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THE INTERSECTION OF GLOBAL FRAGILITY AND CLIMATE RISKS

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THE INTERSECTION OF GLOBAL FRAGILITY AND CLIMATE RISKS

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ACRONYMS

ACLED	Armed Conflict Location and Event Data
CCAPS	Climate Change and African Political Stability
CEPSA	Complex Emergencies and Political Stability in Asia
CIA	Central Intelligence Agency
CV	Coefficient of Variation
DEM	Digital Elevation Model
DRC	Democratic Republic of the Congo
FACTRS	Fragility and Conflict Technical and Research Services
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
MEPV	Major Episode of Political Violence
MENA	Middle East and North Africa
PPP	Purchasing Power Parity
UNEP/GRID	United Nations Environment Programme Global Resource Information Database
UNHCR	United Nations High Commissioner for Refugees
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

Project Summary

States with high exposure to climate hazards face multi-faceted challenges, including physical and livelihood risks for the population that may 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.

This study examines highly fragile states with 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.

This study has produced several novel analytical products. 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 and proportion of people 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.

Methods

The climate exposure measure developed for this study identifies places that are most likely to be vulnerable to a combination of climate hazards. It assesses climate hazard exposure using historical data on six key hazards: cyclones, floods, wildfires, rainfall anomalies, chronic aridity, and low-elevation coastal zones susceptible to storm surges and future sea-level rise. The measure thus provides information on the specific hazards that locations face, as well as their accumulated exposure to the six hazards considered here. This subnational measure identifies places that have faced chronic exposure to these climate hazards in the recent past, using the most up-to-date sources for which globally comprehensive data are available. With the exception of the coastal zones indicator, the indicators used in this study do not speak to projected future climate changes, but rather vulnerability to current climate hazards. Future climate exposure patterns may be different, but as a proxy for climate exposure in the near to medium term, this measure is instructive. Though climate exposure patterns change slowly, this measure of climate exposure should be updated periodically using new data as they are released. This measure does not capture all aspects of exposure for some very small island nations like the Maldives, which have exposure areas smaller than the pixel size captured by some indicators used in this study.

The fragility measure developed for this study 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. The measure developed here is similar in composition and outcome to USAID's internal methods and framework for analyzing fragility.[1] Like USAID's internal measure, this study's measure assesses fragility in state effectiveness and legitimacy in four key spheres: political, security, economic, and social. It 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. Based on the accumulation of these scores, 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.

This project captures the intersection of fragility and climate risks in three ways. The first mechanism—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 allows comparison of countries across all fragility categories on a single map, but it loses some granularity in the subnational climate exposure data that must be aggregated to the first administrative level. The second mechanism—a series of fragility and climate overlays—maintains the highest level of granularity possible in the subnational climate exposure data; these maps use climate exposure as the base layer and add a semi-transparent layer over all countries except those in one fragility category, allowing viewers to see the detailed subnational climate exposure patterns in states in a particular fragility category. The third mechanism—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 in ArcGIS, producing statistics that can be compared across countries.

"Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; as noted, this includes only countries with populations over 500,000. "High" climate exposure areas are those that are one standard deviation or more above the global mean exposure. "Very high" exposure areas are those four standard deviations or more above the global mean exposure.

Findings

Fragile States with High Climate Risks

A majority of highly fragile states—26 of the 39 states with the *highest* or *high* fragility—have a large number of people or large proportion of the population facing high climate risks. States with more than 1 million people living in *high* exposure areas are mostly located in sub-Saharan Africa, followed by the Middle East and North Africa (MENA) and South and Southeast Asia. India stands out with more than 118 million people in *high* exposure areas, followed by Nigeria with 41 million, Egypt with 33 million, Democratic Republic of the Congo (DRC) with 19 million, and Burma with 15 million.

Eight highly fragile states have more than 25 percent of their populations living in *high* exposure areas, and 13 more have at least 10 percent of their populations living in *high* exposure areas. Sierra Leone stands

1 See USAID 2005 and ARD Consortium 2005.

out with 100 percent of its population living in *high* exposure areas, followed by Guinea with 64 percent, Cambodia with 45 percent, and Cameroon and Egypt with 39 percent each.

Nine of these highly fragile states have more than 1 million people facing not just *high* but *very high* climate exposure. These states with large numbers of people facing *very high* exposure are primarily located in South and Southeast Asia and in the MENA region. India stands out with more than 44 million people living in *very high* exposure areas, followed by Egypt with 13.7 million and Burma with 8 million. Three of these states—Cambodia, Egypt, and Burma—have not only a large *number* of people in *very high* exposure areas but also a large *percentage* of the population living in these areas: Cambodia with 20 percent, Egypt with 16 percent, and Burma with 15 percent.

Several highly fragile states have extensive land areas at risk. Highly fragile states with large land areas facing high exposure are located predominantly in sub-Saharan Africa, with the remainder in Asia and North Africa and one in Latin America. Four of these states—Burma, Cambodia, Guinea-Bissau, and Sierra Leone—have sizable portions of territory facing not just *high* but *very high* climate exposure.

State legitimacy is poor across nearly all states with high compound fragility-climate risks. Poor state legitimacy contributes more to the overall fragility of these states, on average, than poor state effectiveness does. Improving state legitimacy will thus be key to increasing stability and reinforcing government-led efforts to address climate risks.

Multiple climate stressors often affect the same populations and locations in highly fragile states. Populations in high exposure areas often face not just a single type of climate stressor but *several* overlapping climate stressors in that location—from riverine flooding and coastal inundation to droughts and wildfires. This can heighten overall vulnerability and can also place repeated stress on a range of institutions and social and economic systems.

Single climate hazards are just as damaging as multiple hazards in a few highly fragile states. While this study seeks to identify highly fragile states with high exposure to *multiple* climate hazards, it must also note the few highly fragile states that face high exposure to a *single* climate hazard to a degree that risks exceeding the state's capacity to address it. These states include Mali, Niger, Republic of the Congo, and Yemen.

Compound fragility-climate risks can heighten insecurity, but conflict is context specific. Even in states with similarly high compound fragility-climate risks and similar rates of violence, conflict differs greatly. This can be seen in the Sahel, where Ethiopia hosts long-standing rebel conflict and experiences new pressures related to representation and land planning; Sudan hosts anti-state conflict and elite conflict; Chad hosts "overflow" conflict from neighboring states; and Mali experiences accumulated challenges from Islamist, secessionist, elite, and civil society contentions. This underscores that the politics that give rise to competition in one region are unlikely to be the same as those in another region.

Some states with high compound fragility-climate risks—such as India—experience higher rates of "social" or "civic" conflict, such as riots and protests in areas where the reach of the state is sufficient to address challenges. A high rate of these types of conflict can suggest that the basis for positive state-society relationships is present, but the mechanisms for communication and reform require further support.

Several states with high compound fragility-climate risks—DRC, Nigeria, Pakistan, and Sudan—host multiple, long-term conflicts. These patterns of very high, sustained violence indicate that state institutions from the national to the local level are continually pressured and challenged. The state's inability to reduce the violence suggests that national institutions are presently too weak to address key political, economic, and social drivers of conflict.

Fragility is an important dimension in understanding the indirect pathways between climate risks and potential conflict outcomes. The research team does not seek to establish a causal relationship between climate exposure and instability. In the broader literature, evidence suggesting that conflict occurs as a direct result of climate-related or climate-sensitive factors is contested, with scholars increasingly studying the indirect pathways between climate hazards and conflict outcomes through factors like economic growth, food prices, and migration. Considering state fragility in this analysis is key, as a government's ability to manage these economic and social processes can impact whether a population becomes more or less vulnerable to the climate risks it faces. Conversely, considering state fragility can also enhance our ability to identify where resilience efforts can have co-benefits for climate, environment, and conflict prevention goals.

Opportunities for Action

Addressing climate risks in fragile states could yield win-win opportunities for enhancing resilience and reducing fragility. Poor state legitimacy—reflecting public perceptions that the state is unwilling or unable to meet public needs—contributes more to the fragility of states, on average, than poor state effectiveness does, and this trend is even more pronounced in states with high compound risks. State actions that respond to public needs for reducing climate vulnerabilities could simultaneously reduce both climate risks and the legitimacy deficits that often contribute most heavily to fragility in these states.

Investing in states that have high state effectiveness increases the likelihood of development funds being used to reduce both fragility and climate-related vulnerability. Many (but not all) states with high compound risks have improved their state *effectiveness* scores over the last 15 years, even while enduring poor or worsening state *legitimacy* scores. These states have thus been steadily building state capacity and, with it, an increasing chance of being able to effectively implement state policies in the spheres where that capacity has grown.

In states affected by sustained conflict, investment in institutional changes is a critical component of mitigating overall state weakness and therefore of strengthening the ability to respond to climate risks. Several states with high compound fragility-climate risks are also embroiled in multiple long-term conflicts that both reflect and contribute to deep weaknesses in state capacity. This is an important consideration in assessing the capacity of the state to respond to fragility and climate risks. The existence of sustained conflict signals the inability of the state to control its territory or advance reforms to address the political, economic, and social issues that lead to violence. These states are thus less likely than others to have the capacity needed to implement policies to address either fragility or climate risks in a robust or sustained way without institutional changes.

Efforts to forestall the *emergence* of high compound fragility-climate risks in the future could focus on shoring up the capacity of states that today have *moderate* fragility and *very high* climate risks. If fragility worsens in these states, large numbers of people could become more vulnerable to the very high exposure risks they face.

Interventions to Reduce and Prevent Compound Risks

Understanding where fragility and climate exposure overlap and interact can help to identify interventions to reduce compound risks. Among states with high compound risks, three groups stand out as having extensive but distinct exposure challenges, presenting different opportunities and focal points for intervention. While the key findings of this research focus on highly fragile states, opportunities exist to catalyze change in countries across the fragility spectrum.

Group 1: Act Now and Leverage Finance. These highly fragile states have more than 1 million people, more than 10 percent of the population, and a sizable portion of territory facing *high* or *very high* exposure.

Climate hazards thus place extreme stress on these states in terms of the population and land area exposed, with exposure risks dispersed over a sizable portion of the territory, which could narrow livelihood choices and create broad additional requirements for the state. Addressing such exposure risks is likely to require significant investment. However, the large *numbers* of people affected could draw international involvement, and the large *portion* of the population affected could draw domestic political will to respond to public needs, creating a potential for alignment of international and domestic priorities and opportunities to leverage important sources of finance. This group includes Angola, Burma, Cambodia, Cameroon, Chad, DRC, Egypt, Guinea, Iraq, Libya, Nigeria, Sierra Leone, South Sudan, Sudan, and Uganda.

Group 2: Identify Targeted and Prioritized Investments. These highly fragile states have either a large number of people or a large portion of the population facing *very high* exposure, concentrated in small portions of the state. The concentrated nature of this *very high* population exposure could be an opportunity for targeted interventions that address the specific climate risks affecting a large population in a very small area. It should be noted, however, that many states in this group also face compound fragility-climate risks in less densely populated parts of the state; interventions in these states should thus also consider population risks in areas where state fragility dynamics impede effective responses to high climate exposure across the state. This group includes Colombia, Egypt, India, Iran, Iraq, Libya, Mauritania, Nigeria, and Pakistan.

Group 3: Monitor Early and Avoid Escalation. Moderately fragile states like Bangladesh, China, Ecuador, the Philippines, Russia, and Venezuela have large numbers of people and/or large proportions of their populations facing *very high* climate exposure risks. Climate hazards can thus place extreme stress on states that are already coping with other substantial stressors that have placed them in the *moderate* fragility category. If fragility worsens, and these states are not able to address their climate risks effectively, large numbers of people could become even more vulnerable to the very high climate risks they face.

Conclusion

Compound fragility-climate risks can heighten the insecurity of populations by increasing their vulnerability to humanitarian emergencies and instability. During humanitarian emergencies, compound fragility-climate risks can pose a direct risk to survival if exposure to climate hazards escalates into a disaster due to a fragile state's insufficient capacity or willingness to respond to the needs of its populace. Within this context of overlapping risks, it is critical to note that future instability may be characterized less by large-scale battles between organized groups and more by increasing disorder that is low-level, persistent, and diffuse, perpetuated by agents ranging from the local to the international.

Understanding how compound fragility-climate risks can contribute to future instability thus requires determining the links between local groups, their operations, and their relationships to larger national or international groups; determining the goals and constraints of these groups and how these tie into the local landscape of instability; and, lastly, determining the likelihood that social improvements will reduce the resilience of extreme ideologies and the recourse to violent conflict. In the near term, analysts should expect more instability due to the increasing number of political transitions and challenges to power as well as those likely to happen in the future. The risks of instability in particular states are embedded in forms of governance and existing political competition locally, nationally, and regionally—all of which can be affected by the kinds of strains that climate stress and fragility can place on people and their governments. This study seeks to identify key global fragility and climate patterns and country-specific risks to inform assessments of how these dynamics coalesce to foster instability, strain state capacity, and undermine human security. It is hoped that the measures and metrics developed here provide new tools for assessing the intersection of fragility and climate risks and for identifying states' distinct fragility and climate patterns that present opportunities and focal points for intervention.

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,[2] individual climate hazard risks at the global level,[3] and composite climate risks at the regional level.[4] 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.[5]

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. 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.

2 See for example Marshall and Elzinga-Marshall 2016 and Messner et al. 2016.
3 See for example UNEP/GRID-Geneva.
4 See for example Busby et al. 2013.
5 Rüttinger et al. 2015.

2.0 METHODS

2.1 Climate Exposure Measure

The climate exposure measure developed for this study seeks to identify places that are most likely to be vulnerable to a combination of climate hazards.[6] It assesses climate hazard exposure using historical data on six key hazards shown in Table 1: cyclones, flood events, wildfire events, rainfall anomalies, chronic aridity, and low-elevation coastal zones susceptible to storm surges and future sea-level rise. These hazards are then aggregated in a single composite measure. This requires that the data be normalized on the same scale, assigned a weight, and then combined. Each indicator is normalized in terms of the distribution of its values relative to all values on that indicator worldwide. The indicators are then equally weighted (though the weight of the rainfall indicator is split between the two rainfall hazards) and added together.[7] This climate exposure measure thus provides information on the specific hazards that locations face, as well as their accumulated exposure to the six hazards considered here.

TABLE 1: INDICATORS USED TO ASSESS CLIMATE EXPOSURE

Hazard (weight)	Indicator	Scale	Data Years
Cyclones (20%)	Tropical cyclones average sum of winds (km per year)	2 km x 2 km resolution	1970-2009
Flood events (20%)	Number of flood events for inland surface waters per 100 years	1 km x 1 km resolution	1999-2007
Wildfire events (20%)	Number of wildfire events per year	1 km x 1 km resolution	1995-2011
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
Chronic aridity (10%)	Coefficient of variation based on monthly rainfall	0.5 degree	1980-2013
Low-elevation coastal zones (20%)	Low-lying coastal areas within 0 to 10 km above sea level	90 m x 90 m resolution	2014

This subnational measure of exposure identifies places that have faced chronic exposure to climate hazards in the recent past, using data for the most recent and broadest set of years available. Preference was placed on data that had the finest spatial resolution and most recent data with global coverage. With the exception of the coastal zones indicator, the indicators used in this study do not speak to projected future climate changes, but rather vulnerability to current climate hazards. Future climate exposure patterns may be different, but as a proxy for climate exposure in the near to medium term, this measure is instructive. Though climate exposure patterns change slowly, this measure of climate exposure should be updated periodically using new data as they are released.

6 The global climate exposure measure developed for this study for USAID is based on similar regional measures developed by Joshua W. Busby, Todd G. Smith, Nisha Krishnan, and Charles Wight for the Robert Strauss Center for International Security and Law's U.S. Defense Department-funded programs on Climate Change and African Political Stability (CCAPS) and Complex Emergencies and Political Stability in Asia (CEPSA).
7 See Appendix A for a complete list of data sources, the rationale for including each indicator, the process for mapping individual climate hazards, and the process for calculating total climate exposure.

This measure does not include the full spectrum of climate hazards. For example, while it includes wildfires, it does not yet include a measure of heat wave events.[8] Moreover, climate hazards may intersect with other environmental phenomena such as land degradation.[9] Therefore, this measure should be understood as a combination of the best available global data at the time of this study and also as an invitation for further research and for combination with other data sources.[10]

This study uses the climate exposure measure and underlying indicators to produce a series of maps depicting subnational patterns of climate exposure worldwide. To assess the degree of climate exposure in statistical terms, this study also calculates the mean climate exposure for the world and then identifies each country's total population, percent of population, and extent of territory in areas that are one, two, three, and four standard deviations above the mean climate exposure.[11] This is helpful in identifying which parts of a country's territory and population are located in areas that are far above—or very far above—this global mean exposure. For example, the majority of people globally (60 percent) live below the global mean climate exposure. Another 26 percent live within one standard deviation above the mean. Only 14 percent of the world's population lives in areas that are one standard deviation or more above the global mean. Further, only 6 percent of these people live in areas that are four standard deviations or more above the global mean. This study uses these metrics to define *high* climate exposure areas as those that are one standard deviation or more above the global mean exposure. This study defines *very high* exposure areas as those that are four standard deviations or more above the global mean exposure.

It is important to note that methodologies for aggregating and analyzing spatial data, including the methodologies used in this study, can sometimes obscure the reality of phenomena that have variation smaller than the pixel size used in the study. In the case of this study, some very small islands lack data for certain indicators—particularly those for chronic aridity and rainfall anomalies—which are aggregated to 0.5-degree grid squares (approximately 55 km by 55 km at the equator). This is the case, for example, for the Maldives, which consist of almost 1,200 small coral islands. For very small island nations like the Maldives, this study's measure captures some aspects of exposure—such as low-elevation coastlines since that indicator has sufficiently fine-grained data—but it may not capture other aspects of exposure—such as chronic aridity and rainfall anomalies since these islands' exposure areas are smaller than the pixel size captured by these indicators. This underscores that it is important to consider the particular circumstances of unique locations rather than relying solely on the maps to indicate exposure.

2.2 Fragility Measure

To assess the intersection of fragility and climate risks globally, this study produces a new fragility measure.[12] Producing a 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's measure is similar in composition and outcome to USAID's

8 The authors have recently acquired new heat wave data from Robert Kopp at Rutgers University but have yet to fully process it in a way that was possible for application to this project. This could be a valuable addition to future iterations of global climate exposure measures.

9 In their ongoing climate vulnerability work on Asia, the authors are working with geographers at the University of Oklahoma to develop a measure of land degradation using remote sensing data.

10 It should be noted that this study's authors are not climatologists but are political scientists who have employed this set of physical indicators in their wider climate security vulnerability models as part of research on Africa and Asia funded by the U.S. Department of Defense. This work has appeared in a range of peer-reviewed journals and has been cited by the Intergovernmental Panel on Climate Change (IPCC). See for example Busby, Smith, and Krishnan 2014; Busby et al. 2014; Busby et al. 2013; and Adger et al. 2014.

11 The complete set of calculations is available in: Smith, Krishnan, and Busby 2016; and Krishnan, Busby, and Smith 2016. The global mean climate exposure is the average of all pixel values globally for the overall climate exposure measure. Because the overall climate exposure measure reflects the weighted sum of the six individual hazard indicators, normalized on a common scale, the actual value of the global mean exposure is not a particularly meaningful number on its own. What is meaningful, however, is the exposure of particular locations relative to this global mean, as this allows the study to convey which parts of countries or populations are distributed far above—or very far above—this global mean exposure.

12 The global fragility measure was compiled specifically for this study by Roudabeh Kishi and Andrew Linke with contributions from Clionadh Raleigh, Ashley Moran, and USAID Office of Conflict Management and Mitigation personnel.

internal methods and framework for analyzing fragility.[13] Like USAID's internal measure, this study's 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.

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

This is a country-level measure in which overall fragility reflects an accumulation of scores on a range of state effectiveness and legitimacy indicators, as Table 2 shows. 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.[14] 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.[15] This study compiles the raw data and resulting fragility measure for each year from 2000 to 2014 to allow comparison over time.

In this report, "highly fragile states" are defined as those in the *highest* and *high* fragility categories in the fragility measure's most recent year, 2014.

13 See USAID 2005 and ARD Consortium 2005.
14 See Appendix B for the complete list of indicators and data sources, the rationale for including each indicator, and the process used to assess countries' relative state capacity and state-society relationship on a global scale.
15 It should be noted that some countries with populations under this threshold, which are thus not captured in this fragility measure due to data availability, may still face fragility risks (like the Solomon Islands) or climate risks (like Kiribati and other small, low-lying island nations).

2.3 Compound Fragility-Climate Risk Assessment

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

The first mechanism—**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. In this map, each country's national-level fragility category is applied to all administrative divisions in the country.[16]

The second mechanism—**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. These maps use 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.

The third mechanism—**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,[17] producing statistics that can be compared across countries. In this way, it is possible to examine which highly fragile states have large portions of their population or territory in areas of high climate exposure.

The study's new climate exposure measure, fragility measure, and compound risk-assessment mechanisms provide a range of findings related to the intersection of global fragility and climate risks. These findings identify fragile states with high climate risks, opportunities for interventions in these states, and worldwide patterns in climate exposure and fragility.

16 See Appendix C for the process and data used to create the bivariate map depicting compound fragility-climate risks.

17 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 Appendix A for a complete description of the process used to calculate overall climate exposure and define the pixel size.

3.0 FINDINGS

3.1 Fragile States with High Climate Risks

This study seeks to identify the locations where fragility and climate risks intersect globally. 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. To do so, this study examines both the population and territory exposed to climate risks in fragile states.

3.1.1 Population Exposed in Fragile States

The majority of people globally (60 percent) live below the global mean climate exposure. Another 26 percent live within one standard deviation above the mean. Only 14 percent of the world's population lives in areas facing *high* climate exposure, defined here as areas one standard deviation or more above the global mean. Further, only 6 percent of these people live in areas facing *very high* climate exposure, defined here as areas four standard deviations or more above the global mean.

Highly fragile states—as a group—do not have a disproportionately larger part of their populations exposed to higher climate risks than non-fragile states do. In fact, the *highest* fragility states, on average, have the same percentage of people living in highly exposed areas as is seen globally. The *high* fragility states have a slightly lower percentage of people living in highly exposed areas than what is seen globally (see Table 3).

TABLE 3: AVERAGE PERCENTAGE OF POPULATION FACING CLIMATE RISKS AT VARIED LEVELS OF FRAGILITY

Level of Fragility	Avg. % of Population in *High* Exposure Areas	Avg. % of Population in *Very High* Exposure Areas
Global average	14%	6%
Highest fragility states	14%	2%
High fragility states	11%	4%
Moderate fragility states	16%	9%
Some fragility states	23%	12%
Low fragility states	10%	6%

Note: "High exposure" areas are one standard deviation or more above the global mean exposure. "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data sources: Kishi and Linke 2016; Smith, Krishnan, and Busby 2016.

However, in the fragile states that *do* have larger numbers of people exposed, these numbers are significant. A majority of highly fragile states—26 of the 39 states with the *highest* or *high* fragility—have a large number of people or large proportion of the population living in areas with *high* climate exposure (see Table 4).[18] States with more than 1 million people living in *high* exposure areas are located predominantly in sub-Saharan Africa, with 12 states in sub-Saharan Africa, four in the MENA region, four

18 Table 4 lists countries in the *highest* and *high* fragility *categories* with large populations in *high* exposure areas. Countries in the *highest* fragility category that do not have over 1 million people in areas with *high* climate exposure are Afghanistan, the Central African Republic, Eritrea, Mali, Republic of the Congo, Somalia, Yemen, and Zimbabwe. Countries in the *high* fragility category that do not have over 1 million people in areas with *high* climate exposure are Burundi, Equatorial Guinea, Guinea-Bissau, Haiti, Laos, Mauritania, Niger, Syria, Timor Leste, and Ukraine. While these countries do not have high *overall* climate exposure—which captures high exposure to multiple hazards—some of them face high exposure to a single hazard. Those states are discussed in more detail in Section 3.1.4 Single Climate Risks in Fragile States.

in South and Southeast Asia, and one in South America. India stands out with more than 118 million people living in *high* exposure areas, followed by Nigeria with 41 million, Egypt with 33 million, DRC with 19 million, and Burma with 15 million.

Eight highly fragile states have more than 25 percent of their populations living in *high* climate exposure areas, and 13 more have at least 10 percent of their populations living in *high* exposure areas (see Table 4). Sierra Leone stands out with 100 percent of its population living in *high* exposure areas, followed by Guinea with 64 percent of its population, Cambodia with 45 percent, and Cameroon and Egypt with 39 percent each.

TABLE 4: HIGHLY FRAGILE STATES WITH LARGE POPULATION IN HIGH CLIMATE EXPOSURE AREAS[19]

More than 1 Million People in *High* Exposure Areas		More than 10% of Population in *High* Exposure Areas	
India	118,625,684	Sierra Leone	100%
Nigeria	41,390,300	Guinea	64%
Egypt	33,208,361	Cambodia	45%
DRC	19,398,276	Cameroon	39%
Burma	15,925,053	Egypt	39%
Cameroon	8,105,362	Burma	29%
Guinea	7,201,019	Mauritania	28%
Cambodia	6,775,592	DRC	26%
Pakistan	6,524,792	Nigeria	24%
Sierra Leone	5,597,459	Equatorial Guinea	20%
Sudan	5,471,859	Chad	19%
Uganda	4,365,159	Angola	18%
Iraq	3,791,594	Libya	17%
Angola	3,370,226	Sudan	16%
Ethiopia	3,173,591	Uganda	13%
Chad	2,127,706	South Sudan	12%
Colombia	1,988,544	Iraq	12%
Iran	1,936,188	Guinea-Bissau	12%
Cote d'Ivoire	1,760,619	Eritrea	11%
South Sudan	1,380,789	India	10%
Libya	1,016,683	Central African Republic	10%

Note: "Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; this includes only countries with populations over 500,000. "High exposure" areas are one standard deviation or more above the global mean exposure.

Data sources: Kishi and Linke 2016; Smith, Krishnan, and Busby 2016.

19 See Appendix D for a list of all highly fragile states and their population sizes and percentages living in *high* exposure areas. As described in more detail in Sections 1.0 and 2.1, this study's climate exposure measure captures states' exposure to multiple climate hazards since the resources, infrastructure, and mobilization required to respond to multiple, diverse threats can exceed state capacity and social capital in fragile states. States that face high exposure to only a single climate hazard thus do not rank high on this list as having *high* overall climate exposure relative to the rest of the world.

Nine of these highly fragile states have more than 1 million people facing not just *high* but *very high* climate exposure, as Table 5 shows. Unlike the fragile states with large populations facing *high* climate risks—which are located mostly in sub-Saharan Africa—fragile states with large populations facing *very high* climate risks are located predominantly in South and Southeast Asia and in the MENA region (see Table 5). This includes four states in South and Southeast Asia (Burma, Cambodia, India, Pakistan), three in the MENA region (Egypt, Iran, Iraq), one in sub-Saharan Africa (Nigeria), and one in South America (Colombia). India stands out with more than 44 million people living in *very high* exposure areas, followed by Egypt with 13.7 million and Burma with 8 million.

Three of these states—Cambodia, Egypt, and Burma—have not only a large *number* of people in *very high* exposure areas but also a large *percentage* of their populations living in these areas: Cambodia with 20 percent, Egypt with 16 percent, and Burma with 15 percent. Burma and Cambodia have stand-out risk as fragile states with a large number of people facing *very high* exposure (8 million in Burma and 3 million in Cambodia), a large percentage of their populations facing *very high* exposure, and a notable percentage of their territories facing *very high* exposure (see Table 5).

TABLE 5: HIGHLY FRAGILE STATES WITH LARGE POPULATION OR TERRITORY IN VERY HIGH CLIMATE EXPOSURE AREAS[20]

More Than 1 Million People in *Very High* Exposure Areas		More Than 10% of Population in *Very High* Exposure Areas		5% or More of Territory in *Very High* Exposure Areas	
India	44,113,082	Cambodia	20%	Sierra Leone	18%
Egypt	13,730,433	Mauritania	18%	Cambodia	11%
Burma	8,003,903	Egypt	16%	Guinea-Bissau	9%
Nigeria	4,502,705	Burma	15%	Burma	5%
Cambodia	3,111,643	Sierra Leone	11%		
Iraq	2,288,241	Libya	11%		
Pakistan	1,701,838				
Iran	1,125,579				
Colombia	1,043,704				

Note: "Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; this includes only countries with populations over 500,000. "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data sources: Kishi and Linke 2016; Smith, Krishnan, and Busby 2016; Krishnan, Busby, and Smith 2016.

3.1.2 Territory Exposed in Fragile States

Another way to assess compound fragility-climate risks is by the extent of territory in fragile states that is highly exposed to climate hazards. Most of the highly fragile states with large amounts of highly exposed territory are in sub-Saharan Africa, with the remainder located in Asia and North Africa and one in Latin America.

In sub-Saharan Africa, these states are located in Central Africa (Angola, Cameroon, the Central African Republic, Chad, DRC), East Africa (Eritrea, South Sudan, Sudan, Uganda), and West Africa (Guinea, Nigeria, Sierra Leone), as Figure 1 shows. In Asia, these states are dotted across the southern part of the continent, stretching from the Middle East (Iraq) through South Asia (parts of India) and Southeast Asia (Burma, Cambodia). In North Africa, these states are Egypt and Libya. In South America, only one state, Colombia, has high fragility and climate risks. This set of states experiences both the highest levels of

20 See Appendix E for a list of all highly fragile states and their population sizes and percentages living in *very high* exposure areas.

fragility globally—ranking in the *highest* or *high* fragility categories—and high territory exposure to a range of climate hazards.

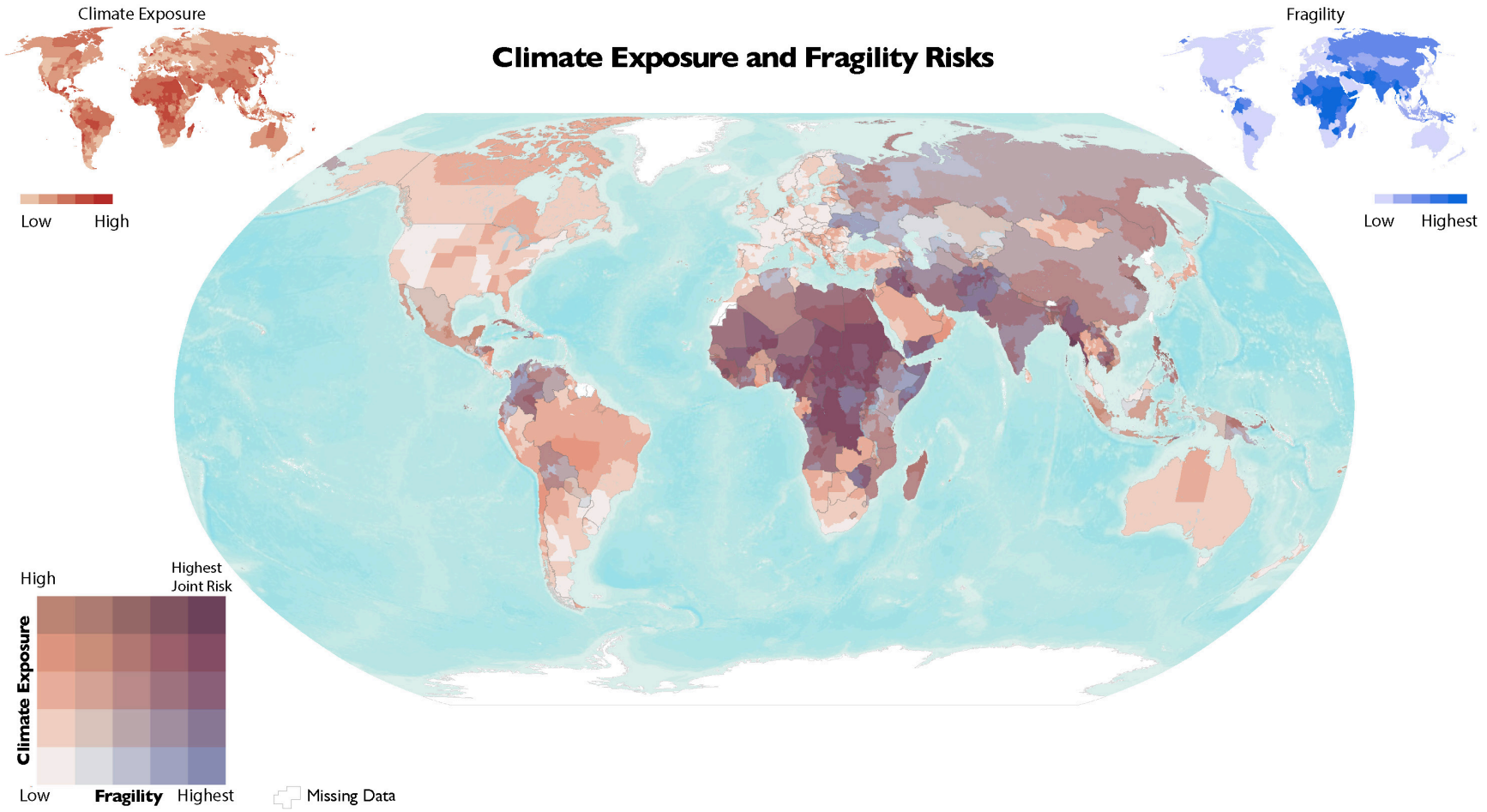
Four of these highly fragile states have sizable portions of territory facing not just *high* but *very high* climate exposure. These are Sierra Leone with 18 percent of its territory facing *very high* climate exposure, Cambodia with 11 percent, Guinea-Bissau with 9 percent, and Burma with 5 percent, as Table 5 shows. The impact of having territory in *very high* exposure areas, however, should be determined in conjunction with assessments of the size of the state's population living in those areas, as Table 5 also shows.

Figure 1 reflects one way to consider how the territories of fragile states are affected by climate risks. It 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 where data are available.[21] 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.

Figures 2 through 6 present an alternative way of assessing how the territories of fragile states are affected by climate risks, while maintaining the highest level of granularity possible in the subnational climate exposure data. These maps use 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.

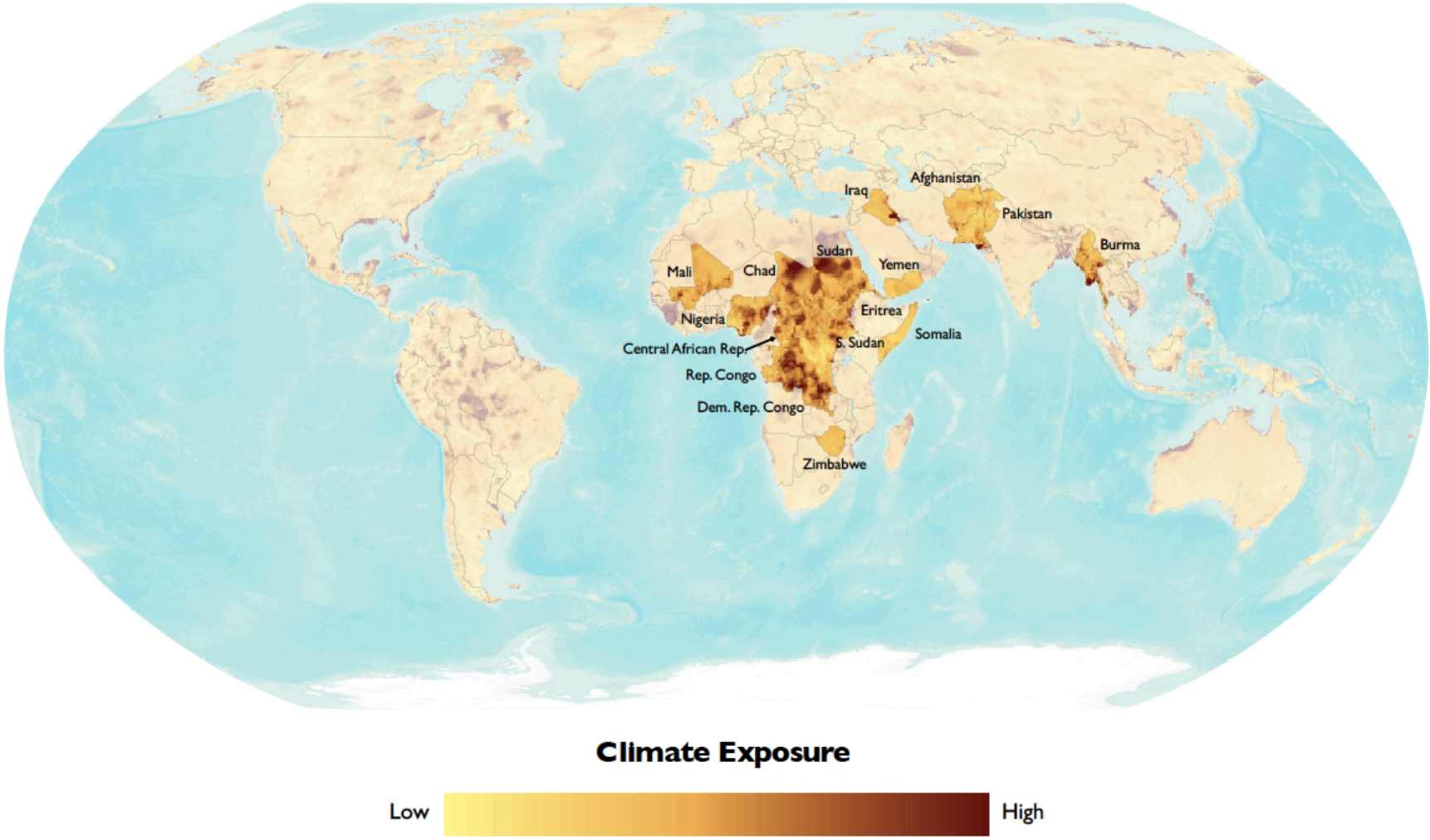
21 Appendix C describes the process used to create this bivariate map. The calculations and data used to create this map are available in Smith et al. 2016.

FIGURE 1: CLIMATE EXPOSURE AND FRAGILITY RISKS



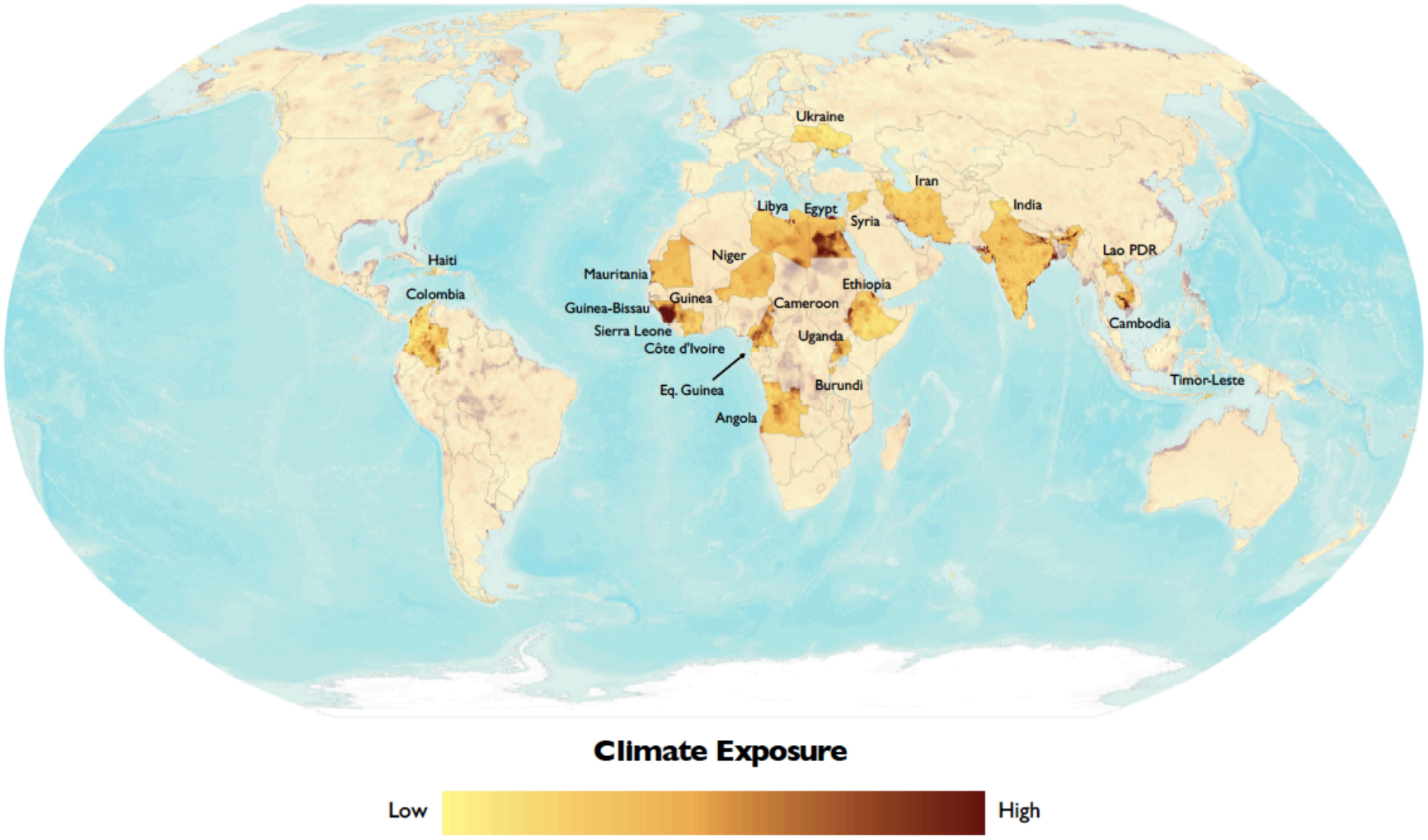
Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas
Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 2: CLIMATE EXPOSURE AND HIGHEST FRAGILITY COUNTRIES



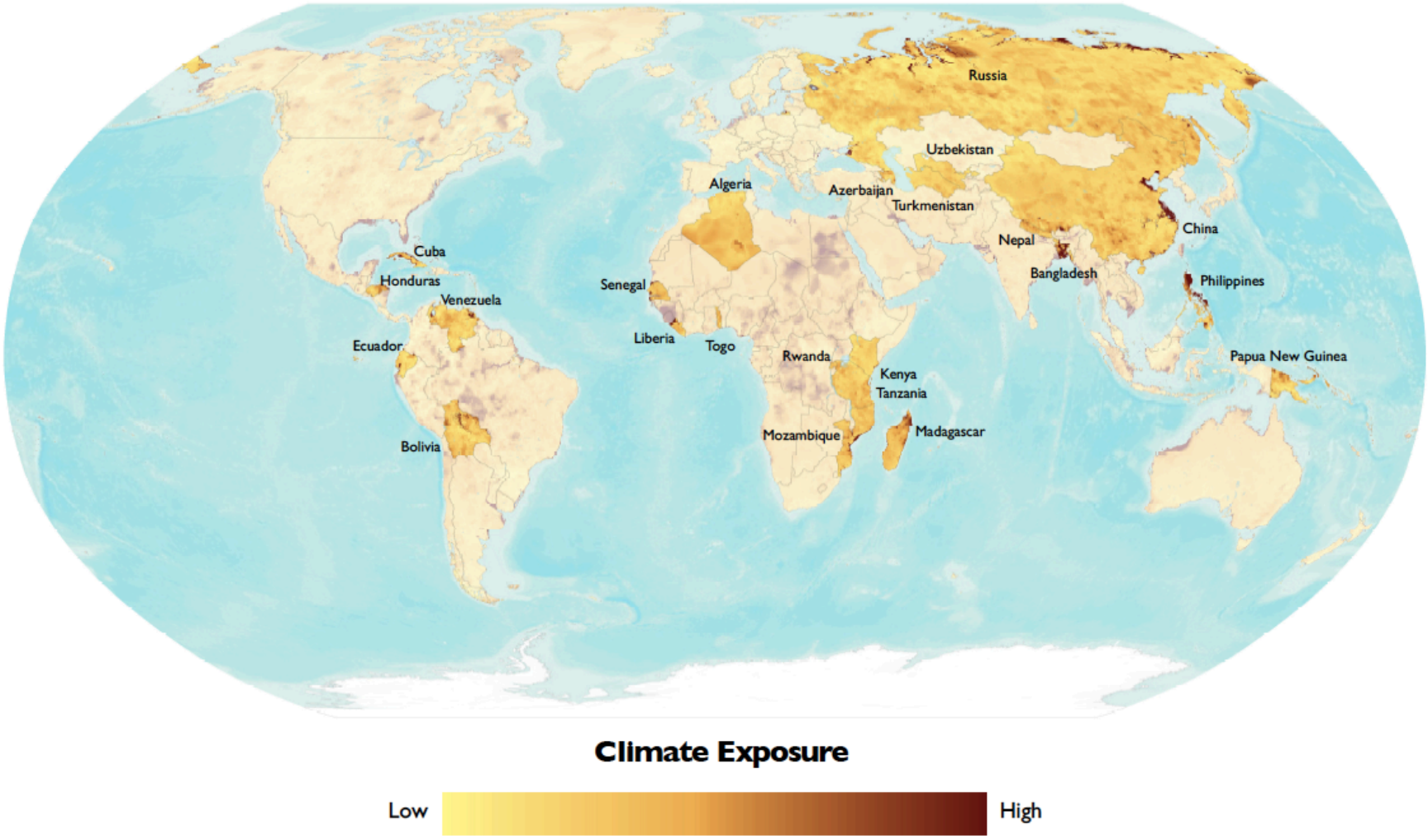
Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas
Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 3: CLIMATE EXPOSURE AND HIGH FRAGILITY COUNTRIES



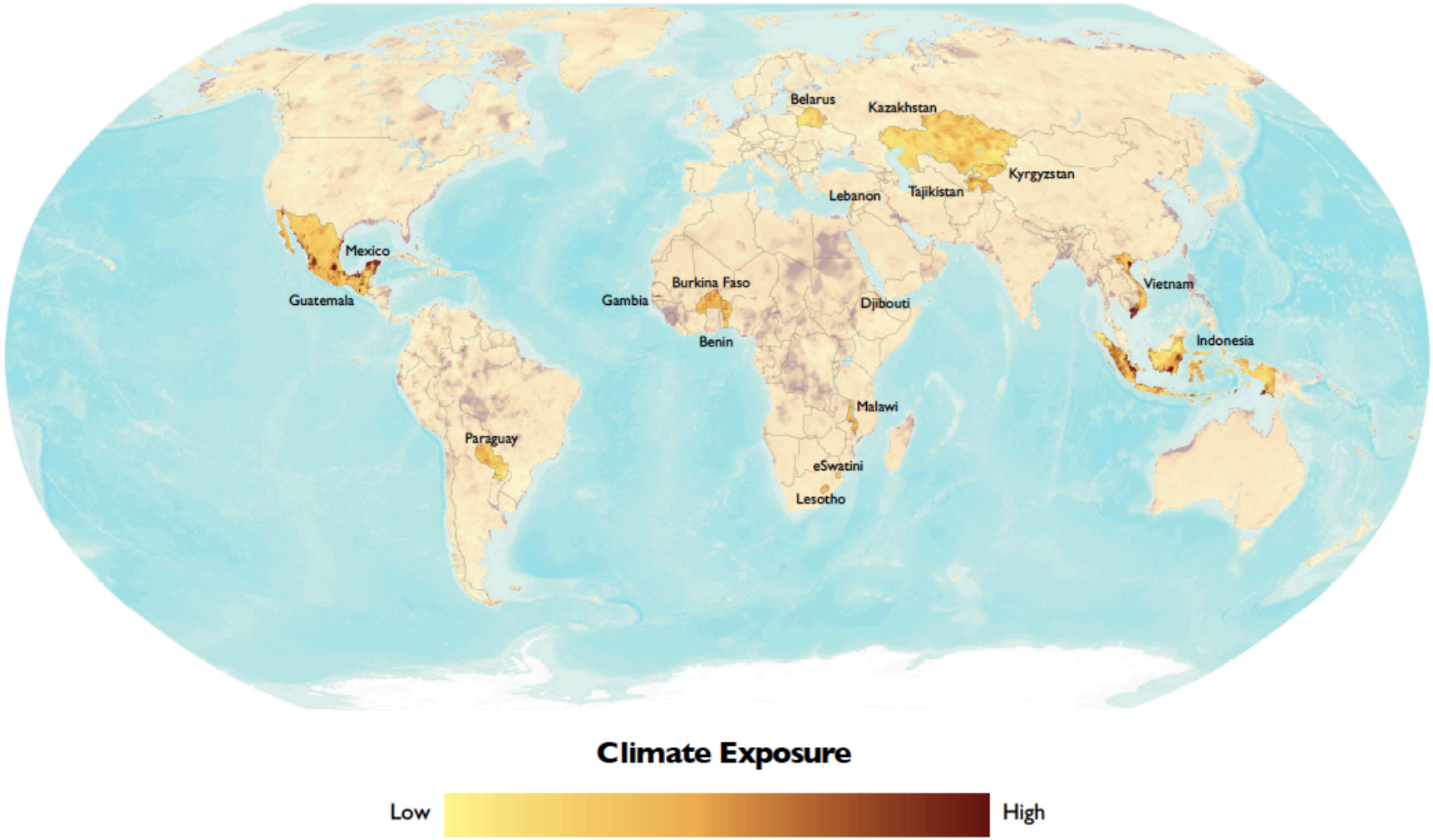
Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas
Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 4: CLIMATE EXPOSURE AND MODERATE FRAGILITY COUNTRIES



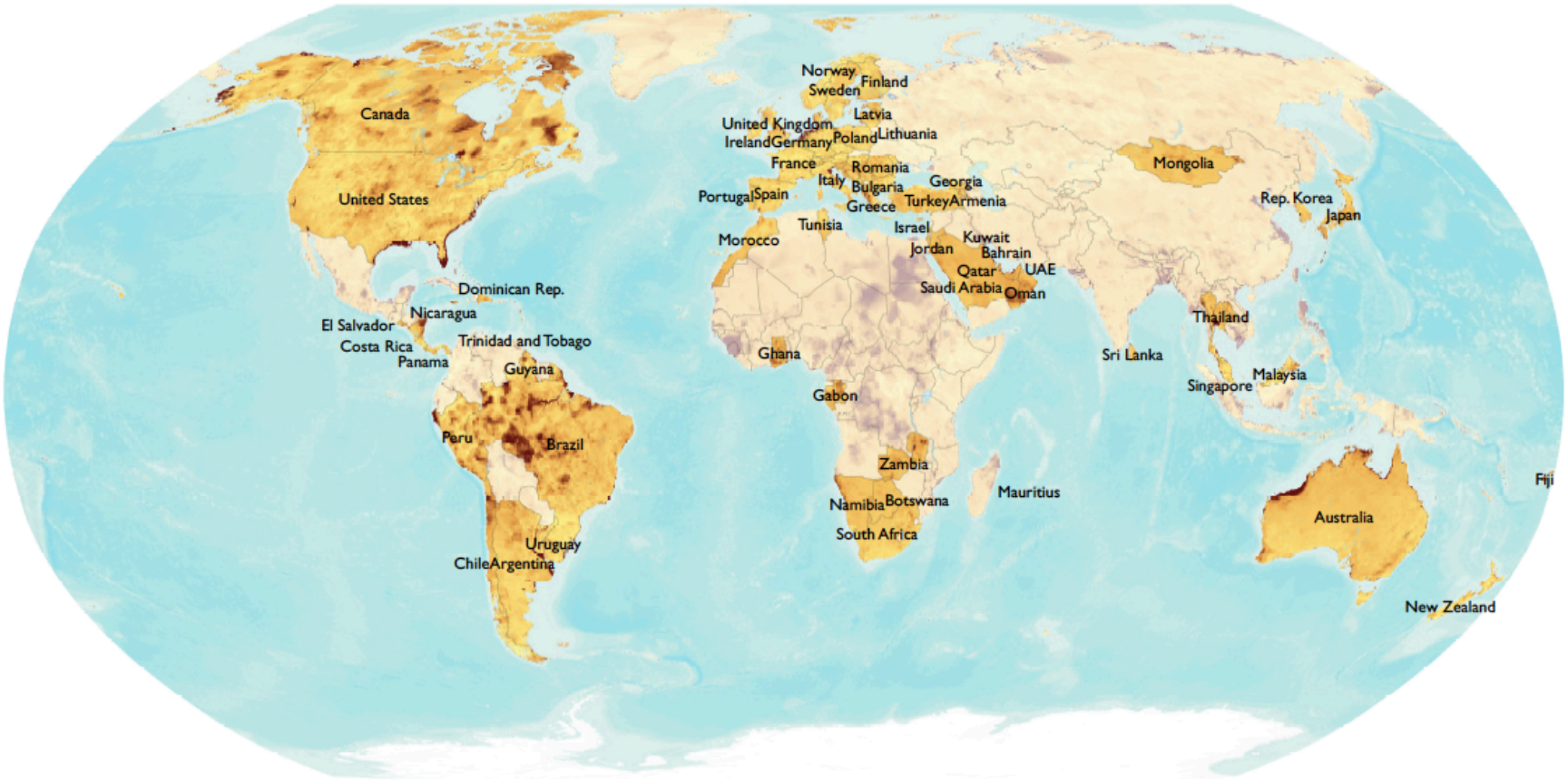
Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas
Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 5: CLIMATE EXPOSURE AND COUNTRIES WITH SOME FRAGILITY



Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas
Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 6: CLIMATE EXPOSURE AND LOW FRAGILITY COUNTRIES



Note: All country names for "low" fragility in Europe could not be included on this map due to space constraints

Climate exposure data sources: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas

Fragility data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

3.1.3 Multiple Climate Risks in Fragile States

As detailed earlier in this section, populations in *high* and *very high* exposure areas face not just a single type of climate hazard but *several* overlapping climate hazards in that location—from riverine flooding and coastal inundation to droughts and wildfires. This can heighten overall vulnerability and can also place repeated stress on a range of institutions and social and economic systems.

In South Asia, populations in *very high* exposure areas in eastern India face negative rainfall anomalies, inland flooding along the Brahmaputra River, coastal flooding along low-elevation coastal zones, and cyclone risks along the eastern coast; populations in western India also face chronic aridity and cyclone risks on the coast of Gujarat state (see figures 9, 12, 13, 15, 17, 18). Populations in *very high* exposure areas in southern Pakistan face chronic aridity, cyclone risk along the coast, coastal inundation risk in low-elevation coastal zones in Sindh province, and some inland flooding risk (see figures 9, 13, 15, 17, 18).

In Southeast Asia, populations in *very high* exposure areas in Burma face risks from negative rainfall anomalies, wildfires, cyclones, and low-elevation coastal zones in the southern part of the country (see figures 9, 12, 16, 17, 18). Populations in Cambodia face negative rainfall anomalies and inland flooding along the Mekong River (see figures 9, 12, 15).

In the MENA region, populations in *very high* exposure areas in Iraq face chronic aridity across much of the country, negative rainfall anomalies in the eastern part of the country, and coastal inundation risks in low-elevation coastal zones on the Persian Gulf (see figures 9, 12, 13, 18). Populations in Iran face chronic aridity in parts of the country, negative rainfall anomalies in the northwestern part of the country, and coastal inundation risks in low-elevation coasts along the northern Persian Gulf (see figures 9, 12, 13, 18). In Egypt, populations in densely populated *very high* exposure areas in the Nile River delta face both chronic aridity and coastal inundation risks (see figures 11, 13, 18).

In sub-Saharan Africa, populations in Nigeria face risks from extensive negative rainfall anomalies across the eastern, central, and southern parts of the country; chronic aridity and flooding in the northeast; and risks of coastal inundation, inland flooding, and wildfires in the Niger Delta region (see figures 12, 13, 15, 16, 18). In South America, populations in Colombia face risks from coastal inundation on the northwestern coast and negative rainfall anomalies across the southern part of the country (see figures 10, 12, 18).

3.1.4 Single Climate Risks in Fragile States

While this study seeks to identify highly fragile states that have high exposure to *multiple* climate hazards, it would be remiss if it failed to note the few highly fragile states that face exceedingly high exposure to a *single* climate hazard. While these states do not face multiple climate hazards, and thus do not show up as highly exposed in terms of overall climate exposure in this study, they have high exposure to one climate hazard to a degree that risks exceeding state capacity to address it.

In the *highest* fragility category, these states include: Yemen, which has high chronic aridity in much of its territory, nascent state institutions challenged by ongoing civil conflict, and deep societal insecurities stemming from poor water management policies and inequitable access to water resources (see Figure 13); Mali, which has high chronic aridity over much of its territory, deep social cleavages, and multiple long-term conflicts involving the state and varied non-state actors (see Figure 13); and the Republic of the Congo, which has experienced negative rainfall anomalies over much of its territory in the last two and a half decades alongside poor economic development and recurrent political instability (see Figure 12). In the *high* fragility category, this includes Niger, which has endured political turmoil, chronically poor development and public infrastructure, and high chronic aridity across most of its territory (see Figure 13).

3.1.5 Fragility in States with Compound Fragility-Climate Risks

Three important points should be made about the type of fragility experienced by states with high compound fragility-climate risks. First, poor state legitimacy—reflecting public perceptions that the state is unable or unwilling to meet public needs—contributes more to the fragility of states, on average, than poor state effectiveness does.[22] This trend is even more pronounced for the subset of states with high compound risks than it is in states with high fragility risks alone: 73 percent of states with compound fragility-climate risks have worse legitimacy deficits than effectiveness deficits, compared to 64 percent of all states in the *high* and *highest* fragility categories.[23] Second, legitimacy deficits have been steadily worsening over the last 15 years in most states with high compound fragility-climate risks, but not in states that today have low fragility (see Table 11). Improving state legitimacy will thus be key to increasing stability and reinforcing government-led efforts to address climate risks in those countries. Third, for states with high compound risks that are in the *highest* fragility category, their state effectiveness deficits have *also* been worsening over the last 15 years.[24]

3.1.6 Instability Risks in States with Compound Fragility-Climate Risks

There is a strong overlap between the *highest* fragility levels and high levels of political violence in both Africa and South and Southeast Asia in recent years, as Figure 7 shows.[25] This is due, in part, to the inclusion of insecurity within this study's fragility metrics. What is clear across the study is that compound fragility-climate risks can heighten insecurity, but conflict is context specific. This is seen in several ways.

First, even in states with similarly high compound fragility-climate risks and similar rates of violence, conflict outcomes can differ greatly. This can be seen in the Sahel belt of Africa, which is home to many countries experiencing both high climate exposure and the *highest* or *high* levels of fragility. Yet, instability within these countries differs. In Ethiopia, long-standing rebel conflict continues and new pressures related to representation and land planning have erupted in regions surrounding the capital. In neighboring Sudan, conflicts in Darfur and in the Nuba Mountains are both anti-state and characterized by increasing rates of local, armed organization against a repressive state, while additional political challenges have also emerged from elite conflict and disputes with civil society in the capital. Chad, in contrast, tends to experience "overflow" conflict from neighboring states in areas far from the capital where the state has limited direct reach. At the same time, Niger has managed to keep the most radical and volatile elements of its politics under control while neighbors are actively at war. Their shared neighbor of Mali has conflicts across the state (and closely following transport lines), which are the accumulated challenges from Islamist, secessionist, elite, and civil society contentions.

Second, some states with high compound fragility-climate risks—such as India—experience higher rates of "social" or "civic" conflict, such as riots and protests in areas where the reach of the state is sufficient to address challenges. A high rate of these specific types of conflict can suggest that the basis for positive state-society relationships is present, but the mechanisms for communication and reform require further support.

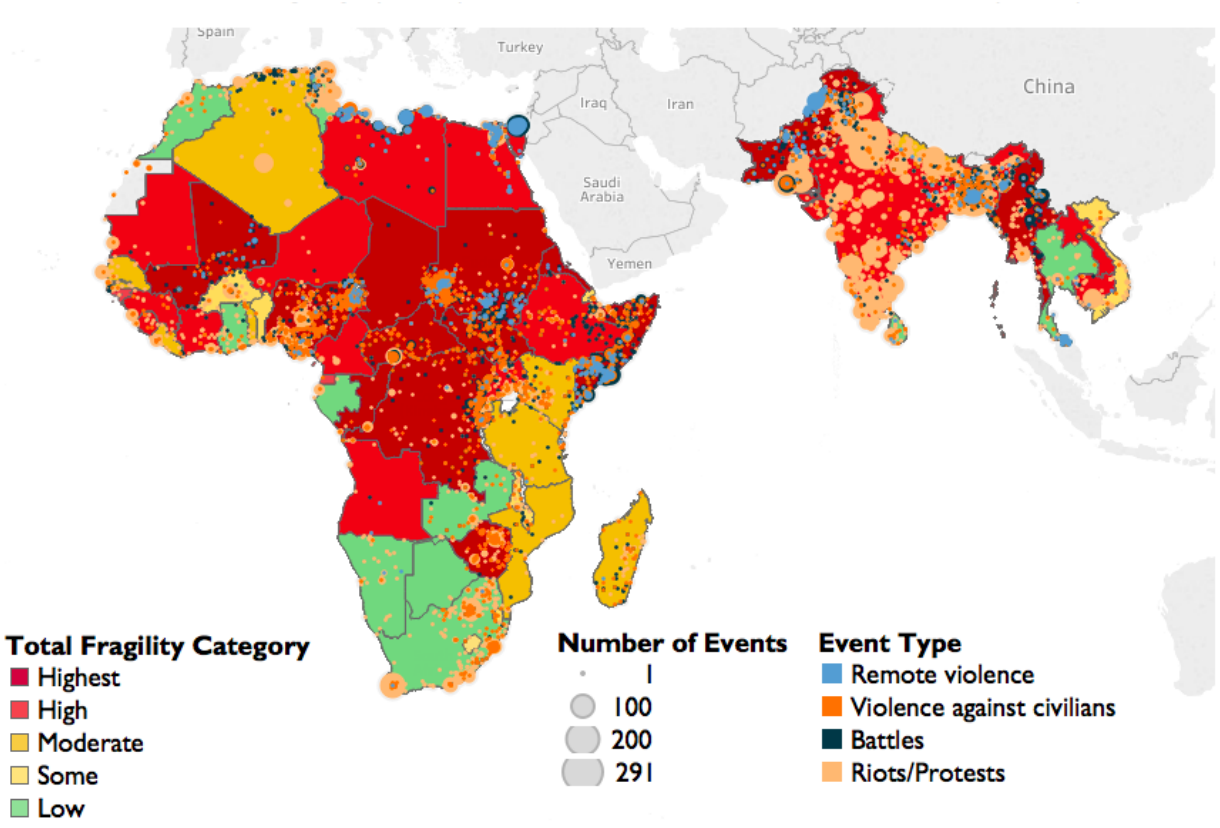
22 The exceptions—states where state effectiveness deficits are worse than state legitimacy deficits in the most recent year—are the Central African Republic, Colombia, Cote d'Ivoire, DRC, Guinea-Bissau, Mauritania, and Sierra Leone. For the other 19 states with high compound risks (listed in Table 6), it was instead legitimacy deficits that were worse than effectiveness deficits in 2014. This is the case even for states that saw dramatic worsening of their *effectiveness* scores over the last 15 years (e.g., Burma, Egypt, Libya, and Pakistan, as Table 6 shows); these states started out with relatively poor *legitimacy* scores that saw little change and relatively good *effectiveness* scores that deteriorated and thus saw a high degree of change over the last 15 years. For annual fragility scores, see Kishi and Linke 2016.

23 Table 6 lists the 26 states with high compound fragility-climate risks. Figures 2 and 3 show all 39 states in the *highest* and *high* fragility categories. State *legitimacy* and *effectiveness* scores for these states are detailed in Kishi and Linke 2016.

24 Section 3.5 on Global Fragility Risks discusses these patterns in more detail.

25 Figure 7 includes conflict data only for Africa and South and Southeast Asia, as this was the geographic extent of data included in the Armed Conflict Location and Event Data (ACLED) at the time of the initial drafting of this study.

FIGURE 7: FRAGILITY AND CONFLICT IN AFRICA AND SOUTH AND SOUTHEAST ASIA



Data sources: 2015 data from Armed Conflict Location and Event Data Project (ACLED). 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Marshall, Gurr, and Jaggers; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

Third, among states with compound fragility-climate risks, many of those with the *highest* level of fragility host multiple, long-term conflicts that have cycled through several stages.[26] These states include DRC, Nigeria, Pakistan, and Sudan.[27] Concurrent, yet distinct, ongoing conflicts have several important implications for states. Importantly, they indicate that state institutions from the national to the local level are continually pressured and challenged. These patterns of very high, sustained violence that states have been unable to reduce also suggest that national institutions may be weakened to the point of being presently unable to reform to address key political, economic, and social issues that lead to violence. These conflict patterns also indicate that the state is likely hosting varied motivations for and responses to these multiple ongoing conflicts, and these are different from the local responses that would be seen to the same triggers or grievances in the case a single, locally based conflict. The politics that give rise to competition in one region are unlikely to be the same as those in another region, and both may be unrelated to larger national tensions. However, in the context of a large national conflict between the state and opposition, multiple discrete episodes and contests may emerge during instability and the ensuing volatility of established patronage and alliance systems.

26 The ACLED data used here define political violence as "the use of force by a group with a political purpose or motivation. ACLED defines political violence through its constituent events, the intent of which is to produce a comprehensive overview of all forms of political conflict within and across states. A politically violent event is a single altercation where often force is used by one or more groups for a political end, although some instances - including protests and non-violent activity - are included in the dataset to capture the potential pre-cursors or critical junctures of a conflict." See Raleigh and Dowd 2017.
27 See Moran et al. 2018c for this study's report on Nigeria.

Fragility is thus an important dimension in understanding the indirect pathways between climate risks and potential conflict outcomes. The research team does not seek to establish a causal relationship between climate exposure and instability. This is in part because the varied time frames and spatial resolutions across the exposure and fragility data do not lend themselves to that kind of analysis. This is also because, as the IPCC's 2014 report concludes, evidence suggesting that conflict occurs as a direct result of climate-related or climate-sensitive factors is contested,[28] with scholars increasingly studying the indirect pathways between climate hazards and conflict outcomes through factors such as economic growth, food prices, and migration. Considering state fragility in this analysis is thus key, as a government's ability to manage these economic and social processes can impact whether a population becomes more or less vulnerable to the climate risks it faces. Analyzing compound fragility-climate risks can highlight how these factors interact and how they manifest in individual countries. As Figure 7 shows, the geography of violence suggests that there is not a clear relationship between exposure to climate risks and the distribution of conflict. If conflict *were* clearly driven by climate changes, one would expect patterns in the forms, locations, and goals of conflict to align with particular climate patterns. However, there is considerable heterogeneity in conflict patterns across regions that environmental factors alone cannot explain. This finding underscores the role that governance plays in the development of conflict, and it also highlights the analytical value of understanding compound fragility-climate risks.

As is noted in the debate on climate security, conflict patterns do show that poor management of broader environmental factors can contribute to already unstable and unequal conditions that in turn lead to organized violence. Such environmental factors include management of land distribution, precious and extractable resources, land use regulations, water access, and migration routes, among others. States with compound fragility-climate risks that are prone to such environmental factors contributing to instability include, as prominent examples, Ethiopia where land use planning has been the subject of protests in both the Oromo and Amhara regions, and India where land use and water politics following a drought have resulted in continued rioting. In other countries, the link between environmental factors and instability has been too much of a focal point at the expense of focusing on the role of domestic politics in contributing to instability. In countries like DRC, domestic politics are closely linked to the political economy of local areas, agricultural progress, and migration routes—all factors linked to environmental sectors and resources that can contribute indirectly to instability.

3.2 Opportunities for Action

The patterns and trends seen in intersecting fragility and climate risks suggest several opportunities for action in states with high compound risks.

First, addressing climate risks in fragile states could yield win-win opportunities for enhancing resilience and reducing fragility. As noted, poor state legitimacy—reflecting public perceptions that the state is unwilling or unable to meet public needs—contributes more to the overall fragility of states, on average, than poor state effectiveness does, and this trend is even more pronounced for states with high compound fragility-climate risks. Further, average *legitimacy* scores have been steadily worsening over the last 15 years in today's fragile states. This is a key consideration in assessing potential responses in states with compound fragility-climate risks. Since fragility in these states is composed in greater part of deficits in state legitimacy, state actions that respond to public needs for reducing climate vulnerabilities could simultaneously reduce both climate risks and the legitimacy deficits that contribute to fragility in these states.

Second, investing in states that have high state effectiveness can increase the likelihood of development funds being used to reduce both fragility and climate-related vulnerability. Many (but not all) states with high compound risks have substantially improved their state *effectiveness* scores over the last 15 years,

28 Adger et al. 2014.

even while enduring worsening state *legitimacy* scores (as in Cambodia, Guinea, and Sudan), poor and largely static *legitimacy* scores (as in Mauritania), or poor but improving *legitimacy* scores (as in Angola, Ethiopia, Sierra Leone, and Uganda). Several others have seen more modest improvements in state *effectiveness* scores while experiencing worsening state *legitimacy* scores (Chad, Equatorial Guinea) or poor but improving *legitimacy* scores (Guinea-Bissau), as Table 6 shows. These states have thus been steadily building state capacity and, with it, an increasing chance of being able to effectively implement state policies in the spheres where that capacity has grown.

Third, in states affected by sustained conflict, investment in institutional changes is a critical component of mitigating overall state weakness and therefore of strengthening the ability to respond to climate risks. Several states with high compound fragility-climate risks—DRC, Nigeria, Pakistan, and Sudan—are also embroiled in multiple long-term conflicts that both reflect and contribute to deep weaknesses in state capacity. This is an important consideration in assessing the capacity of the state to respond to both fragility and climate risks. The existence of sustained conflict signals the inability of the state to control its territory or advance reforms that address the political, economic, and social issues that lead to violence. These states are thus less likely than others to have the capacity needed to implement policies to address either fragility or climate risks in a robust or sustained way without institutional changes.

Fourth, efforts to forestall the *emergence* of high compound fragility-climate risks in the future could focus on shoring up the capacity of states that today have *moderate* fragility and *very high* climate risks. Several moderately fragile states (China, Ecuador, Russia, and Venezuela) have acute climate exposure risks with a large number of people or a large portion of the population facing *very high* exposure in an area that is less than 2 percent of the state's territory. Other moderately fragile states like Bangladesh and the Philippines face a confluence of risks, with a large number of people, large portion of the population, and large land area facing *very high* exposure.[29] Bangladesh has more than 53 million people, 33 percent of its population, and 35 percent of its territory facing *very high* exposure; the Philippines has more than 19 million people, 18 percent of its population, and 15 percent of its territory facing *very high* exposure. While these states are not highly fragile, climate hazards can place extreme stress on their population. If fragility worsens, and these states are not able to address the climate risks effectively, large numbers of people could become more vulnerable to the *very high* exposure risks they face.

3.3 Interventions to Reduce and Prevent Compound Risks

Understanding where fragility and climate exposure intersect can help identify interventions to reduce such compound risks. Twenty-six highly fragile states have large numbers of people or large percentages of their populations living in *high* or *very high* climate exposure areas (see tables 4 and 5). Table 6 notes how these states compare across the several metrics used in this report for assessing climate exposure risk and fragility trends. Among these states with high compound risks, three groups stand out as having extensive but distinct exposure challenges, presenting different opportunities and focal points for intervention. While the key findings of this research focus on highly fragile states, opportunities exist to catalyze change in countries across the fragility spectrum.

3.3.1 Group 1: Act Now and Leverage Finance

These highly fragile states have more than 1 million people, more than 10 percent of the population, and a sizable portion of territory facing *very high* exposure (Burma, Cambodia) or *high* exposure (Angola, Cameroon, Chad, DRC, Egypt, Guinea, Iraq, Libya, Nigeria, Sierra Leone, South Sudan, Sudan, Uganda). Climate hazards thus place extreme stress on these states in terms of the population and land area exposed, with exposure risks dispersed over a sizable portion of the territory, which could narrow

29 See Moran et al. 2018a for this study's report on Bangladesh.

livelihood choices and create additional requirements for the state. Addressing climate exposure risks dispersed over such a sizable portion of territory is likely to require significant investment. However, the large *numbers* of people affected could draw international involvement, and the large *portion* of the population affected could draw domestic political will to respond to public needs, creating a potential for alignment of international and domestic priorities and opportunities to leverage important sources of finance.

In this group, for example, Nigeria faces among the highest compound fragility-climate risks globally. It has very high fragility and suffers from ongoing conflict that severely limits the state's ability to respond to climate challenges. At the same time, environmental stress contributes to the severity of land conflicts and food shortages the country now faces. Nigeria's current crisis in the North, for example, reflects internationally declared emergency conditions and famine risks that are not caused by climate factors alone but also by longstanding environmental stress coupled with poor national management of the security, economic, and social conditions in that region. While the North endures chronic aridity and high overall climate exposure, this famine risk appears to be primarily driven by political violence disrupting harvests and aid supplies rather than by climate factors alone. Likewise, the escalating security situation in the Middle Belt involves a highly climate-exposed region where the state has provided only limited response to growing food insecurity and ongoing tensions between Fulani herders and non-Fulani farmers over the use of land and water resources. Similarly, rising tensions in the climate-exposed Niger Delta reflect a long-standing secessionist movement driven in large part by disputes over state management of oil revenues, deteriorating environmental conditions, and economic development challenges.

While Nigeria is pursuing climate actions through international frameworks for national adaptation planning, the country's ability to address its widespread, diverse climate risks depends greatly on its state capacity and societal resilience. Yet, the country's fragility has increased considerably in the last 15 years. Nigeria's crises in the North, Middle Belt, and Niger Delta highlight how compound fragility-climate risks can heighten populations' insecurity by increasing their vulnerability to humanitarian emergencies and conflict. All three regions show evidence of high climate stress and limited state capacity to adequately respond to interrelated environmental, social, economic, and security dynamics. Nigeria's ongoing crises also highlight that opportunities to change the country's trajectory do exist, particularly at the institutional level, and may be best leveraged in non-traditional ways that can yield benefits for both peace and climate adaptation.[30]

3.3.2 Group 2: Identify Targeted and Prioritized Investments

These highly fragile states have either a large number of people or a large portion of the population facing *very high* exposure, concentrated in small portions of the state (less than 5 percent of the state's territory). These include Colombia, Egypt, India, Iran, Iraq, Libya, Mauritania, Nigeria, and Pakistan. In some places, the concentrated nature of this *very high* population exposure could be an opportunity for targeted interventions in these areas that address the specific climate risks affecting a large population in a very small area. It should be noted, however, that many states in this group also face chronic, unaddressed risks from high exposure in less densely populated parts of the state. Interventions in these states should thus consider not only high-profile, densely populated areas but also less densely populated, high exposure areas where national fragility dynamics impede effective responses.

In this group, for example, Colombia experiences *very high* climate exposure concentrated in small portions of the country and high fragility that stems largely from ongoing political violence related to both longstanding and new sources of conflict. The April 2017 flood in the southern city of Mocoa provides a key example of how compound fragility-climate risks can pose critical challenges in Colombia. Mocoa's

30 See Moran et al. 2018c for this study's report on Nigeria.

drought and flood risks are exacerbated by the city's expansion into floodplains as its population has grown in recent years, particularly due to the arrival of people displaced by conflict. Vulnerability to climate risks in this region has also been made worse by a lack of government regulation around both settlement and deforestation. The convergence of climate risks and government mismanagement of those risks, as well as state deficiencies in addressing the conflict and displacement that put more people in harm's way, combined to make the April 2017 flood in Mocoa one of Colombia's worst disasters on record.

A similar confluence of fragility and climate risks is seen in the routine flash flooding that besets the country's largest coastal city, Barranquilla. Positioned in a low flood plain next to the Magdalena River delta, the city faces substantial flooding risks from storm surge and riverine flooding, which is made worse by limited government planning and responses to address these risks. For example, the city lacks rainwater storm drains, so the population experiences flash flooding through city streets during heavy rains. This combination of climate risks and state mismanagement leads to loss of life, infrastructure damage, and decreased economic productivity. The concentrated nature of this population exposure could be an opportunity for targeted interventions in these areas to address the specific climate risks affecting a large population in a very small area. Colombia's effective political institutions, well-developed social service delivery systems, and strong regulatory foundation for economic policy position the state to improve its regulatory capacity in the other areas where it is currently deficient and to effectively address these issues.[31]

3.3.3 Group 3: Monitor Early and Avoid Escalation

Moderately fragile states like China, Ecuador, Russia, and Venezuela have acute risks with a large number of people or large proportion of the population facing *very high* exposure in a concentrated portion of the state's territory. Other moderately fragile states like Bangladesh and the Philippines face a confluence of risks, with a large number of people, large proportion of the population, and large land area facing *very high* exposure. Climate hazards can thus place extreme stress on these states that are already experiencing other substantial stressors that place them in the *moderate* fragility category. If fragility worsens, and these states are not able to effectively address the climate risks in these areas, large numbers of people could become more vulnerable to the very high climate risks they face.

In this group, for example, Bangladesh is widely recognized as facing among the highest levels of climate exposure globally. Yet its resilience depends not only on building its capacity to address its specific climate risks, but also on mitigating the fragility dynamics that prevent the state from operating in an effective and responsive way. Instability in the country stems from a national conflict between two political parties, urban public discontent, and rural communal violence. The national conflict between rival political parties has been accompanied by cycles of violence during elections and by increasing activity from extremist groups capitalizing on the political turmoil to gain ground. These growing political and security challenges have left the state unable to maintain consistent control in urban areas and uninvolved in managing land conflicts in rural areas—both areas that face myriad and increasingly common climate hazards. This combination of domestic forces is made even more precarious by the recent influx of Rohingya refugees from Burma, who are now living in overcrowded tent camps in highly climate-exposed areas along Bangladesh's southeast coast. Thus, while Bangladesh has built state capacity to respond to climate hazards like cyclones and floods and has reduced state fragility in the social and economic spheres, continued progress could be hampered if the state's fragile political and security situation is not addressed.[32]

31 See Moran et al. 2018b for this study's report on Colombia.
32 See Moran et al. 2018a for this study's report on Bangladesh.

TABLE 6: STATES WITH HIGHEST COMPOUND FRAGILITY-CLIMATE RISKS

Region/State	Population Exposure				Land Exposure		Fragility		
	Over 1m People in *High* Exposure	Over 10% of Pop. in *High* Exposure	Over 1m People in *Very High* Exposure	Over 10% of Pop. in *Very High* Exposure	Large Land Area with Exposure	5%+ Land in *Very High* Exposure	*Total Fragility* % Change 2000-2014	*Effectiveness Deficits* % Change 2000-2014	*Legitimacy Deficits* % Change 2000-2014
Sub-Saharan Africa									
Angola	■	■			■		↓28%	↓50%	↓6%
Cameroon	■	■			■		↑24%	↑24%	↑24%
Central African Rep.		■			■		↑69%	↑26%	↑167%
Chad	■	■			■		↑6%	↓4%	↑15%
Cote d'Ivoire	■						↑2%	↑44%	↓23%
DRC	■	■			■		↓9%	↓3%	↓15%
Equatorial Guinea		■					↑5%	↓5%	↑14%
Eritrea		■			■		↑4%	0%	↑6%
Ethiopia	■						↓15%	↓21%	↓8%
Guinea	■	■			■		↓10%	↓24%	↑9%
Guinea-Bissau		■				■	↓6%	↓4%	↓10%
Mauritania		■		■			↓7%	↓13%	0%
Nigeria	■	■	■		■		↑35%	↑12%	↑67%
Sierra Leone	■	■		■	■	■	↓34%	↓16%	↓54%
South Sudan	■	■			■		-	-	-
Sudan	■	■			■		↑5%	↓23%	↑37%
Uganda	■	■			■		↓28%	↓24%	↓32%
MENA									
Egypt	■	■	■	■	■		↑100%	↑280%	↑44%
Iran	■		■				↑23%	0%	↑37%
Iraq	■	■	■		■		↑33%	↑10%	↑52%
Libya	■	■		■	■		↑100%	↑129%	↑88%
South & SE Asia									
Cambodia	■	■	■	■	■	■	↓3%	↓38%	↑39%
India	■	■	■				↑8%	↑5%	↑10%
Burma	■	■	■	■	■	■	↑7%	↑14%	↑3%
Pakistan	■		■				↑46%	↑108%	↑19%
South America									
Colombia	■		■		■		↓2%	↑9%	↓14%

Note: "Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; this includes only countries with populations over 500,000. This table includes only the highly fragile states with sizable populations or territories in *high* or *very high* climate exposure areas. "High exposure" areas are one standard deviation or more above the global mean exposure. "Very high exposure" areas are four standard deviations or more above the global mean exposure. In the percent change columns, the up arrow indicates that the country's *total fragility* score, *effectiveness deficit* score, and/or *legitimacy deficit* score went up over those 15 years, indicating an increase in fragility; the down arrow indicates that the country's *total fragility* score, *effectiveness deficit* score, and/or *legitimacy deficit* score went down over those 15 years, indicating a decrease in fragility. This table does not include the percent change in fragility scores for South Sudan since the country does not have a fragility score for the year 2000 prior to its establishment as a country.

Data sources: Kishi and Linke 2016; Krishnan, Busby, and Smith 2016; Smith, Krishnan, and Busby 2016.

3.4 Global Climate Exposure Patterns

While Section 3.1 explores findings on the intersection of fragility and climate risks worldwide, this section presents findings on the key underlying climate exposure patterns. It highlights the main areas of concern from this study's analysis of climate exposure patterns worldwide, including both fragile states and non-fragile states.[33] The maps and source files are also available for others to analyze as well.[34]

3.4.1 Overall Climate Exposure

All regions of the world contain areas of high exposure. Many of these are located along coasts that are subject to cyclones and storm surge, but others are inland in areas facing chronic drought or flooding. Areas with the highest overall climate exposure face a confluence of hazards in the same location.

Figure 8 shows climate exposure levels in regions worldwide. In the Western Hemisphere, high exposure in coastal areas of the eastern U.S. seaboard extends westward from Florida to the Gulf of Mexico. There is also a ring of high exposure from the Gulf of Mexico and pockets of the Caribbean that extends southward to the Yucatán in Mexico, down to the northern coast of Honduras. Western Brazil in and around the Amazon has high exposure that extends into Bolivia. There are also pockets of high exposure in other parts of the Americas, namely in northeastern Canada near the border of Newfoundland and Quebec and just north of the Great Lakes.

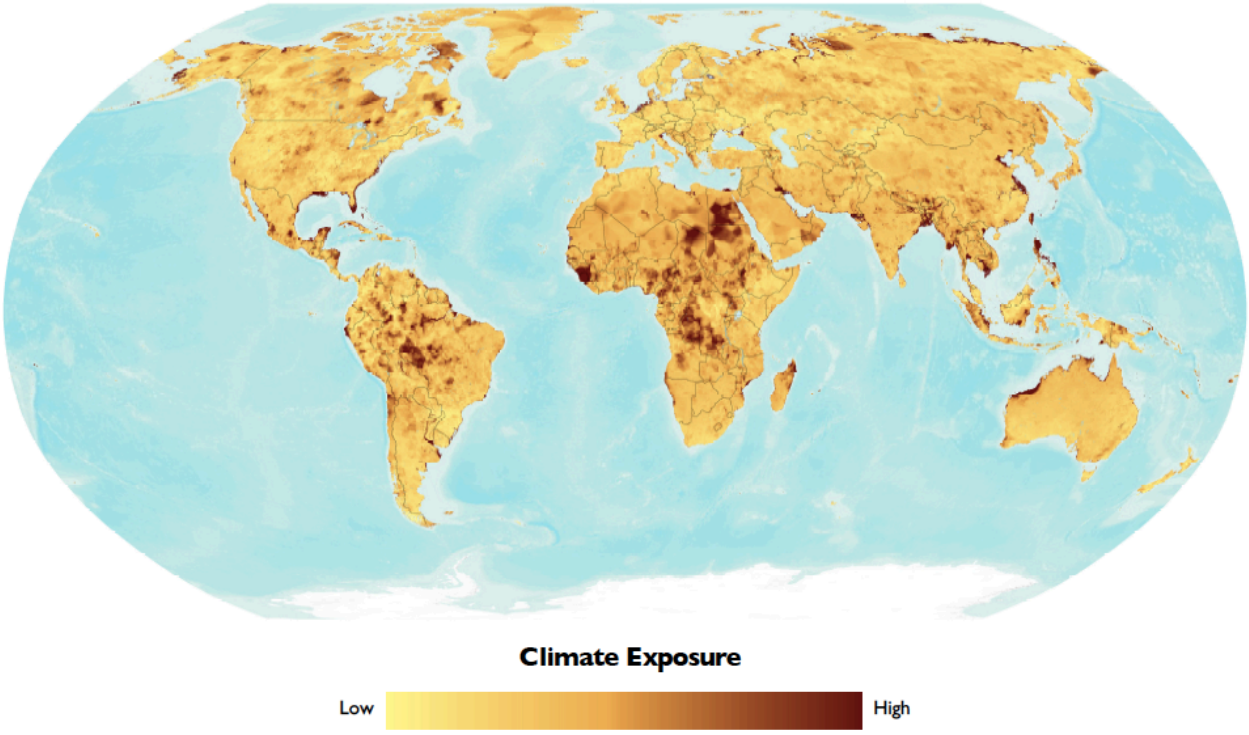
Asia also has pockets of high coastal exposure, namely in Pakistan, India, Bangladesh, Burma, China, southern Vietnam, parts of Indonesia, and the island of Luzon in the Philippines. The northwestern coast of Australia also has high overall climate exposure.

Africa's overall climate exposure is extensive throughout Central Africa in the DRC, Central African Republic, Cameroon, Chad, pockets of South Sudan, and Sudan, then extending north into Egypt. In West Africa, the high exposure areas include Guinea and parts of Nigeria. The eastern coasts of Madagascar and Mozambique also face high exposure.

In the Middle East, areas that face notable overall exposure include southern Iraq near the city of Basra. Russia's northernmost coastal areas in the Arctic also face high exposure. Similarly, in Europe, coastal areas in Holland, Germany, and particularly the eastern United Kingdom face high exposure.

33 See Section 2.1 and Appendix A for a detailed discussion of the indicators and process used to create this study's climate exposure measure.
34 See Section 5.0 for a list of reports, data, and maps available from this study.

FIGURE 8: CLIMATE EXPOSURE



Data source: Global Precipitation Climatology Centre; UNEP/GRID-Europe; Viewfinder Panoramas

However, there are other ways of assessing exposure risk in terms of the total population that faces high exposure to climate hazards and the percentage of the population that faces high exposure. The first reveals densely populated countries, such as China and India, where large population centers face high exposure, particularly along coasts and rivers. The second shows small countries and territories, particularly low-lying islands, where large portions of the population face high exposure. Countries and territories in this second group are not easily visible at the global scale.

A number of small low-lying islands do not appear in the fragility indicators due to data availability. For many of these countries and territories, climate change is likely an existential threat. Therefore, this particular indicator—the percentage of a country's or territory's population facing *very high* exposure—may be useful in identifying places that face substantial climate and stability risks, as efforts to relocate populations or spontaneous movements by citizens could trigger serious political challenges for would-be recipient countries. Already, Australia and New Zealand have faced resettlement demands from Pacific Island nations such as Kiribati, the Marshall Islands, and Tuvalu.[35]

This study calculates the mean climate exposure for the world and then identifies the total population and percent of the population living in locations that are one, two, three, and four standard deviations above the mean climate exposure.[36] This study uses LandScan 2013 population data to make these calculations. Many countries face both high population growth and significant rural-to-urban migration. Both may increase the absolute number of people facing high exposure, particularly since port cities are often dynamic economic hubs that are home to growing populations and a growing number of migrants but that are also subject to storm surge and cyclone risks.

35 Koser 2012.
36 The complete set of calculations is available in Smith, Krishnan, and Busby 2016.

As Table 7 shows, more than 100 million people in China live in areas with *very high* climate exposure, defined here as areas that are four standard deviations or more above the global average for climate exposure. Bangladesh has more than 53 million people in *very high* climate exposure areas. India follows with more than 44 million people, and Vietnam and Indonesia round out the top five with more than 37 million and 26 million people, respectively. Other countries with large numbers of people facing *very high* climate exposure include the United States, Japan, the Philippines, Egypt, and Thailand.

TABLE 7: TOP 15 COUNTRIES OR TERRITORIES WITH LARGEST POPULATION IN VERY HIGH EXPOSURE AREAS

Country or Territory	Population	Country or Territory	Population	Country or Territory	Population
1. China	107,048,429	6. United States	24,176,175	11. Burma	8,003,903
2. Bangladesh	53,385,535	7. Japan	20,173,835	12. Netherlands	7,473,996
3. India	44,113,082	8. Philippines	19,134,979	13. Brazil	5,593,270
4. Vietnam	37,823,127	9. Egypt	13,730,433	14. Nigeria	4,502,705
5. Indonesia	26,376,281	10. Thailand	11,105,864	15. Cambodia	3,111,643

Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data source: Smith, Krishnan, and Busby 2016.

As Table 8 shows, the top 15 countries or territories with the highest percentage of their population facing *very high* exposure include a number of islands (Cayman Islands, Cocos Islands, Maldives, Turks and Caicos, Kiribati, U.S. Minor Outlying Islands, Northern Mariana Islands).[37] This group also includes two coastal countries in South America (Suriname, Guyana), two Middle Eastern countries (United Arab Emirates, Bahrain), the Netherlands, Vietnam, and Bangladesh. Bangladesh and Vietnam have both a large number of people and a high proportion of their populace facing *very high* exposure to climate hazards.

TABLE 8: TOP 15 COUNTRIES OR TERRITORIES WITH LARGEST SHARE OF POPULATION IN VERY HIGH EXPOSURE AREAS

Country or Territory	Pop. Share	Country or Territory	Pop. Share	Country or Territory	Pop. Share
1. Cayman Islands	88%	6. Maldives	45%	11. Kiribati	41%
2. Suriname	71%	7. Netherlands	45%	12. Vietnam	41%
3. Cocos Islands	70%	8. Turks and Caicos Isl.	44%	13. U.S. Minor Outlying Isl.	40%
4. Guyana	69%	9. Bahrain	44%	14. Bangladesh	33%
5. United Arab Emirates	47%	10. Marshall Islands	41%	15. Northern Mariana Isl.	32%

Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data source: Smith, Krishnan, and Busby 2016.

An alternative way to approach this is to examine the extent of a country's geographic area facing *very high* physical exposure. 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

37 As noted in Section 2.0 on methods, it is important to note that methodologies for aggregating and analyzing spatial data, including the methodologies used in this study, can sometimes obscure the reality of phenomena that have variation smaller than the pixel size used in the study. In the case of this study, some very small islands lack data for certain indicators, particularly those for chronic aridity and rainfall anomalies, which are aggregated to 0.5-degree grid squares (approximately 55 km by 55 km at the equator). This is the case for the Maldives, which consist of almost 1,200 small coral islands—the highest point of which is 2.4 meters above sea level. The Maldives are, therefore, highly exposed to sea-level rise. One might argue that 100 percent of the population is thus exposed. The country is perhaps less exposed to other potential climate hazards, or has exposure areas that are smaller than the pixel size used to aggregate exposure risk for these hazards, and thus the Maldives do not show up as having the highest exposure on this composite exposure measure. This is a good illustration of why it is important to consider the particular circumstances of unique locations rather than relying solely on the maps to indicate exposure.

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.[38]

Table 9 shows that, in terms of the countries or territories with the largest *numbers* of pixels in *very high* exposure areas, several large countries top the list. These include Russia, the United States, Canada, China, and India.

TABLE 9: TOP 15 COUNTRIES OR TERRITORIES WITH LARGEST NUMBER OF PIXELS IN VERY HIGH EXPOSURE AREAS

Country or Territory	# of Pixels	Country or Territory	# of Pixels	Country or Territory	# of Pixels
1. Russia	3,062,238	6. Brazil	428,953	11. Vietnam	238,381
2. United States	1,294,086	7. Indonesia	392,575	12. Philippines	210,059
3. Canada	692,984	8. Australia	377,925	13. Argentina	205,266
4. China	669,549	9. Mexico	278,758	14. Burma	163,197
5. India	453,569	10. Bangladesh	252,541	15. Bolivia	147,019

Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data source: Krishnan, Busby, and Smith 2016.

Table 10 shows that countries and territories with a large *proportion* of pixels in *very high* exposure areas include mostly small islands, as well as Bahrain, the Netherlands, and Bangladesh.

TABLE 10: TOP 15 COUNTRIES OR TERRITORIES WITH LARGEST PERCENTAGE OF PIXELS IN VERY HIGH EXPOSURE AREAS

Country or Territory	% of Pixels	Country or Territory	% of Pixels	Country or Territory	% of Pixels
1. Cayman Islands	70%	6. Kiribati	47%	11. Clipperton Island	35%
2. Turks and Caicos Isl.	64%	7. Bahrain	42%	12. British Ind. Ocean Terr.	29%
3. Bahamas	64%	8. Netherlands	41%	13. U.S. Minor Outlying Isl.	27%
4. Cocos Islands	50%	9. Tokelau	41%	14. British Virgin Islands	26%
5. Spratly Islands	50%	10. Bangladesh	35%	15. Seychelles	25%

Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.

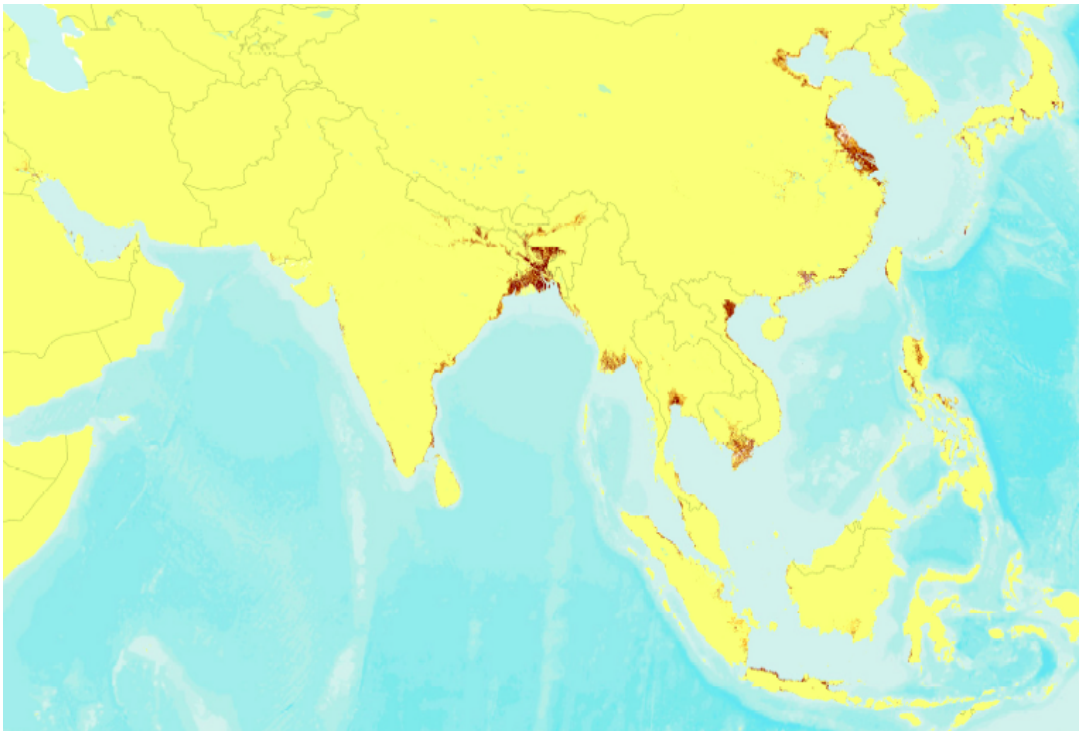
Data source: Krishnan, Busby, and Smith 2016.

Bangladesh is notable across all assessments, as it has a large absolute number of people highly exposed, a high proportion of its population highly exposed, a large land area highly exposed, and a high proportion of its area highly exposed. Vietnam and the Philippines face similar challenges.

Figures 9 through 11 show locations worldwide that have *very high* climate exposure. Though sub-Saharan Africa exhibits *high* exposure throughout the region (as Figure 8 shows)—and contains the majority of fragile states with large populations facing *high* exposure (as Table 4 shows)—the locations worldwide facing *very high* exposure are predominantly located in South and Southeast Asia; parts of the Americas, Europe, and North Africa; and islands around the world (as shown in tables 7-10 and figures 9-11). The countries in sub-Saharan Africa that do have sizable areas or populations facing *very high* exposure are Guinea-Bissau, Mauritania, Nigeria, and Sierra Leone (see tables 5-6).

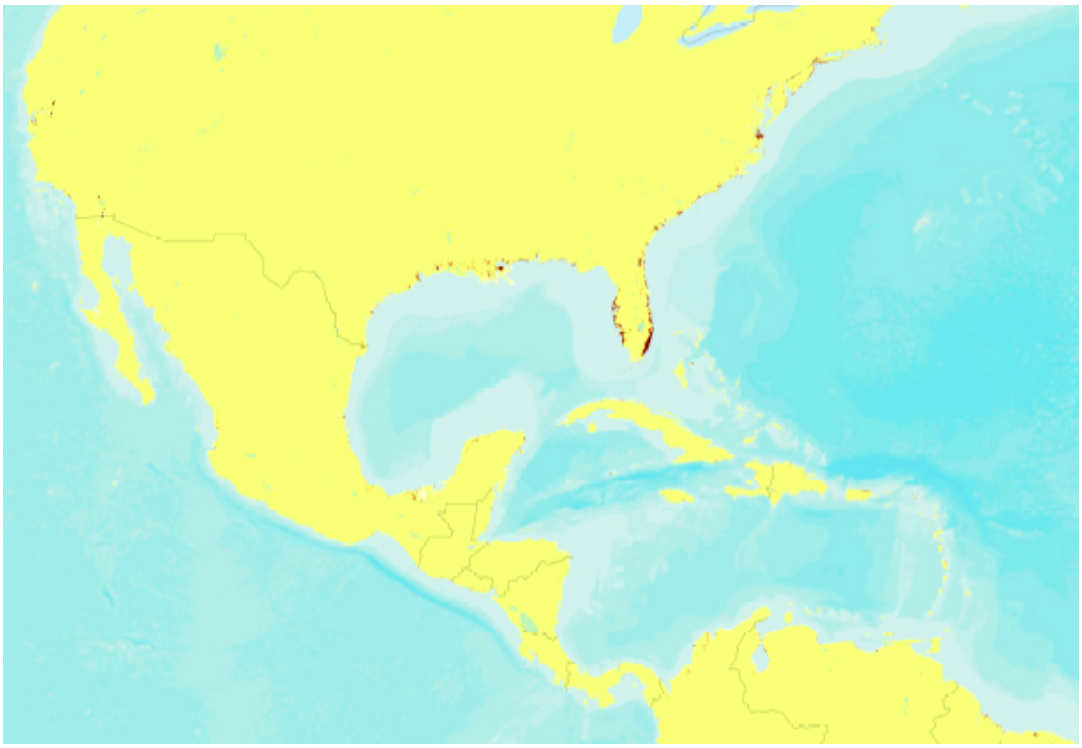
38 The complete set of calculations is available in Krishnan, Busby, and Smith 2016.

FIGURE 9: AREAS IN ASIA WITH VERY HIGH EXPOSURE



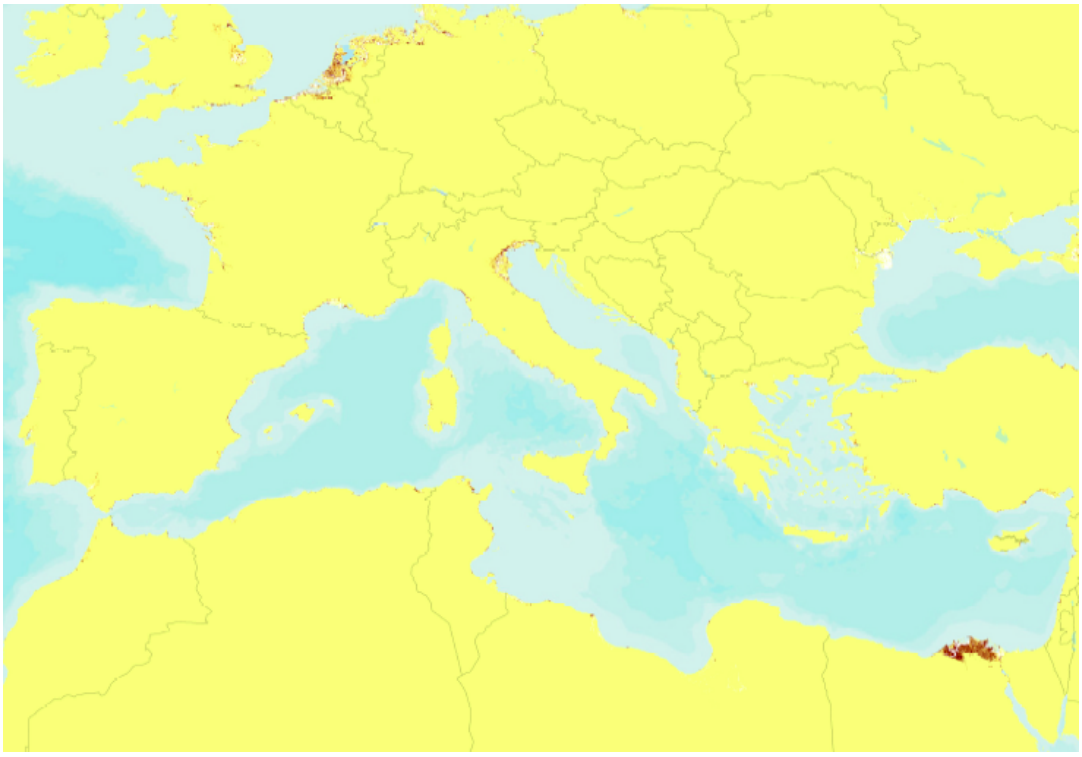
Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.
Data source: Krishnan, Busby, and Smith 2016.

FIGURE 10: AREAS IN THE AMERICAS WITH VERY HIGH EXPOSURE



Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.
Data source: Krishnan, Busby, and Smith 2016.

FIGURE 11: AREAS IN EUROPE AND NORTH AFRICA WITH VERY HIGH EXPOSURE



Note: "Very high exposure" areas are four standard deviations or more above the global mean exposure.
Data source: Krishnan, Busby, and Smith 2016.

While aggregate portraits of exposure are useful, it can also be helpful to examine the geographic distribution of exposure patterns for different hazards.

3.4.2 Rainfall Measures

This study includes two rainfall measures—one that captures areas that have experienced large negative deviations from historical levels and another that captures chronic aridity. While the former is perhaps more clearly related to anthropogenic climate change, areas that receive very little rainfall are already marginal for agriculture and human populations, so any perturbations in the normal climate are potentially very dangerous for the ability of populations to sustain productive activities.[39]

Negative Rainfall Anomalies

As Figure 12 shows, areas that have experienced the most severe negative rainfall deviations include much of western Brazil over the Amazon, extending to southeastern Peru and southern Colombia, as well as pockets in Chile extending down to the tip of South America. There are also pockets in southern Mexico, Honduras, and eastern Nicaragua.

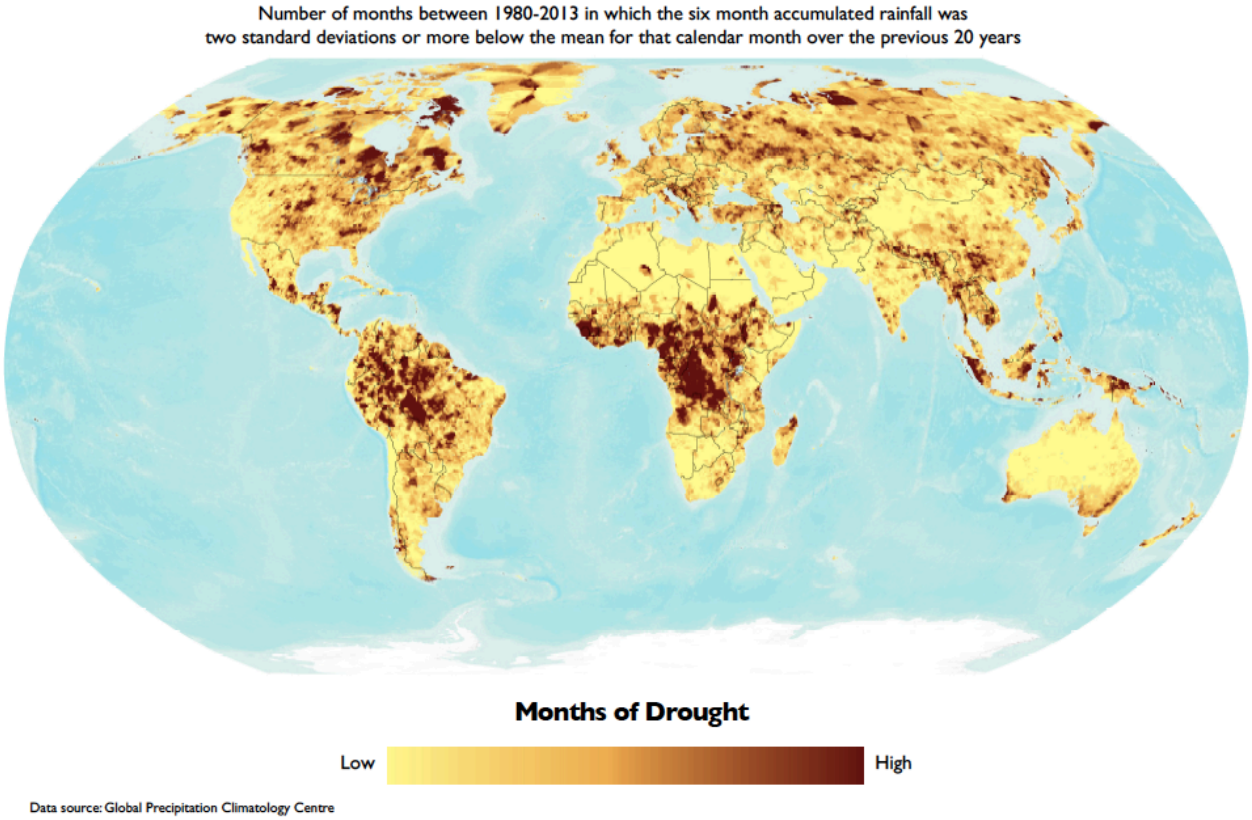
In Africa, the areas that have experienced these rainfall anomalies include much of the DRC—an area that is typically very wet. This underscores that this measure reflects large deviations from the normal rainfall patterns but is not itself a reflection of absolute water scarcity. It also captures areas that were very wet historically but have in recent years been less wet, whether moving from very high rainfall to high rainfall, or high rainfall to low rainfall. In Africa, this pattern of large negative rainfall anomalies extends from

39 The inclusion of chronic aridity in the climate exposure measure stems from the research team's previous research on Africa, where interviewees said semi-arid areas like northern Kenya were especially worrisome in the context of climate change.

Guinea in West Africa across Nigeria through much of Central Africa and across East Africa to Ethiopia and Eritrea.

In Asia, areas with large declines in rainfall include the South Caucasus, eastern Iraq, western Iran, much of Indonesia (especially Sumatra), Papua New Guinea, southern China, and pockets across South and Southeast Asia in Nepal, Bangladesh, eastern India, Burma, Laos, Cambodia, and Vietnam. In Latin America, areas with large rainfall declines include western Brazil, Colombia, and Peru. Further north, much of Canada and northern and western Russia also stand out as experiencing large negative rainfall deviations over the last several decades.

FIGURE 12: RAINFALL ANOMALIES



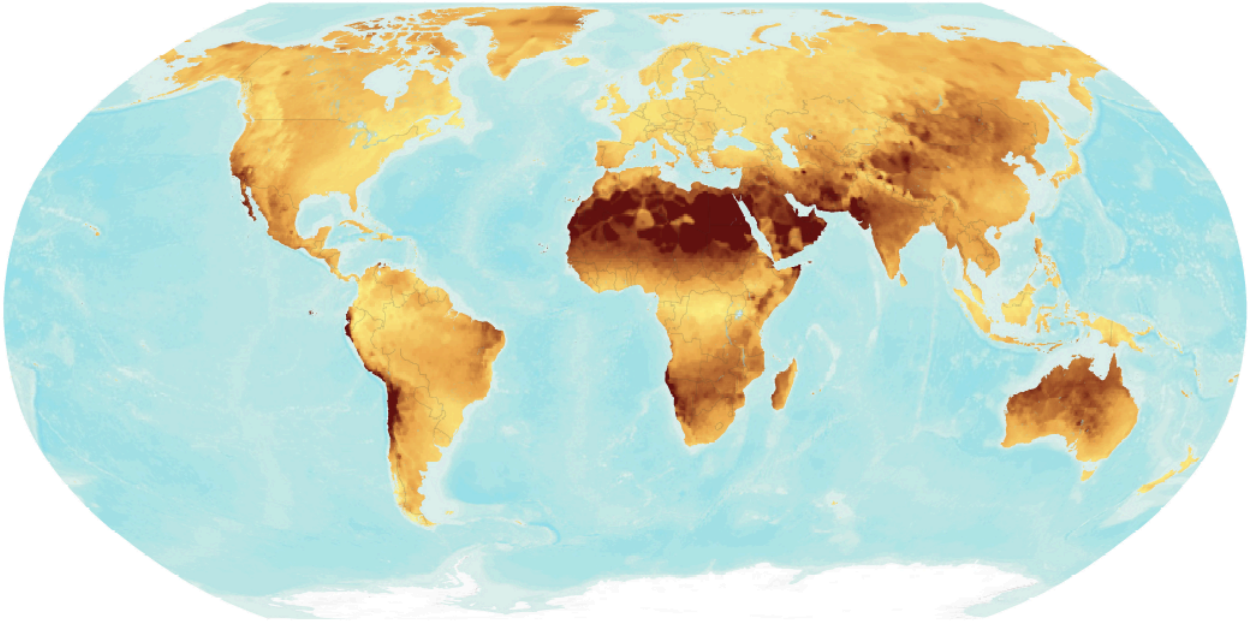
Chronic Aridity

Figure 13 shows the patterns for chronic aridity. Of particular interest are areas that receive very little rain but have some population. Deserts, for example, often are thinly populated or unpopulated over extensive parts of their range.

Most of the areas in Figure 13 that experience the highest levels of chronic aridity are deserts with sparse populations (as Figure 14 shows). These include: the Sahara, Libyan, and Sinai Deserts in North Africa; the Namib and Kalahari Deserts in southwestern Africa; the Sechur and Atacama Deserts along the west coast of South America; the Ad Dahna and Rub-Al-Khali Deserts in Saudi Arabia; the Sonoran, Mojave, and Chihuahuan Deserts in southern California and Mexico; the Thar Desert in Pakistan; several deserts in Central Asia, including the Gobi; and several deserts in Australia.

FIGURE 13: CHRONIC ARIDITY

Measured as the coefficient of variation based on monthly rainfall
(long-term standard deviation in rainfall divided by long-term mean rainfall) between 1980-2013. Low CV reflects places with consistent rainfall.
High CV reflects places with long periods of very little rain punctuated by short periods of high rainfall.

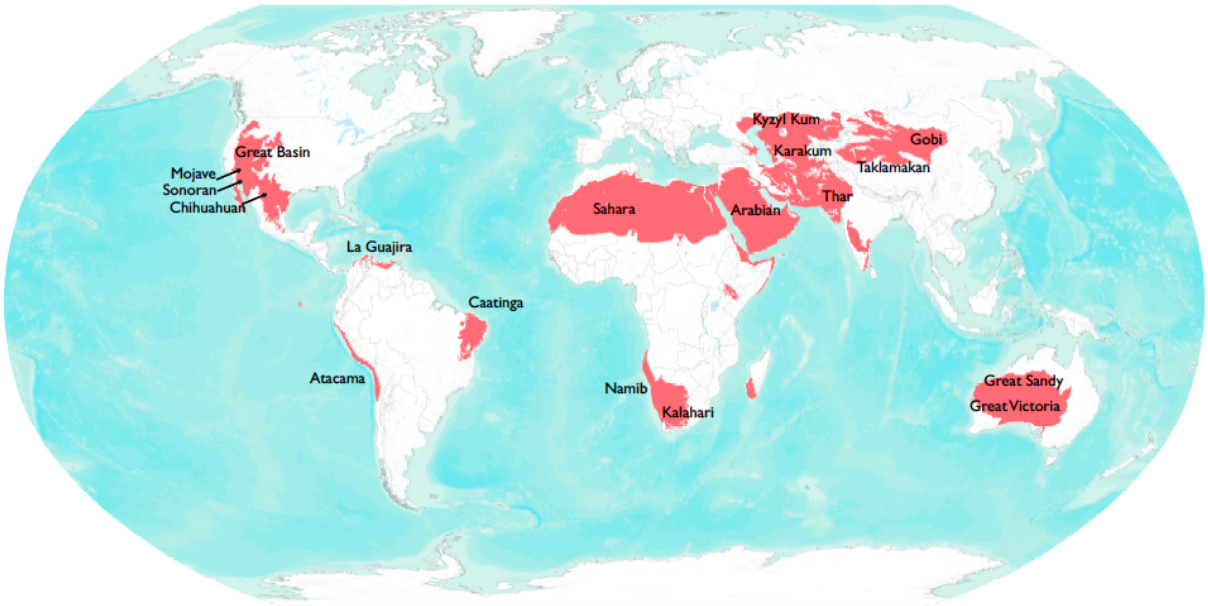


Coefficient of Variation (CV)

Low — High

Data source: Global Precipitation Climatology Centre

FIGURE 14: DESERTS CORRESPONDING WITH CHRONIC ARIDITY



Data source: The Nature Conservancy (Olson and Dinerstein 2002)

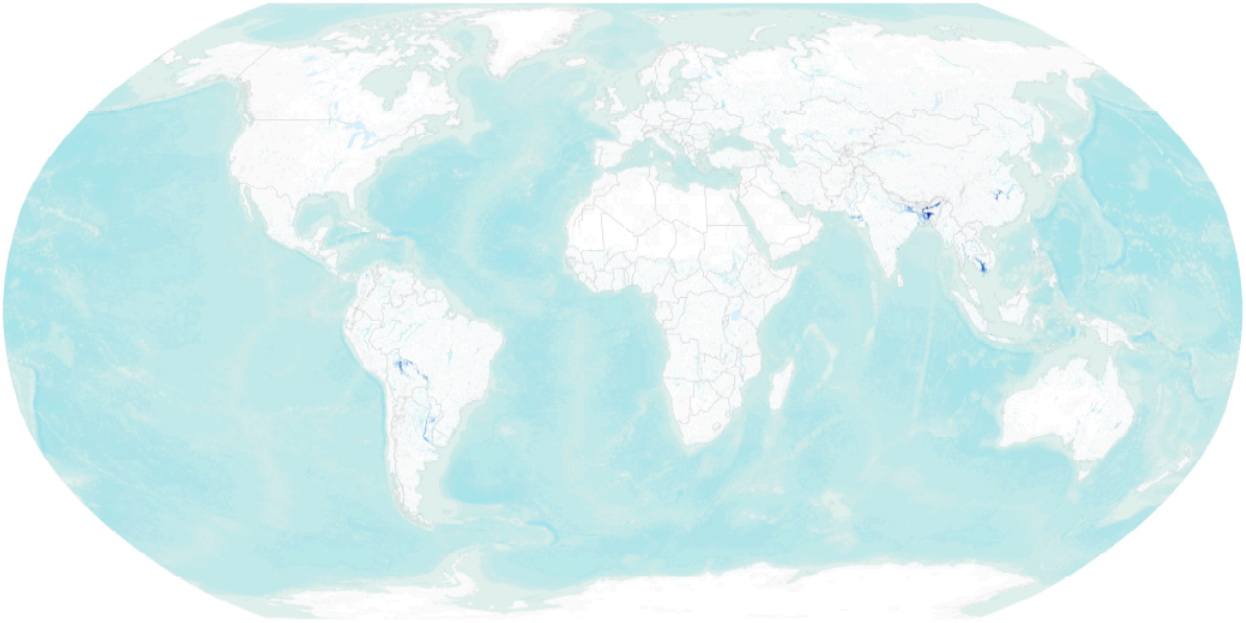
Other areas with relatively high chronic aridity that *do* have larger human populations include the Sahel band south of the Sahara that extends from Senegal in West Africa to Eritrea in East Africa, the arid and semi-arid lands in northern Kenya and southern Somalia and Ethiopia, the Nile River delta region in Egypt, population centers across the Middle East, southern Pakistan, and western India.

3.4.3 Floods

Beyond the two measures associated with rainfall, this study's exposure measure includes a third indicator to assess flood risk.[40] As Figure 15 shows, flood risks globally occur along a number of major rivers. These include the Mekong (Vietnam, Cambodia), Indus (Pakistan), Ganges river system (India, Bangladesh), Brahmaputra river system (eastern India, Bangladesh), Chao Phraya and its tributaries (Thailand), Yangtze (China), Rio Beni and Rio Mamore (Brazil, Bolivia), Parana (Argentina), and Pampanga on the island of Luzon (Philippines).

FIGURE 15: FLOOD EVENTS

Observed flood events for inland surface waters from 1999-2007 combined with a GIS model to scale the data to represent the estimated number of events per 100 years



Data source: UNEP/GRID-Europe

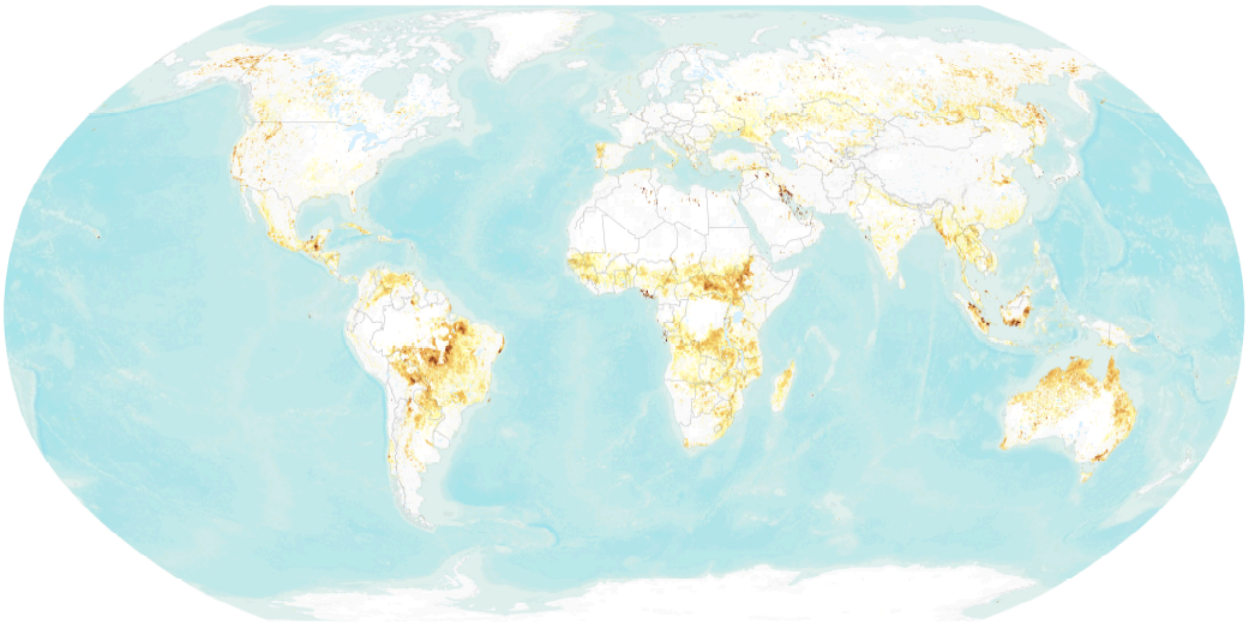
40 The flood indicator is derived by combining observed flood events from 1999 to 2007 with a GIS model using statistical estimation of peak-flow magnitude. It is scaled to represent the estimated number of flood events per 100 years. See Appendix A for a complete description of the flood indicator.

3.4.4 Wildfires

The fourth indicator in this study's climate exposure measure is an indicator assessing wildfire risk. As Figure 16 shows, notable hotspots for wildfires are found in Australia, Asia, the Americas, and sub-Saharan Africa. In Asia, Indonesia (Kalimantan and Sumatra) and Burma see the highest levels of wildfire activity. In the Americas, central Brazil, eastern Bolivia, Guatemala, southern Mexico, and pockets in the western United States stand out as having high exposure to wildfires. In sub-Saharan Africa, areas of high wildfire frequency include the southern part of DRC, South Sudan, the Central African Republic, and western Ethiopia, and southern Nigeria. There are several off-shore wildfire readings that come from natural gas flaring, particularly off the coast of West Africa and in the Persian Gulf.

FIGURE 16: WILDFIRE EVENTS

Estimated number of events per year per pixel for the period 1995-2011



Data source: UNEP/GRID-Europe

3.4.5 Cyclones

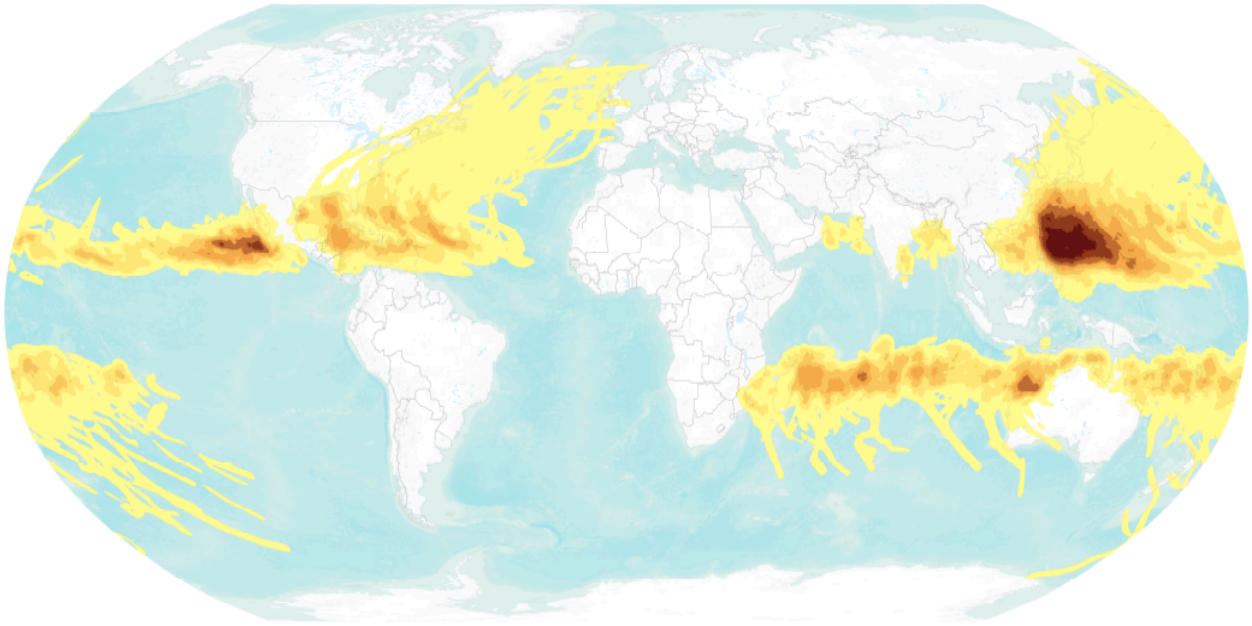
The fifth indicator in this study's exposure measure is an indicator assessing cyclone risk. As Figure 17 shows, the areas of historically high cyclone exposure in Southeast Asia include areas just east of the Philippines—encompassing a number of smaller islands like Guam, Marshall Islands, Micronesia, and Palau—and extend to Hong Kong, Taiwan, Vietnam, Japan, South Korea, and North Korea. Other areas at risks of cyclones in Asia include eastern coastal India, from the city of Chennai up to Odisha state, extending across the Bay of Bengal to Bangladesh and Burma. Areas in western India in Gujarat state extending across the Sir Creek to southern coastal Pakistan are also at high cyclone risk.

In Africa, high cyclone risks are located off the eastern coast, with Madagascar and Mozambique being notable hotspots. In the Atlantic, cyclone risks exist along the coast of the United States, from Florida

north to New York and Canada.[41] Cyclones risks are extensive throughout the Gulf of Mexico and the Caribbean, including island countries such as Haiti, the Dominican Republic, Cuba, and Jamaica. Cyclone exposure extends across to Cancún in Mexico, the states of Quintana Roo and the Yucatán. On the western side of Mexico, the Puerto Vallarta area is also subject to cyclones.

FIGURE 17: CYCLONES

Average sum of winds measured as frequency and speed of cyclone events over oceans and land for the period 1970-2009



Data source: UNEP/GRID-Europe

3.4.6 Low-Elevation Coastal Zones

Cyclone risks are not the only source of coastal exposure. Low-elevation coastal zones are subject to sea surge from storms and will become increasingly at risk from sea-level rise. This measure maps areas from 0 to 10 meters above sea level as a gauge of risk from coastal inundation. As Figure 18 shows, these small pockets are scarcely visible on global maps, but reflect key areas of risk for these countries.[42]

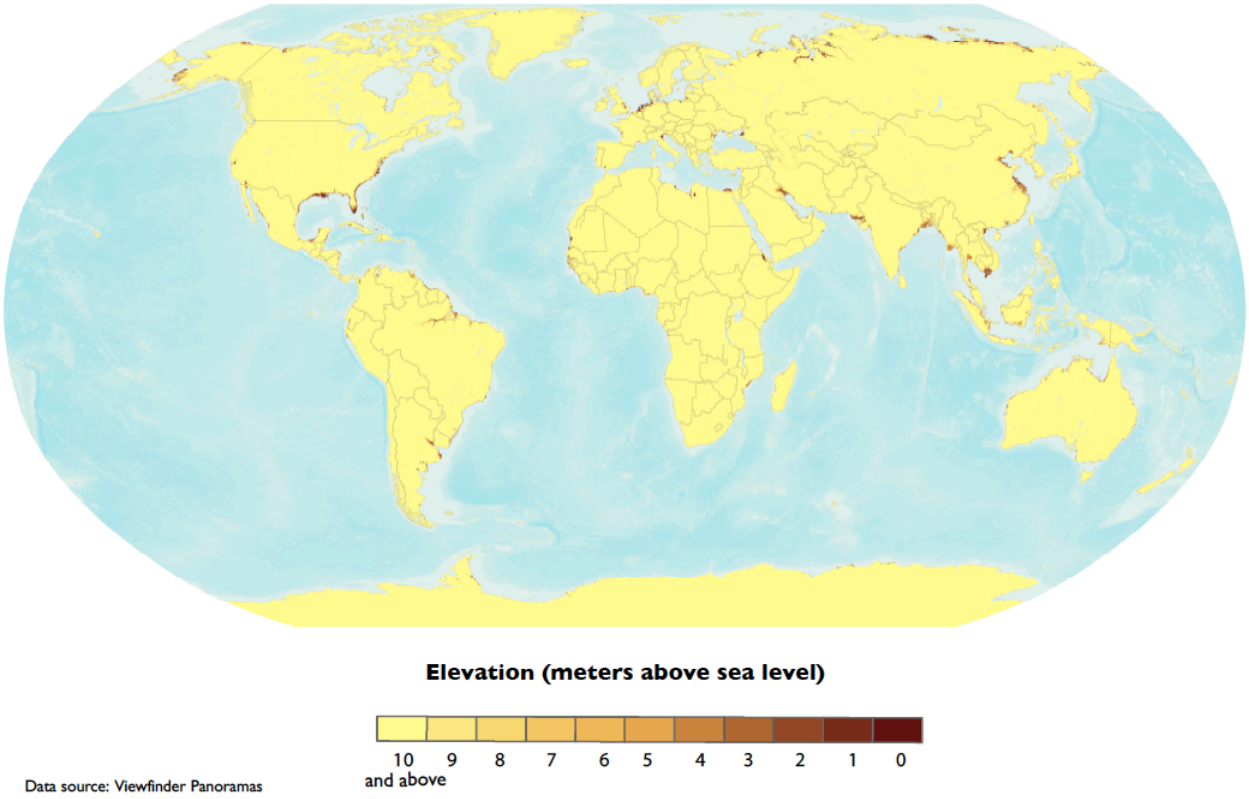
Notable areas for this type of climate risk in the Americas include a number of areas in the United States, including Florida (including the city of Miami), the Gulf Coast (including New Orleans), and much of the Eastern seaboard (including the city of New York); pockets along the eastern coast of Mexico and Central America; and pockets along the northern coast of South America and eastern Argentina. In Europe, the Netherlands (including Amsterdam and The Hague), Germany (including Hamburg and Bremen), and Poland (Gdansk) are notable areas at high levels of risk. In Africa, coastal Mozambique, the Nile River delta in Egypt, the Niger Delta in Nigeria, and the coast of Mauritania stand out as areas of high risk of coastal

41 For good maps of Atlantic Coast cyclone risks dating back to the 1850s, see Livingston 2015.
42 For interactive maps of different sea-level rise configurations, see http://geology.com/sea-level-rise.

inundation. In the Middle East, areas at particular risk of coastal inundation are in the northern Persian Gulf in southern Iraq (including Basra), Kuwait, and the western tip of Iran.

In Asia, notable areas include southern Pakistan (Sindh province), parts of eastern India near Bangladesh (in the state of West Bengal), most of Bangladesh, southern Burma (in the Ayeyarwady region), coastal Thailand (around Bangkok), the Mekong Delta (including Ho Chi Minh City) and northern coast (around the city of Haiphong) in Vietnam, eastern coastal China (around the city of Tianjin, coastal Shandong province, and the cities of Shanghai and Guangzhou), Indonesia (near the city of Jakarta), and pockets of the northern coast of Russia.

FIGURE 18: LOW-ELEVATION COASTAL ZONES



3.5 Global Fragility Patterns

While Section 3.1 explores findings on the intersection of fragility and climate risks worldwide, this section presents findings on the key underlying fragility dynamics. It highlights fragility patterns and trends seen worldwide and in key regions experiencing increases or decreases in fragility over the last 15 years.[43]

3.5.1 General Patterns and Trends in Fragility

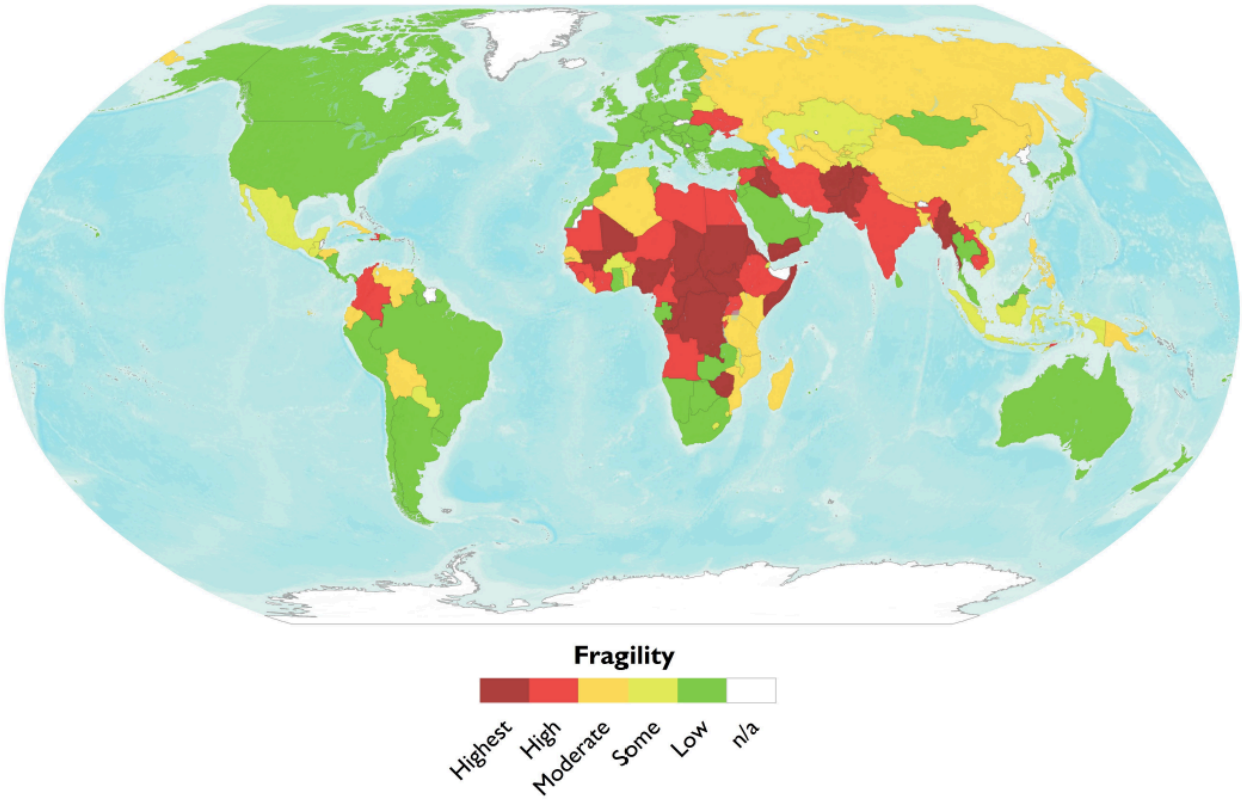
The highest levels of fragility are most prevalent today in sub-Saharan Africa and across southern Asia stretching from the Middle East to southeast Asia. Of the 16 states with the *highest* fragility levels, 11 are located in sub-Saharan Africa, two in the Middle East, and three across Southwest, South, and Southeast Asia (see figures 2 and 19). In sub-Saharan Africa, these are the Central African Republic, Chad, DRC,

43 See Section 2.2 and Appendix B for a detailed discussion of the indicators and process used to create this study's fragility measure. The complete set of fragility scores and raw data is available in Kishi and Linke 2016.

Eritrea, Mali, Nigeria, Republic of the Congo, Somalia, South Sudan, Sudan, and Zimbabwe. In the Middle East, these are Iraq and Yemen. Stretching eastward across southern Asia, these are Afghanistan, Pakistan, and Burma.

Of the 23 states with *high* fragility, 11 are in sub-Saharan Africa (Angola, Burundi, Cameroon, Cote d'Ivoire, Equatorial Guinea, Ethiopia, Guinea, Guinea-Bissau, Niger, Sierra Leone, Uganda), four are in South and Southeast Asia (Cambodia, India, Laos, Timor Leste), three are in North Africa (Egypt, Libya, Mauritania), two are in the Middle East (Iran, Syria), two are in Latin America and the Caribbean (Colombia, Haiti), and one is in Eurasia (Ukraine). These are shown in figures 3 and 19.

FIGURE 19: TOTAL FRAGILITY (2014)



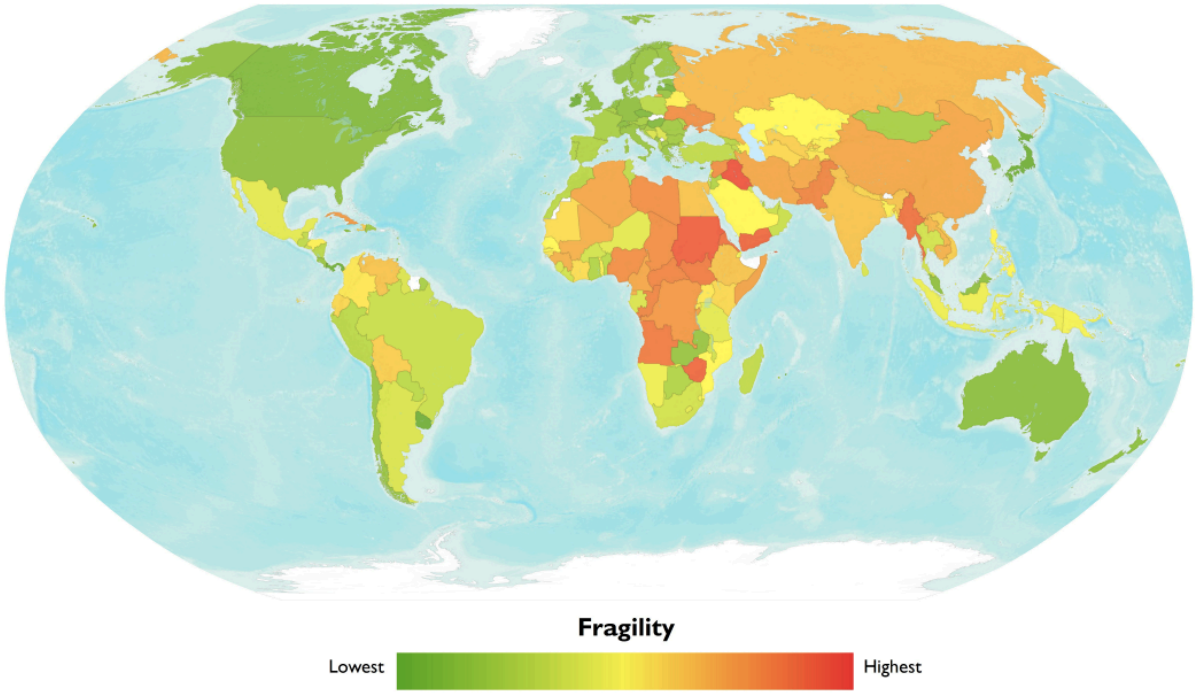
Data sources: 2014 data from Center for Systemic Peace; CIA; Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Political Instability Task Force; Marshall, Gurr, and Jaggers; U.S. Committee for Refugees and Immigrants; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

Note: All Central Intelligence Agency (CIA) data included in this study's fragility measure and reflected in this report's maps are unclassified data from the CIA World Factbook.

Across all levels of fragility, countries have, on average, larger deficits in legitimacy than in capacity.[44] In other words, deficits in the legitimacy of the state—reflecting public perceptions that the state is unwilling or unable to meet public needs—contribute more to the fragility of states, on average, than do capacity deficits. This is true in *every* fragility category, from the least fragile states to the most, as shown in figures 20 and 21 and Table 11. This is a key consideration in assessing potential responses in states with compound fragility-climate risks. Since fragility is composed more of deficits in state legitimacy, in states that have high fragility and climate risks, state actions that respond to public needs for reducing climate vulnerabilities could have the dual effect of reducing both climate risks and fragility simultaneously.

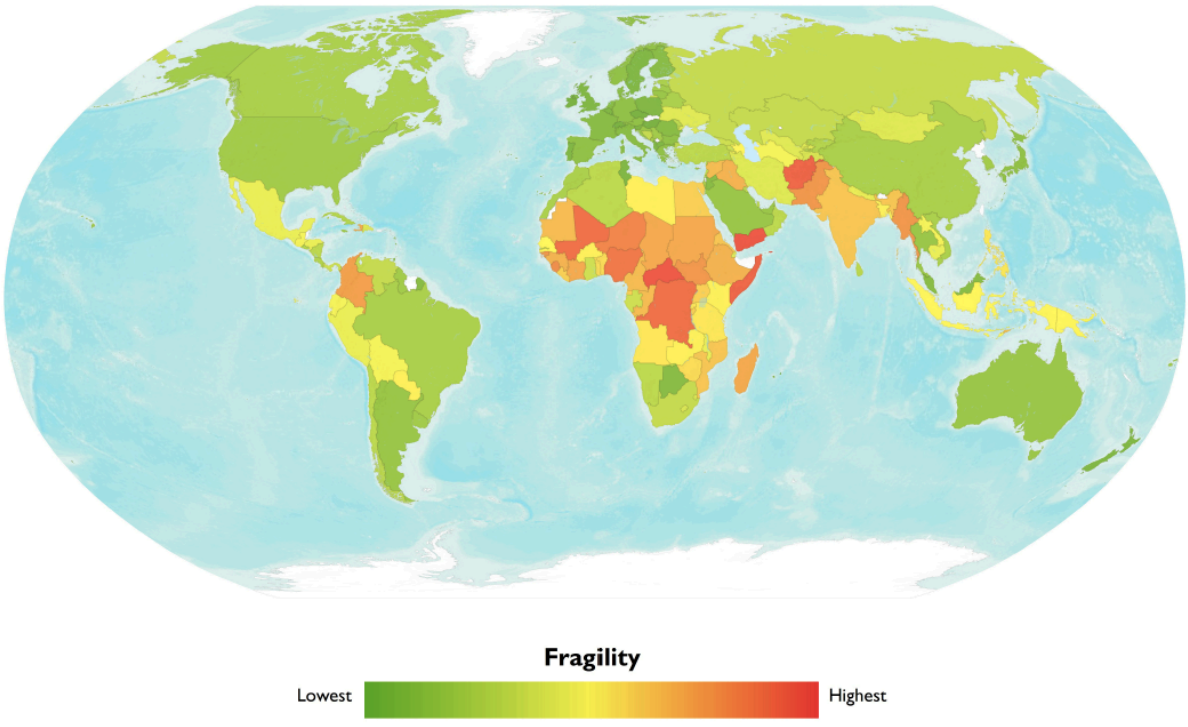
44 For examples of this trend, see this study's Bangladesh and Nigeria reports in Moran et al. 2018a and Moran et al. 2018c.

FIGURE 20: TOTAL LEGITIMACY (2014)



Data sources: 2014 data from Gibney et al.; Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; Pilster and Böhmelt; Marshall, Gurr, and Jaggers; World Bank; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 21: TOTAL EFFECTIVENESS (2014)



Data sources: 2014 data from Center for Systemic Peace; CIA; Kaufmann, Kraay, and Mastruzzi; Political Instability Task Force; U.S. Committee for Refugees and Immigrants; World Bank

While fragility in states at *all* levels of fragility stems more from poor legitimacy, legitimacy has been steadily declining over time in today's fragile states, but not in states with *low* fragility. For states falling in the *low* fragility category today, their *legitimacy* scores have been steadily improving over the last 15 years, as Table 11 shows. These states with *low* fragility today have thus been making steady, sustained gains in building social capital and strengthening the social compact between the state and society. On the other hand, for states falling in the top four fragility categories today, their legitimacy deficits have been steadily growing over the last 15 years, as Table 11 shows.

Further, for states in the *highest* fragility category today, their effectiveness deficits have *also* been steadily rising over the last 15 years.[45] While it is intuitive that the most fragile states would have deficits across the board—in both the legitimacy and effectiveness of the state—this finding reflects two important points. First, fragility is the result of slow-moving trends where declines across multiple spheres slowly accumulate. Second, this trend seen in today's *highest* fragility states—whereby both legitimacy *and* effectiveness deficits have been growing over the last 15 years—is not seen for any other fragility category. Instead, in states with *high*, *moderate*, and *some* fragility, the growing legitimacy deficits seen in these states over the last 15 years have been offset somewhat by commensurate improvements in state effectiveness, as Table 11 shows.

TABLE 11: CHANGES OVER TIME IN TODAY'S FRAGILE STATES

2014 Fragility Category (# of countries)	*Legitimacy Deficits*		*Effectiveness Deficits*	
	Avg. Score in Category 2014	% Change 2000-2014	Avg. Score in Category 2014	% Change 2000-2014
Highest fragility states (15)	31.7	↑20.6%	26.5	↑13.8%
High fragility states (23)	23.2	↑1.9%	19.8	↓1.3%
Moderate fragility states (23)	19.5	↑14.6%	14.2	↓14.6%
Some fragility states (17)	14.9	↑2.4%	11.6	↓14.0%
Low fragility states (80)	6.8	↓13.7%	4.8	↑2.1%

Note: South Sudan is in the *highest* fragility category in 2014, but it is excluded from this table since it does not have a fragility score for the year 2000 prior to its establishment as a country. The total number of *highest* fragility states in 2014 is thus 16 countries.

Data source: Kishi and Linke 2016.

3.5.2 Regional Patterns and Trends in Fragility

In regions that saw *decreasing* state fragility over the last 15 years—East Africa, West Africa, Southeast Asia, Eurasia, and Central and Eastern Europe—most of these improvements came from improved overall *effectiveness* scores.[46] While these regions show markedly different patterns in which specific aspects of state effectiveness and legitimacy improved or declined over the last 15 years, all saw improvements in the average *economic effectiveness* scores of states in the region.[47] Likewise, all of these regions except Eurasia saw improved average *security legitimacy* scores for states in the region.[48]

45 For an example of this trend, see this study's report on Nigeria in Moran et al. 2018c.

46 See Appendix F for countries included in each region discussed in this section.

47 As noted in the introduction, this study's fragility measure assesses fragility in state effectiveness and legitimacy in four key spheres: political, security, economic, and social. The measure can thus be used to track changes seen in eight dimensions of the state: *political effectiveness*, *security effectiveness*, *economic effectiveness*, *social effectiveness*, *political legitimacy*, *security legitimacy*, *economic legitimacy*, and *social legitimacy*. Appendix B details the components of these eight dimensions, and Section 6.0 provides maps of these eight dimensions for 2014. *Economic effectiveness* includes indicators of GDP per capita, poverty headcount ratio, and primary commodity exports.

48 *Security legitimacy* includes indicators of state use of political terror, the presence of militant groups against the state, and the number of rivaling military organizations.

As Table 12 shows, countries in East Africa have among the highest average fragility scores but saw substantial improvements in these scores, which decreased on average by 8.3 percent from 2000 to 2014. These improvements came mostly from improved state *effectiveness* scores and to a lesser extent from improved *legitimacy* scores. A similar trend is seen in West Africa, though countries in West Africa on average started with slightly better—though still high—fragility scores and saw a slightly smaller improvement than countries in East Africa.

At mid-tier levels of fragility, countries in Southeast Asia and Eurasia decreased their overall fragility through gains in state *effectiveness* scores, but these countries did so even in the face of worsening state *legitimacy* scores, as Table 12 shows. In Eurasia, the stand-out sub-region for improvement is the South Caucasus—Armenia, Azerbaijan, and Georgia—which saw an average improvement in overall fragility of 19.3 percent from 2000 to 2014, driven by large gains in state *effectiveness* scores.

Central and Eastern Europe is the only outlier in this trend of effectiveness gains generally outstripping legitimacy gains in regions where fragility decreased over the last 15 years. Countries in Central and Eastern Europe have, on average, among the lowest fragility scores globally and saw the largest percentage improvement in their average fragility scores, which decreased by 34.4 percent from 2000 to 2014 (see Table 12). But unlike other regions in this group, Central and Eastern Europe made these gains not only from large improvements in state *effectiveness* scores but from even larger improvements in state *legitimacy* scores.

TABLE 12: REGIONS DECREASING IN FRAGILITY FROM 2000 TO 2014

Region	*Total Fragility* Avg. Score in Region 2014	*Total Fragility* % Change 2000-2014	*Legitimacy Deficits* % Change 2000-2014	*Effectiveness Deficits* % Change 2000-2014
East Africa	43.1	↓8.3%	↓1.9%	↓14.8%
West Africa	37.6	↓3.1%	↓0.4%	↓5.3%
Southeast Asia	30.2	↓3.2%	↑1.7%	↓9.7%
Eurasia	28.2	↓8.9%	↑0.9%	↓22.2%
Central and Eastern Europe	8.6	↓34.4%	↓37.5%	↓27.8%

Note: The range of observed *total fragility* scores for all countries in 2014 is 0–69. Regional averages weight each country score equally.
Data source: Kishi and Linke 2016.

In regions that saw *increasing* fragility over the last 15 years—North Africa, the Middle East, Southern Africa, South America, and Central America—most of these changes came from worsening state *legitimacy* scores. While these regions differed in which aspects of state effectiveness and legitimacy improved or declined, all saw substantial worsening of average *security legitimacy* scores of states in the region.

As Table 13 shows, countries in North Africa, the Middle East, and South America have seen the highest increases in fragility, which increased on average in each region by 19.6 percent, 18.7 percent, and 17.4 percent, respectively, from 2000 to 2014. Increasing fragility in North Africa, South America, and Southern Africa has been composed mostly—or, in the case of Southern Africa, solely—of worsening state *legitimacy* scores. Increasing fragility in the Middle East has been composed in equal parts of worsening state *legitimacy* and *effectiveness* scores.

Central America is the only outlier in this trend of legitimacy deficits contributing more to fragility than effectiveness deficits in regions where fragility increased over the last 15 years. Countries in Central America saw, on average, a substantial increase in their fragility scores, which rose by an average of 11.9

percent from 2000 to 2014, as Table 13 shows. But unlike the other regions in this group, Central America's worsening fragility was due more to worsening *effectiveness*-deficit scores.

TABLE 13: REGIONS INCREASING IN FRAGILITY FROM 2000 TO 2014

Region	*Total Fragility* Avg. Score in Region 2014	*Total Fragility* % Change 2000-2014	*Legitimacy Deficits* % Change 2000-2014	*Effectiveness Deficits* % Change 2000-2014
North Africa	31.5	↑19.6%	↑29.7%	↑6.0%
Middle East	29.3	↑18.7%	↑18.7%	↑18.7%
Southern Africa	24.9	↑1.9%	↑5.1%	↓1.5%
South America	23.9	↑17.4%	↑19.8%	↑14.6%
Central America	18.8	↑11.9%	↑5.9%	↑18.0%

Note: The range of observed *total fragility* scores for all countries in 2014 is 0–69. Regional averages weight each country score equally.
Data source: Kishi and Linke 2016.

Two regions—Central Africa and South Asia—have among the highest average fragility scores and saw minimal change in these scores over the last 15 years. In both of these regions, improvements in state *effectiveness* scores were offset by worsening state *legitimacy* scores, as Table 14 shows.

TABLE 14: REGIONS WITH MINIMAL CHANGE IN FRAGILITY FROM 2000 TO 2014

Region	*Total Fragility* Avg. Score in Region 2014	*Total Fragility* % Change 2000-2014	*Legitimacy Deficits* % Change 2000-2014	*Effectiveness Deficits* % Change 2000-2014
Central Africa	48.9	↑0.5%	↑7.4%	↓7.2%
South Asia	41.2	↑0.8%	↑3.9%	↓2.6%

Note: The range of observed *total fragility* scores for all countries in 2014 is 0–69. Regional averages weight each country score equally.
Data source: Kishi and Linke 2016.

4.0 CONCLUSION

This study has sought to identify the locations where fragility and climate risks intersect around the world. This identifies fragile states where the size of population or territory exposed to climate risks may exceed the state capacity and social capital needed to respond. But this study also identifies states with compound fragility-climate risks that have been steadily *improving* state capacity and, with it, their chances of being able to implement curative policies in the spheres where that capacity has grown. Across nearly all of these states with high compound risks, however, state legitimacy remains poor and is thus a key area that must improve or risk contributing to future instability.

Compound fragility-climate risks can heighten the insecurity of populations by increasing their vulnerability to humanitarian crises and instability. During humanitarian emergencies, compound fragility-climate risks can pose a direct risk to survival if exposure to climate hazards escalates into a disaster due to fragile states' insufficient capacity or willingness to respond to the needs of their populace. Within this context of overlapping risks, several factors are critical to understanding how future instability could occur either as political instability or, in the worst case, the breakout of armed conflict.[49] First, future instability may be characterized less by large-scale battles between organized groups and more by increasing disorder that is low-level, persistent, and diffuse, perpetuated by agents ranging from the local to the international. Second, it is thus key to determine the links between local groups, their operations, and their relationships to larger national or international groups. This sheds light on the landscape of instability that can be expected in that location and country. Third, it is key to distinguish between the goals and constraints of the various groups (including the state) and how these tie into this local landscape of instability. Lastly, if state or international actors can improve the lives of those at the very bottom of a society, the resilience of extreme ideologies and the recourse to conflict diminish. These will not go away, however, and they can be repurposed and recycled into different, less volatile forms of instability that emerge in competition between elites, for example around elections and the selection of government officials.

In the near term, analysts should expect more instability due to the increasing number of political transitions and challenges to power as well as those likely to happen in the future. The risks of instability in particular states are embedded in forms of governance and political competition locally, nationally, and regionally—all of which can be affected by the strains that climate stress and fragility can place on people and their governments. This study has sought to identify key global fragility and climate patterns and country-specific risks to inform assessments of how these dynamics coalesce to foster instability, strain state capacity, and undermine human security. It is hoped that the measures and metrics developed here provide new tools for assessing the intersection of fragility and climate risks and for identifying the distinct fragility and climate patterns in states that present opportunities and focal points for intervention.

49 For examples of how compound fragility-climate risks contribute to instability, see this study's reports on Bangladesh, Colombia, and Nigeria in Moran et al. 2018a, Moran et al. 2018b, and Moran et al. 2018c.

5.0 SUPPLEMENTAL MATERIALS: 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.

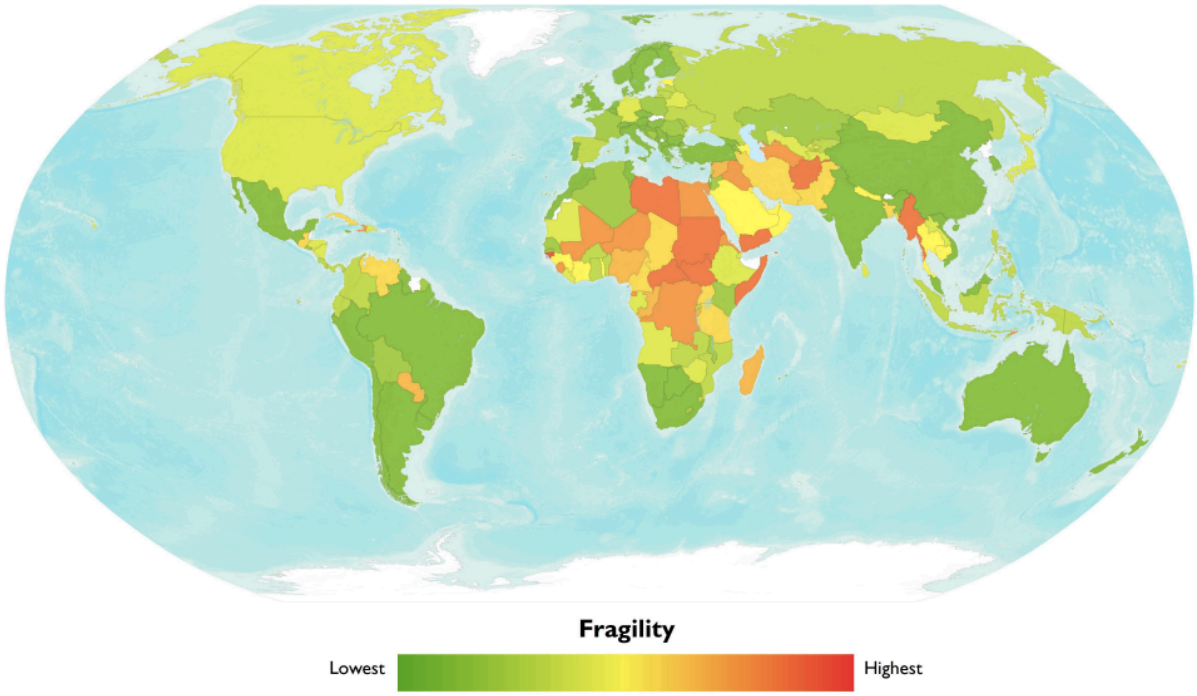
Roudabeh Kishi and Andrew Linke. 2016. *Global Fragility Dataset*, Produced for USAID Office of Conflict Management and Mitigation. Austin: Robert Strauss Center for International Security and Law.

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.

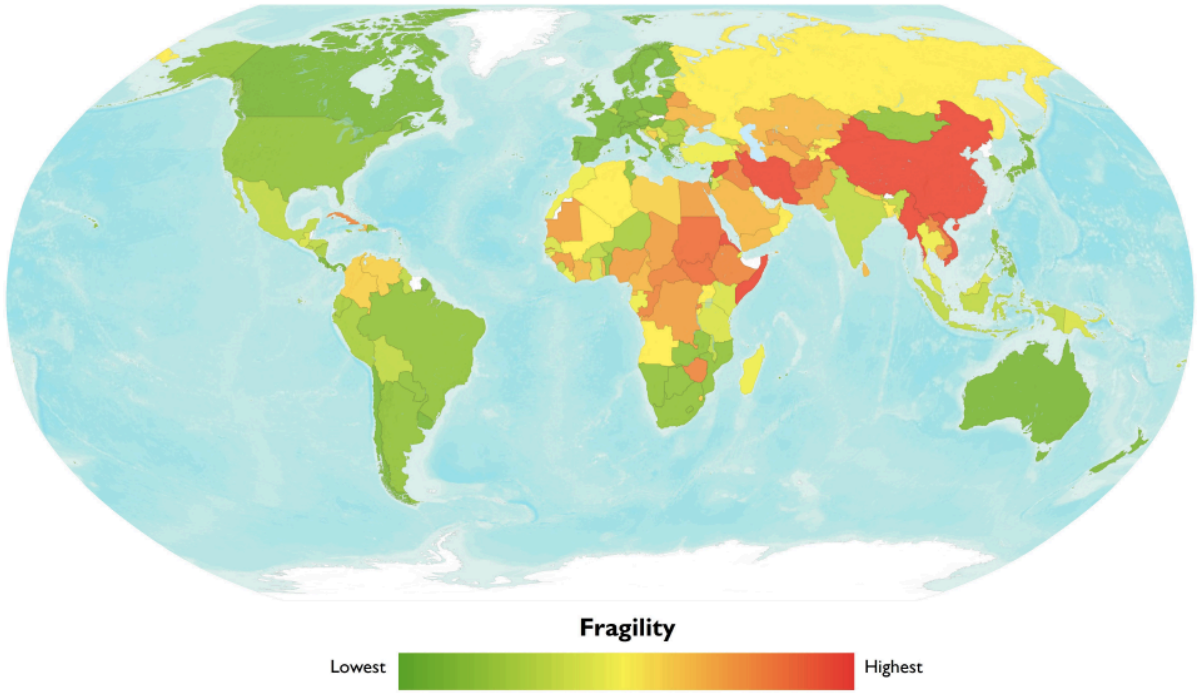
6.0 SUPPLEMENTAL MAPS: DIMENSIONS OF FRAGILITY

FIGURE 22: POLITICAL EFFECTIVENESS (2014)



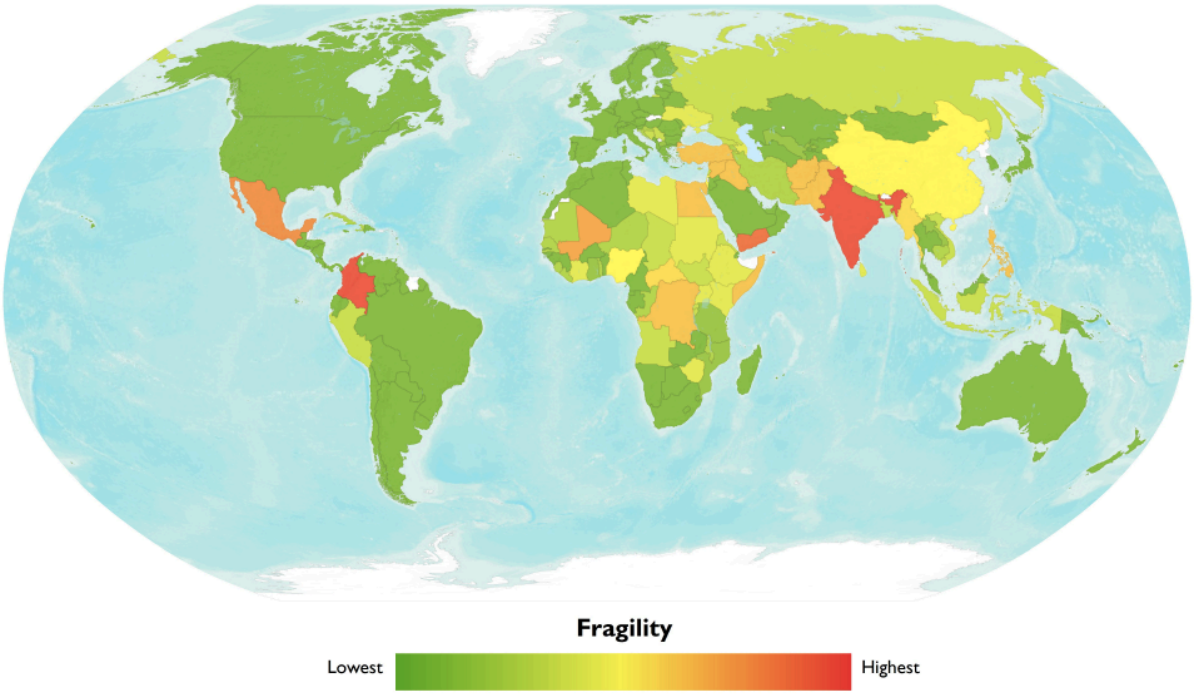
Data sources: 2014 data from Center for Systemic Peace; CIA; Kaufmann, Kraay, and Mastruzzi; World Bank

FIGURE 23: POLITICAL LEGITIMACY (2014)



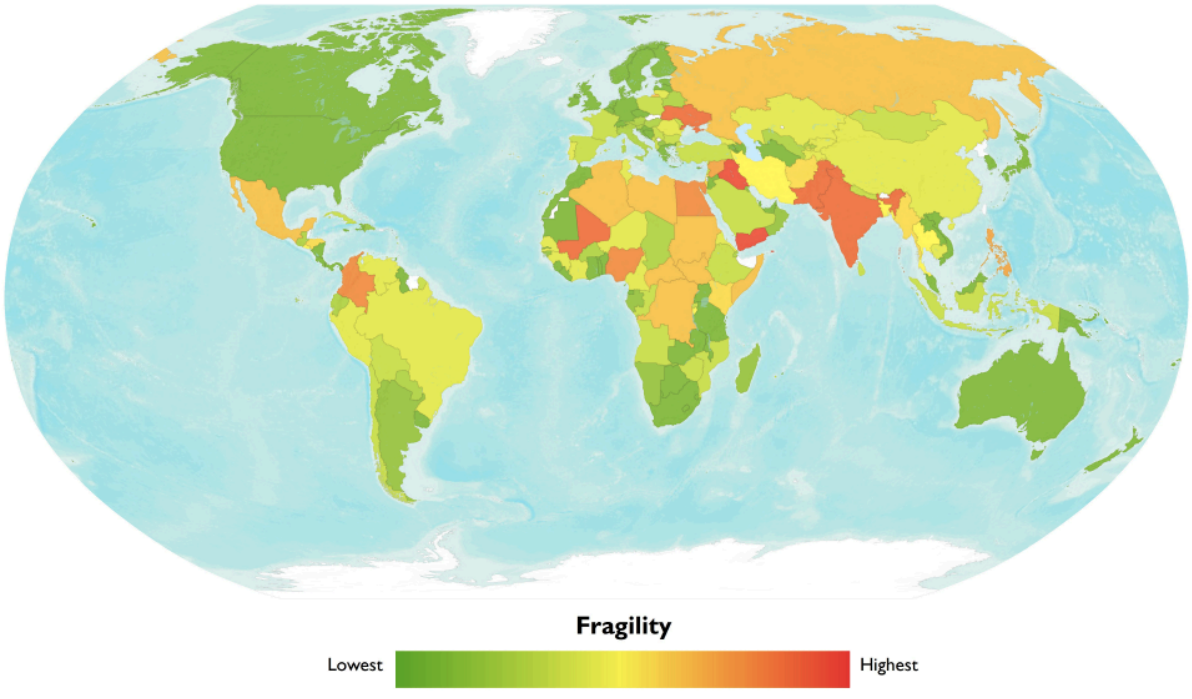
Data sources: 2014 data from Kaufmann, Kraay, and Mastruzzi; Marshall, Gurr, and Jaggers; World Bank

FIGURE 24: SECURITY EFFECTIVENESS (2014)



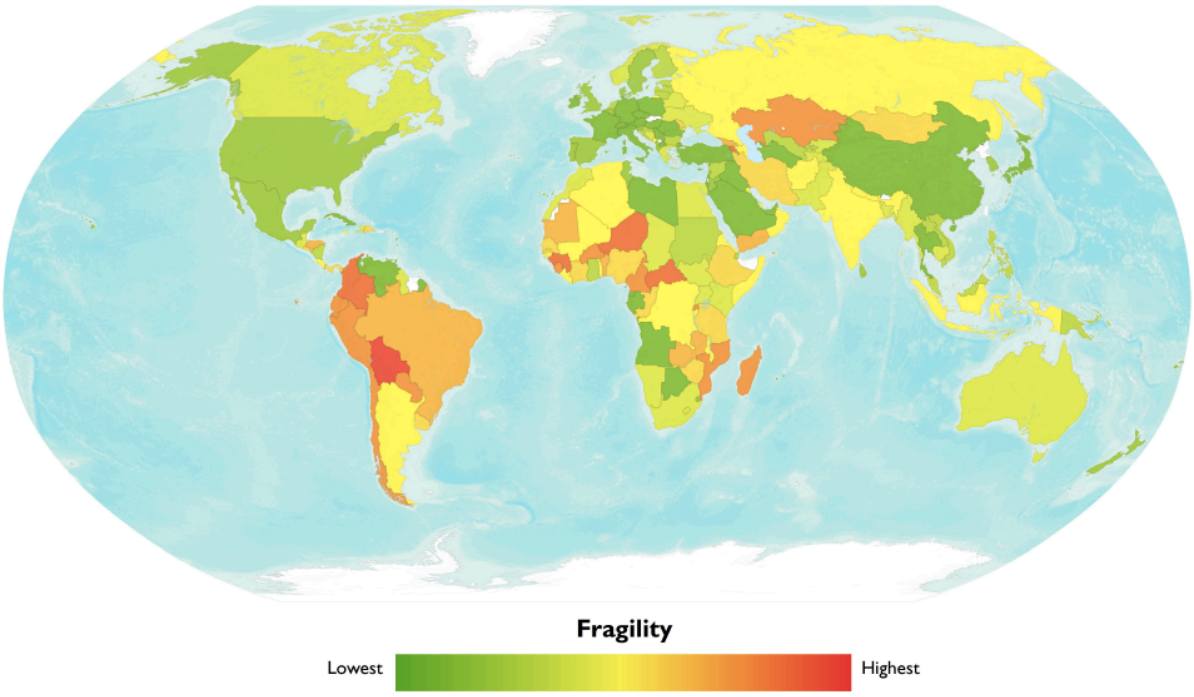
Data sources: 2014 data from Center for Systemic Peace; Political Instability Task Force; U.S. Committee for Refugees and Immigrants

FIGURE 25: SECURITY LEGITIMACY (2014)



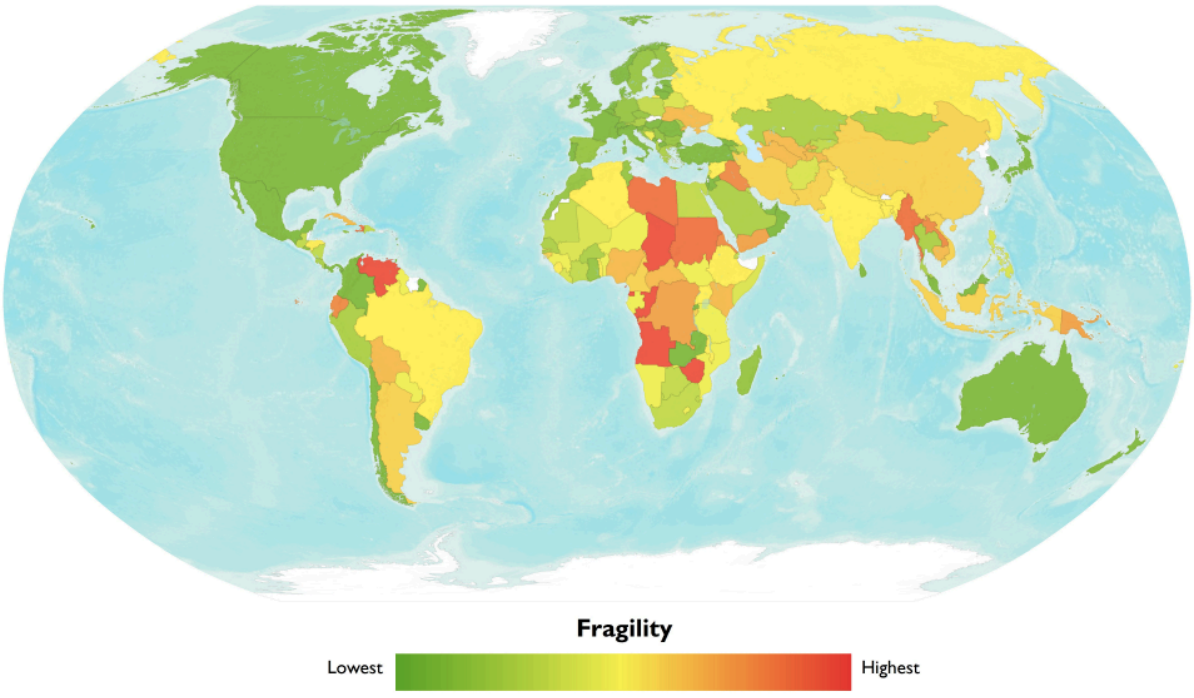
Data sources: 2014 data from Gibney et al.; Pilster and Böhmelt; Compilation of armed conflict datasets and consultations with conflict experts

FIGURE 26: ECONOMIC EFFECTIVENESS (2014)



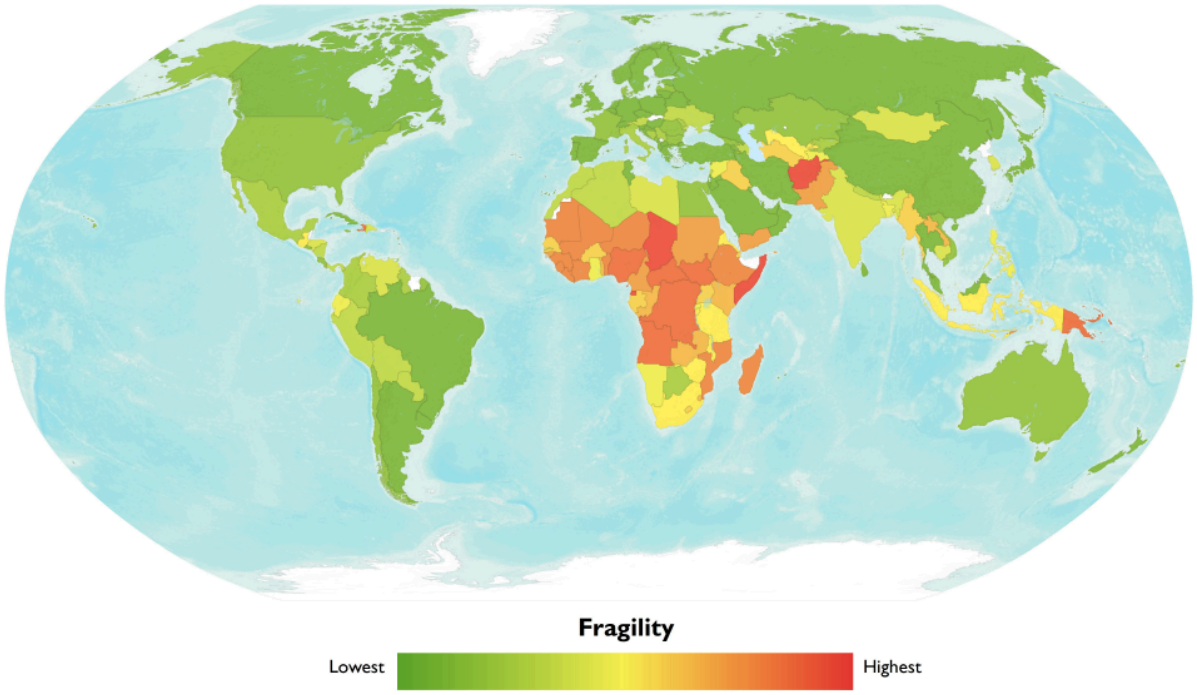
Data sources: 2014 data from World Bank

FIGURE 27: ECONOMIC LEGITIMACY (2014)



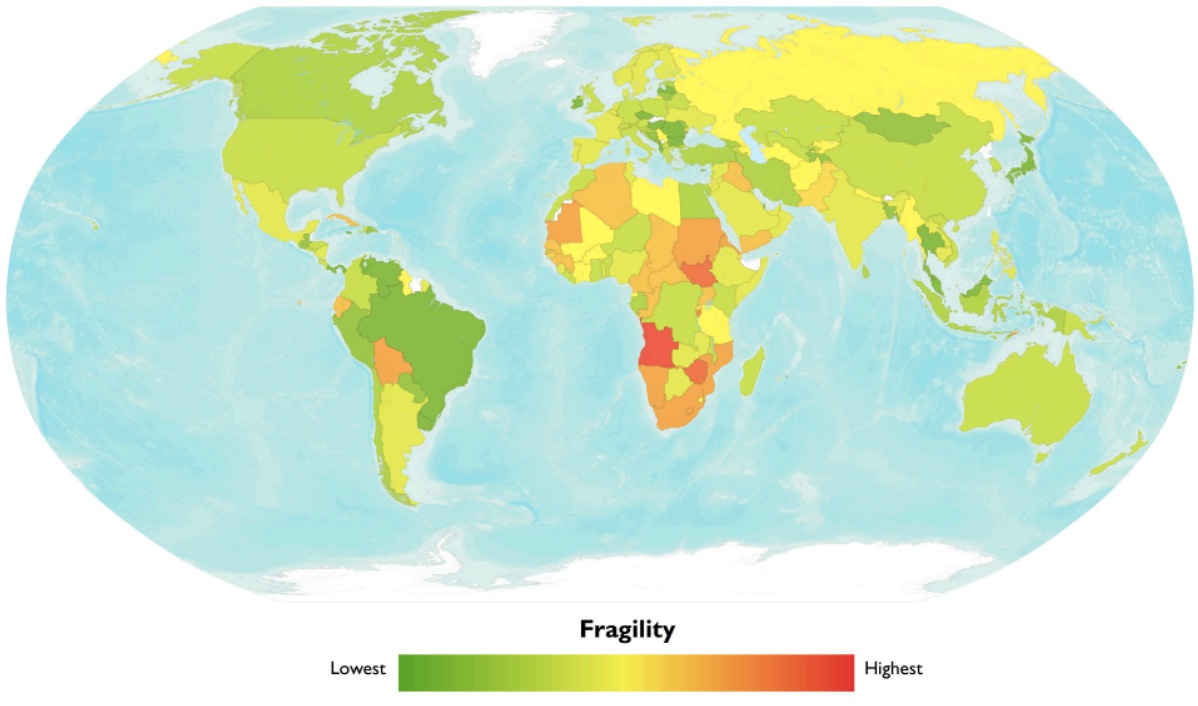
Data sources: 2014 data from Kaufmann, Kraay, and Mastruzzi; Miller, Holmes, and Kim; World Bank

FIGURE 28: SOCIAL EFFECTIVENESS (2014)



Data sources: 2014 data from World Bank

FIGURE 29: SOCIAL LEGITIMACY (2014)



Data sources: 2014 data from World Bank

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Smith, Todd G., 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.

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APPENDIX A. PROCESS AND DATA USED TO CREATE CLIMATE EXPOSURE MEASURE

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 appendix outlines the process of mapping individual climate hazards, the rationale for including particular indicators, and the process of calculating total climate exposure.[50]

A.1 Individual Climate Hazards

In this study, historical, geo-referenced climate hazard data on cyclones, floods, and wildfires are from UNEP/GRID-Europe.[51] The data on rainfall anomalies and chronic aridity are from the Global Precipitation Climatology Centre.[52] The data on low-elevation coastal zones are derived from Viewfinder Panoramas.[53]

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. The *cyclones* indicator is mapped in Figure 17.

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. The *flood events* indicator is mapped in Figure 15.

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

50 The resulting model is available as maps and raster layers in Busby et al. 2016.
51 Data are available at http://preview.grid.unep.ch/index.php?preview=data&lang=eng.
52 Data are available at www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html.
53 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 *wildfire events* indicator is mapped in Figure 16.

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 *rainfall anomalies* indicator is mapped in Figure 12.

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 *chronic aridity* indicator is mapped in Figure 13.

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). The *low-elevation coastal zones* indicator is mapped in Figure 18.

TABLE A-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

A.2 Total Climate Exposure

A.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.[54] Low scores approaching 0 represent minimal exposure, and high scores approaching 100 represent maximal exposure.

A.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.

A.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)]

The map of *total climate exposure* thus shows overall levels of climate exposure at the subnational level across the globe (see Figure 8).

54 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).

APPENDIX B. PROCESS AND DATA USED TO CREATE FRAGILITY MEASURE

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.[55] 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 appendix outlines the indicators, data sources, and process used to assess countries' relative state capacity and state-society relationship on a global scale.[56]

B.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 B-1 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.

B.2 Indicators and Clusters

Table B-1 summarizes the 24 indicators that compose this fragility measure.

55 See USAID 2005 and ARD Consortium 2005.
56 The complete dataset is available in Kishi and Linke 2016. The resulting maps are available in Kishi et al. 2016.

TABLE B-1: 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

B.3 Methodology

B.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.

B.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. The map of *total fragility* thus shows the countries that fall into each of these five categories (see Figure 19).

B.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 (see figures 22-29).

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 (see figures 20-21).

B.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.[57]

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.[58] 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.

57 See Kishi and Linke 2016.
58 See ARD Consortium 2005.

B.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.

B.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.

B.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.

B.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.

APPENDIX C. PROCESS AND DATA USED TO CREATE BIVARIATE MAP

The bivariate map uses the total climate exposure data and total fragility data. The bivariate map represents the intersection of fragility and climate exposure at the first administrative division level for all countries for which data are available. It is created using the first administrative division polygon files from the Global Administrative Areas database version 2.8.

The country-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.[59]

The cross-tabulation of the five fragility categories and the five climate exposure categories are represented on the final bivariate map (see Figure 1).

59 The calculations and data used to create this bivariate map are available in Smith et al. 2016.

APPENDIX D. POPULATION IN HIGH EXPOSURE AREAS IN HIGHLY FRAGILE STATES

Country	Size of Population in *High* Exposure Areas	Portion of Population in *High* Exposure Areas
India	118,625,684	10%
Nigeria	41,390,300	24%
Egypt	33,208,361	39%
DRC	19,398,276	26%
Burma	15,925,053	29%
Cameroon	8,105,362	39%
Guinea	7,201,019	64%
Cambodia	6,775,592	45%
Pakistan	6,524,792	3%
Sierra Leone	5,597,459	100%
Sudan	5,471,859	16%
Uganda	4,365,159	13%
Iraq	3,791,594	12%
Angola	3,370,226	18%
Ethiopia	3,173,591	3%
Chad	2,127,706	19%
Colombia	1,988,544	4%
Iran	1,936,188	2%
Cote d'Ivoire	1,760,619	8%
South Sudan	1,380,789	12%
Libya	1,016,683	17%
Mauritania	955,476	28%
Ukraine	856,349	2%
Haiti	756,120	8%
Eritrea	652,941	11%
Somalia	619,266	6%
Yemen	589,247	2%
Central African Republic	496,995	10%
Mali	420,434	3%
Laos	313,775	5%
Republic of the Congo	194,391	4%
Guinea-Bissau	179,360	12%
Equatorial Guinea	141,099	20%
Afghanistan	125,181	0.4%
Syria	81,708	0.4%
Timor-Leste	81,498	7%
Niger	75,653	0.5%
Zimbabwe	1,068	0.01%
Burundi	989	0.01%

Note: "Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; this includes only countries with populations over 500,000. "High exposure" areas are one standard deviation or more above the global mean exposure.

Data sources: Kishi and Linke 2016; Smith, Krishnan, and Busby 2016.

APPENDIX E. POPULATION IN VERY HIGH EXPOSURE AREAS IN HIGHLY FRAGILE STATES

Country	Size of Population in *Very High* Exposure Areas	Portion of Population in *Very High* Exposure Areas
India	44,113,082	4%
Egypt	13,730,433	16%
Burma	8,003,903	15%
Nigeria	4,502,705	3%
Cambodia	3,111,643	20%
Iraq	2,288,241	7%
Pakistan	1,701,838	1%
Iran	1,125,579	1%
Colombia	1,043,704	2%
Libya	640,509	11%
Sierra Leone	630,495	11%
Mauritania	630,199	18%
Ukraine	559,033	1%
Cote d'Ivoire	491,149	2%
Guinea	456,666	4%
Sudan	371,659	1%
Cameroon	317,673	2%
Haiti	306,781	3%
Somalia	304,724	3%
Yemen	185,567	1%
Angola	178,531	1%
Guinea-Bissau	85,814	6%
Timor-Leste	63,118	5%
Eritrea	62,490	1%
Ethiopia	36,201	0.04%
Syria	28,544	0.15%
DRC	21,358	0.03%
Equatorial Guinea	14,964	2%
Republic of the Congo	4,578	0.10%
Laos	1,325	0.02%
Afghanistan	-	0%
Burundi	-	0%
Central African Republic	-	0%
Chad	-	0%
Mali	-	0%
Niger	-	0%
South Sudan	-	0%
Uganda	-	0%
Zimbabwe	-	0%

Note: "Highly fragile states" are defined here as those in the *highest* and *high* fragility categories in 2014; this includes only countries with populations over 500,000. "Very high exposure" areas are four standard deviations or more above the global mean exposure.

Data sources: Kishi and Linke 2016; Smith, Krishnan, and Busby 2016; Krishnan, Busby, and Smith 2016.

APPENDIX F. REGIONAL DEFINITIONS

The regional definitions used for the calculations in this report are taken from several sources. For continents and other clearly defined regions (e.g., South America and Central America), this analysis uses the geographic boundaries for those regions. For regions defined in varying ways by different institutions (e.g., Central Africa and the Middle East), this analysis uses definitions from the U.S. Defense Department or the U.S. State Department, as available, since these agencies have open-source lists of most regions around the world. This aims to reduce the use of definitions from multiple agencies that may have overlap or gaps across their regional definitions.

This study's fragility measure includes countries with populations over 500,000, as this is the population threshold for some of the underlying indicators used to create the fragility measure. As such, countries with populations under 500,000 and countries otherwise excluded from the fragility measure due to missing data are not included on the regional lists below.

The regions referenced in this report are thus defined as follows:

Asia

Eurasia: Countries on the border of Europe and Asia, including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan

South Asia: Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka

Southeast Asia: Burma, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam

Europe

Central and Eastern Europe: Countries in this fragility dataset that were in the Eastern bloc after WW II, including Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Germany, Hungary, Latvia, Lithuania, Macedonia, Montenegro, Poland, Romania, Serbia, Slovakia, and Slovenia

Eurasia: Countries on the border of Europe and Asia, including Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Russia, Tajikistan, Turkey, Turkmenistan, Ukraine, and Uzbekistan

Latin America

Central America: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, and Panama

South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Uruguay, and Venezuela

Middle East and North Africa

Middle East: Countries in this fragility dataset identified by the U.S. State Department as the Near East, excepting those that it identifies in North Africa; the included countries are Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, and Yemen

North Africa: Countries identified by the U.S. Africa Command as North Africa, including Algeria, Egypt, Libya, Mauritania, Morocco, and Tunisia; in this analysis, Egypt is considered only in the North Africa region since the majority of its territory is on the African continent

Sub-Saharan Africa

Central Africa: Countries in this fragility dataset identified by the U.S. Africa Command as Central Africa, including Angola, Burundi, Cameroon, the Central African Republic, Chad, DRC, Equatorial Guinea, Gabon, and the Republic of the Congo

East Africa: Countries identified by the U.S. Africa Command as East Africa, including Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania, and Uganda

Southern Africa: Countries in this fragility dataset identified by the U.S. Africa Command as Southern Africa, including Botswana, eSwatini, Lesotho, Malawi, Mozambique, Madagascar, Mauritius, Namibia, South Africa, Zambia, and Zimbabwe

West Africa: Countries in this fragility dataset identified by the U.S. Africa Command as West Africa, including Benin, Burkina Faso, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo

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