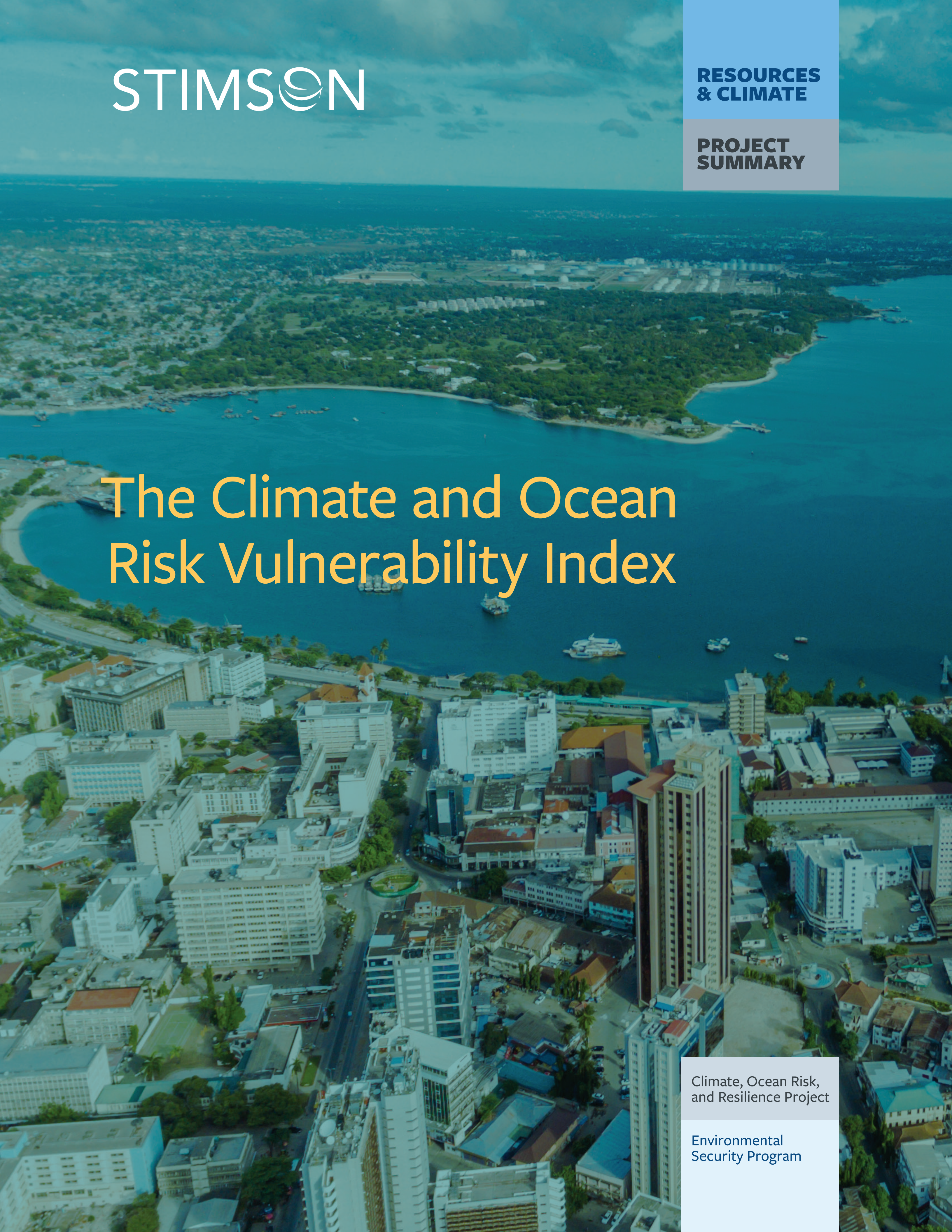

STIMSON

RESOURCES & CLIMATE

PROJECT SUMMARY

The Climate and Ocean Risk Vulnerability Index

Climate, Ocean Risk, and Resilience Project

Environmental Security Program

Coastal Cities are at the Forefront of the Climate Crisis

The climate crisis has arrived, and coastal cities are the most vulnerable places. The Climate and Ocean Risk Vulnerability Index (CORVI) is a tool to identify the financial, political, and ecological risks that climate change poses to coastal cities. With CORVI, decision makers can target their investments to build resilience where it matters most.

The climate crisis has arrived and the science linking climate and ocean risk is undeniable. The recent IPCC report on the Ocean and the Cryosphere states that our oceans are at a tipping point. Sea levels are projected to rise by up to a meter by 2100 due to a combination of sea ice melt and thermal expansion. Moreover, the average intensity of extreme weather events are projected to increase by up to 10 percent, with rainfall associated with these events projected to rise by at least 7 percent per degree of warming on the sea surface. These interconnected impacts of the changing climate are having serious consequences on developing coastal cities facing population growth, their environment and ecosystems, as well as the associated economic and social structures that support national, regional, and global security.

On top of these stressors, many developing cities area already dealing with underlying economic and social issues, such as poverty, outdated infrastructure, poor governance, and corruption.

As climate change worsens, this intersection of social, economic, and environmental issues may leave governments in developing cities unable to provide basic services and protections to its citizens, which could lead to unrest, instability, and possibly conflict. Despite growing recognition of the impact of climate and ocean risks on security in coastal cities, there is a lack of decision tools to help integrate these multiple risk factors at the city level.

Against this backdrop, governments, financial institutions, development organizations, and the private sector need tools which identify and prioritize issues of greatest climate and ocean risk.

To create a more holistic picture of these vulnerabilities, the Stimson Center has developed the Climate and Ocean Risk Vulnerability Index (CORVI), which quantifies diverse climate and oceans risks at the city level. The objective of CORVI is to drive investment towards issues of greatest risk, and provide a tool for decision makers to help them prioritize necessary action to mitigate these risks.

What is CORVI?

CORVI is an integrated assessment of climate and ocean risks for coastal cities. It combines empirical and expert survey data to measure ecological, financial, and political risk across 10 categories and 95 sub indicators, giving policymakers critical insights into the challenges their cities face.

CORVI provides an integrated assessment of climate and ocean risks for coastal cities. In a competitive funding environment, ensuring scarce resources are used efficiently is critical. By measuring ecological, financial, and political risk through ten risk category's and 95 sub indicators, the CORVI highlights the greatest risks coastal cities face. Each indicator is scored between 1 and 10, with 10 indicating greatest risk.

The CORVI is different from other indices in two ways. First, unlike other environmental indices which tend to focus on the national level, CORVI is city based, providing city level detail on the nature and impact of climate and ocean risks.[1] Second, CORVI uses a methodology that combines empirical and expert survey data through structured expert judgement.[2] This approach provides a contextual and data driven assessment of the diverse security risks. More

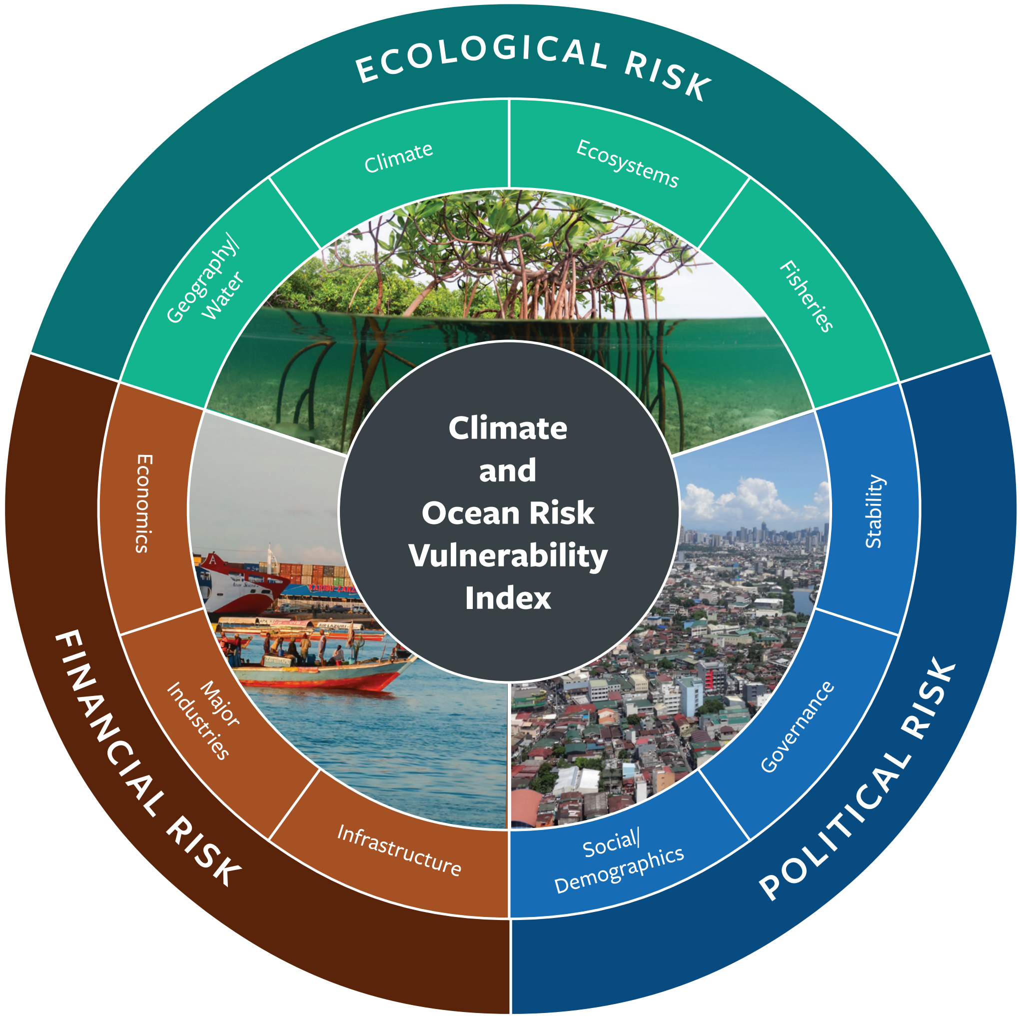

Figure 1: CORVI risk indicators (sub indicators not shown).

information on the CORVI methodology can be found in the appendix.

By viewing the diverse nature of climate and ocean risks at the city level, CORVI integrates risks which are all too often viewed through a singular lens. Ecological risks, such as climate change, ecosystem health, the state of near and offshore fisheries, and geographical factors such as coastal erosion provide important metrics to understand the environmental changes which coastal cities face.

When these ecological risks are considered in context with financial risk, a different picture emerges. Major industries such as tourism, fishing, and shipping, which are dependent on ecosystems services, are essential for the economic and food security of city residents. These sectors are also highly vulnerable to a changing climate. Moreover, the infrastructure on which coastal cities depend, such as air and seaports, are vulnerable to increased intensity of storms and sea level rise.

Finally, political capacity is at the heart of how cities respond to increased climate and ocean risk. Political risk in the form of weak social and political institutions, when integrated with environmental pressures such as rising temperatures, in addition to financial risks such as high unemployment and degraded infrastructure such as informal housing can lead to social instability, and reduce the capacity of a city to adequately respond to the overall threat posed by the climate crisis.

Preliminary Results

CORVI was successfully piloted in two Caribbean cities: Castries, Saint Lucia and Kingston, Jamaica. In 2020 the Stimson Center will complete assessments in the East African cities of Mombasa, Kenya and Dar es Salaam, Tanzania, and work with partners to complete assessment in Fiji and other nations in the Pacific Region.

Castries, Saint Lucia

CASTRIES INTEGRATED RISK PROFILE					
Ecological Risk		**Financial Risk**		**Political Risk**	
Ecosystems	6.18	Economics	7.20	Social/Demographics	5.25
Climate	5.52	Infrastructure	5.16	Stability	4.81
Fisheries	5.28	Major Industries	4.42	Governance	4.55
Geography/Water	4.02				

Built on reclaimed land, Castries is situated on the west coast of Saint Lucia. With 1.2 million tourists arriving by cruise ship or air in 2018, a significant portion of the city's population is employed in tourism related industries which support the neighboring district of Gros Islet. As such the geographic study area was expanded to include the Gros Islet district, in addition to Castries. This area comprises 50 percent of the national population.

Saint Lucia is a leader among Caribbean states who have prioritized responses to climate change. Yet at the same time it suffers from climate and ocean risks related to its high reliance on a single industry which is dependent on its coastal and marine environment. Furthermore the city faces growing concerns over degraded fresh and marine water quality, diminished ecosystems such as coral reefs, and a significant increase in droughts across Saint Lucia, which is leading to increased water scarcity throughout the study area, effecting agricultural food productivity.

Figure 2: Cruise Ship Leaving Castries. Source: Stimson Center.

Strengths: Despite the vulnerabilities across the city, Castries has shown success in building resilience in its fishing industry through increased aquaculture production and fisheries monitoring. CORVI results also show that Castries has been successful at building resilience in its social and governance sectors, reflected in improved disaster capacity response and high rule of law scores. Finally, efforts to combat storm surge and flooding at Port Castries through pump installation and sea walls has reduced risk towards this critical piece of infrastructure. However, marine debris during extreme weather events such as a hurricane remains a significant risk.

Challenges: With its economy heavily concentrated in coastal tourism, Castries is vulnerable to any significant change in tourist numbers. Forty percent of the population of Castries is directly employed in tourism, with many more employed in secondary sectors and within the informal economy. This points to the importance of this industry to the health of the city and national economy. A single extreme weather event could devastate this industry.

While tourism provides economic security for many residents in Castries, a lack of effective regulation has also contributed to increased risk. Low water quality and poor waste water treatment degrade the long-term sustainability of the industry. This also has negative secondary impacts on coral reef health, as well as increasing the risk of flooding. These impacts act as threat multipliers, damaging the fishery and tourism sectors. Finally, high youth unemployment and unregulated settlement construction in at-risk areas reduce the capacity of Castries to recover from extreme weather events, as unplanned settlements contribute to flood risk.

Opportunities to build resilience: While economic indicators such as high youth unemployment, lack of industrial diversification, and inequality score highest for risk, survey responses from local experts indicate that progress is already being made on those indicators. In addition, expert surveys indicate that future investments should prioritize resilience towards heat and drought events. Finally, flood risk and its associated impacts on water contamination can be reduced through improved city planning. Flood resilience projects such as slope stabilization and improved drainage – already being undertaken in Castries East – should be expanded to build resilience.

Kingston, Jamaica

KINGSTON INTEGRATED RISK PROFILE					
Ecological Risk		**Financial Risk**		**Political Risk**	
Ecosystems	5.78	Economics	5.77	Social/Demographics	5.62
Climate	5.16	Infrastructure	5.14	Stability	5.38
Fisheries	5.16	Major Industries	4.55	Governance	4.43
Geography/Water	4.48				

Located in a one of the largest natural harbors in the world and enclosed by the Blue Mountains, Kingston is the seat of government for Jamaica and the largest entity in the national economy. To fully capture climate and ocean risk in Kingston, the study area was expanded to include the town of Portmore, as the majority of its residents work in Kingston. The population of this study area is 765,000, or 26 percent of the overall population. CORVI findings shows that Kingston's comparatively diversified economy lowers its vulnerability to extreme weather events, as it is not dependent on one industry for its economic security. However, vulnerability in key indicators such as informal housing, waste water management, and a high level of shoreline development increase its risk to extreme weather events.

Strengths: CORVI results show that Kingston has had notable success in building resilience to climate and ocean risks. Its diverse economy – primarily composed of services, shipping, and tourism – lowers Kingston's risk, as reliance on a single industry increases a cities vulnerability to extreme weather events. Improved fresh water management and flood resilience measures for sea and air port are two examples of how Kingston has reduced infrastructure risk.

Challenges: Rapid urbanization is an issue which is increasing climate and ocean risks across many of the CORVI indicators. A large informal economy, high unemployment, and unregulated settlement construction have all been exacerbated by the fast pace of urbanization. High unemployment has also led to a greater reliance on subsistence and artisanal fishing for economic and food security. Informal housing construction has occurred in areas that are vulnerable to storm surge and sea level rise. These risks, along with relatively high levels of crime and social tension, hinder the ability of Kingston to respond to extreme weather events.

Figure 3: Informal settlements in Kingston. Source: iStock.

The cascading social risks are further exacerbated by degraded ecosystems. Declining coral reefs and mangroves across Jamaica impact the artisanal fishing sector, increasing the vulnerability of the poorest which rely on catch for nutrition and employment. Ultimately, the combination of social and ecological pressures increases the vulnerability for the poorest residents of Kingston.

Opportunities to build resilience: While socio-economic issues such as high unemployment and informal housing are difficult to tackle, successful outcomes in these areas will have positive secondary impacts for other priority categories, such as ecosystems. Ensuring settlement construction does not negatively impact ecological systems and prioritizing sustainable urban planning are two areas which can positively impact multiple high risk indicators. Overall the index shows Kingston is well-placed to deal with projected climate and ocean risks. However, such resilience could be overwhelmed if social issues such as crime and inequality go unaddressed.

Appendix: Methodology

Empirical and survey data is collected, where possible, on all 95 indicators, which form the 10 categories. This data is combined using an innovative methodology. CORVI uses structured expert judgement (SEJ) to combine empirical and survey data to produce a holistic assessment relative to other cities in a geographic region. Each indicator and risk category are scored from 1 to 10, with 10 indicating highest risk.

The use of city level empirical data and surveys from stakeholders within each city, allows CORVI assessment to reflect the specific risks that the coastal city is facing. In addition, as the number of survey responses increase, indicators become more robust over time.

What is structured expert judgment?

SEJ is a social science technique which seeks to quantify risk when existing empirical data is inadequate. Through structured interviews and surveys, as well as a series of weighting procedures to ensure data is representative, SEJ allows researchers to quantify topics that might otherwise be impossible to study in a systematic fashion. As SEJ is often applied to specialized fields where empirical data is scarce, it is a useful method for analyzing small sample sizes.

In climate change research SEJ provides a method to bring expert knowledge to bear on these important problems.[8] Examples of using SEJ include the link between climate change and conflict[9], the contribution of sea ice to sea level rise[10], and the impact of invasive species on ecosystem services.[11] In all these cases, expert knowledge is combined with empirical data to reduce uncertainty and produce stronger conclusions.

Indicator Factors

Each indicator is made up of five factors which together provide a holistic assessment of the past, current, and future risk trends. Empirical data is collected on current and past observed risk (factors 1 and 2), while survey data is collected on all five risk factors.

1. The **Baseline** measures the current level of risk for a particular indicator relative to other coastal cities in the region.[3]
2. **Observed trends** assesses the direction of risk for the past 10 years.
3. **Expected trends** assesses the direction of risk in the next 10 years.[4]
4. **Magnitude** assesses the degree of expected future trend change, relative to other cities in the region.
5. Finally, **Impact** assesses how the future change in the risk indicator will impact a particular coastal city. A single factor may not correlate with increased risk in its own, but when combined with other risks, could be significant.

Combining Empirical and Survey Data

While empirical data on the impacts of climate and ocean risks has greatly improved, data gaps remain. To overcome this challenge, CORVI uses a combination of empirical data and surveys from subject matter experts (SMEs) to collect data that would otherwise be unavailable. This data was the combined with empirical data using SEJ to produce a comparative score for each indicator in the index.[5]

SMEs are identified through desk research and extensive outreach to stakeholders in the target coastal cities. These experts then refer the Stimson research team to other stakeholders with appropriate expertise using the "snowball" method.[6] SMEs include academics, government officials, civil society activists, and representatives from the business community. Finally, to ensure survey data gathered adheres to the scientific principle's neutrality, accountability, and validation, survey answers are compared to empirical data to weight experts through a coherence check.[7] This ensures that experts who answers do not match empirical data are not weighted as highly as those who do.

Weighting Indicators in a Risk Category

Finally, individual indicator scores are combined into a final risk category score through a three step weighting process. First, indicator responses have to meet a minimum data threshold to be included in the final risk category score.[12] Second, indicators are weighted for data confidence. Third, using survey data, indicators are weighted on importance, relative to other indicators in that category.[13]

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Acknowledgements

The authors would like to thank AXA XL as a founding partner for their generous financial support. Special thanks to our research team Lindsay Getschel, Dr. Maia Call, and Dr. Teddy Allen, and to the projects Climate Advisory Board who provided detailed feedback through the project. Further thanks to the subject matter experts who provided their expertise through the survey process.

About Stimson

The Stimson Center is a nonpartisan policy research center working to protect people, preserve the planet, and promote security & prosperity

Endnotes

1. Examples include the Environmental Performance Index, the Ocean Health Index, and the ND-GAIN index.
2. Roger Cooke, *Experts in uncertainty: Opinion and Subjective Probability in Science* (New York: Oxford University Press, 1991).
3. Baseline data was collected from 2016 where possible. The only exception are indicators relating to climate change, where a 15 year average (2003-2018) is used to account for slow onset changes to the geophysical environment.
4. The only exception to the 10 year trend measure are climate change indicators, which use a 15 year trend horizon to account for slow onset changes.
5. For an introduction to structured expert judgement, see Cherie Maestas, "Expert Surveys as a Measurement Tool: Challenges and New Frontiers," in Lonna Rae Atkeson and R. Michael Alvarez (eds) *The Oxford Handbook of Polling and Survey Methods* (Oxford: Oxford University Press, 2018).
6. Snowball sampling or chain-referral sampling is a non-probability sampling technique used when samples have traits that are difficult to find. In this sampling technique, existing subjects provide referrals to recruit additional subjects required for a research study.
7. Abigail Colson and Roger Cooke, "Expert Elicitation: Using the Classical Model to Validate Experts' Judgements," *Review of Environmental Economics and Policy* 12, no. 1 (2018): 113-132.
8. M. Granger Morgan, "Certainty, Uncertainty, and Climate Change," *Climatic Change* 108, no. 4 (2011): 707–721.
9. Katharine J. Mach et. al., "Climate as a Risk Factor for Armed Conflict," *Nature* 571 (2019): 193–197.
10. Jonathan L. Bamber, Michael Oppenheimer, Robert E. Kopp, Willy P. Aspinall, and Roger M. Cooke, "Ice Sheet Contributions to Future Sea-Level Rise from Structured Expert Judgment," PNAS 116, no.23 (2019).
11. Tobias Schwoerer, Joseph M Little, and Milo D Adkison, "Aquatic Invasive Species Change Ecosystem Services from the World's Largest Wild Sockeye Salmon Fisheries in Alaska," *Journal of Ocean and Coastal Economics* 6, no. 1. (2019).
12. Indicator scores are excluded is they do not have empirical data or less than 3 expert surveys. It is important to note, that these indicators are still included in the final report, as highlighting these data gaps can drive future research in these risk areas.
13. For more information on index weighting see Salvatore Greco, Alessio Ishizaka, Menelaos Tasiou, Gianpiero Torrisi, "On the Methodological Framework of Composite Indices: A Review of the Issues of Weighting, Aggregation, and Robustness," *Social Indicators Research* 141, no. 1 (2019): 61–94.