THE ROBERT S. STRAUSS CENTER
FOR INTERNATIONAL SECURITY AND LAW

Compound Fragility and Climate Risks Study

Methodology
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1.0 PROJECT SUMMARY

States with high exposure to climate hazards face multi-faceted challenges, including physical and livelihood risks for the population that force states to redirect scarce resources to adaptation or humanitarian response efforts and strain the capacity of states that, in many cases, are still solidifying democratic institutions and mechanisms for meeting public needs. Similarly, fragility can affect many aspects of a state's capacity and legitimacy across its political, economic, social, and security spheres. When states face fragility and climate risks simultaneously, the risks and challenges are compounded.

This study seeks to identify the locations where fragility and climate risks co-occur around the world. Since these places with compound fragility-climate risks may be more vulnerable to humanitarian emergencies or instability, understanding the distinct fragility and climate challenges they face could present opportunities and focal points for intervention. Prior quantitative and mapping efforts have separately assessed fragility risks at the global level,[1] individual climate hazard risks at the global level,[2] and composite climate risks at the regional level.[3] This study is the first quantitative and mapping effort to assess the intersection of fragility and climate risks globally. It builds on the groundbreaking work commissioned by the G7 that developed an integrated framework for assessing compound fragility-climate risks.[4]

This study examines highly fragile states that have high exposure to multiple climate hazards. The reason for this is straightforward: responding to high exposure to even a single hazard requires substantial resources, infrastructure, and mobilization, yet a country that has high exposure to multiple hazards requires such resources, infrastructure, and mobilization many times over to address each of these diverse hazards. For a highly fragile state—for instance Burma, which faces substantial risks from both slow-onset hazards like droughts and rapid-onset hazards like cyclones and coastal inundation—these diverse threats and required responses can exceed state capacity and social capital.

To analyze the intersection of fragility and climate risks worldwide, this study develops several novel analytical products.[5] These include:

- A new composite measure of climate exposure allowing assessment of subnational exposure patterns worldwide;
- A new longitudinal fragility measure allowing assessment of state effectiveness and legitimacy in the political, security, economic, and social spheres of states worldwide;
- Metrics on the number of people and the proportion of the population facing high and very high exposure in fragile states;
- Metrics on the extent of territory facing very high exposure in fragile states; and
- Maps showing the locations of overall climate exposure and individual hazard risks, overall fragility and sectoral risks, and the intersection of fragility and climate risks worldwide.

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1 See for example Monty G. Marshall and Gabrielle Elzinga-Marshall. 2016. *Table 1: State Fragility Index and Matrix 2015.* Vienna: Center for Systemic Peace; and J.J. Messner et al. 2016. *Fragile States Index 2016.* Washington: The Fund for Peace.

2 See for example United Nations Environment Programme Global Resource Information Database-Geneva (UNEP/GRID-Geneva). *Global Risk Data Platform,* http://preview.grid.unep.ch.

3 See for example Joshua W. Busby, Todd G. Smith, Kaiba L. White, and Shawn M. Strange. 2013. Climate Change and Insecurity: Mapping Vulnerability in Africa. *International Security* 37, 4: 132-172.

4 Lukas Rüttinger, Dan Smith, Gerald Stang, Dennis Tänzler, Janani Vivekananda, Oli Brown, Alexander Carius, Geoff Dabelko, Roger-Mark De Souza, Shreya Mitra, Katharina Nett, Meaghan Parker, and Benjamin Pohl. 2015. *A New Climate for Peace, Taking Action on Climate and Fragility Risks.* Washington: Adelphi, International Alert, Woodrow Wilson International Center for Scholars, and European Union Institute for Security Studies.

5 The global maps and analysis based on these products is available in Ashley Moran, Joshua W. Busby, Clionadh Raleigh, Todd G. Smith, Roudabeh Kishi, Nisha Krishnan, and Charles Wight. 2018. *The Intersection of Global Fragility and Climate Risks*. Washington: U.S. Agency for International Development (USAID) Office of Conflict Management and Mitigation. The complete set of resources available from this study is listed in Section 5.0 of this methodology document.

2.0 CLIMATE EXPOSURE

The climate exposure portion of this study aims to identify places most likely vulnerable to a combination of climate hazards. Geographic location makes some countries more susceptible to climate hazards. Within countries, some areas, such as the coasts, have more exposure to certain kinds of climate hazards. This study assesses climate hazard exposure using historical data on the frequency and magnitude of six hazards, including cyclones, flood events, wildfire events, rainfall anomalies, and chronic aridity. The sixth hazard is a measure of low-elevation coastal zones, which may be susceptible to storm surges and future sea-level rise.

The goal is to identify places that in the recent historical record have faced high exposure to climate-related hazards. This seeks to get a snapshot of places of chronic concern over a long enough time period to say that these are places that have been historically affected by climate-related hazards. The indicators included here use the most recent data available. Some of these indicators, like cyclones, have longer-term data available, while others like floods have data for fewer years. In all cases, this project uses the most recent and broadest set of years for which global data are available to get the best snapshot of climate exposure in the recent past, as close as possible to the present.

This document outlines the process of mapping individual climate hazards, the rationale for including particular indicators, and the process of calculating total climate exposure.[6]

2.1 Individual Climate Hazards

In this study, historical, geo-referenced climate hazard data on cyclones, floods, and wildfires are from UNEP/GRID-Europe.[7] The data on rainfall anomalies and chronic aridity are from the Global Precipitation Climatology Centre.[8] The data on low-elevation coastal zones are derived from Viewfinder Panoramas.[9]

Cyclones are represented by data from the UNEP/GRID-Europe platform called "average sum of winds." It is meant to capture both frequency and speed of cyclone events. It is measured in kilometers/year for the period 1970-2009. This study does not restrict the dataset to only land-based cyclones. As the map shows, cyclone incidence is primarily over oceans. The resolution of the cyclones data is approximately 2 km x 2 km.

Flood events are derived by UNEP/GRID-Europe by combining observed flood events from 1999 to 2007 (obtained from the Dartmouth Flood Observatory) and a GIS model using statistical estimation of peak-flow magnitude. It is scaled to represent the estimated number of events per 100 years. The resolution of the flood data is 1 km x 1 km.

Wildfire events are represented by data from UNEP/GRID-Europe reflecting the estimated number of wildfire events per year per pixel, or grid cell, from 1995-2011. The UNEP/GRID-Europe data is derived from the European Space Agency, which used the following algorithm to determine wildfires: http://due.esrin.esa.int/page_wfaalgo.php. The wildfires source dataset had a minimum of seven events. Thus, to represent the best-case scenario, i.e. no fires, this study adds a '0' raster to the dataset. This standardizes the outcomes of the normalization procedure (described further below). The resolution of

6 The resulting model is available as maps and raster layers in Joshua W. Busby, Todd G. Smith, Nisha Krishnan, and Charles Wight. 2016. *Subnational Climate Exposure Indicator Maps and Raster Layers*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law. The maps and analyses derived from them are also available in Ashley Moran, Joshua W. Busby, Clionadh Raleigh, Todd G. Smith, Roudabeh Kishi, Nisha Krishnan, and Charles Wight. 2018. *The Intersection of Global Fragility and Climate Risks*. Washington: USAID Office of Conflict Management and Mitigation.

7 Data are available at http://preview.grid.unep.ch/index.php?preview=data&lang=eng.

8 Data are available at www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html.

9 Data are available at http://viewfinderpanoramas.org/dem3.html.

the wildfire data is 1 km x 1 km. The fire events that appear over oceans and deserts are understood to be permanent hot spots such as gas flares.

The *rainfall anomalies* indicator is defined as the number of months between 1980-2013 in which the six-month accumulated rainfall was two standard deviations or more below the average for that calendar month over the previous 20 years. Using data from the Global Precipitation Climatology Centre, this study calculates whether a given six-month period deviated strongly from the 20-year average for the same six months. This creates a rolling 20-year average based on accumulated rainfall for the previous six months. The resolution of the rainfall anomalies data is 0.5 degrees (approximately 55 km x 55 km at the equator).

The *chronic aridity* indicator is based on the same data from the Global Precipitation Climatology Centre for the period of 1980-2013. It is the coefficient of variation based on monthly rainfall (the long-term standard deviation in rainfall divided by the long-term mean rainfall), which seeks to capture exposure risk in places that receive low rainfall overall punctuated only by a few high-rainfall events. In places that receive consistent rainfall throughout the year, the standard deviation is small and the mean is large, leading to a low coefficient of variation (CV). On the other hand, in places with long periods of very little rain punctuated by short periods of high rainfall, the standard deviation is large and the mean is small, leading to a high CV. In these places, small deviations in rainfall will generate large changes in the CV. This thus helps capture chronic aridity. The resolution of the chronic aridity data is 0.5 degrees.

The *low-elevation coastal zones* indicator is included to represent future risk from rising sea levels. This study uses a digital elevation model (DEM) from Viewfinder Panoramas to extract the 1-10 meter coastal zone for the world. The DEM resolution is 3 arc seconds (90 m).

TABLE 1: INDICATORS AND SOURCES USED TO ASSESS CLIMATE EXPOSURE

Hazard (weight)	Indicator	Scale	Years of Data Used	Source
Cyclones (20%)	Tropical cyclones average sum of winds (km per year)	2 km x 2 km resolution	1970-2009	UNEP/GRID-Europe
Flood events (20%)	Number of flood events for inland surface waters per 100 years	1 km x 1 km resolution	1999-2007	UNEP/GRID-Europe
Wildfire events (20%)	Number of wildfire events per year	1 km x 1 km resolution	1995-2011	UNEP/GRID-Europe
Rainfall anomalies (10%)	Number of months between 1980-2013 in which the 6-month accumulated rainfall was two standard deviations or more below average for that calendar month over the previous 20 years	0.5 degree	1980-2013	Global Precipitation Climatology Centre
Chronic aridity (10%)	Coefficient of variation based on monthly rainfall	0.5 degree	1980-2013	Global Precipitation Climatology Centre
Low-elevation coastal zones (20%)	Low-lying coastal areas within 0 to 10 km above sea level	90 m x 90 m resolution	2014	Viewfinders Panoramas

2.2 Total Climate Exposure

2.2.1 Normalizing the Data

Since all six indicators in this model were initially measured using different units and scales, this study first normalizes all indicators on a scale from 0 to 100, using percent rank.[10] Low scores approaching 0 represent minimal exposure, and high scores approaching 100 represent maximal exposure.

2.2.2 Accommodating Different Resolutions

Data for these six indicators are also of different spatial resolutions. While normalizing these layers, the raw data's resolutions are honored (e.g. the floods layer kept a resolution of 1 km x 1 km). However, when these datasets are combined, as described in the next section, this study imposes a uniform pixel size. The pixel size of the final exposure raster is 0.00416667 degrees x -0.00416667 degrees, or 15 arc seconds x 15 arc seconds, which is roughly 460 m x 460 m at the equator. This resolution maintains the underlying patterns of the data while providing processing efficiencies.

2.2.3 Calculating Total Exposure

Each indicator is weighted equally within the model, with the exception of the two rainfall-related indicators (rainfall anomalies and chronic aridity). Given that these two indicators are meant to capture different but related phenomena associated with rainfall and that future changes in rainfall patterns will likely result in changes to both phenomena, the model divided the weight between them. Thus, while cyclones, wildfires, floods, and low-elevation coastal zones each represent 20 percent of the total climate exposure, the remaining 20 percent of the total score is split equally between rainfall anomalies and chronic aridity. This value is calculated at the pixel level. The resulting calculation for total climate exposure is shown below.

Total Climate Exposure = [(0.2 x Floods) + (0.2 x Cyclones) + (0.2 x Wildfires) + (0.2 x Low-Elevation Coastal Zones) + (0.1 x Chronic Aridity) + (0.1 x Rainfall Anomalies)]

10 Percent ranks represent the dispersion between the minimum and maximum. Percent ranks show where a given value is in percentage terms between the minimum and maximum score as represented by the equation (max - value) / (max - min).

3.0 FRAGILITY

To help achieve this study's goal of identifying the intersection of fragility and climate risks globally, this study develops a new fragility measure. Developing a new measure specifically for this purpose provides a comprehensive fragility measure while avoiding use of existing fragility measures that include environmental indicators and thus should not be overlaid on climate hazards.

This study uses open-source data to create a measure of state fragility that is similar in composition and outcome to USAID's internal methods and framework for analyzing fragility.[11] Like USAID's internal measure, the new measure assesses fragility in state effectiveness and legitimacy in four key spheres: political, security, economic, and social. This is based on an understanding of fragility as being rooted in poor state capacity and poor state-society relationships, both of which can contribute to instability. Poor state capacity and state-society relationships can lead to and perpetuate other forms of overt instability, including conflict or an inability to address and mitigate stresses such as a changing environment, difficult global financial situations, or conflict in neighboring states.

This document outlines the indicators, data sources, and process used to assess countries' relative state capacity and state-society relationship on a global scale.[12]

3.1 Structure of Fragility Measure

This is a country-level measure in which overall fragility reflects an accumulation of scores on a range of effectiveness and legitimacy indicators. Effectiveness indicators assess the capacity of public-sector institutions and practices. Legitimacy indicators assess the degree of direct or indirect public support for government arrangements, officials, and practices. These two sets of indicators are subdivided into political, security, economic, and social indicators to capture state effectiveness and legitimacy in each of these four key spheres. The resulting eight clusters each include three indicators, as Table 2 shows. Based on the accumulation of scores across these 24 indicators, each state is given an overall fragility score and classified in one of five fragility categories: *low*, *some*, *moderate*, *high*, and *highest* fragility.

The fragility measure includes countries with populations over 500,000, as this is the population threshold for some of the underlying indicators used to create this fragility measure. This study compiles the raw data and resulting fragility measure for each year from 2000 to 2014 to allow comparison over time.

3.2 Indicators and Clusters

Table 2 summarizes the 24 indicators that compose this fragility measure.

11 See USAID. 2005. *Fragile States Strategy*. Washington: USAID; and ARD Consortium: ARD Inc., University of Maryland, and ISciences, L.L.C. 2005. *Measuring Fragility, Indicators and Methods for Rating State Performance*, Produced for USAID Bureau for Democracy, Conflict, and Humanitarian Assistance/Office of Conflict Management and Mitigation. Washington: USAID.

12 The complete dataset is available in Roudabeh Kishi and Andrew Linke. 2016. *Global Fragility Dataset*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law. The resulting maps are available in Roudabeh Kishi, Andrew Linke, Charles Wight, Ashley Moran, and Clionadh Raleigh. 2016. *National Fragility Indicator Maps*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law. The maps and analyses derived from them are also available in Ashley Moran, Joshua W. Busby, Clionadh Raleigh, Todd G. Smith, Roudabeh Kishi, Nisha Krishnan, and Charles Wight. 2018. *The Intersection of Global Fragility and Climate Risks*. Washington: USAID Office of Conflict Management and Mitigation.

TABLE 2: INDICATORS USED TO ASSESS STATE FRAGILITY

Type	Effectiveness	Legitimacy
Political	Quality of public service No. of successful coups d'état in last five years Government tax revenue as percent of GDP	Competitiveness of political participation Citizen participation in selecting government Asylum requests as percent of population
Security	Intensity of ongoing armed conflict Size of displaced population Proportion of country affected by conflict	State use of political terror Presence of militant groups against the state Number of rivaling military organizations
Economic	GDP per capita Poverty headcount ratio Primary commodity exports as percent of total	Control of corruption Rule of law and property rights protection Number of days to start a business
Social	Infant mortality rate Child immunization rates Percent of population with access to improved water source	Military expenditures as percent of GDP Percent of parliamentary seats held by women Life expectancy at birth

3.3 Methodology

3.3.1 Indicator Fragility Scores

A country's fragility score for each indicator is assessed relative to other countries, and it is a measure of where the country lies relative to the rest of the world. This study converts the raw data for each indicator into a fragility score for each indicator. It assigns fragility scores to each indicator as follows: Countries are divided into eight groups using quantiles (using the -xtile- command in Stata). The four groups with the lowest fragility values are categorized as *low* fragility, receiving a value of 0. The four groups with the higher fragility values are categorized as *some*, *moderate*, *high*, and *highest* fragility, receiving a value of 1 through 4, respectively. Because categories are defined by fragility scores, the number of countries in each group is not the same. Countries with the same indicator fragility score are not split into different indicator fragility categories.

3.3.2 Total Fragility Score

A country's *total fragility* score in a given year is the sum of the 24 fragility scores on the underlying indicators. Countries' *total fragility* scores are then assigned to the five *total fragility* categories as follows: Countries below the median are categorized as *low* fragility, receiving a value of 0. Countries above the median are divided into four categories defined as *some*, *moderate*, *high*, and *highest* fragility, receiving a value of 1 through 4, respectively. Because categories are defined by fragility scores, the number of countries in each group is not the same. Countries with the same *total fragility* score are not split into different *total fragility* categories.

In the year mapped, 2014, the observed *total fragility* scores range from 0-69. The *total fragility* categories are thus distributed across the full range of observed scores (0-69). This study uses observed rather than possible scores so that categories reflect the full range of fragility seen in the data.

3.3.3 Cluster Fragility Scores

To analyze patterns of fragility across key spheres (political, security, economic, and social) and state features (effectiveness and legitimacy), this study also sums indicators' fragility scores at the cluster level. Thus, in addition to the *total fragility* scores, the dataset and maps also include representations of fragility summed (i) for each of the eight clusters, labeled in the data and maps as *political effectiveness*, *political legitimacy*, *security effectiveness*, *security legitimacy*, *economic effectiveness*, *economic legitimacy*, *social effectiveness*, and *social legitimacy*, (ii) for all four effectiveness clusters, labeled in the data and maps as *total effectiveness*, and (iii) for all four legitimacy clusters, labeled in the data and maps as *total legitimacy*.

For each of the eight clusters, the maximum cluster fragility score that a country can receive is 12; this is the maximum possible sum of a cluster's three indicators, which are each valued individually from 0-4. In the year mapped, 2014, at least one of the eight clusters had the maximum possible score of 12. Each of the eight cluster maps thus uses a gradient distributed across the full range of 13 possible scores (0-12). This allows for comparability across the various clusters to assess which clusters are driving fragility in each country.

For *total effectiveness*, the maximum possible score is 48; this is the maximum possible sum of the four effectiveness clusters, which are each valued individually from 0-12. Likewise, for *total legitimacy*, the maximum possible score is 48; this is the maximum possible sum of the four legitimacy clusters, which are each valued individually from 0-12. In the year mapped, 2014, the observed *total effectiveness* and *total legitimacy* scores range from 0-34 and 0-38, respectively. The *total effectiveness* and *total legitimacy* maps thus use a gradient distributed across the full range of observed scores (0-38). This study maps observed rather than possible scores here for two reasons. First, this aligns with the approach taken in mapping *total fragility*, where this study converts *total fragility* scores to *total fragility* categories (0-5, or *low* to *highest*) based on the range of observed *total fragility* scores (0-69) rather than possible *total fragility* scores (0-96). Second, mapping the observed scores ensures the mapping process reflects the full range of fragility scores seen in the data. This study maps both *total effectiveness* and *total legitimacy* using the highest observed range seen across either of these measures because this allows comparability across these two requisite state features (effectiveness and legitimacy) to assess which feature is driving fragility in each country.

3.4 Indicator Sources and Rationale for Inclusion

The source and rationale for including each indicator is described below. This study's accompanying dataset includes detailed information about each indicator, including the variable name, variable description, indicator source, and indicator name in this study's dataset and in the original dataset. This study's dataset includes the raw data and resulting fragility measure for 2000 to 2014 to allow comparison over time.[13]

Where possible, this study defers to data sources previously used by USAID for maximum comparability to USAID's internal methods and framework for analyzing fragility.[14] In cases where data are missing in the main source, other sources are used to supplement missing information, and those supplemental sources are also noted below. If no other sources are available to supplement missing information for a given year, data are filled in using a moving average—i.e. using data for the indicator in the country for surrounding years.

13 See Roudabeh Kishi and Andrew Linke. 2016. *Global Fragility Dataset*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

14 See ARD Consortium: ARD Inc., University of Maryland, and ISciences, L.L.C. 2005. *Measuring Fragility, Indicators and Methods for Rating State Performance*, Produced for USAID Bureau for Democracy, Conflict, and Humanitarian Assistance/Office of Conflict Management and Mitigation. Washington: USAID

3.4.1 Political Indicators

Effectiveness

Indicator 1: Quality of public service

- *Source*: Kaufmann, Kraay, and Mastruzzi, World Governance Indicators
- *Description*: This indicator captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.
- *Rationale*: The quality of public service provision is a directly observable outcome of effective governance.

Indicator 2: Number of successful coups d'état in last five years

- *Source*: Marshall and Marshall, Center for Systemic Peace, Coups d'État Events Dataset
- *Description*: This indicator captures the number of successful coups d'état that occurred in the year of record and the previous four years.
- *Rationale*: Coups d'état represent an inability of the government to manage internal conflict over the allocation of political power; instead, the conflict escalates until the government itself is replaced by an opposing faction from within.

Indicator 3: Government revenues, as percentage of Gross Domestic Product (GDP)

- *Source:* World Bank, World Development Indicators; Supplemented with International Monetary Fund data and then unclassified CIA World Factbook data when missing
- *Description:* Tax revenue refers to compulsory transfers to the central government for public purposes. Certain compulsory transfers such as fines, penalties, and most social security contributions are excluded. Refunds and corrections of erroneously collected tax revenue are treated as negative revenue.
- *Rationale:* The ability of a government to fund itself through taxes and other forms of revenue is an indicator of the overall effectiveness of government institutions.

Legitimacy

Indicator 4: Competitiveness of political participation (absence or presence of factionalism)

- *Source:* Marshall, Gurr, and Jaggers, Polity IV Project, Political Regime Characteristics and Transitions Dataset
- *Description:* This indicator captures the extent to which alternative preferences for policy and leadership can be pursued in the political arena.
- *Rationale:* The presence of factional politics, rather than secular competitive politics with routine transfer of power to competing groups, is an observable outcome of weak political legitimacy.

Indicator 5: Citizen participation in selecting government

- *Source:* Kaufmann, Kray, and Mastruzzi, World Governance Indicators
- *Description:* This indicator captures perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as the degree of freedom of expression, freedom of association, and a free media.

- *Rationale:* Governments that are open to public participation in the political process and accountable to the public and independent media outlets build political legitimacy with their constituents.

Indicator 6: Asylum requests, as percentage of the population

- *Source:* World Bank, World Development Indicators
- *Description:* Refugees are people who are recognized as refugees under the 1951 Convention Relating to the Status of Refugees or its 1967 Protocol, or the 1969 Organization of African Unity Convention Governing the Specific Aspects of Refugee Problems in Africa; people recognized as refugees in accordance with the United Nations High Commissioner for Refugees (UNHCR) statute; people granted refugee-like humanitarian status; and people provided temporary protection. Asylum seekers—people who have applied for asylum or refugee status and who have not yet received a decision or who are registered as asylum seekers—are excluded. Palestinian refugees (and their descendants) are people whose residence was in Palestine between June 1946 and May 1948 and who lost their homes and means of livelihood as a result of the 1948 Arab-Israeli conflict. Country of origin generally refers to the nationality or country of citizenship of a claimant. Data originally from UNHCR Statistical Yearbook and data files, complemented by statistics on Palestinian refugees under the mandate of the United Nations Relief and Works Agency for Palestine Refugees in the Near East, as published on its website.
- *Rationale:* Applications for political asylum represent people who express a loss of faith in the political legitimacy of their home government by taking diplomatic steps to leave the country.

3.4.2 Security Indicators

Effectiveness

Indicator 7: Intensity of ongoing armed conflict

- *Source:* Center for Systemic Peace, Major Episodes of Political Violence Dataset
- *Description:* This indicator reflects the magnitude score of episode(s) of civil violence involving that state in that year. The scale is from 1 (lowest) to 10 (highest) for each major episode of political violence (MEPV). Magnitude scores for multiple MEPVs are summed. Zero denotes no episodes.
- *Rationale:* States that fail to keep their population safe from armed conflict can be considered to be fragile or failing, depending on the magnitude of the conflict.

Indicator 8: Size of displaced population

- *Source:* U.S. Committee for Refugees and Immigrants, Forcibly Displaced Populations Dataset
- *Description:* The indicator reflects the sum of the *source* variable and *Internally Displaced Persons* variable. The *source* variable is the number of refugees (x1000) originating in the named country at the end of the designated year for years between 1964 and 2008. The *Internally Displaced Persons* variable is the number of internally displaced persons (x1000) in the named country at the end of the designated year for years between 1964 and 2008. These data are multiplied by 1000 to result in "actual" numbers for consistency with data from the Internal Displacement Monitoring Centre.
- *Rationale:* States with large displaced populations are failing to provide sufficient human security to their populations.

Indicator 9: Proportion of country affected by conflict

- *Source:* Political Instability Task Force, State Failure Problem Set

- *Description:* This indicator measures how much of the country is directly or indirectly affected by ethnic or revolutionary fighting or political protest in a given year. A province, region, or city is "directly affected" if fighting/terrorist attacks/political protest occur there at any time during the year; it is "indirectly affected" if the area has significant spillover effects from nearby fighting, for example refugee flows, curtailment of public services, or imposition of martial law. If open conflict expands or contracts during the course of the year, it is coded according to its greatest extent.
- *Rationale:* The inability of the state to exert a monopoly on the use of force over all of its territory is a strong indicator of poor security effectiveness. The proportion of a country's area affected by fighting associated with ethnic or revolutionary wars represents territory that is outside the effective control of the state. It should be noted, however, that there may be other areas outside the effective control of the state where there are no ongoing ethnic or revolutionary wars, which would not be captured by this indicator.

Legitimacy

Indicator 10: State use of political terror

- *Source:* Gibney et al., Political Terror Scale
- *Description:* This indicator measures the level of political violence and terror that a country experiences in a particular year based on a 5-level "terror scale" originally developed by Freedom House. The data used in compiling this index come from three different sources: the yearly country reports of Amnesty International, the U.S. State Department Country Reports on Human Rights Practices, and Human Rights Watch's World Reports.
- *Rationale:* State-sponsored political terror, by definition, targets groups opposed to the state with various forms of violent coercion. This portion of the fragility measure is particularly focused on coercion directed at personal security, as opposed to economic, social, or political forms of force.

Indicator 11: Presence of militant groups against the state

- *Source:* Compilation of armed datasets and consultations with conflict experts
- *Description:* This indicator is a dummy measure of the existence of significant organized violence against the regime or security services.
- *Rationale:* The existence of such groups is a clear sign that groups are seeking alternate means outside the state for the provision of security.

Indicator 12: Effective number of ground-combat compatible military organizations (counterbalancing measure)

- *Source:* Pilster and Böhmelt, Coup-Proofing (2012)
- *Description:* "[Data] incorporate information on both the number of rivaling military organizations and their respective strengths to capture the degree to which a state divides its military manpower into rivaling organizations." This measure identifies all ground-combat compatible military organizations in each country, including both regular forces (e.g., regular and active army and marine corps troops), as well as paramilitary organizations. The index calculates the degree to which a country engages in counterbalancing in a given year, as a result of the effective number of ground-combat compatible military organizations in the country. Higher levels of counterbalancing denote an increased threat of violence or overthrowing from internal opposition.
- *Rationale:* A state experiencing a heightened threat of overthrow from within its own military reflects a loss of legitimacy within its own state forces. State regimes that feel the need to excessively counterbalance in order to thwart this threat have poor security legitimacy.

3.4.3 Economic Indicators

Effectiveness

Indicator 13: GDP per capita (PPP, current US$)

- *Source:* World Bank, World Development Indicators
- *Description:* GDP per capita based on purchasing power parity (PPP) is GDP divided by midyear population. GDP 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. This GDP value divided by the population of a country accounts for the per capita effect of GDP. Data are in current U.S. dollars.
- *Rationale:* GDP per capita is the most widely accepted measure of economic development.

Indicator 14: Poverty headcount ratio at $1.90 a day (2011 PPP) (percent of population)

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator captures the percentage of the population living on less than $1.90 a day at 2011 international prices. As a result of revisions in PPP exchange rates, poverty rates for individual countries cannot be compared with poverty rates reported in earlier editions.
- *Rationale:* Economic effectiveness should also be measured by the ability of the national government to keep people out of poverty.

Indicator 15: Primary commodity exports, as percentage of total

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator captures the sum of agricultural raw materials exports (as percent of merchandise exports), ores and metals (as percent of merchandise exports), and fuel exports (as percent of merchandise exports).
- *Rationale:* Countries that are highly dependent on primary commodity exports have less well-developed economies than those that export value-added goods and services.

Legitimacy

Indicator 16: Control of corruption

- *Source:* Kaufmann, Kray, and Mastruzzi, World Governance Indicators
- *Description:* This indicator captures perceptions of the extent to which there is control of public power being exercised for private gain—including both petty and grand forms of corruption—and control of "capture" of the state by elites and private interests.
- *Rationale:* As the dataset authors note, "[t]he presence of corruption is often a manifestation of a lack of respect of both the corrupter (typically a private citizen or firm) and the corrupted (typically a public official or politician) for the rules which govern their interactions, and hence represents a failure of governance according to our definition." A lack of respect for economic rules in a country can be understood as a deficit in a state's economic legitimacy.

Indicator 17: Rule of law and property rights protection

- *Source:* Miller, Holmes, and Kim, Index of Economic Freedom

- *Description:* The index covers 10 freedoms—from property rights to entrepreneurship—in 186 countries. The economic freedom measure is based on 10 quantitative and qualitative factors, grouped into four broad categories, or pillars, of economic freedom: (1) Rule of Law (property rights, freedom from corruption); (2) Limited Government (fiscal freedom, government spending); (3) Regulatory Efficiency (business freedom, labor freedom, monetary freedom); and (4) Open Markets (trade freedom, investment freedom, financial freedom). Each of the ten economic freedoms within these categories is graded on a scale of 0 to 100. A country's overall score is derived by averaging these ten economic freedoms, with equal weight given to each.
- *Rationale:* As the authors note, "[t]he ability to accumulate private property is the main motivating force in a market economy, and the rule of law is vital to a fully-functioning, free market economy. Secure property rights give citizens the confidence to undertake commercial activities, save their income, and make long-term plans because they know that their income and savings are safe from expropriation." The degree to which citizens are able to exercise economic freedoms can be understood as a key indicator of a state's economic legitimacy.

Indicator 18: Number of days to start a business

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator captures the number of calendar days needed to complete the procedures to legally operate a business; if a procedure can be sped up at additional cost, the fastest procedure, independent of cost, is chosen.
- *Rationale:* The more difficult it is to start a business, the more likely people will opt out of the formal economy and operate within the informal economy. This can be understood as an indication of the legitimacy of the formal economic sector.

3.4.4 Social Indicators

Effectiveness

Indicator 19: Infant mortality rate

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator reflects the number of infants dying before reaching one year of age, per 1,000 live births in a given year.
- *Rationale:* Infant mortality is an indicator of the state's ability to provide a broad range of social services, including adequate healthcare, environmental quality, food, housing, and education.

Indicator 20: Child immunization rates

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator reflects the percentage of children ages 12-23 months who received the diphtheria, pertussis, and tetanus vaccination and measles vaccination before 12 months or at any time before the survey. The variable uses the minimum of the two values between the percentage of children ages 12-23 months immunized for diphtheria, pertussis, and tetanus and the percentage of children ages 12-23 months immunized for measles.
- *Rationale:* Immunization programs represent a complex form of socio-technical infrastructure that requires coordination among many elements of society. Immunization programs must be recreated each year and, therefore, changes in the ability of government and society to deliver such services tend to be reflected in year-to-year changes.

Indicator 21: Percentage of population with access to improved water source

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator is the percentage of the population using an improved drinking water source. The improved drinking water source includes piped water on premises (piped household water connection located inside the user's dwelling, plot or yard) and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection). Data come from the World Health Organization/United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation.
- *Rationale:* A state that does not provide its population with access to improved water and sanitation is failing to meet one of its basic obligations to its populace.

Legitimacy

Indicator 22: Military expenditures, as percentage of GDP

- *Source:* World Bank, World Development Indicators
- *Description:* Military expenditures data originally reported by the World Bank's World Development Indicators come from the Stockholm International Peace Research Institute. They are derived from the North Atlantic Treaty Organization definition, which includes all current and capital expenditures on the armed forces, including peacekeeping forces, defense ministries and other government agencies engaged in defense projects, paramilitary forces if these are judged to be trained and equipped for military operations, and military space activities. Such expenditures include military and civil personnel, including retirement pensions of military personnel and social services for personnel; operation and maintenance; procurement; military research and development; and military aid (in the military expenditures of the donor country). Excluded are civil defense and current expenditures for previous military activities, such as for veterans' benefits, demobilization, conversion, and destruction of weapons. This definition cannot be applied for all countries, however, since that would require much more detailed information than is available about what is included in military budgets and off-budget military expenditure items. For example, military budgets might or might not cover civil defense, reserves and auxiliary forces, police and paramilitary forces, dual-purpose forces such as military and civilian police, military grants in kind, or pensions for military personnel.
- *Rationale:* Countries that use a high proportion of their GDP to support their military effectively "starve" the broader population of social services in favor of the military.

Indicator 23: Proportion of seats held by women in national parliament

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator reflects the percentage of parliamentary seats in a single or lower chamber held by women.
- *Rationale:* Women holding positions of power within a state speaks to the gender equality in the country. Low gender equality indicates poor social legitimacy.

Indicator 24: Life expectancy at birth, total

- *Source:* World Bank, World Development Indicators
- *Description:* This indicator reflects the average of male and female life expectancy in years, which indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.
- *Rationale:* Life expectancy rates provide an overall indication of the degree to which the government is focused on meeting the most basic health, housing, and food needs of its populace.

4.0 COMPOUND FRAGILITY-CLIMATE RISKS

This project captures the intersection of fragility and climate risks in three ways. All assess this intersection using the *total climate exposure* and *total fragility* measures described above.

4.1 Fragility-Climate Bivariate Map

The first mechanism of compound risk assessment—a bivariate map—integrates the fragility and climate data before they are mapped to show the intersection of fragility and climate risks at the first administrative division level for all countries for which data are available. This approach allows comparison of countries across all fragility categories on a single map. However, it loses some granularity in the subnational climate exposure data, which must be aggregated to the first administrative division to be cross-tabulated with the fragility data.

The bivariate map uses the *total climate exposure* data and *total fragility* data. It is created using the first administrative division polygon files from the Global Administrative Areas database version 2.8.

In this map, each country's national-level fragility category is applied to all administrative divisions in the country. The bivariate map thus retains the five fragility categories seen in the total fragility measure, classifying areas as having *low*, *some*, *moderate*, *high*, or *highest* fragility.

The climate exposure category is based on a k-median clustering algorithm. The median climate exposure score for each administrative division is determined with spatial analysis in ArcGIS. These median scores are then clustered into five categories of low to high exposure using the k-median algorithm contained in Stata.[15]

The cross-tabulation of the five fragility categories and the five climate exposure categories are represented on the final bivariate map.

4.2 Fragility-Climate Overlay Maps

The second mechanism of compound risk assessment—a series of fragility and climate overlay maps—provides an alternative way to see the intersection of fragility and climate risks while maintaining the highest level of granularity possible in the subnational climate exposure data.

The fragility-climate overlays use the *total climate exposure* data and *total fragility* data. The maps use *total climate exposure* as the base layer and add a semi-transparent layer over all countries except those in one fragility category. This allows viewers to see the detailed subnational climate exposure patterns in states in a particular fragility category. This series of fragility and climate overlays thus includes five maps, showing climate exposure risks in countries with *low*, *some*, *moderate*, *high*, and *highest* fragility.

These maps are snapshots of the intersection of two slow-moving risks, both of which use the most updated data possible at the time of their release. The climate exposure component reflects places that have chronic exposure to climate-related hazards, and this is overlaid with a measure of fragile states taken in 2014, which was the most recent year available for some of the underlying indicators in the fragility measure.

15 The calculations and data used to create this bivariate map are available in Todd G. Smith, Charles Wight, Nisha Krishnan, Roudabeh Kishi, Andrew Linke, Joshua W. Busby, Ashley Moran, and Clionadh Raleigh. 2016. *Climate and Fragility Bivariate Map Data*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

4.3 Population- and Territory-Based Metrics

The third mechanism of compound risk assessment—population- and territory-based metrics of climate exposure in fragile states—examines what portions of a country's population and territory are located in areas of high climate exposure. The analysis is conducted at the pixel level in ArcGIS,[16] producing statistics that can be compared across countries. In this way, it is possible to examine which highly fragile states also have large portions of their population or territory in areas of high climate exposure.

To produce the population-based metrics, this study calculates the mean climate exposure for the world and then identifies the total population and percent of a country's population living in locations that are one, two, three, and four standard deviations above the mean climate exposure.[17] This study uses LandScan 2013 population data to make these calculations. This study defines *high* exposure areas as those that are one standard deviation or more above the global mean exposure, and *very high* exposure areas as those that are four standard deviations or more above the global mean exposure.

To produce the territory-based metrics, this study calculates the number of pixels in each country that are four standard deviations or more above the mean exposure value for the world. It also compares this to the total number of pixels in the country. This generates a value for the total number of pixels in *very high* exposure areas and the percent of each country's pixels that face *very high* exposure.[18]

16 A pixel is the smallest unit of information in an image. The smaller the pixel size, the more fine-grained the resolution of the overall image. The pixel size of the climate exposure raster is 0.00416667 degrees x -0.00416667 degrees, or 15 arc seconds x 15 arc seconds, which is roughly 460 meters x 460 meters at the equator. See Section 1.0 of this methodology document for a complete description of the process used to calculate overall climate exposure and define the pixel size.

17 The complete set of calculations is available in Todd G. Smith, Nisha Krishnan, and Joshua W. Busby. 2016. *Population-Based Metrics of Subnational Climate Exposure*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

18 The complete set of calculations is available in Nisha Krishnan, Joshua W. Busby, and Todd G. Smith. 2016. *Territory-Based Metrics of Subnational Climate Exposure*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

5.0 RESOURCES AVAILABLE FROM THIS STUDY

5.1 Reports

Ashley Moran, Joshua W. Busby, Clionadh Raleigh, Todd G. Smith, Roudabeh Kishi, Nisha Krishnan, and Charles Wight. 2018. *The Intersection of Global Fragility and Climate Risks*. Washington: U.S. Agency for International Development (USAID), Office of Conflict Management and Mitigation.

Ashley Moran, Clionadh Raleigh, Joshua W. Busby, Charles Wight, and Nisha Krishnan. 2018. *Fragility and Climate Risks in Bangladesh*. Washington: USAID Office of Conflict Management and Mitigation.

Ashley Moran, Clionadh Raleigh, Joshua W. Busby, and Charles Wight. 2018. *Fragility and Climate Risks in Colombia*. Washington: USAID Office of Conflict Management and Mitigation.

Ashley Moran, Clionadh Raleigh, Joshua W. Busby, and Charles Wight. 2018. *Fragility and Climate Risks in Nigeria*. Washington: USAID Office of Conflict Management and Mitigation.

5.2 Data and Maps

Joshua W. Busby, Todd G. Smith, Nisha Krishnan, and Charles Wight. 2016. *Subnational Climate Exposure Indicator Maps and Raster Layers*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

Todd G. Smith, Nisha Krishnan, and Joshua W. Busby. 2016. *Population-Based Metrics of Subnational Climate Exposure*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

Nisha Krishnan, Joshua W. Busby, and Todd G. Smith. 2016. *Territory-Based Metrics of Subnational Climate Exposure*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

Roudabeh Kishi and Andrew Linke. 2016. *Global Fragility Dataset*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

Roudabeh Kishi, Andrew Linke, Charles Wight, Ashley Moran, and Clionadh Raleigh. 2016. *National Fragility Indicator Maps*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

Todd G. Smith, Charles Wight, Nisha Krishnan, Roudabeh Kishi, Andrew Linke, Joshua W. Busby, Ashley Moran, and Clionadh Raleigh. 2016. *Climate and Fragility Bivariate Map Data*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.