003 to 2020.

Notes: (1) Some of the DB sub-indices have incurred criticism, e.g., labor regulations; however, the overall DB is a widely accepted and applied indicator of countries' investment climate. (2) Some of the DB indicators are highly correlated with other readiness indicators, for instance, the rule of law indicator. The relevance of the index has also been challenged by some countries.

GOVERNANCE READINESS

GOVERNANCE INDICATOR 1: Political stability and non-violence

Description: An indicator directly from the World Governance Indicators (WGI), "capturing perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism."

Rationale: There is a well-established relationship between foreign financial inflow (including investment and aid) and political stability and violence (e.g. Bennett & Green, 1972; Busse & Hefeker, 2007; McGillivary, 2011), suggesting that a stable political environment is more attractive to general investment from outside a country, including the adaptation investment.

Data Source: WGI Political stability and Absence of Violence/Terrorism: Estimate

Time Series: 1996, 1998, 2000; Annual updates from 2002-Present for most countries

GOVERNANCE INDICATOR 2: Control of corruption

Description: An indicator directly from the World Governance Indicators (WGI), "capturing perceptions from firms and households survey respondents and public, private, and NGO sector experts worldwide of public power exercised for private gain, including both petty and grand forms of corruption, as well as 'capture' of the state by elites and private interests."

Rationale: Corruption is known to have a negative impact on foreign investment (e.g. Beata& Wei, 2000; Habib &Zurawicki, 2002), and measuring the control of corruption implies government integrity and accountability (Sampson, 2004). It is also one of the important indicators in Country Policy and Institutional Assessment that attempts to assess how executives can be held accountable for fund uses (The World Bank Group, 2010). Control of corruption is therefore used as an indicator of governance readiness.

Data Source: WGI Control of Corruption: Estimate

Time Series: 1996, 1998, 2000; Annual updates from 2002-Present for most countries

GOVERNANCE INDICATOR 3: Regulatory quality

Description: An indicator directly from the World Governance Indicators (WGI), "capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development."

Rationale: The quality of regulation measures the performance of country institutions, an important factor in deploying adaptation actions and adaptation-related policies (e.g. Globerman & Shapiro, 2003; Daude & Stein, 2007; Gani, 2007).

Data Source: WGI Regulatory Quality: Estimate

Time Series: 1996, 1998, 2000; Annual updates from 2002-Present for most countries

GOVERNANCE INDICATOR 4: Rule of law

Description: An indicator directly from the World Governance Indicators (WGI), "capturing perceptions from firms and households survey respondents and public, private, and NGO sector experts worldwide of confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence."

Rationale: Like political stability and control of corruption, rule of law is a quality of society that encourages foreign investment in general (e.g. Alesina & Dollar, 2000; Burnside & Dollar, 2004), hence the adaptation investments.

Data Source: WGI Rule of Law: Estimate

Time Series: 1996, 1998, 2000; Annual updates from 2002-Present for most countries

SOCIAL READINESS

SOCIAL INDICATOR 1: Social inequality

Description: The country's poorest quintile's share in national income or consumption.

Rationale: The poorest populations are likely to be the most vulnerable to climate impacts (Tol, et al., 2004). Social inequality causes skewed distribution incomes and of vulnerability, and the exaggerated impacts on the poorest may further skew income distribution. Thus, social inequality exacerbates a country's capacity to adapt to climate change.

Data Source: Poorest quintile's share in national income or consumption, percentage, MDG Indicators

Time Series: 1995 to 2012. Most of the countries do not have annual updates (retired).

SOCIAL INDICATOR 2: Information Communication Technology (ICT) infrastructure

Description: A composite indicator from 4 sub-indicators that consider both the access to and the use of ICT infrastructure: mobile phone subscription per 100 persons, fixed phone subscription per 100 persons, fixed broad-band subscription per 100 persons, and percent of individuals using the internet. Data for all four are available from the annual ICT Development Index (IDI) database. The mobile phone subscription measures the subscription to public mobile services including the post-paid and prepaid subscriptions (World Development Indicators, 2014). The fixed phone subscription is assumed to measure of the active number of analog fixed telephone lines, ISDN channels, fixed wireless (WLL), public payphones and VoIP subscription (International Telecommunication Union, 2010). The fixed broad-band subscription refers to the number of broadband subscribers with a digital subscriber line, cable modem, or other high-speed technology (World Development Indicators, 2014). The individual internet use measures the proportion of internet users with access to the worldwide network (World Development Indicators, 2014).

Rationale: ICT infrastructure can facilitate many features of adaptation. For example, it enables knowledge integration and learning and key ingredients of adaptive capacity (Pant and Heeks 2011); it provides technical support for early warning systems; and it can strengthen local organizations that implement adaptation (Singh and Singh 2012).

Calculation: The overall ICT infrastructure indicator takes the average over the scores of the four sub-indicators.

Data Source:

Mobile phone subscription per 100 persons, WDI

Fixed phone subscription per 100 persons, ITU

Fixed broad-band internet subscription per 100 persons, WDI

Internet user per 100 persons, WDI

Time Series: Not all sub-indicators have coverage from 1995 to Present. The range of data availability is from 4-5 updates since 1995 to annual report. But the overall score is the average of the available sub-indicators. Therefore, the scores in the end are on the annual basis.

SOCIAL INDICATOR 3: Education

Description: A measure of enrollment in tertiary education to represent the education level of a country. It is approximated by the ratio of the enrollment in tertiary education (regardless of age) to the population of the age group that officially corresponds to tertiary education attendance.

Rationale: Education is considered as an important strategy to build up adaptive capacity and identify adaptation solutions appropriate to local context (Maddison, 2006; Smit & Pilifosova, 2001; Mercer, 2010). In particular, enrolment in secondary or tertiary education is a significant contributor, more than primary education, to adaptive capacity (Tol & Yohe, 2007).

Data Source: School Enrollment, tertiary (% gross), WDI

Time Series: 1995-Present. The frequency of data reporting ranges from no report to annual update.

SOCIAL INDICATOR 4: Innovation

Description: A measure of the number of patent applications, filed through the Patent Cooperation Treaty procedure or with a national patent office, by residents per capita.

Rationale: Innovation is the engine of growth (Solow 1994). It also is a fundamental force behind capacity building and climate change adaptation because research and technology are necessary to define adaptation solutions (Smit & Skinner, 2002; Adger, et al., 2008).

Calculation: A simple calculation of the per capita measure of the residents' patent applications.

Data Source: Patent applications, residents, WDI; Population, WDI

Time Series: Patent: 1995-Present. The frequency of data reporting ranges from no report to annual update. Population: 1995-Present.

Notes: The numbers of national patent registrations are not necessarily comparable across countries as the costs and incentives to register patents vary. There are alternative indicators of innovation, e.g. number of scientists, R&D expenditures, number of literature citations, etc. There is no comprehensive measure of innovation.

V. ND-GAIN Reference Points

ND-GAIN scales measures using the "proximity-to-reference point" approach, which scores the level of vulnerability and readiness by the distance to the ideal status, (i.e. least vulnerable is 0 and most ready is 1). 0 for vulnerability or 1 for readiness is considered "full score," and measure scores can be used to assess distance from a desired state. Reference points in ND-GAIN follow rules such as:

- **Rule 1:** The baseline maximum or minimum of the observed raw data, rounded to integer numbers when applicable.
- **Rule 2:** The logical reference points derived from the common adaptation or development practices.
- **Rule 3:** The reference points identified by the data source.

The reference points for individual measures are provided in Table 3 below. The tag 1-3 stands for the rule above that applies to each reference point.

Table 3 ND-GAIN Indicators Reference Points

Sector	Indicator	Reference Points	Baseline Min	Baseline Max
Food	Projected change of cereal yields	3.56[1]	-0.389	3.563
	Projected population Change	-20%[1]	-0.20272	0.8355
	Food import dependency	0%[2]	0	1.037
	Rural population	0%[2]	0	92.789
	Agricultural capacity	Area equipped for irrigation: 28%[1] Fertlizer use 200 tonnes/1000Ha[1] Pesticide use: 10 tonnes of active ingredients/1000Ha[1]	0	1

		Tractor use: 1100/100 sq. km of arable land[1]		
	Child malnutrition	0%[2]	0	15
Water	Projected change of annual runoff	100%[1]	0	1
	Projected change of annual groundwater recharge	100%[1]	0	1
	Fresh water withdrawal rate	0%[2]	0	100
	Water dependency ratio	0%[2]	0	73.32
	Dam capacity	4932 m^3 *per capita*[1]	0	4932
	Access to reliable drinking water	100%[2]	54.99	100
Health	Projected change of deaths from climate change induced diseases	1.03[2]	1.025	1.19
	Projected change in vector-borne diseases	-8.1 months	-8.16	64.86
	Dependency on external resource for health services	0%[2]	0	29.42
	Slum population	0%[2]	0	97
	Medical staff	12.3‰[1]	0	12.32
	Access to improved sanitation facilities	100%[2]	19	99.5
Ecosystems	Projected change of biome distribution	11%[1]	0.11	0.96

	Projected change of marine biodiversity	0[1]	0	0.88
	Natural capital dependency	0[2]	0	0.46
	Ecological footprint	0.35 Ha per capita[1]	0.35	4.84
	Protected biome	100[3]	0	100
	Engagement in international environmental conventions	1[2]	0	1
Human Habitat	Projected change of warm periods	30%[1]	29.99	113.31
	Projected change of flood hazard	-4%[1]	-0.0395	0.161395
	Urban concentration	0.0053[1]	0.00534	1
	Age dependency ratio	28%[1]	0.28	0.5334
	Quality of trade and transport infrastructure	5[3]	1	5
	Paved roads	100%[2]	0.8	100
Infrastructure	Projected change of hydropower generation capacity	141%[1]	-1.82	1.411
	Projected change of sea level rise impacts	0%[1]	0	0.113
	Dependency on imported energy	0%[2]	0	99.93
	Population living under 5m above sea level	0%[1]	0	24.11

	Electricity access	100%[2]	18.62	100
	Disaster preparedness	1[1]	0.05	1
Economic Readiness	Doing business	0.99[3]	0.01	0.99
Governance Readiness	Political stability and non-violence	2.5[3]	-2.5	2.5
	Control of corruption	2.5[3]	-2.5	2.5
	Regulatory quality	2.5[3]	-2.5	2.5
	Rule of law	2.5[3]	-2.5	2.5
Social Readiness	Social Inequality	13.4%[1]	0	13.4
	Ict Infrastructure	Fixed phone subscription: 60%[3] Mobile cellular subscription: 190%[3] Internet user: 100%[3] Fixed broadband internet subscription: 60%[3]	0	0.893
	Education		0.2094	70.17
	Innovation		0	0.00023

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