Global Climate Change and State Stability

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Summary

Background and tasking

Several studies in recent years have pointed to the national security implications of global climate change. [1-4]. The National Intelligence Council (NIC) conducted a National Intelligence Assessment (NIA) on this subject. They concluded that climate change will impact all nations, and in some cases, could affect state stability in ways that have implications for U.S. national security interests [5]. The NIC also laid out a set of future research needs to help inform U.S. policy with respect to climate change and national security planning. The NIC seeks to identify countries that current research suggests are both highly exposed to various climate change impacts and are unlikely to show resilience in response.

To support these research needs, the NIC asked CNA to examine countries that could become unstable from climate change in the near (2020-2025) and long (2040-2045) terms. Specifically, we were asked to:

- Identify those countries that are most exposed to climate impacts (water scarcity, agricultural degradation, sea level rise/encroachment, and extreme weather events) both in the short term and the long term;
- Assess these countries' resilience to the impacts of climate change; and
- Discuss the implications of these findings for the security interests of the United States.

CNA was not asked to conduct any original data collection for this study, but instead to base our analysis on existing research from reputable sources. We were asked to highlight the methodological difficulties of conducting research on this topic.

Methodology

We derived a list of the countries most exposed to climate impacts in the short term (2020-2025) based on the historical record of frequency and intensity of droughts, severe weather events, agricultural degradation, and sea-level rise. To this data, which we obtained from the International Development Association (IDA) of the World Bank, we added an additional risk category of water scarcity related to a country's geography and precipitation rates.

To estimate long-term (2040-2045) exposure, we assumed the continuation of current and short-term trends in climate effects, but added consideration of new effects caused by glacial melt and other causes of water scarcity.

We estimated resilience of these countries based on analysis from the Joint Global Change Research Institute (JGCRI) at the University of Maryland, which assigns resilience scores based on quantitative indicators of economic and social factors. We then combined our categorization of countries most exposed to climate effects in the short term with resilience scores to create a 3-tier ranking of countries most susceptible to political and humanitarian crises as a result of future climate change effects.

An appendix presents some reflections on the strategic significance to the U.S. of the countries in the first 2 tiers, based on recent literature and on insights from CNA subject matter experts.

Throughout this study we used only unclassified sources.

Summary of findings

In the short term (2020–2025), 11 of the 14 of the countries we identified as most vulnerable to political and/or humanitarian crises as a result of climate impacts (i.e., our Tier 1) are located in Africa, and 9 of the 14 are in north or central Africa. In the long term (2040-2045) these same countries remain highly vulnerable; however, due to decreasing water supplies caused by glacial melt Bolivia, Ecuador, and Nepal also merit special attention, and crises in China and India are

increasingly likely. Our study suggests that climate change poses the greatest threat in terms of political and social upheaval to the regions of north and central Africa, and south Asia.

Organization of this report

In the first section we identify the states most exposed to the impacts of climate change both in the short and long term. The second section introduces estimates of the resilience of these countries, and combines our evaluation of country exposure and expected resilience to create a 3-tier ranking of countries most vulnerable to political and/or humanitarian crises as a result of climate impacts. In the third section we briefly discuss the methodological challenges we encountered during the study. An appendix offers preliminary thoughts regarding the strategic importance of these countries to the security interests of the United States.

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States' exposure to climate change

Short term (2020-2025)

Most models of climate change effects such as those of the Intergovernmental Panel on Climate Change (IPCC) 2007 [6], estimate effects decades into the future. To assess which countries are most vulnerable to climate change in the shorter term, we obtained the index of countries "most at risk from climate-related threats" from the World Bank International Development Association (IDA) [6].

This list was drawn from all IDA-eligible countries, and is based on the 25-year record of naturally-caused crises in these countries and their economic and human costs. This list is especially suitable for our study because it disaggregates countries' exposure to climate change to specific types of risk, including drought, flood, severe weather events, sea-level rise, and agricultural degradation.

Because the future is uncertain, estimates of the future are based on assumptions regarding the degree to which present trends will continue or new trends will emerge. In our short-term projection, the assumption implicit in the IDA list is that, generally speaking, regions and countries that have suffered the most from naturally caused events in the recent past are those most likely to suffer from similar events in the near future. This assumption–that the short-term future will most likely be similar to today, but with current trends continuing–is supported by virtually all models of future climate change effects, including the United Nations IPCC 2007 report.

The IDA report lists the countries expected to be most affected by all the types of future risk relevant to our study but one: water scarcity. Several countries and regions of the world are threatened already by a shortage of water for human and agricultural use, and are exhausting aquifers faster than they can be replenished. Again, in our analysis the implicit assumption is that these countries that are already expe-

riencing water scarcity are likely to be those to experience it the most in the future, largely because the replenishment of many of these fresh water sources is impossible and we expect the human demand for these resources only to increase over the next 15 years.

Our estimate of the likely risk, for all IDA-eligible countries, of water scarcity, is based on a joint publication of the United Nations Environment Programme (UNEP) and its collaborating centre UNEP/GRID-Arendal in Norway [7]. The 12 countries listed as currently the most threatened by water scarcity are: Morocco, Mauritania, Tunisia, Algeria, Kenya, Rwanda, Burundi, Burkina Faso, Yemen, Eritrea, Egypt, and Djibouti.

Table 1 presents the 44 countries identified by the IDA and the UNEP/GRID-Arendal report to represent overall exposure to the impacts of climate change. For each country we show the categories of threat to which it is exposed. We assume that the more categories to which the country is exposed, the greater will be its overall exposure to negative effects of climate change. Several of the nations shown face only one of the six categories of exposure; no nation displays more than three categories. The countries that show exposure in three categories are: Bangladesh, China, India, Mauritania, and Vietnam.

This index does not consider the intensity of each risk factor. Because intensity is related to a panoply of national factors and conditions, it is difficult to evaluate with confidence. We return to considerations of relative intensity in the next section of the paper.

Table 1. Climate change exposure in selected countries

	Drought	Flood	Storm	1-m storm surge	Agriculture	Water Scarcity
Malawi	x				x	
Ethiopia	x				x	
Niger	x				x	
Mauritania	x			x		x
Eritrea	x					x
Sudan	x				x	
Chad	x					
Kenya	x					x
Iran	x					
Bangladesh		x	x	x		
China		x	x	x		
India	x	x			x	
Cambodia		x				
Mozambique		x				
Laos		x				
Pakistan		x				
Sri Lanka		x				
Thailand		x				
Viet Nam		x	x	x		
Benin		x				
Rwanda		x				x
Philippines			x			
Madagascar			x			
Moldova			x			
Mongolia			x			
Haiti			x			
Honduras			x			
Egypt				x		x
Tunisia				x		x
Indonesia				x		
Mexico				x		
Myanmar				x		
Senegal				x		
Libya				x	x	

Table 1. Climate change exposure in selected countries (continued)

	Drought	Flood	Storm	1-m storm surge	Agriculture	Water Scarcity
Zimbabwe				x		
Mali					x	
Zambia					x	
Morocco					x	x
Algeria					x	x
Democratic Republic of the Congo					x	
Djoubuti						x
Yemen						x
Burundi						x
Burkina Faso						x

Long term (2040–2045)

The farther into the future we estimate the effects of climate change, the more variables are involved and the lower is our confidence that we can make an accurate and comprehensive prediction. Our assumption continues to be that currently observed trends will generally continue; however, over the longer term (2040-2045) other trends will also emerge. Therefore, all of the countries expected to be highly exposed to climate change effects in the next 20 years are also those most vulnerable 30-40 years from now, though some additional countries are expected to face new, severe risks particularly relating to water scarcity.[1] In terms of the evolving effects of climate change, a 10-year time difference is generally insignificant. It is partly for this reason, for example, that the United Nations' latest climate change report extends its projections to the 2077-2100 time frame, in order to capture the longer-term, more dramatic anticipated effects from climate change.

One potentially severe type of future climate change-related risk that is not captured in the data upon which our country list is based is glacial melt, and the water scarcity that may result. Glacial melt is occurring with increasing rapidness around the world. In the Andean countries of South America and in Himalayan countries glacial melt

poses a high risk of future water shortage. The capitals of Bolivia and Ecuador, for example, draw most of their water from sources fed by shrinking glaciers, as do various agricultural zones. Nepal is similarly threatened, as are major river valleys in China and India.[2]

In addition, sea level rise poses a serious threat to low-lying island states such as the Maldives or the Pacific microstates of Kiribati, Nauru, and Vanuatu. Over the long term, particularly 100 years or more into the future, sea-level rise could threaten the existence of these nations. However, these small island nations are not included in our list because these expected effects from sea-level rise are not likely to occur within the timeframe of our study.

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1. We considered using estimated temperature change as a proxy for longer-term exposure to climate change impacts. Our assumption was that temperature change is the key driver behind larger effects such as weather or groundwater availability. We analyzed temperature data for our selected countries covering the years 1970-2004 and compared those to projected temperatures out to 2100, based on the IPCC report's A1 B projection (a relatively conservative projection which assumes balanced utilization of resources and technologies ranging from energy supply to end use).

   We found that temperatures in most of our countries of interest are expected to increase by virtually the same amount: 1 to 1.5 degrees Celsius. Exceptions were high latitude countries such as Russia and Canada, where temperature rise is expected to be higher. However, these relatively wealthy and stable countries are not of key interest to our study. This temperature change-based approach posed two problems: 1) near-equal effect does not help us to distinguish degrees of effect across countries, our key purpose; 2) national-level estimates do not capture local-level effects, where climate change impacts are expected to be strongest. For these reasons we decided not to use projected temperature change as a proxy for long-term impacts.

2. See Lester Brown's article "Could Food Shortages Bring Down Civilization?," in *Scientific American*, May 2009.

Summary

By comparing countries' degrees of exposure to six potential impacts of climate change, we have identified six countries that are most vulnerable. These six countries are likely to be significantly affected by at least three of the six identified risk factors. With the exception of China, these countries are located in South Asia or Africa. Considering the severe human and economic damage that can result from any one of these factors, any combination of such factors poses a tremendous danger to these populations and, potentially, to their economic and political systems. In the following section we turn to the question of what capabilities these countries, and others, are likely to have in responding to these dangers.

Comparing states' exposure and resilience

Resilience index

We now address the expected resilience of the countries that we have determined to be most significantly exposed to climate change.

We obtained resilience data from the Vulnerability-Resilience Indicators Model (VRIM) developed by JGCRI, a joint research program between the University of Maryland and the Pacific Northwest National Laboratory[8]. The VRIM model allows for resilience score comparison between countries based on a combination of social, economic and environmental factors.[3] In the model, resilience is defined as the ability to cope with or recover from exposure to climate change induced shocks. The model calculates resilience scores per country on a scale of 1 to 100.

The VRIM does not include political risk or governance factors in the calculation of the resilience scores. We address this limitation below.

Results

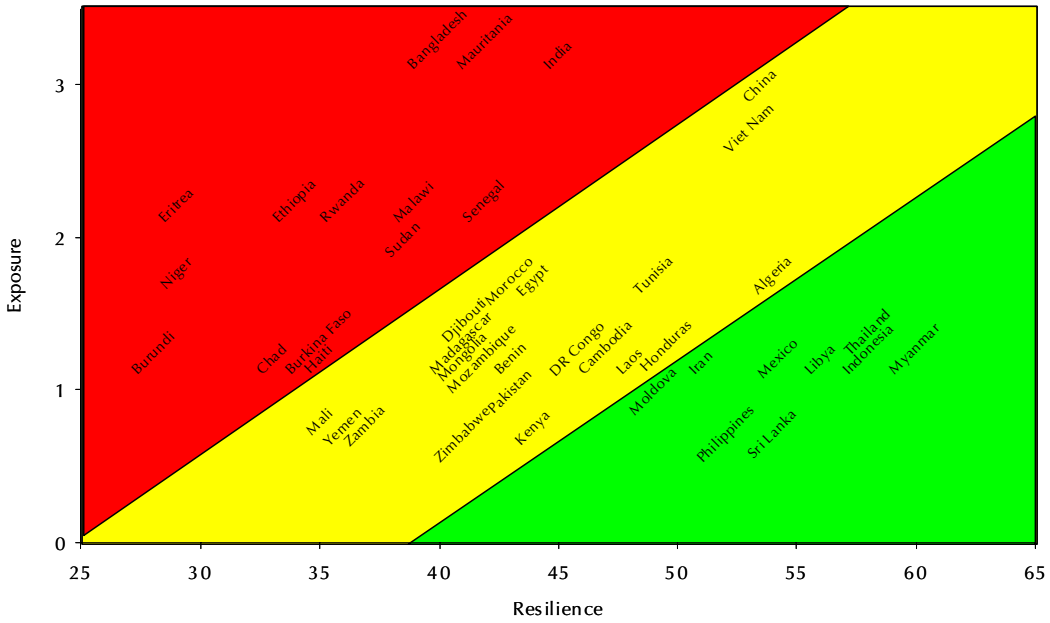
Base case

Figure 1 combines the short-term exposure of the 44 countries from table 1 with their resilience scores according to the VRIM. We categorize the countries into three tiers. The Tier-1 countries have high exposure but low resilience. These 14 countries are shown in the section shaded in red in figure 1. Tier-2 countries, shown in the section shaded yellow, have either high exposure and high resilience or low

3. These factors include settlement/infrastructure sensitivity; food security; ecosystem sensitivity; human health sensitivity; water resource sensitivity; economic capacity; human and civic resources and environmental capacity.

exposure and low resilience. Tier-3 countries, shown in the section shaded green, have low exposure and high resilience.

Figure 1. States' exposure and resilience



Further considerations

The VRIM is extremely useful as a quantitative estimate of national resilience. However, it is not comprehensive. There are several additional factors, or country characteristics, that must also be considered when evaluating a country's resilience to climate change effects. Most importantly, the VRIM does not include assessments of governance or the capacity of a government to provide effective security and public services. Although this is captured to some extent in data on economic growth, infrastructure, and human capital, other factors are excluded including levels of corruption, bureaucratic efficiency, and political instability. Other factors that must be considered are a country's degree of integration into the global economy, rates of population growth, and

potable water provision. Recalculation of the formal model behind the VRIM is outside of the scope of this study. Instead, we add these factors qualitatively, on a case-by-case basis, with considerations of how they affect our assumption that short-term trends generally continue into the longer-term future.

Governance

We first examined the World Bank Governance Indicators obtained from the organizations's web site [9]. The World Bank Governance Indicators reflect the statistical compilation of responses on the quality of governance given by a large number of survey respondents in industrial and developing countries as reported by a number of survey institutes, think tanks, non-governmental organizations, and international organizations. These indicators measure the following aspects of a national government's operation:

- Voice and Accountability;
- Political Stability and Absence of Violence;
- Government Effectiveness;
- Regulatory Quality;
- Rule of Law; and
- Control of Corruption.

Table 2 presents the governance scores for the countries listed in table 1.

Table 2. Governance scores, in percentile bins[a]

Percentile bin			
0-10%	10-25%	25-50%	50-75%
Eritrea	Ethiopia	Madagascar	Tunisia
Sudan	Niger	Moldova	Morocco
Chad	Iran	Mongolia	
Myanmar	Bangladesh	Honduras	
Zimbabwe	Cambodia	Fiji	
DR Congo	Laos	Egypt	
Afghanistan	Pakistan	Indonesia	
	Haiti	Mexico	
	Libya	Senegal	
	Angola	Mali	
	Sierra Leone	Zambia	
		Algeria	
		Philippines	
		Rwanda	
		Malawi	
		Mauritania	
		Kenya	
		China	
		India	
		Mozambique	
		Sri Lanka	
		Thailand	
		Vietnam	
		Benin	

a. These percentile bins are from the original World Bank report [9].

There is a general relationship between governance and resilience. Of the 44 countries in Table 1, only Tunisia and Morocco have governance scores above the 50th percentile. It is important to consider that the VRIM scores do not include a comprehensive measure for governance. Therefore, our resilience estimates are likely to be overly optimistic.

Globalization, global inequality

A report from the Development Concepts and Doctrine Center (DCDC) of the UK Ministry of Defence projects strategic trends out to 2036 [10]. It identifies three key issues: globalization, climate change, and global inequality, and associates specific risks associated with each of these issues.

DCDC suggests that Africa is likely to be the hardest-hit region when taking these factors into account, and notes that Latin America could face challenges as well. DCDC identifies Colombia, Peru and Mexico as three countries whose profile could make them candidates for our Tier-1 by 2040. However, these projections are based on the assumption that current levels of insurgency in these countries are likely to continue or increase to 2040, which may not occur. DCDC estimates that Haiti is likely to suffer ongoing political instability partly as the result of climate change effects. In Haiti, a combination of environmental and man-made stressors will likely produce a requirement for massive humanitarian assistance.

Population growth to 2040

Countries that are expected to experience explosive population growth by 2040 are also likely to show less resilience toward climate change. Overpopulation will effect indictors used to calculate resilience in the VRIM model such as food security, economic capacity and human and civic resources. The International Institute for Applied Systems Analysis (IIASA) has formulated probabilistic population growth estimates to 2040. These estimates are given in Table 3 [11]. We make the following observations:

- World population as a whole is expected to rise by 21%; however significant regional variance is predicted.
- Sub-Saharan Africa's population is expected to nearly double, from its current level of approximately 740 million assuming that no new major disease pandemics occur. Rapid population growth in Africa could generally lower resilience scores.
- The countries of Benin, Zimbabwe, Democratic Republic of the Congo, Kenya, Mozambique and Angola display low exposure

and low resilience scores on figure 1. Rapid population growth may be an additional factor pushing these countries toward instability.

- A 27% increase in population is expected for South Asia. This change will likely have an adverse impact on the resilience of India and Bangladesh. India could shift to the left on Figure 1 as population growth erodes its resilience. A rise in population will likely dampen the prospects for successful adaptation to the effects of climate change in Bangladesh.
- Declining population may improve China's resilience capacity.
- Pacific Asia will experience a 22% increase in population. This trend, compounded with sea level rise, could contribute to instability as coastal regions and small island states are increasingly threatened.

Table 3. Expected population change (in percentage) from 2008 to 2040

Region	Change
North Africa	31
Sub Saharan Africa	45
North America	20
Latin America	26
Central Asia	30
Middle East	37
South Asia	27
China	-2
Pacific Asia	22
Japan / Oceania	-6
Western Europe	-40
Eastern Europe	-18
European FSU Russia	23
World	21

In sum, by 2040 a general rise in population will put pressure on resilience capacity in much of Asia, the Middle East and Latin

America, but no region will experience these effects more than Sub-Saharan Africa.

Water scarcity in 2040

In addition to population growth, water scarcity is likely to have a profound effect on many of the countries by 2040. Water scarcity as a geographic issue is included in our identification of countries most exposed to climate change effects in the short term. However, in regard to the longer term, the capability of a country to access and provide potable water to its population under conditions of duress is an extremely important element of its resilience. The distinction is that water scarcity as an element of exposure is related to a country's geography; water scarcity as an element of resilience is related to the country's capacity for providing water to meet the needs of its people. For example, a wealthy country facing extreme water scarcity could afford to import water, while a poor country in the same situation may face large-scale emigration and/or collapse.

According to the United Nations World Water Assessment Program [12], the 12 most water stressed countries are: Afghanistan, Ethiopia, Chad, Cambodia, Sierra Leone, Angola, Mauritania, Rwanda, Equatorial Guinea, Democratic Republic of Congo, Eritrea, and Madagascar. In these cases the disappearance of naturally occuring water sources combines with poor government capacity for water provision, suggesting that long-term impact from water scarcity could be extremely severe. In other parts of central Africa, however, precipitation is expected to increase.

In the Middle East, it is possible that some of the least resilient Arab countries such as Iraq could rise to a higher level of concern by 2040 despite their rather high resilience scores. One reason for this is their reliance on water desalinization units that could be subject to malfunction or sabotage.

Summary

The inclusion of factors such as governance, globalization, inequality, population trends, and water availability suggests that some countries not at risk in the short term might be in the 2040-2045 time period.

Specifically, trends in water availability and population growth suggest that India, Bangladesh and Thailand may be worse off in the 2040-2045 time frame than is reflected by their current position on figure 1. In Latin America, Bolivia's and Peru's resilience could decrease from their current moderate levels.

Rapid population growth, water scarcity and in some cases poor governance are likely to be key drivers that will cause several Middle Eastern countries to become at risk. The effect of these factors on Africa is likely to be profound. While water scarcity's effect on Africa will be mixed, population growth, a recent history of conflict, and poor governance indicate that by 2040, resilience will continue to diminish in this region.

Methodological challenges

We faced various methodological challenges in conducting this study. First and foremost, estimations of a country's future political and socio-economic circumstances are largely speculative, and naturally tend to be biased toward the continuation of the status quo. Our forecast, like many others, may underestimate the likelihood of sudden, unforeseen shocks, particularly in our long-term estimates. However, we account for at least one form of emerging, and potentially severe, crises: those associated with water scarcity caused by glacial melt.

The fact that our sources differed in their methods for generating estimates of climate effects per country complicated our task of combining lists from different sources. For example, the method used to create a list of countries most threatened in the short term was not appropriate for estimating long-term impacts, because the data from which it was derived do not include future shocks (e.g., glacial melt and disappearance).

Another general challenge is that national-level estimations are essentially problematic because the severity of anticipated climate effects differs dramatically across local areas. The greater a country's geographic diversity, the more difficult it is to assign a countrywide score for estimated climate impact.

Last, only section 3 includes in its analysis some consideration for the intensity of anticipated climate effects, and their particular acuteness in regards to specific national characteristics (e.g., demographics, water scarcity, ethnic divisions, etc.). In order to create more robust estimates, future analysis of this type should dedicate more resources to the resolution of these methodological challenges.

Despite these challenges, the country lists and categorization in this study are helpful as a general indicator of what countries, and regions, face the highest degree of danger from currently observed

trends. We anticipate, for example, that central and sub-Saharan Africa, for example, and South Asia (particularly Bangladesh and India) are two regions most likely to be destabilized politically in the-future as a result of climate impacts.

Appendix: Implications for the United States

In this appendix we offer preliminary thoughts regarding the strategic significance to the United States of some of the countries highlighted as especially vulnerable to the impacts of climate change. We organize this discussion in terms of countries falling within the three tiers of our exposure-resilience matrix. This discussion is informed by recent strategic assessments by U.S. and British research organizations and by input from subject matter experts within CNA. The exercise of predicting future global environmental, political, economic, and security conditions is highly speculative, and the reader is urged to interpret this information accordingly.

Tier 1: high risk/low resilience

Of the Tier-1 countries, Afghanistan, Bangaldash, India, and Sudan are those widely recognized as of high strategic relevance to the U.S.

India's relationship with Bangladesh is one important consideration for the U.S. Since neighboring Bangladesh is fragile and important strategically, it may be a candidate for future U.S. assistance. The U.S. might be motivated to intervene there because that nation could harbor Islamic extremists and also because of its potential for conflict with India. Sudan is the only sub-Saharan country in Tier-1 believed to be of highest strategic importance.

International Alert, a British research organization, lists countries most at risk of armed conflict from climate change, and seven of our Tier-1 countries are on their list: Bangladesh, Ethiopia, Eritrea, India, Rwanda, Senegal, and Sudan. Countries on the Horn of Africa are especially significant because they receive much U.S. military involvement. Malawi and Madagascar are also states likely to face a high risk of political instability (but not necessarily armed conflict) due to climate change.

The nature of alliance structures is an important factor in determining strategic significance. For example, while Chad appears on Tier 1, this country's traditional ties to France make it is less strategically important to the U.S. Likewise, part of North Africa falls within the European sphere of influence.

Mauritania is an especially interesting case. The countries in the Sahel region, such as Mauritania, are characterized by ungoverned spaces that can harbor extremists. It is expected to experience drought, sea-level rise, and water scarcity and that these risks coincide with a low resilience score. Mauritania also has had a recent history of conflict likely to be exacerbated by environmental trends to 2036. However Mauritania is currently of modest strategic importance to the U.S.

Tier 2: high risk/high resilience, low risk/low resilience

In the Middle East, Egypt will likely continue to be a key strategic partner until 2040. Although Egypt currently has a low cumulative exposure score, the situation may worsen significantly by 2040 due to factors such as sea level rise. A humanitarian crisis in Egypt is almost certain to warrant a U.S. response. Morocco is particularly significant among the Tier-2 countries due to the long history of cultural ties with the U.S. and the presence of U.S. military bases.

Even if the threat of terrorism diminishes, Pakistan will continue to be strategically important to the U.S. for other reasons, such as its status as a nuclear state.

Angola is particularly significant becuase of its control of natural resources. Any instability that results from climate change in that country could threaten the flow of oil to the U.S.

Like Angola, The Democratic Republic of the Congo is relatively important among the Tier-2 countries because it possesses strategic mineral resources such as coltan. Instability in this country tends to spill over into neighboring regions. The situation in this country could lower resilience sufficiently to cause it to qualify as a Tier-1 country well before 2040.

Tier 3: low risk/high resilience

The countries found in this tier are least likely to experience climate related instability in the short term. That is not to say that developments in these nations will be no cause for concern. Instability in tier-3 countries such as Indonesia, Iran, Mexico, and Thailand would be highly inimical to U.S. interests. Even a relatively small amount of instability in Mexico, for example, would have enormous implications for the United States.

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