The GCRP Compound Risk Monitor:

A global early warning tool for tracking compound risk

TECHNICAL NOTE

This note was produced by the Secretariat of the Global Crisis Risk Platform, with inputs from a multi-disciplinary team of WB colleagues

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EXECUTIVE SUMMARY

Countries face an increasingly complex risk landscape. The impact of a single shock—an earthquake, a food crisis, or a disease outbreak—can amplify existing stressors or potentially initiate a cascade of shocks, leading to larger and more sustained impacts on lives, livelihoods, and development outcomes. With the potential to cause significant economic impacts, complex crises can hinder progress in poverty reduction, especially in low-income and fragile countries.

The ongoing COVID-19 pandemic is a prime example of a complex crisis with considerable adverse consequences on economies in both high- and low-income countries. Not only is the pandemic reducing the ability of countries to respond to wider threats, but the occurrence of any additional shocks—whether natural, political or economic—during the COVID-19 crisis is likely to hinder the recovery process, further entrench existing vulnerabilities, and significantly roll back development gains.

The Global Crisis Risk Platform (GCRP) was endorsed by the Board of Executive Directors in 2018 to strengthen the World Bank's ability to identify, mitigate, and respond to complex crises.[1] One of the core objectives of the GCRP is to support the identification of countries facing compound risks to inform prioritization and investments in risk management. While risk monitoring tools exist within and outside the Bank, there currently is no in-house multidimensional risk-monitoring system to support the Bank's institutional capacity to identify compound risks. Where they exist, in-house risk monitoring approaches vary across sectors, and end users (primarily CMUs and Bank management) receive information about risks from different sources, with different frequency, and in different formats.

To contribute to the GCRP's vision, the GCRP Compound Risk Monitor (CRM) presented in this note builds on existing risk monitoring efforts to support the identification and monitoring of compound risks. More specifically, the CRM is an early warning system based on a simple flagging methodology, highlighting countries experiencing changing risk conditions across multiple dimensions of compound risk. Its design is guided by the need for simplicity, transparency, and flexibility, thus providing decision makers with easily interpretable and relevant data-driven analysis. As such, the CRM is not to be understood as a precise index of compound risk, nor is it meant to forecast future compound crises. It should be seen as a means of highlighting countries and regions requiring increased vigilance given heightened compound risk levels across key risk dimensions.

From a conceptual point of view, the CRM breaks compound risk down into six dimensions: i) natural hazards, ii) food security, iii) conflict and fragility, iv) macro-fiscal dynamics, v) socio-economic vulnerability, and vi) health risks. These six dimensions can be seen as preconditions (or catalysts) likely to contribute to compounding effects. Each dimension integrates aspects related to exposure, vulnerability, and response capacity. For each dimension of compound risk, the CRM provides three country-level outlooks: a) an overview of a country's existing predisposition to specific threats, typically based on an evaluation of structural conditions and underlying capacities related to each risk dimension ("Underlying Vulnerability"); b) a dynamic view of changing risk conditions, signaling countries that are experiencing (or are expected to experience) an intensification of risk conditions ("Emerging Threat"); and c) a combined outlook that weighs Emerging Threat against a country's Underlying Vulnerability ("Overall Compound Risk"). The latter outlook can be seen as a high-level approximation of the level of vigilance needed in considering whether emerging threats are likely to materialize into compound crises.

[1] The GCRP Board paper is available at: http://documents1.worldbank.org/curated/en/660951532987362050/pdf/GCRP-Board-Paper-26-June-FINAL-06272018.pdf

The CRM aims to support the Bank's institutional capacity to monitor risks that threaten countries' efforts to end extreme poverty and boost shared prosperity. Its main use case is in providing Bank Management, Regional Management, IDA Management and Country Management Units (CMUs) with systematic updates on the global risk landscape and flag 'hotspots' of concern—countries and regions where the potential for compound risk is intensifying. In addition, it can support client dialogue on risk management by presenting a holistic view of country-level risk. Finally, the data and resources underlying the CRM can be used by project teams seeking specific risk information. While the CRM is not a turnkey solution to all risk monitoring needs, it serves as an important decision-support tool among the range of risk analytics tools available to WB management and staff.

The CRM is the first of a suite of outputs focused on compound risk under the GCRP program. In particular, information from the CRM database will be made accessible to WB stakeholders through an interactive dashboard (see Box 1). The dashboard will enable easy visualization of CRM outputs, facilitate interpretation, and allow users to tailor insights from the CRM to their individual needs. Through the dashboard, the CRM will act as an aggregator of risk information, compiling risk information produced and used across the WB and directing users to sector-specific risk analyses and resources. As part of the GCRP program, the CRM will also feed into regular horizon scanning exercises that will combine its data-driven outputs with detailed qualitative insights from sector and regional experts to develop regular compound risk briefings tailored to the needs of target users.

The purpose of this note is to present the methodological considerations underlying the CRM and provide examples of the outputs it can produce. The paper outlines the indicators underlying the CRM and the methodology adopted to aggregate these indicators into compound risk outlooks along six dimensions. It also highlights areas for further consideration in refining the CRM going forward.

1. INTRODUCTION

1.1. Background

Compounding crises threaten development gains. The impact of a single shock—an earthquake, a food crisis, or a disease outbreak—can amplify existing stressors or potentially initiate a cascade of shocks, leading to larger and more sustained impacts on lives, livelihoods, and ultimately development outcomes. With the potential to cause significant economic impacts, compounding risks can hinder progress in poverty reduction, especially in low-income and fragile countries.

Understanding different types of risk and their interactions is therefore essential to supporting risk-informed development. Despite this, risks are often assessed and monitored in isolation. This can lead to an incomplete understanding of risk, how it materializes and where it is concentrated. It can also lead to large biases in estimates of the probability and severity of compounding shocks.

The World Bank is working to enhance its ability to identify, monitor, and address risks holistically across sectors and geographies. As part of this effort, the GCRP was endorsed by the Board in 2018 as an institutional mechanism to improve the way the Bank tracks and manages crisis risks in order to ultimately: (i) promote risk-informed investments to support crisis prevention and preparedness; and (ii) strengthen institutional capacity for early response, especially where a combination of shocks amplifies impacts or spills across borders.

The CRM presented in this note supports the vision of the GCRP by providing a tool to enhance the World Bank's institutional capacity to prepare for and respond to complex crises that threaten the organization's twin goals of ending extreme poverty and boosting shared prosperity.

1.2. Objectives and vision of the CRM

The CRM is an early warning system to track compound risk at the country-level, drawing on a wide range of pre-existing risk databases and indexes. It identifies countries experiencing changing risk conditions across multiple dimensions of compound risk and serves as an aggregator of wider WB risk analyses. The CRM allows easy identification of 'hotspot' areas—i.e., countries and regions where multiple compounding threats may substantially set back progress on economic development and poverty alleviation. To do so, the CRM tracks interactions between six dimensions of compound risk: i) natural hazards, ii) food security, iii) conflict and fragility, iv) macro-fiscal dynamics, vi) socio-economic vulnerability, and vii) health risks. These six dimensions can be seen as leading contributors to further compounding effects.

Using a set of indicators across each of the six risk dimensions, the CRM provides three country-level risk outlooks. The first is a gauge of a country's underlying level of vulnerability ("Underlying Vulnerability"). It is an overview of a country's predisposition to specific threats, typically based on an evaluation of structural conditions and underlying capacities related to each risk dimension. The second outlook is a measure of changing risk conditions ("Emerging Threat"). It signals countries that are experiencing (or are expected to experience) an intensification of risk conditions. The third is a combined outlook that weighs Emerging Threat against a country's Underlying Vulnerability ("Overall Compound Risk"). This combined measure should be seen as a high-level approximation of the vigilance needed in monitoring and responding to changing risk conditions in a given country, considering the inherent limitations of an outlook which combines two measures that do not share identical indicators or thresholds.

1.3. Target audience and use cases

The CRM has been developed as a core deliverable of management's commitments to the Board per the GCRP paper. The CRM is designed to serve primarily as an internal World Bank risk monitoring tool, with the target user group being composed of World Bank senior management as well as IDA management. The CRM provides decision-makers with a high-level, global overview of compound risk through systematic updates on underlying vulnerabilities and emerging threats. By flagging potential compounding risks at global and regional levels, it draws attention to areas that require increased vigilance, and helps support anticipatory decision making. The information produced by the Monitor can serve as an input for portfolio-level discussions at the global and regional level, thus supporting the GCRP's function as an institutional platform reinforcing the monitoring of and response to complex crises, as envisioned in the GCRP Board paper.

Beyond management, technical and operational staff across the WB can benefit from the CRM in their dialogue with clients and partners on risk management.

- **At the corporate level,** the CRM can supplement existing corporate risk management tools and processes by identifying emerging areas of complex crises requiring senior management's attention. Current corporate risk management processes rely on bottom-up identification and escalation of risks from the project-level, while the CRM can provide a top-down view of emerging threats and changing contexts in client countries. As such, the CRM can be used as an input into OPCS's Integrated Risk List or Pipeline Risk and Corporate Review processes.

- **At the regional and country level:** While the CRM is not a substitute for local expertise, especially in the context of countries that are already experiencing protracted crises, Country Management Units (CMUs) and task teams may benefit from CRM outputs in a number of ways. First, the tool can help them identify emerging threats in operations and their potential impacts on project outcomes. Emerging Threat values can serve as a trigger for task teams to explore secondary risks likely to emerge and impact the achievement of the project's development outcomes. It can prompt early thinking by task teams on mitigation measures to minimize the impact of these risks on project results. In addition, regional and country teams can use the CRM during project design to inform the ambitiousness of results being pursued given the compound risk context of the country's operating environment. The CRM can also inform the assessment of regional and country contexts related to compound risk during the design of strategic processes such as Country Partnership Frameworks (CPF) and Systematic Country Diagnostics (SCD). Key statistics from the CRM can for instance be extracted to understand how countries in a specific region are faring compared to neighboring countries or regions. Lastly, the CRM provides enough flexibility to access the underlying data at a disaggregated level, separating Underlying Vulnerability from Emerging Threat and thus enabling CMUs and task teams to apply their own aggregation methods. As such, the CRM can be used as a clearinghouse for data from detailed sectoral assessments and monitoring tools.

To respond to the diversity of needs of the above-mentioned end users, the tool will be deployed through a phased rollout. The team plans to start rollout of the tool at the corporate and regional levels to further refine the methodology and outputs to meet the needs of Senior management, Regional management, and corporate teams. Learnings from this initial phase would then inform engagement with additional use cases at country and project level. For instance, (i) at the country level, the CRM could be deployed in selected high-risk countries entering a new CPF programming cycle, and (ii) at project

level, task teams could use the CRM in pilots of operations under preparation and implementation to see how this could inform the design and mitigation for better results. Building on user experiences at all these levels will help in further refining the tool.

Across use all cases, it is important to remember that the CRM is not designed to be a turnkey solution. It is a decision-support tool that will be complemented by nuanced qualitative assessments from WB experts. Combining the data-driven outputs of the CRM with a qualitative assessment (through regular horizon scanning meetings) will help ground-truth its outputs, reflect latest developments not captured in the data (i.e. political economy developments), and explore the different likelihoods and potential impacts of key risk dimensions.

While access to the CRM will be limited to Bank staff, limited external applications could be considered going forward. As an aggregator of risk information and analyses, the CRM can serve as a public good for risk analysts and practitioners. In the future, Bank management may consider making parts of the tool, particularly the data and resources underlying the tool, available to a non-Bank audience, likely through an adapted version that excludes any sensitive outputs. This would contribute to calls for greater collaboration and cooperation around crisis risk monitoring received as part of the G7 and from other partners working on compound risk monitoring, including UN-OCHA, UN-PBSO, UK FCDO and the Centre for Disaster Protection.

1.4. Development of the CRM

Development of the CRM was led by the Secretariat of the GCRP, housed in the WB's FCV Group. The work was carried out in close cooperation with teams from across various GPs, including Climate Change, GFDRR, DEC, AGF, FCI, MTI, HNP, POV, and FCV. In addition, the team was able to draw insights from the technical collaboration with a growing community of partners developing similar compound risk monitoring tools, including the United Kingdom Foreign, Commonwealth and Development Office (FCDO), the UK Met Office, the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA), the United Nations Department of Peacekeeping Operations (UN-DPKO), and the Centre of Disaster Protection.[2]

1.5. The GCRP Compound Risk Monitoring & Analytics Program

The CRM is part of a suite of related risk monitoring activities under the GCRP Compound Risk Monitoring & Analytics Program (P173164). These include:

i) An *interactive dashboard* that will visualize outputs from the CRM, allowing users to quickly identify global hotspots and compare risk profiles across countries (see Box 1). This will be the most direct way for users to interact with the CRM and will serve as a gateway platform. The dashboard will also allow users to adjust aggregation methods used in the CRM in accordance with their own preferences and user interests.

ii) A periodic *horizon scanning exercise* which will inform regional and senior WB management on short to medium term compound risk. It will build on the outputs of the CRM, coupled with inputs from a range of sectoral and regional experts, and focus on periodic threats of interest. The insights will be presented at periodic GCRP senior management meetings.

[2] Together these partners are organized as a community of practice, seeking to promote knowledge sharing and advocacy in support of monitoring compound disaster risk within development and humanitarian organisations.

iii) A set of *forward-looking country deep dives*. These will focus on a select number of countries identified through the CRM and prioritized by country, regional, or senior management as demanding greater attention because they are highly prone to emerging compound risks. The case studies will examine key vulnerabilities or threats more closely, to determine entry points for WB engagement and action.

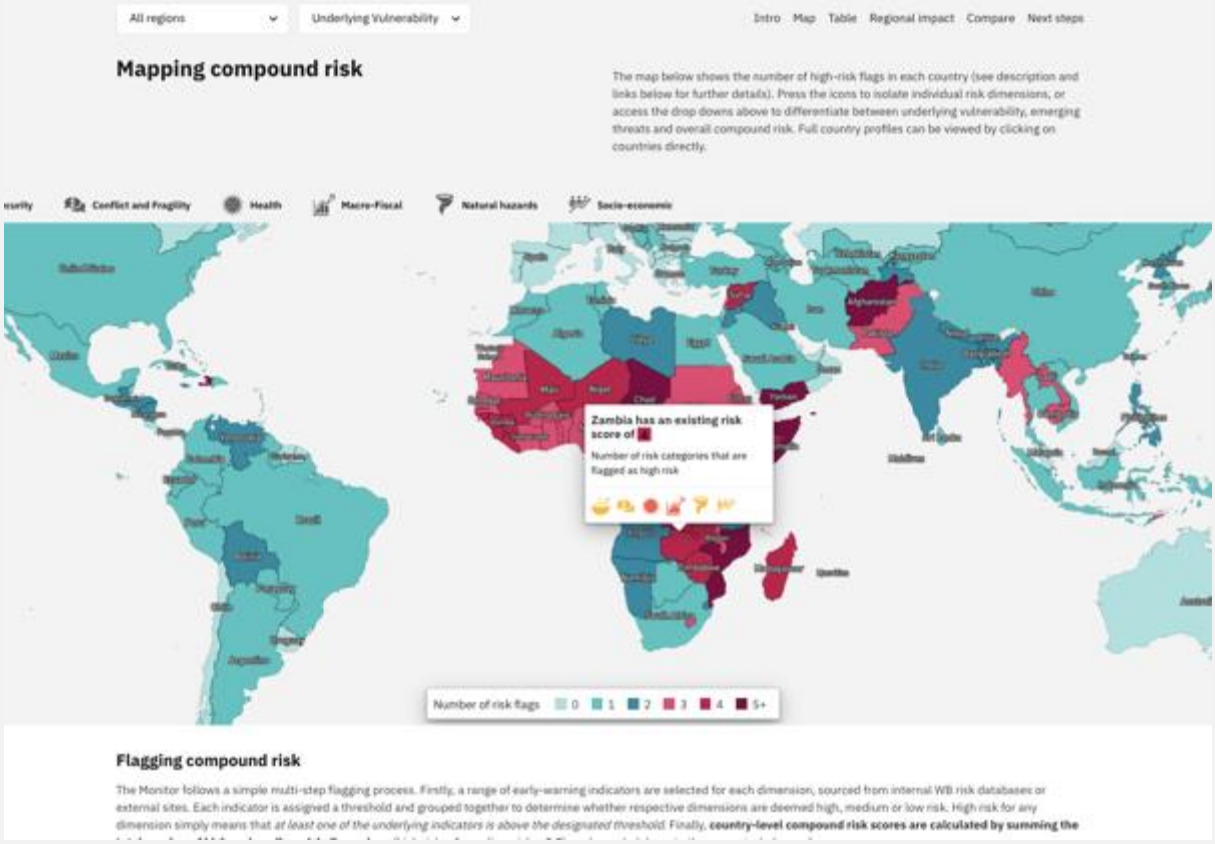
iv) A series of *retrospective country diagnoses* which will examine countries recently exposed to multi-risk threats, identifying early signs and indicators that could have alerted decision makers to the crises that followed.

All four activities will feed directly into continual improvements to the CRM. In addition, the team will sustain an active engagement with key technical partners within and outside the WB to leverage the results of relevant analytical work on risk assessment in refining the CRM.

Box 1: The CRM interactive dashboard

Information from the CRM will be presented and visualized through an interactive dashboard. The dashboard allows users to tailor information in the CRM database to their particular needs, homing in on specific dimensions, countries or regions of interest. More importantly, the dashboard enables users to unpack results of the CRM and understand what indicators and trends are driving high risk scores. Access to the dashboard, which is currently in prototype phase, will be limited to Bank staff given the inclusions of proprietary data and the potential sensitivity of the information presented.

The dashboard is built around a global map profiling the geographic spread of compound risk within the CRM. Users are able to toggle between scores for underlying vulnerability, emerging threats, and overall alert flags, and can also isolate individual risk dimensions.



Note that data shown in the prototype dashboard does not match the current CRM database

Users can also click on countries of interest to access insights into country-level risk profiles (see Annex Figures 10-13). Here, one finds scores for individual indicators which enable an understanding of core drivers of changing risk conditions. Country pages will also direct users to relevant risk information and resources across the Bank and from external partners.

Additional sections allow users to probe the regional distribution of risk flags, highlighting the total population (and proportion) affected by different risk categories in each region. The dashboard also enables the viewer to download all data inputs underlying the CRM for further analysis.

The CRM dashboard is considered “Official Use Only” and therefore accessible only to Bank staff, and initially during the inception phase will be accessible only by password.

2. METHODOLOGY

2.1. Scope: What to expect from the CRM

The Monitor differs from other multi-dimensional risk databases in that it is continuously updated and compiles forward-looking risk information, together with descriptions of historical vulnerability to compound risk. By focusing on potential compounding effects, the CRM aims to complement existing risk tracking systems rather than replace them. In designing the Monitor, the team focused on ensuring a careful balance between complexity (in beginning to explore the interactions between different dimensions of compound risk) and simplicity (in ensuring the outputs of the Monitor are intuitive enough to support decision-makers). Box 2 presents for a short description of the design principles that guided the development of the CRM. The Monitor and its methodology are therefore a live resource, open to continuous updates and refinement as new data sources become available, and based on feedback from both technical experts and potential users (see Section 2.3).

Before delving into the methodology used in compiling the CRM, it is important to clarify how the tool should (and should not) be used.

What the Monitor DOES:

i. **It provides a global overview of country-level compound risk.** The CRM does so by drawing on the best available sources of risk information across a range of dimensions of compound risk (six in total) to provide high-level risk summaries for both Underlying Vulnerability and Emerging Threat, as well as providing Overall Compound Risk flags. In addition, the tool aims to encourage decision makers to look at risks holistically, providing multidimensional risk information to actors that might otherwise focus on singular risk factors.

ii. **It acts as a simple alert system, flagging any areas of potential concern that display strong signals and that therefore warrant increased vigilance.** Using the default method, flags are raised whenever one (or more) indicator within a given dimension has exceeded a high-risk threshold. This means that the CRM is inherently proactive: A flag will be raised even in instances where all other indicators within the dimension are not considered high risk. For this reason, users are encouraged to consider and probe the diversity of indicators values, which will be facilitated through the use of an interactive dashboard.

What the Monitor is NOT intended for:

i. **It is NOT a modelling exercise. Nor is it an attempt at precisely projecting the severity of compound risk.** The Monitor highlights countries and regions where concerns exist relating to one or multiple dimensions. In this way, the CRM is designed as a flagging system. This differs from systems aimed at precisely quantifying the timing and magnitude of future risks. Decision-makers should see the CRM as a high-level guidance tool, to be complemented by supplemental and more in-depth risk analytics to inform specific policy and operational decisions. For example, the CRM cannot substitute a detailed sub-national risk profile or a probabilistic model that quantifies the likely magnitude and frequency of natural hazards in a given country over different time periods.

ii. **It is NOT designed with the aim of ranking countries.** Given its reliance on a flagging system, like-for-like rankings of countries within the CRM are not considered appropriate. Instead, users should prioritize use of the tool to observe how a country's risk changes over time as well as to provide a broad overview of the geographic spread of compound risk.

iii. **It is NOT meant to replace sector-specific risk monitoring tools.** The CRM collates information from a range of sector-specific risk monitoring tools. These are used as source indicators that feed into the CRM model (with high and low risk thresholds assigned to each). While the Monitor presents summarized risk profiles across all respective sectors, they are not meant to replace them. Through the dashboard, the CRM will point users to relevant sector-specific risk tools and data repositories for further insights.

iv. **It is NOT a complete measure of compound risk.** Risk is decidedly multi-dimensional. Capturing and quantifying all possible risks that a country faces is an impossible task. Instead, the CRM focuses on six distinct dimensions of compound risk. These are used as lenses through which levels of risk facing a given country are inferred. Future work on the CRM will focus on quantifying precise interactions and weights between these dimensions and may explore the integration of additional dimensions.

Box 2: Design principles

The design of the CRM was guided by four key design principles:

1. **Simplicity.** Given the large number of data sources underlying the CRM, simplicity is paramount to ensure that risk information is easy to communicate and interpret. Users should be able to quickly identify the main dimensions contributing to a country's level of compound risk. The planned user interface, in the form of a web-based interactive dashboard, will give users access to a wide variety of descriptive information and visualizations.
2. **Flexibility.** The CRM has a range of potential users, each with their own informational needs. Accordingly, many aspects of the Monitor are designed to be easily tailored to users' needs. One example is the choice of high/low thresholds used for classifying indicators and risk dimensions. In addition, users may want to place higher emphasis on particular dimensions or isolate upcoming threats that may be of interest.
3. **Disaggregating risk information across time-periods.** Decision-makers often require information related to a range of timescales, ranging from historical trends to long-term projections of future risk. With this in mind, the Monitor is designed in a way that intuitively showcases levels of compound risk related to a range of time-periods of interest.
4. **Building on existing multidimensional risk indexes.** Whenever possible, the CRM builds on existing risk monitoring initiatives, aligning dimensions, indicators and aggregation methods where appropriate and adding new dimensions that suit the needs and purpose of the CRM. In particular, most multi-dimensional risk indexes provide static snapshots of existing (or systemic risk). The CRM adds notable value in combining these with indicators that reflect continuously updated and forward-looking indicators to provide an outlook on emerging threats conditions. Furthermore, it combines information from Underlying Vulnerability and Emerging Threat to provide a gauge of overall alertness needed in responding to given risk dimensions.

Development and interpretation of any risk monitoring system requires an understanding of the considerable technical challenges involved in tracking risk. In particular, there are two main methodological challenges that affect the design of the Compound Risk Monitor:

- **Data availability.** Risk is inherently multi-dimensional, with no one indicator able to holistically cover all aspects of risk. With this in mind, the CRM draws on a range of existing indexes that aggregate large pools of indicators across different risk dimensions. Inevitably, not all sources of underlying data offer the same level of robustness, and some components are inherently better at comprehensively reflecting local risk conditions than others. For example, while there is a relative abundance of real-time information on exposure to natural hazards and occurrence of conflict events, few resources exist to track household-level socio-economic vulnerability. In

addition, risk information is geographically patchy, with few data sources providing full global coverage. The CRM therefore aggregates information from a range of data sources. This often means that the reliability of respective dimensions of compound risk used in the CRM will vary at different spatial scales, requiring careful interpretation of the underlying metrics that feed into it. For example, FEWSNET provides a comprehensive assessments of food security conditions in the 30 countries it covers. Yet, outside of this, analysts are typically reliant on alternative proxies to assess real-time conditions, many of which are far less reliable.

- **Different methods for data aggregation can result in vastly different risk outcomes**. Given that tracking of compound risk requires multiple sources of information, the choice of how to combine and weight different indicators looms large. This applies not only to how individual dimensions are represented, but also to interactions between them. For example, deciding whether certain groupings of dimensions (e.g. conflict, macro-fiscal dynamics, and food security) should be weighted differently to others (e.g. COVID and natural hazards) requires judgement calls in the absence of robust evidence. This is particularly relevant for any attempts at modelling or predicting compound risk (a task the CRM does not attempt to undertake).

In addition to these challenges, it is important to recognize that while representing factors associated with a single risk dimension (e.g. natural hazard risk) comes with a degree of uncertainty, uncertainties in compound risk are inherently much higher. This owes not only to the fact that uncertainties will additively accumulate as individual dimensions are combined in the CRM. It also recognizes that little is currently known about how risk factors amplify or diminish each other when compounded. The GCRP is therefore aware of its responsibility in communicating outputs from the CRM with clear guidance on the scope of the tool.

2.2. Unpacking compound risk in the CRM

There currently is no standard definition of compound risk (Pescaroli and Alexander 2018) and the term is frequently used synonymously with concepts such as 'cascading', 'complex' or 'multi-dimensional' risk. At its most basic, compound risk results from "the combination of two or more events" (IPCC 2012). It refers to any situation in which a single hazard interacts with underlying vulnerabilities and thus influences the extent and impact of secondary or tertiary hazards (Cutter 2018). A recent paper by Zscheischler et al.[3] offer a useful typology of compound risk, anchored in climate science. Compound risk includes: i) the occurrence of multiple threats (either the same or different types of threats) in quick succession; ii) the occurrence of multiple threats in close geographic proximity; and iii) rapid increases in vulnerability leading to heightened sensitivity to future threats (including threats that would otherwise not lead to a crisis).

Compound risk is therefore not only a function of exposure to multiple hazards, but also of the underlying vulnerabilities of the people and communities affected by them. For example, socio-economic vulnerability is often considered an outcome of compounding risk—perhaps a result of two back-to-back cyclones affecting an area. Yet, a sharp increase in poverty can also generate compounding effects by severely weakening household-level capacities to cope with even minor shocks and stressors that would otherwise not lead to major impacts or crises.

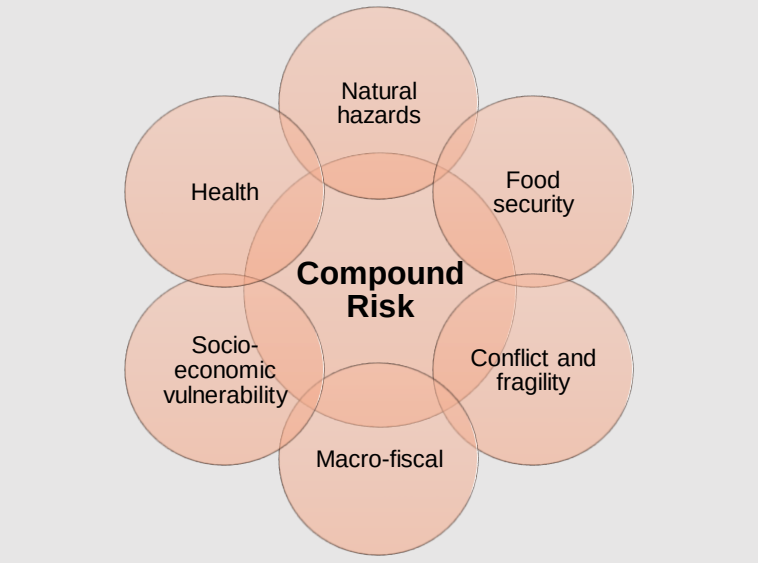
[3] Zscheischler, J., Martius, O., Westra, S., Bevacqua, E., Raymond, C., Horton, R. M., ... & Maraun, D. (2020). A typology of compound weather and climate events. Nature reviews earth & environment, 1(7), 333-347.

The CRM breaks down compound risk into underlying dimensions, each representing risk conditions, threats or vulnerabilities that have the potential to contribute to compound risk. There is no standard framework for compound risk across the risk literature or other risk monitoring initiatives.[4] The CRM team therefore focused on: i) dimensions that are commonly referred to across a range of similar risk monitoring initiatives; ii) dimensions that are relevant to the Bank's mandate and operational interests as highlighted in the 2018 GCRP Board paper; and iii) dimensions for which there is sufficient data availability in tracking changing risk conditions.

Based on these criteria, the CRM separates compound risk into six core dimensions: i) natural hazards, ii) food security, iii) conflict and fragility, iv) macro-fiscal dynamics, vi) socio-economic vulnerability, and vii) health risks.[5] While each is considered distinct, there are inherently strong overlaps across the six dimensions. Indeed, each individual dimension is multi-dimensional in nature, with some degree of inevitable overlap across other dimensions. While this would complicate any attempt to model compound risk as part of a single composite index, the fact that the CRM is based on a flagging system is intended to avert concerns associated with such interactions.

Below we provide further insight into the rationale and scope of the various dimensions underlying the CRM. For a full list of the indicators that feature under each component refer to Section 2.3, Step 1 below.

Figure 1: Breaking compound risk into six dimensions



Note: The graphic above highlights the conceptual overlap between the six dimensions of compound risk selected and Overall Compound Risk. In reality, there are more overlaps across individual dimensions.

[4] The INFORM Risk Index identifies six 'categories' of risk, outlined as: natural hazards; human hazards; socio-economic vulnerability; vulnerable groups; institutional coping capacity; and infrastructural coping capacity. ND-GAIN similarly has six 'sectors' of vulnerability, including: food, water, health, ecosystem services, human habitat and infrastructure; and three 'components' of readiness, comprising: economic readiness; governance readiness; and social readiness. WFP's early-warning of acute food insecurity is another relevant compound risk monitor, tracking changing risk conditions across eight 'risk types': tropical cyclones, locusts, dry conditions, floods, conflict/insecurity, political instability/unrest, displacement and economic crises.

[5] Note that given current the current global risk landscape, an emphasis is placed on COVID-related impacts, particularly for the Health dimension. Over time, this will reorient towards a broader focus on 'Pandemic response capacity' as the impacts of COVID subside globally.

i) **Natural hazards:** Natural hazards are perhaps the threat most typically associated with compound risk. They also feature prominently as core dimensions in a wide range of risk monitoring efforts, including INFORM, ND-GAIN and FAO/WFP's Early Warning Analysis (see Annex Table 1 and Annex Supplementary Text 5). There are many examples of back-to-back (or overlapping) hazards that have resulted in complex crises. The short span between cyclones Kenneth and Idai in Mozambique (2019) and the more recent successive occurrence of hurricanes Eta and Iota in Nicaragua (2020) are good examples of the devastation that natural hazards can inflict on societies and economies. In the context of the CRM, we categorize natural hazards across climate-related events such as floods, droughts and cyclones; geophysical events such as earthquakes and tsunamis; as well as pest-related events such as the locust outbreak currently affecting the Horn of Africa.

ii) **Food security:** As highlighted above, the CRM defines compound risk in relation to the interaction of both hazards and underlying vulnerabilities. In this sense, while food insecurity can often result as consequence of specific threats (such as natural hazards or conflict), high levels of food insecurity can significantly increase a community's sensitivity and vulnerability to other compounding threats. Food insecurity within the CRM is defined as a context in which people do not have adequate physical, social, or economic access to food. This holistic definition recognizes that there is no single metric of food insecurity, and rather demands multi-dimensional measures covering all aspects related to access to sufficient amounts of safe and nutritious food. Food security also features as a core dimension of both the ND-GAIN and FAO/WFP EWA.

iii) **Conflict and fragility:** Fragile and conflict-affected states are among the contexts with the highest potential for compound risk. In particular, coping capacity is often limited, with weakened country systems unable to respond to shocks, exacerbating impacts on lives and livelihoods. The CRM considers both violent conflict, referring to widespread and intense violence across many parts of the country, as well as institutional fragility, invoking countries facing deep institutional crises, either because of poor transparency and government accountability or because of low institutional capacity. The CRM's definition of conflict and fragility mirrors the World Bank's classification of fragile and conflict-affected situations.[6]

iv) **Macro-fiscal:** Economic shocks (and a country's fiscal response) can have large impacts on a country's capacity to deal with future risk as well as its development trajectory. In the context of the CRM, the macro-financial and fiscal risk dimension refers to the general status of a country's economy and the sustainability of fiscal measures adopted. It focuses on aspects related to public sector, corporate, monetary, debt sustainability, banking, and market-related risks.[7] Given the lack of suitable preexisting metrics for tracking Underlying Vulnerability and Emerging Threat related to macro-fiscal risk, the CRM will opt for a phased approach. The dimension will first be based on a modified version of the EIU Risk Briefing score (with further details on the proposed steps outlined in Figure 1). As a second step, the CRM team will seek to replace (or complement) inputs from the EIU with an in-house metric

[6] https://www.worldbank.org/en/topic/fragilityconflictviolence/brief/harmonized-list-of-fragile-situations

[7] Note that household-level category is removed from the MFR heatmap, as it serves as an input to the socio-economic vulnerability dimension

design in collaboration with a variety of Bank units (including CROCR, MTI, FCI and Prospects). See Annex X for further details on the proposed index.

v) **Socio-economic vulnerability:** The inclusion of socio-economic vulnerability in the CRM recognizes that compound risk arises from the interactions of hazards and underlying vulnerabilities. Indeed, a compound event can occur precisely because a community has experienced a rapid deterioration in livelihood outcomes and/or coping capacity, with the latter referring to a community's severely compromised ability to deal with emerging threats—even those that would otherwise not lead to crisis. To complement the use of macro-level inputs, the CRM also monitors socio-economic vulnerability, leveraging the World Bank's unique sources of continuously updated data on household-level dynamics, including poverty projections, inequality level estimates, and remote phone-surveys.[8]

vi) **Health-systems, disease outbreaks and response ('Health systems' hereafter):** The ongoing COVID pandemic is a prime example of the potentially devastating impacts of disease outbreaks on economies and societies. With this in mind, the CRM features a measure of: i) the effectiveness of a country's healthcare system; ii) exposure to ongoing (or potential) health-related threats, namely epidemics and pandemics; and iii) the immediate implications of response options (or lack thereof) on a country's ability to contain an ongoing threat.

The CRM is designed to allow for some degree of flexibility, and the scope of each dimension (as well as the composition of indicators within each) may therefore change gradually over time as the nature of the global risk landscape continues to evolve. For example, the current emphasis on COVID-19 and its secondary impacts is likely to be reassessed over time as the pandemic evolves. To guide this process, the team plans to review the scope of each dimension (and indicators) quarterly, seeking inputs from relevant experts across the institution.

2.3. Risk outlooks within the CRM

Levels of compound risk can be scrutinized in many different ways depending on the interests and needs of intended users. For example, users may be primarily interested in knowing whether a given set of countries is predisposed to compound risks based on historical trends and underlying response capacities. Others may be more interested in understanding the extent to which a given country is experiencing changing risk conditions, based on recent or expected trends. Lastly, some users may wish to take both of these sources of information into account to understand how recent changes in risk conditions are likely to impact on a country's overall levels of compound risk in the near future.

Recognizing the diversity of user needs, the CRM produces three distinct types of risk outlook: Underlying Vulnerability, Emerging Threat, and Overall Compound Risk.

- **Underlying Vulnerability** is a measure of a county's predisposition to the occurrence and impacts of compound crises based on historical trends and underlying coping capacities. It can be thought of as a measure of systemic vulnerability, using static indicators to quantify levels of risk across all six dimensions used in the CRM. The majority of data sources come from multi-dimensional risk indexes that combine elements of exposure, sensitivity, and response capacity to given threats. Most inputs to the CRM are updated on an annual basis (e.g., the EU's INFORM risk index, WFP's Proteus index,

[8] Phone survey data is collected through the COVID-19 High-Frequency Monitoring Dashboard. Link to the publicly available database: https://www.worldbank.org/en/data/interactive/2020/11/11/covid-19-high-frequency-monitoring-dashboard

and the EIU's Global Health Score index),[9] and are therefore considered *static* given the low frequency of updates.

Use-case: Most relevant to decision makers seeking a holistic assessment of compound risk and an understanding of where there is greatest historical exposure to certain risks to help inform decision-making on where investments need to be made to address those risks. This serves as complementary information needed to assess priorities when combined with information on emerging threats.

Strengths: Comprised of comprehensive multi-dimensional indexes and well-established thresholds; an adequate gauge of systemic vulnerability to compound crises.

Limitations: Does not take into account latest trends and changes in underlying risk capacities (e.g., the status and nature of COVID impacts).

- **Emerging Threat** provides the latest available information on indicators of dynamic crisis threats in a country. It uses *dynamic* indicators that reflect a country's immediate status or provide an outlook on the near-to-medium term future (i.e., up to 12 months ahead). Data is similarly sourced from a range of internal and external risk monitoring initiatives that provide regular updates on changes in risk profiles (such as FEWSNET, ACLED, and regional meteorological forecasts).[10] Where possible, Emerging Threat indicators are chosen to align with those used in determining Underlying Vulnerability. It is worth noting that, ideally, emerging compound risk would be further disaggregated into immediate (up to 3 months), short-term (up to 12 months) and medium-to-long-term (up to 3-5 years) risk outlooks. However, data limitations result inthis first iteration of the CRM grouping future risks together. Going forward, the team will work to further refine the forward-looking timescales of the CRM.

  Use-case: Useful in gauging ongoing (or likely) changes in underlying risk reconditions. Can be seen as a measure of Emerging Threat anomalies—i.e., countries and regions that are or are likely to experience heightened or diminished risk in the coming months. The metric is better suited to comparing regional and country-level trends, and is often best placed to identify emerging threats in countries that are not traditionally considered high-risk.

  Strengths: Features continuously updated risk information, often revised on a weekly or monthly basis. Uses a hierarchy of data inputs to balance the need for use of robust data sources alongside geographic coverage.

  Limitations: Limited availability of forward-looking risk information and differences in spatial coverage of data means that care must be taken in comparing emerging threat and Underlying Vulnerability metrics as well as carrying out cross-country comparisons.

- **Finally, Underlying Vulnerability and Emerging Threat values are combined to produce a measure of Overall Compound Risk.** This can be seen as a gauge of vigilance needed in responding to risk conditions in the months ahead. It is meant as an approximate indication of how significant any emerging threats are relative to a country's underlying level of vulnerability. As a result, countries that have seen a modest increase in Emerging Threat, but low levels of Underlying Vulnerability, are weighted downwards, while those that have seen slight increases in Emerging Threat, but high overall levels of Underlying Vulnerability, are weighted upwards. The combined value can be a useful tool for

[9] In the current context, these sources can be thought of as reflecting conditions prior to the COVID pandemic.

[10] In the current context, the information presented here can be thought of as reflecting ongoing risk conditions during the COVID-19 pandemic.

comparisons across countries and regions, but its accuracy is undermined by the fact that Underlying Vulnerability and Emerging Threat indicators are not always directly comparable.

Use-case: Most relevant for decision makers that want a high-level assessment of overall levels of alertness related to compound risk, allowing countries to be directly compared like-for-like.

Strengths: Provides a more accurate reflection of whether recent changes in risk conditions warrant further vigilance. Consistent, simple, and transparent measure. Used by a wide variety of other risk monitoring efforts. More relevant in making comparisons across regions and countries. Overall Compound Risk flags are used as the CRM's default in presenting country level risk profiles.

Limitations: Choice of aggregation procedure can produce different results. Care needed in interpreting values as Emerging Threat and Underlying Vulnerability indicators are not always directly comparable. Assignment of threshold values is more subjective as less easily interpreted (see Annex Supplementary Text 1).

2.4. Summary of steps in designing the CRM

While the CRM provides separate country-level assessments for Underlying Vulnerability and Emerging Threat, the same simple multi-step process is used in calculating values for both.[11]

- **To start with, each dimension of compound risk is broken down into a series of indicators** sourced from a range of internal WB risk databases and, when not available, from external sources. Indicators are grouped separately according to whether they reflect Underlying Vulnerability or Emerging Threat.
- **Each indicator is assigned a threshold deemed to represent 'high risk'. A numeric score is then generated using a bounded min/max normalization procedure**, with bounds assigned to upper (and in some cases lower) risk thresholds.[12] Thresholds are typically assigned via expert consensus and elicitation. Percentiles are used for cases in which widely agreed thresholds are not available.
  Next, indicators within each dimension are grouped together and aggregated. In accordance with the CRM's flagging system, aggregation is typically done by selecting the maximum value across a subset of indicators.[13] In cases where there are clear differences in indicator quality, or where data has limited geographic coverage, a hierarchy of inputs is assigned. The resultant aggregated output flag highlights the highest priority countries with Emerging Threat flags as well as Underlying Vulnerability flags. Separate scores are assigned for Underlying Vulnerability and Emerging Threat.
- **An approximate measure of Overall Compound Risk is also generated for each risk dimension by combining inputs from the Underlying Vulnerability and Emerging Threat scores.** This combined measure can be calculated using two separate approaches, with the choice being left to the user depending on needs and preferences. One approach is to aggregate the two source inputs using a geometric mean , similarly resulting in a score ranging from 0-10. Alert Levels under this approach are grouped into three categories, with scores ranging from 7-10 deemed high alert, scores between 5-7 deemed medium alert status, and scores between 0-5 considered low alert status. A second approach is to apply a filtering system across the two source inputs. This avoids the need to create a country-

[11] Given that overall risk values are calculated using inputs from both underlying vulnerability and Emerging Threat, the procedure is somewhat different (see Annex Supplementary Text 1).
[12] A number of the early warning metrics are binary in nature (i.e., whether a natural hazard has occurred or not). In such cases, indicators are simply assigned a 10 or 0 with no normalised values in between (see Annex Table 1-2 for further details).
[13] Aggregation differs for each dimension of compound risk based on the quality and coverage of underlying indicators. See the Annex for further details.

level score. Instead, alert levels are simply assigned when both inputs have reached a minimum level. For example, high *Overall Compound Risk* for a given risk dimension is assigned when *emerging threat* and *Underlying Vulnerability* are similarly rated as high risk.

- **Country-level profiles are provided by summing the number of dimensions deemed as high (or medium) risk. Three separate measures for Underlying Vulnerability, Emerging Threat, and Overall Compound Risk are provided, recognizing the diversity of user interests.** Country-level scores can either be generated as the sum of risk dimensions deemed high risk or a combination of high and medium risks.[14] The latter is chosen as the default for the remainder of this note.
- **Finally, expert elicitation is used to interpret, modulate, and elaborate on the CRM outputs with qualitative analysis.** The expertise and judgement of WB sectoral experts is an essential element of the overall CRM methodology, guiding indicator selection and aggregation as well as the identification of appropriate thresholds. To help manage the complexity of the analysis, we strive for methodological simplicity. However, this inevitably leads to a loss of accuracy, with the risk of not capturing all areas of interest. Expert elicitation methods can help to circumvent these limitations.

Figures 2 and 3 provide an overview of the composition of the three risk outlooks and how they interact to provide holistic assessments of compound risk.

[14] Note that high risk values for underlying vulnerability and Emerging Threat are represented by a value of 10, while those for Overall Compound Risk flags are represented by values greater than 7 (owing to different aggregation methods). In cases where country-level values are generated using the sum of *both* medium and high-risk dimensions, medium risks are assigned a half value (0.5) compared with a full value (1) for high-risks.

Figure 2: Analytical steps taken in the CRM

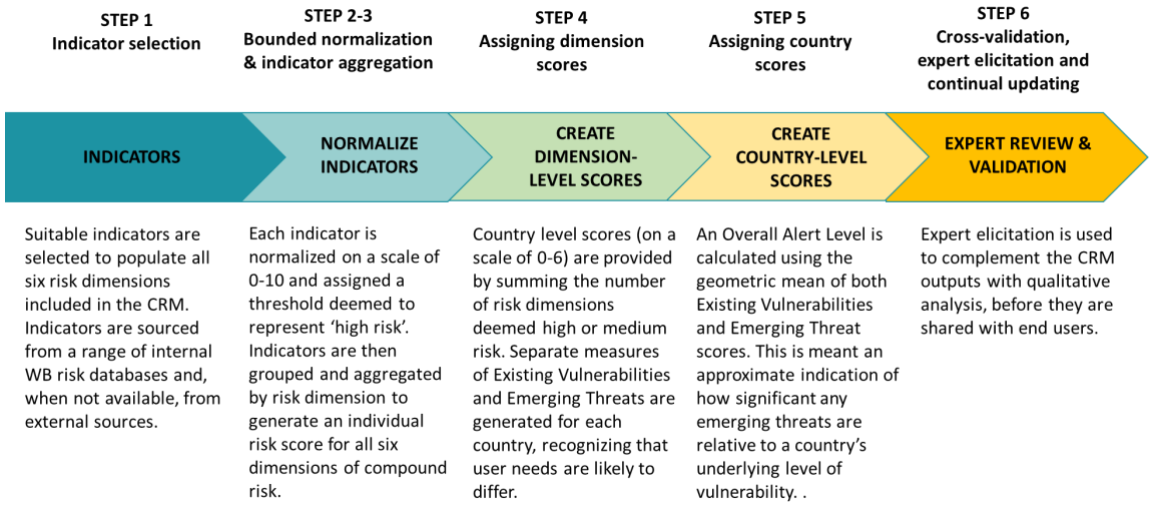
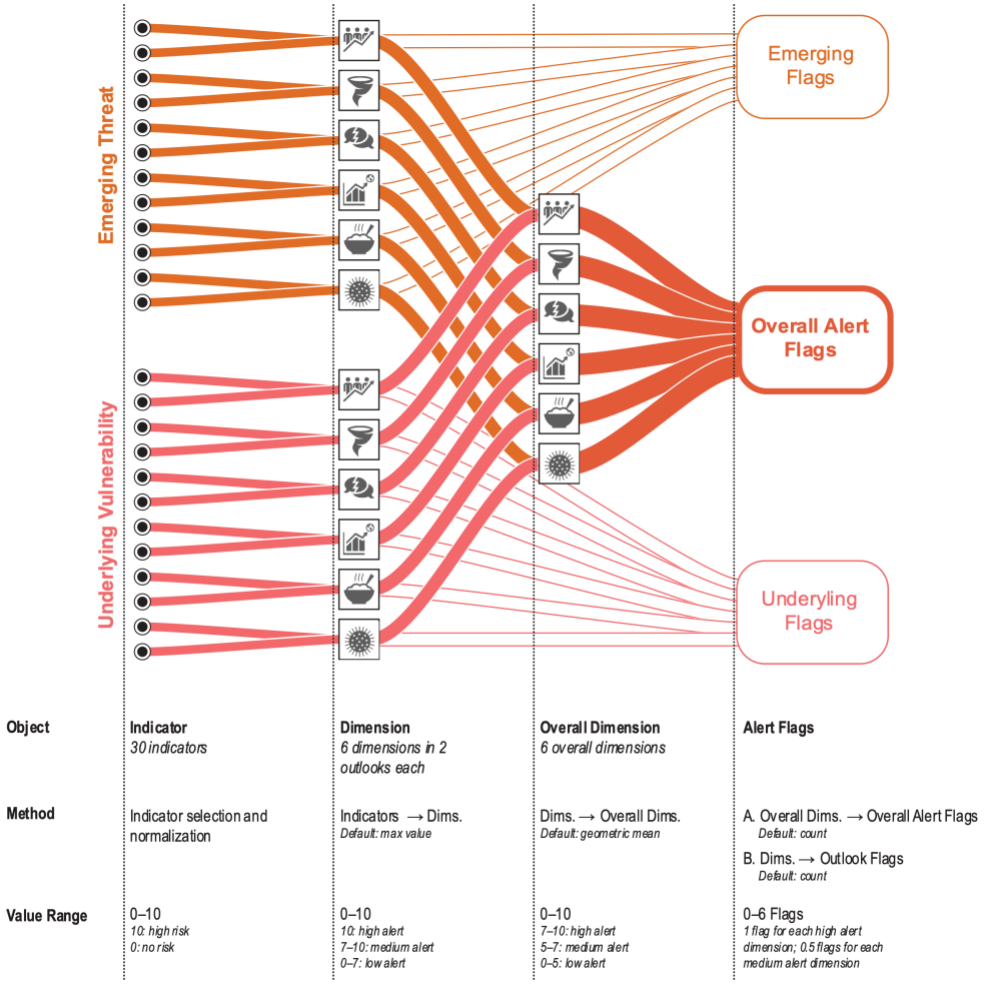


Figure 3: Schematic of the three CRM risk outlooks and their constituent parts



Below we provide full procedural details on the various steps taken in constructing the CRM.

STEP 1: Indicator selection

To begin with, suitable indicators are selected to populate all six risk dimensions included in the CRM (with indicators grouped separately for Underlying Vulnerability and Emerging Threat). Adding to an extensive review of literature and relevant multi-dimensional risk indexes, the CRM team worked with experts across key GPs to identify suitable indicators. The selection was guided by a number of factors, including: (i) whether commonly-used risk metrics already exist; ii) whether relevant indicators are already in use by WB teams; (iii) levels of geographic coverage and data quality; and (iv) frequency of updates. Whenever possible, the team sought to use existing multi-dimensional risk metrics, such as the INFORM Risk Index (see Box 3 and Annex Supplementary Text 5). In cases where a robust multi-dimensional index was unavailable, the team identified a basket of relevant source indicators. In many cases, proxy indicators are used, particularly for Emerging Threat.

Box 3: Scope and overlap with the INFORM Risk index

INFORM Risk Index: The INFORM is a multi-dimensional index aimed at supporting the humanitarian sector. It is a collaboration of the Inter-Agency Standing Committee (IASC) Reference Group on Risk, Early Warning and Preparedness and the European Commission. Results are released on a bi-annual basis.

INFORM's Risk index is split into the six 'categories' of natural, human, socio-economic, vulnerable groups, institutional, and infrastructure risks. Indicators are selected to populate each of the six categories and aggregated to form on overall composite index.

In addition to the Risk Index, INFORM has a number of satellite products that are of relevance to the CRM. In particular, the INFORM Severity index tracks the status of ongoing crises using a combination of quantitative and qualitative insights. More recently, the INFORM COVID-19 index has been tracking a range of real-time metrics gauging exposure to and impact of the pandemic.

The CRM draws on a select range of indicators from across the Risk, Severity and COVID indexes used to populate a number of existing vulnerability dimensions, including natural hazards and socio-economic vulnerability.

For further details on INFORM's methodology as well as other related risk metrics used in the CRM, see Annex Supplementary Text 5.

In the following, we provide a brief summary of considerations in selecting key indicators used to populate the six dimensions of compound risk in the CRM (further highlighted in Table 1 below). For more details on aggregation procedures and thresholds used in each dimension of compound risk, as well as notes on suitability and alternatives, see Annex Tables 1-6.

Table 1: Overview of indicators used in the CRM (see Annex Table 1-2 for details on thresholds and aggregation)

COMPOUND RISK DIMENSION	UNDERLYING INDICATORS	
	UNDERLYING VULNERABILITY	**EMERGING THREATS**
NATURAL HAZARDS	**Indicator(s) used in CRM:** • Natural multi-hazard rating – 2020 (INFORM). Updates: Annual. *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** A range of natural hazard indexes exist, providing a number of options for use in the CRM. Given the CRM's close alignment with the INFORM Risk Index, particularly for measures of underlying vulnerability, use of INFORM's Natural Multi-Hazard Index was considered most appropriate. The index compiles exposure and vulnerability metrics on a range of hazards including earthquakes, tsunami, droughts, floods, and heatwaves. **Alternatives considered:** There are a wide range of natural hazard indexes. Prominent metrics include ND-GAIN, Global Risk Data Platform (UNEP), and the World Risk Report. However, none are considered as comprehensive as the INFORM risk, which is widely used by other risk monitoring initiatives.	**Indicator(s) used in CRM:** • Seasonal forecast index (WB/Columbia University). *Updates: Monthly. Level: 1 (L1)* • Risk of desert locust threat level (FAO). *Updates: Weekly* • INFORM Severity Natural Hazard Crisis monitor (INFORM). Updates: Daily. *(L1)* • GDACS Live Hazard Tracker. Updates: Daily. *(L1)* • ACAPS Risk List for natural hazards. Updates: Weekly. *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** While there are many real-time and forecast-based tracking tools for natural hazards, few compile multi-hazard information to provide a snap-shot of emerging threats. Those that do are often focused on specific regions (e.g., Europe and North America). Under the current iteration of the CRM, information from three mains sources is used. This includes country-level seasonal risk profiles using forecasts derived from Columbia University's International Research Institute for Climate and Society (IRI). The forecast operates on 2-3 months time horizons, with the CRM's index primarily focus on above or below average precipitation. Forecasts also provide estimates of expected impacts from ENSO events. In addition to the seasonal forecast, the CRM makes use of a number of other real-time hazard trackers. This includes inputs from the EU's Global Disaster Alert and Coordination System (GDACS), INFORM's Natural Hazards Crisis tracker, ACAPS Risk List and FAO's Desert Locust Monitor—all of which monitor the severity and impact of ongoing hazard events. **Alternatives considered:** In addition to the three live hazard tracking tools, a number of other options exist including feeds from the USGS, Pacific Disaster Centre, and NOAA. Most have similar coverage and breadth of monitoring systems. To monitor seasonal risks, the CRM currently makes use of a prototype index tracking the proportion of land covered by above or below average expected rainfall. The index has been developed together with Columbia University. Going forward the CRM will make use of a more advanced module that will combine information from the seasonal forecast with forecasts for hurricane basin activity and flood incidence (similarly developed in conjunction with Columbia University).

FOOD SECURITY	**Indicator(s) used in CRM:** • WFP Proteus composite index (WFP). *Updates: Ad hoc* **Data hierarchy:** N/A **Rationale:** Food insecurity, as is the case with most dimensions of compound risk, is inherently multi-dimensional. While a wide range of indicators are suitable, use of a composite index aggregating information across core dimensions of food insecurity was deemed more appropriate for the CRM. Amongst potential metrics, the World Food Programme (WFP)'s Proteus index was chosen for use in the CRM as a holistic measure of predisposed food insecurity and country-level response capacity. The variable is a multi-dimensional composite that groups indicators according to four dimensions: food availability, access, utilization, and stability (see Caccavale and Giuffrida 2020). While the index is comprehensive, it was last updated in 2018, with little indication as to whether the database will be maintained going forward. Consideration will be given to updating use of the Proteus Index going forward (or selecting suitable alternatives) together with the Agriculture and Food GP. **Alternatives considered:** A number of alternative metrics were considered, including the Ending Rural Hunger Index, Hidden Hunger Index, Global Food Security Index, and WFP Hunger Maps. Another option would be to use current FEWS NET IPC ratings or an average of classifications over a set period (such as one year). In consultation with the Agriculture and Food GP, few were deemed to have the coverage or depth required, especially when compared to the Proteus Index.	**Indicator(s) used in the CRM:** • FEWS NET. *Updates: Quarterly. Level: 1 (L1)* • FAO / WFP Early Warning Hotspots of acute food insecurity (FAO/WFP). Updates: Ad hoc. *(L1)* • WB monthly food price estimates. *Updates: Monthly. (L1)* **Rationale:** By far the best-known measure of emerging food insecurity comes from the FEWS NET early warning system. FEWS NET provides periodic and comprehensive multi-agency overviews of current and future food insecurity conditions across 30 monitored countries. In order to ensure alignment with internal WB systems, the choice of indicator threshold is linked to the WB's Crisis Response Window (CRW) Early Response Financing (ERF) trigger. The Monitor also makes use of data from FAO / WFP's acute food insecurity early warning initiative (with similar coverage to FEWS NET). In addition to these measurements of the number of people living in food insecurity, the Monitor also measures food price inflation, using WB microdata on monthly food prices. **Alternatives considered:** Alternative food price volatility metrics were considered in the form of FAO's GIEWS and FPMA metrics. However, the WB's internal metrics were deemed to be better aligned with thresholds used by Ag GP. Similarly, use of WFP's mVAM data may add value going forward.
CONFLICT AND FRAGILITY	**Indicator(s) used in CRM:** • World Bank Fragile and Conflict-affected Situations list. Updates: Annual. *Level: 1 (L1)* • Fragile States Index. Updates annually. (L1) **Data hierarchy:** *N/A* **Rationale:** There are a large number of conflict and fragility indexes provided by academia, civil society, and multi-lateral agencies. Given the need for analytical rigour and to ensure internal consistency within the World Bank, the CRM makes use of the Fragile and Conflict-affected Situations' list as a primary source of data. The metric reflects two main factors: (i) countries affected by violent conflict and (ii) countries with high	**Indicator(s) used in CRM:** • Fatalities related to violent events, demonstrations or non-violent actions (ACLED). *Updates: Monthly*. *Level: 1 (L1)* • Protests, demonstrations, and violent events (ACLED). Updates weekly. *(L1)* • Political disturbance (REIGN). *Updates: Monthly (L1)* • ACAPS Risk List. Updates ad hoc. *(L1)* • EIU Security Risk. Updates monthly. *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** Monitoring or predicting of conflict and fragility-related conditions remains a considerable challenge. Given the uncertainties with many forecasting tools, the CRM currently focuses on observed data. First, the Monitor relies on two indicators from the

	levels of institutional and social fragility. The choice of indicator and threshold was completed in close consultation with FCV. The Monitor also uses the Fragile States Index, a composite measure widely used by international organisations. **Alternatives considered:** A number of alternatives were considered, with the four main sources being (i) the Global Peace Index, (ii) INFORM's Conflict Risk Index, and (iii) the World Bank's Conflict structural model. Given the need to ensure accuracy of assessment and alignment with official World Bank classifications, none were considered as comprehensive or as widely-used as the FCS list. Going forward, the Monitor will seek to align its metrics with FCV's Global and Regional Conflict Risk Monitor.	Armed Conflict Location & Event Data Project database (ACLED). ACLED is a widely used and respected resource, monitoring fatalities on a daily basis. The Monitor uses both the number of 'fatalities related to political disorder and events', and the number of protests, demonstrations and violent events. For both, the Monitor measures how recent months compare to a country's historical baseline. The monitor also tracks 'political disturbance', measured via the Rulers, Elections, and Irregular Governance dataset (REIGN). (Note that REIGN's maintenance is currently paused, and the CRM is temporarily reconstructing it with the IFES election calendar and the Global Instances of Coups dataset. These are updated when new elections are declared and coups occur.) In particular, REIGN captures countries where an irregular election or coup has recently taken place. The CRM makes use of the dataset to flag imminent occurrence of elections in fragile or conflict-affected countries. The monitor also makes use of the ACAPS Risk List and the Economist Intelligence Unit's Security Risk dimension. Use of these indicators to reflect emerging conflict and fragility risk has a number of limitations. In particular, institutional fragility is challenging to reflect accurately. Additional metrics will be considered over time in consultation with FCV. **Alternatives considered:** The GCRP team considered a number of alternatives. In particular, UCDP's Battle-Related Deaths database serves as a useful complement to ACLED. However, the database only includes global coverage commencing October 2020, making it difficult to compare against historical baselines. Going forward, a combination of ACLED and UCDP data sources may be adopted. Related to institutional fragility, the main alternative is INFORM's Severity Index. This metric tracks the severity and status of existing crisis events (with the ability to isolate political and fragility-related events). INFORM is well respected and used by a range of development organizations. Its inclusion within future iterations of the CRM will be actively considered together with the FCV team. In addition, ACAPS and the IRC's Watchlist provide similar forward-looking fragility outlooks, though neither was deemed to be well matched to the CRM's current setup. Over time, choice of the CRM's metrics will align with FCV's Global and Regional Conflict Risk Monitor (currently under development).

MACRO-FISCAL DYNAMICS	**Indicator(s) used in CRM:** • Economist Intelligence Unit (EIU)'s Operational Risk Score: 12-month running mean. *Updates: Monthly (L1)* **Data hierarchy:** N/A **Rationale:** Few holistic measures of exposure and sensitivity to macro-fiscal shocks exist, especially considering the CRM's need for global coverage. With that in mind, the CRM makes use of a combination of macro-economic, trade and financial risk outlooks as part of the EIU's Operational Risk Score (ORS). As a widely used multi-dimensional index, the ORS provides a regularly updated measure of macro-fiscal conditions across a range of different components. It is comprised of 70 grouped indicators across a variety of categories, including financial risk, foreign trade & payments risk, infrastructure risk, labor market risk, legal and regulatory risk, macroeconomic risk, and tax policy risk. For the purposes of the CRM, an average of 12-month scores related to macroeconomic risk, trade and financial risk within the ORS is used to generate an outlook for Underlying Vulnerability. Unlike many alternative risk metrics, such as the WB's Macro-Financial Review index, the ORS is global in nature, profiling risk scores across 180 countries. Use of an 12-month average provides a (relatively) slow-changing assessment of macro-fiscal conditions. Inclusion of past values may also help smooth out some of the forward-looking elements of the EIU. This is also consistent with source indicators for Underlying Vulnerability across other risk dimensions in the CRM, most of which update on an annual basis. **Alternatives considered:** A number of alternatives for macro-economic vulnerability were considered, including use of a wide range of indicators provided under the World Bank's Global Economic Prospects (GEP) and IMF's World Economic Outlook (WEO). In particular, the WB's Macro-Financial Risk Index (MFRI) has close overlaps with the CRM's architecture (both on vulnerability and emerging threat elements of risk). Unfortunately, data from the MFRI is only available for 44 countries, meaning that a hierarchy of different indicators would be needed in regions with large data gaps. Alternatives such as the World Bank's Corporate Vulnerability Index (CVI) and Debt Sustainability Analysis (DSA) are similarly limited, either by concerns over geographic coverage or lack of holistic assessment of macro-fiscal risk conditions. As mentioned in Section 2.2, the CRM is currently trialing an in-house metric design tailored specifically to the CRM's overall framework together with inputs from MTI, FCI, CROCR, and the Prospects Group (see Annex X). If shown to be robust, the CRM will transition to the in-house metric (either by replacing or complementing the EIU risk score) by mid-2021, once the new metric has been trialed and validated.	**Indicator(s) used in CRM:** • Economist Intelligence Unit (EIU)'s Operational Risk Score: Point difference between latest EIU score and 12-month mean. *Updates: Monthly (L1)* • WB Macro-Financial Review Index (MFRI) heatmap of macro risk, risk appetite, and monetary and financial conditions. *Updates: Quarterly. (L1)* **Data hierarchy:** N/A **Rationale:** To gauge whether macro-fiscal risk conditions within a given country are worsening (or likely to worsen in the coming months) the CRM uses a point difference between the latest monthly EIU ORS score and average scores for the previous year (excluding the current period). This provides an overview of countries where the macro-fiscal environment has recently deteriorated relative to expected conditions. A similar measure is used by the EIU in referring to upgrades and downgrades in macro-fiscal conditions. Given the ORS updates on a monthly basis, the metric provides a regular snapshot of emerging threats. With global coverage across a range of macro-fiscal elements, use of the ORS does not require a hierarchy of data inputs to fill coverage gaps (as with other multi-dimensional macro-fiscal outlooks). Alongside this, the CRM uses MFRI's composite measures of risk appetite, financial and monetary conditions, and macroeconomic risk. **Alternatives considered:** A number of variants are possible using a similar EIU setup. For example, rather than using a simple point difference, deviations could instead be calculated using a Z-score. However, given that EIU scores are currently only available for the prior 12 months (with many countries exhibiting little variation during this time period), use of a difference in values is currently preferred. Efforts are currently underway to secure access a longer timeseries of OSR data, which may facilitate an update of methods. In addition, the current approach compares values for the current monthto the 12-month mean. While this provides a decent gauge of recent upgrading/downgrading of macro-fiscal conditions, it may be of use to extent the observational period to 3 (or even 6) months. This would allow for broader terms to emerge (especially for risk conditions that materialize slowly over time or have lagged effects). However, this extended approach would only be suitable with access to longer-term OSR timeseries data (past 12 months), something the CRM team are actively pursuing. In addition, and as mentioned previously, the CRM team will continue to trial an in-house measure for tracking emerging macro-fiscal threats. The measure will seek to extend existing WB metrics (such as the MFRI, CVI, DSA, etc.) to allow for

			greater geographic coverage and better fit within the scope of the CRM's analytical framework.
SOCIOECONOMIC VULNERABILITY	**Indicator(s) used in CRM:** • INFORM Socio-economic Vulnerability index. Updates: Annual **Data hierarchy:** N/A	**Indicator(s) used in CRM:** • Percentage point change in the number of people below $2.05 poverty line (WB). *Updates: Quarterly. (L1)*	

	Rationale: As with many of the compound risk dimensions, socio-economic vulnerability is a multi-dimensional concept. Its inclusion in the CRM recognises that compounding events are a product not only of exposure to consecutive (or overlapping) hazards, but the ability of people and communities to cope with and respond to emerging threats. Severe heightening of socio-economic vulnerabilities can often lead to compounding events, even in cases where exposure to mild overlapping threats would otherwise not lead to a disaster. With that in mind, the CRM currently makes use of the INFORM's Socio-Economic Vulnerability Index as a composite measure comprised of traits related to deprivation, inequality, dependency, uprootedness, and composition of vulnerable groups. **Alternatives considered:** There are a large number of socio-economic vulnerability indexes. These include OPHI's Multi-dimensional Poverty Index (Oxford), the UN Human Development Index, and the ND-GAIN Vulnerability Index (Notre Dame). Many country-level outcomes across these indexes are correlated, and use of INFORM is consistent with its inclusion in a number of other dimensions.	• WB Macro-Financial Review Index (MFRI) heatmap of household-level risk. *Updates: Quarterly*. *(L1)* • Percentage point change in unemployment rate (IMF). Updates: Quarterly. *(L1)* • ACAPS Risk List. Updates ad hoc. *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** Finding real-time global measures of socio-economic vulnerability is a considerable challenge, particularly regarding those that reflect household-level conditions and coping capacities. Having consulted widely with the WB's Prospects team, Poverty and Equity GP, and Development Data Group, the CRM team assembled a basket of indicators. The first metric concerns country-level poverty projections. Figures are taken from the World Bank's Macro Poverty Outlook (MPO), with forecasted percentage point differences in the proportion of people living below $1.90 chosen as a proxy for deteriorating household-level coping capacities. Percentage point differences for both 2021-2020 and 2020-2019 are used in the current iteration, recognising that the knock-on implications of increased poverty on household-level vulnerability can persist for long periods of time. In addition to poverty, inclusion of unemployment forecasts is included to factor future changes[15] in labour conditions and livelihood opportunities using the IMF's World Economic Outlook. As with GDP inputs, percentage point differences for both 2021-2020 and 2020-2019 are used (for the same reasons).[16] Alongside this, the CRM uses MFRI's composite measure of household-level risk (made up of changes to household debt-to-GDP ratios and unemployment rates during the previous quarter). **Alternatives considered:** Suitable alternatives for social-economic vulnerability are actively being considered together with DEC and Poverty and Equity GP. One option may be the inclusion of estimates of inequality as a proxy for increased vulnerability in lower income quantiles. However, forward looking estimates for inequality are not currently available. Instead, estimates of forecasted unemployment are included as an indicator with close overlaps and characteristics of being a driver of inequality.
HEALTH SECURITY AND PANDEMIC RESPONSE	**Indicator(s) used in CRM:** • COVID vulnerability index (INFORM). Updates: Annual. Level: 1 *(L1)* • Global Health Security Index, a composite index made up of a variety of health-related indicators (EIU). *Updates: Annual.* *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** Choice of indicators for measuring pre-existing health security capacity remains contentious. Prior to the COVID-19 pandemic, the most	**Indicator(s) used in CRM:** • WHO Disease Outbreak News (DONs) Alert. *Level: 1 (L1)* • Epidemics (IFRC). Updates ad hoc. *(L1)* **Data hierarchy:** Level 1: All source indicators are assigned Level 1 **Rationale:** The two measures of emerging risk are provided by the WHO's Disease Outbreak News (DONs) alerts, a real-time system providing information on all disease outbreaks notified to the WHO, and the IFRC's list of on-going epidemics.

[15] Note that current changes in unemployment are featured in the MFRI heatmap.

[16] Inclusion of 2020-2019 figures will be continually reviewed over time, and likely to drop in the latter quarters of 2021. Differential threshold values are also discussed in Annex Table 2

	comprehensive and commonly referred to metric for pandemic preparedness was the Global Health Security Index (GHS). The measure is a composite index combining 85 sub-indicators (across 6 health categories) with solicitation of a panel of 21 leading health experts. While the measure is undoubtedly comprehensive, it has proven a relatively poor correlate of present day COVID-19 exposure and response, especially considering high rates of incidence and impact in Europe and North America, coupled with lower-than-expected impacts in parts of Africa and Southeast Asia. With that in mind, and in consultation with the Health GP, the CRM includes the GHS Index alongside a COVID-specific metric developed by the European Union's Joint Research Centre INFORM initiative. The INFORM COVID Risk Index is an adaptation of the INFORM initiative's Epidemic Risk Index, used to support prioritization of preparedness and early response actions for the primary impacts of the pandemic. The two inputs are aggregated, with high-risk thresholds assigned by the GCRP team in consultation with Health GP. **Alternatives considered:** Alternatives were considered in the form of the Epidemic Preparedness Index (Oppenheim et al. 2018). However, many similar indexes are less comprehensive than the GHS and suffer from the same lack of correlation in predicting the country-level impacts of COVID-19.	**Alternatives considered:** A large number of metrics exist in tracking the impacts of COVID-19. Alternatives that may add value to future iterations of the CRM include excess mortality and test positivity rates. However, gaps in data coverage and quality limit their inclusion at the present. Given the changing nature of COVID's impacts on Global health systems, the CRM will periodically review choice and prominence of COVID-19 metrics in consultation with the WB's Health GP. Inclusion of other suitable metrics such as vaccination coverage are currently being explored.

STEP 2: Bounded normalization

The next step in the process is normalizing each indicator on a scale from 0 – 10. In doing so, the CRM assigns each indicator an upper and lower bound based on high and low risk thresholds. In most cases, expert elicitation was used to define bounds for the min-max normalization process. All indicator values above the upper threshold are then assigned a value of 10 (and considered high risk), while values below the lower threshold are assigned 0 (considered little-to-no risk), and all other values receive a normalized score that falls somewhere in-between (using the formula below). The normalized procedure is described below, where $IndicatorRaw_i$ represents a country's score for a given indicator *i* (for all values in-between the threshold bounds). $ThresholdLower_i$ and $ThresholdUpper_i$ are the designated lower and upper thresholds for respective indicators, and $IndicatorNorm_i$ is the normalized indicator score ranging from 0-10.

$$IndicatorNorm_i = \frac{IndicatorRaw_i - ThresholdLower_i}{ThresholdUpper_i - ThresholdLower_i} * 10$$

Where possible, the CRM seeks to align upper and lower bounds with risk thresholds used by other WB teams or based on widespread expert consensus. There are three exceptions to this procedure, requiring some degree of subjective interpretation. Firstly, where no expert consensus on risk thresholds exist, normalized bounds are assigned via percentiles (typically $95^{th}/5^{th}$). Secondly, in cases where pre-existing vulnerability *categories* are specified, or where differences between risk categories are non-linear, the CRM defaults to using expert-defined categories as the basis of indicator scores. For example, the World Bank's Debt Sustainability Analysis (DSA) rates countries' likelihood of external debt distress in the three categories 'low', 'moderate',; and 'high'. In this case, the CRM manually aligns scores with the DSA categories (using values of 3, 7, and 10 respectively). Lastly, in instances where binary indicator outcomes exist—e.g., whether a drought is ongoing or not—the CRM simply assigns a 10 or 0, with no normalized values in-between.

There are three reasons for transforming raw indicator scores using bounded normalization:

- It allows for ease of comparability across indicators, with all scores falling between 0-10.
- It reduces the influence of outliers. Many sources of risk information are heavily skewed, and provision of upper and lower bounds helps to diminish their influence on all intermediary scores (although this can also be addressed using Z-scores).
- It allows for simple and transparent identification of high/low risk countries. A score of 10 means that a country has exceeded the designated threshold for the respective indicator, while a score of 0 represents a country that is considered very low risk. This simplicity of interpretation is of particular use when it comes to aggregating indicators to form a single score for each dimension of compound risk.

STEP 3: Indicator aggregation

After the normalization procedure, indicators are grouped and aggregated by risk dimension to generate an individual risk score for all six dimensions of compound risk. Separate levels are assigned for Underlying Vulnerability and Emerging Risk. The simplest and most transparent way of aggregating scores is to take the maximum value across grouped risk indicators for each given dimension:

$$RiskDimension = \max_{i=1\ldots n} \{IndicatorNorm_i\}$$

Here $RiskDimension$ is the score for a given dimension of compound risk *r,* with the maximum score for all normalized indicators ($IndicatorNorm_i$) selected across the suite *(i= 1…n).* For example, if a given

country's food security is made up of three source indicators (with scores of 5, 7, and 8 respectively), then food security risk will simply be listed as the highest value in the suite (8 in this case). In each of these cases, normalized values are aligned with the upper (and lower) bounds defined by expert elicitation and represent high (and low) risk. The process mimics the methodology of a number of similar risk monitoring systems, including the WB's Macro-Financial Risk Index. This step results in a score for each dimension of compound risk ranging from 0-10. A risk dimension with a score of 10 implies that at least one of the grouped indicators in the dimension is above the risk threshold.

In some instances, dimensions consist of indicators with variable quality. For example, a selection of inputs may be high-quality with limited geographic coverage. Others may reflect weaker proxies but provide data for all countries. In such instances, a hierarchy of data inputs is specified (see Tables 1 and Annex Tables 1-2). Firstly, the nature of the data hierarchy is established, typically by grouping indicators into two levels: Level 1 (consisting of high-quality low coverage indicators) and Level 2 (lower quality higher coverage). For dimensions that use a data hierarchy, scores are assigned solely on the basis of Level 1 indicators wherever country data exists (i.e., the maximum value of all Level 1 indicators). In countries where no Level 1 data is available, the CRM reverts to aggregating Level 2 data instead. For example, in the case of the Food Security component, FEWS NET is used as a Level 1 data source, meaning that in countries where available information exists FEWS NET ratings take precedence. In cases where data is unavailable, the CRM falls back on food price volatility data (gathered by the WB's Food Price Monitor) as a proxy for food insecurity.

While this aggregation method is very easy to implement and interpret, methodological simplicity inherently comes with tradeoffs (for alternative methods considered see Supplementary Material Text 1 in the Annex). In this case, sole use of max values means that false positives are more likely than with other methods. For example, if a chosen country's three food security indicators are observed as 10, 2, and 3 respectively, then the max score of 10 would fail to represent this diversity. This is especially problematic in examples where there may be a large number of source indicators in a given dimension of compound risk (and therefore higher likelihood that at least one score is a 10), or where poor proxies are used (that may not be in line with the suite of other indicators). Similarly, a max system does little to differentiate between the severity of high-risk countries. Returning to the same food security example, a country with scores of 10, 10, and 10 would be rated the same as the previous example of 10, 2 and 3. Finally, use of a data hierarchy means that cross-country comparisons can be problematic as different countries may use different data inputs. Given the alternative of limiting information to only countries with the highest-quality data, and perhaps misrepresenting the geographic spread of risk further, the CRM adopts the hierarchy approach while seeking to clearly communicate all sources of inputs.

STEP 4: Approximating Overall Compound Risk

While information from the Underlying Vulnerability and Emerging Threat dimensions is useful in and of itself, many users of the CRM will want to weigh recent or upcoming threats against a country's underlying levels of vulnerability. As such, the CRM produces a third output (termed "Overall Compound Risk") for each risk dimension by combining values for Underlying Vulnerability and Emerging Threat. The default approach is to aggregate the two scores using a geometric mea (see Annex X for alternatives that use a filtering approach). The approach provides a broad overview of the level of alertness needed in weighing the importance of changing risk conditions relative to a country's coping capacity—i.e., a gauge of vigilance required in monitoring ongoing (or upcoming) in the months ahead relative to normal conditions. With that in mind, combining vulnerability and emerging threat elements ensures that countries that have seen a modest increase in Emerging Threat, but low levels of Underlying

Vulnerability, are weighted downwards, while those that have seen slight increases in Emerging Threat, but high overall levels of Underlying Vulnerability, are weighted upwards.

The CRM's proposed method is very similar to approaches taken by INFORM and other multi-dimensional risk indexes. Here $RiskDriverMax_r$ is the Emerging Threat score for dimension *r,* and Underlying Vulnerability is represented by $ExistingRisk_r$.

$$AlertLevel_r = \sqrt[2]{RiskDimensionMax_r \cdot ExistingRisk_r}$$

This result in scores ranging from 0-10, which can similarly be grouped into three broad categories. Scores ranging from 7-10 are deemed to represent a high-alert status, scores between 5-7 are seen as medium alert status, and scores between 0-5 considered low-alert status.

The combined score should be considered a more accurate reflection of the level of alertness needed in monitoring and responding to given risks—one that permits comparisons across countries in a more direct manner than the Emerging Threat score (which charts changing risk conditions relative to the norm). The benefits of combining scores from Underlying Vulnerability and Emerging Threat into a single high-level measure can be seen in how the approach weighs the two scores together. Despite the need for vigilance in any context facing intensification of emerging threats, alert levels are likely to be far reduced in countries with low levels of vulnerability (owing to the fact that severe crises are less likely). Similarly, concern should be far higher whenever a vulnerable country experiences a worsening of risk conditions (even if a slight or moderate). Indeed, in the context of supporting early action for crisis risk prevention, these are typically the countries and contexts of primary interest. It is, however, worth remembering that the CRM is designed as a flagging system, not as a predictive tool. A high Overall Compound Risk value does not mean that a compound crisis is expected to materialize. Instead, it signals the preconditions and catalytic environment for one.

Use of a geometric average seeks to better account for the close relationship between Underlying Vulnerability and Emerging Threat, as well as the fact that outcomes are likely to be multiplicative. The same approach is used in a number of other risk metrics (including INFORM) and is well supported in the wider risk literature (see Guillaumont 2009). However, it is important to note that Overall Compound Risk can similarly be calculated using a number of the alternative methods, such as an arithmetic mean or max value, with each having its own strengths and weaknesses. A detailed discussion and comparison of different options is presented in Section 3.2.

STEP 5: Determining country alert levels for Underlying Vulnerability, Emerging Threat, and Overall Compound Risk

Alongside separate scores for all six risk dimensions, the CRM also assigns country-level scores summarizing risk profiles for Underlying Vulnerability, Emerging Threat, and Overall Compound Risk. These are done by summing (or "flagging") the total number of risk dimensions classified as high (or high and medium) within a given country. While use of a combined metric helps to put a country's current (and future) risk conditions into perspective, care should be taken in interpreting Overall Compound Risk given the fact that indicators (and thresholds) Underlying Vulnerability and Emerging Threat are not wholly compatible across all risk dimensions. For this reason, the CRM present all three country-level scores separately, allowing the user to determine which measure is of most relevance given the intended use.

The most straightforward method is to assign a "1" for each risk dimension classified as high risk. For example, if a country has Emerging Threat flags for food security and socio-economic vulnerability (i.e., scores of 10 across both risk dimensions), then the country's Emerging Threat score will be 2.

$$RiskDimensionHigh_r = \begin{cases} 1 & RiskDimensionCategory_r = HighRisk \\ 0 & RiskDimensionCategory_r \neq HighRisk \end{cases}$$

$$TotalCompoundRisk_c = \sum_{r=1}^{6} RiskDimensionHigh_r$$

This results in a single country-level score ranging from 0-6. A score of 6 (or 6 risk flags as referred to in the CRM) simply implies that all six dimensions are considered high risk. The method tells us how many dimensions are considered high-risk and can be used to gauge whether multiple preconditions exist for emerging compound crises. It is easy to compute, and above all, simple to interpret: A country's score (whether for Underlying Vulnerability, Emerging Threat, or Overall Compound Risk) is equivalent to the number of high-risk dimensions for a given country. It also allows for the status of emerging compound risk to be readily compared, both within and across countries—noting, however, the various methodological caveats outlined above.

Classification of risk dimensions into categories differs slightly between Underlying Vulnerability, Emerging Threat and Overall Compound Risk, owing to the different aggregation methods used. Risk dimension scores of 10 are classified as high risk for Underlying Vulnerability and Emerging Threat, implying that at least one of the grouped indicators is above the high-risk threshold (based on the Max Value approach). Dimension scores ranging from 7-10 are deemed medium risk. For Overall Compound Risk, risk dimensions with scores ranging between 7-10 are labelled high risk, owing to the fact that scores are derived from a combination of Vulnerability and Emerging Threat elements. Dimensions with scores from 5-7 are therefore classified as medium risk.

Given that risk is seldom (if ever) binary, a second approach is to assign an intermediary score for all medium-risk countries. This recognizes the limitations of assigning a 0 to all dimensions below the high-risk threshold. Indeed, countries with dimension scores just under the high-risk threshold are likely to be of much higher risk than those far below the lower threshold. Accordingly, the CRM calculates an alternative measure of Underlying Vulnerability and Emerging Threat by assigning a half-value to medium-level risks.

$$RiskDimensionHighMed_r = \begin{cases} 1 & RiskDimensionCategory_r = HighRisk \\ 0.5 & RiskDimensionCategory_r = MedRisk \\ 0 & RiskDimensionCategory_r = LowRisk \end{cases}$$

$$TotalCompoundRisk_c = \sum_{r=1}^{6} RiskDimensionsHighMed_r$$

In this instance, compound risk ($TotalCompoundRisk$) in country c is calculated as the sum of all medium-risk dimensions (assigned a 0.5) and high-risk dimensions (assigned a 1). For example, a country with a high-risk flag for Health and a medium-risk flag for Food Security would be listed as having a total of 1.5 compound risk flags. This is not as intuitive as the previous setup. However, it is still relatively easy to interpret and communicate. More importantly, a combination of high and medium risk flags provides

a more holistic representation of underling risk conditions. When employing the CRM database and interactive dashboard, users will be able to differentiate between the two methods (i.e., high-risk only or medium and high-risk). For this reason, **the combined medium and high-risk flagging system is used as the default for the remainder of this Note.**[17]

While the CRM is based on a simple sum of risk flags as a means of promoting ease of interpretability and transparency, a number of aggregation options exist. For example, the CRM team also considered use of an averaging method. Country-level scores could then be calculated as the average of the six dimension-level scores. However, this approach suffers from many of the same weaknesses as use of averaging methods in deciding individual dimension-level scores. In particular, compound crises tend to occur when underlying dimensions of risk are above a country's coping capacity (i.e., above high-risk thresholds). They can also occur when just two or three dimensions of compound risk interact, even if conditions in other dimensions are relatively stable. For example, a country with three emerging dimensions above the high-risk threshold (i.e., scores of 10) and three dimensions below the high-risk threshold (i.e., scores of 0) would only have an average Emerging Threat score of 5 despite displaying heightened preconditions for compound risk (recognizing that average Emerging Threat scores would range from 0-10 rather than 0-6). Instead, use of the flagging system clearly highlights instances where coping capacities are likely to be exceeded across any of the six dimensions and does not dilute overall results when other dimensions might be experiencing normal (or below-normal) risk conditions. For this reason, the CRM is built around a max-value flagging system. However, users are free to download the data manually and adjust the methodology accordingly.

STEP 5: Cross-validation, expert elicitation and continual updating

Finally, expert elicitation is used to complement the CRM's outputs before they are shared with end users in the Bank. The expertise and judgement of WB sectoral experts is an essential element of the overall CRM methodology, guiding indicator selection, aggregation as well as identification of appropriate thresholds. Furthermore, before they are shared with end users, quantitative results from the CRM will be cross-checked by WB sector and regional experts to detect anomalies in the flag-based system, as well as to complement the CRM's findings with rich qualitative insights from a range of WB experts.

To support this expert elicitation process, a Technical Steering Group will be set up building on the informal working level consultations conducted during the methodological design phase. The Steering Group will allow for continuous expert inputs into the CRM methodology as well as review of CRM outputs. The Steering Group will include at least one focal point for each of the six dimensions of compound risk and it is expected that it will be convened quarterly as part of the GCRP's horizon scanning exercises. The quarterly horizon scan will include the output of the CRM as well as additional interpretation provided by the Technical Steering Group that would modulate the understanding of the quantitative CRM outputs.

[17] Aggregation of the conflict and fragility dimension is an exception. This is calculated using an arithmetic mean owing to the fact that Underlying Vulnerability values are derived from a simple binary indicator (whether or not the country is included on the FCS list). Reasons for this are further elaborated in Section 3.2.

3. RESULTS

3.1. Overview of Underlying Vulnerability, Emerging Threat, and Overall Compound Risk flags

Below we present a snapshot of results from the CRM, showcasing the types of outputs that can be made available to decision-makers through the CRM. Further breakdown of summary plots and results can be seen in Annex Tables 5-7 and Annex Figures 11-14.

Figure 3 below shows the geographic spread of the concentration of high-risk flags as part of the CRM's Underlying Vulnerability outlook (i.e., a snapshot of historic predisposition to different types of risk). The map reveals a pronounced clustering of countries prone to multiple overlapping threats in Sub-Saharan Africa (SSA). Indeed, of the sixteen countries with four high-risk flags or more, only five are situated outside of SSA. Despite this concentration, very high-risk countries (i.e., those with five risks of more) remain relatively evenly spread, with Haiti, Somalia, Yemen comprising the top three countries in the CRM's outlook. Risk conditions in Afghanistan, Syria, and Yemen are similarly pronounced (with four and half flags each), alongside a large number of risk prone countries across SSA. Unsurprisingly the concentration and spread of Underlying Vulnerability presented under the CRM has many parallels with other multi-dimensional risk indexes, such as INFORM and ND-GAIN.

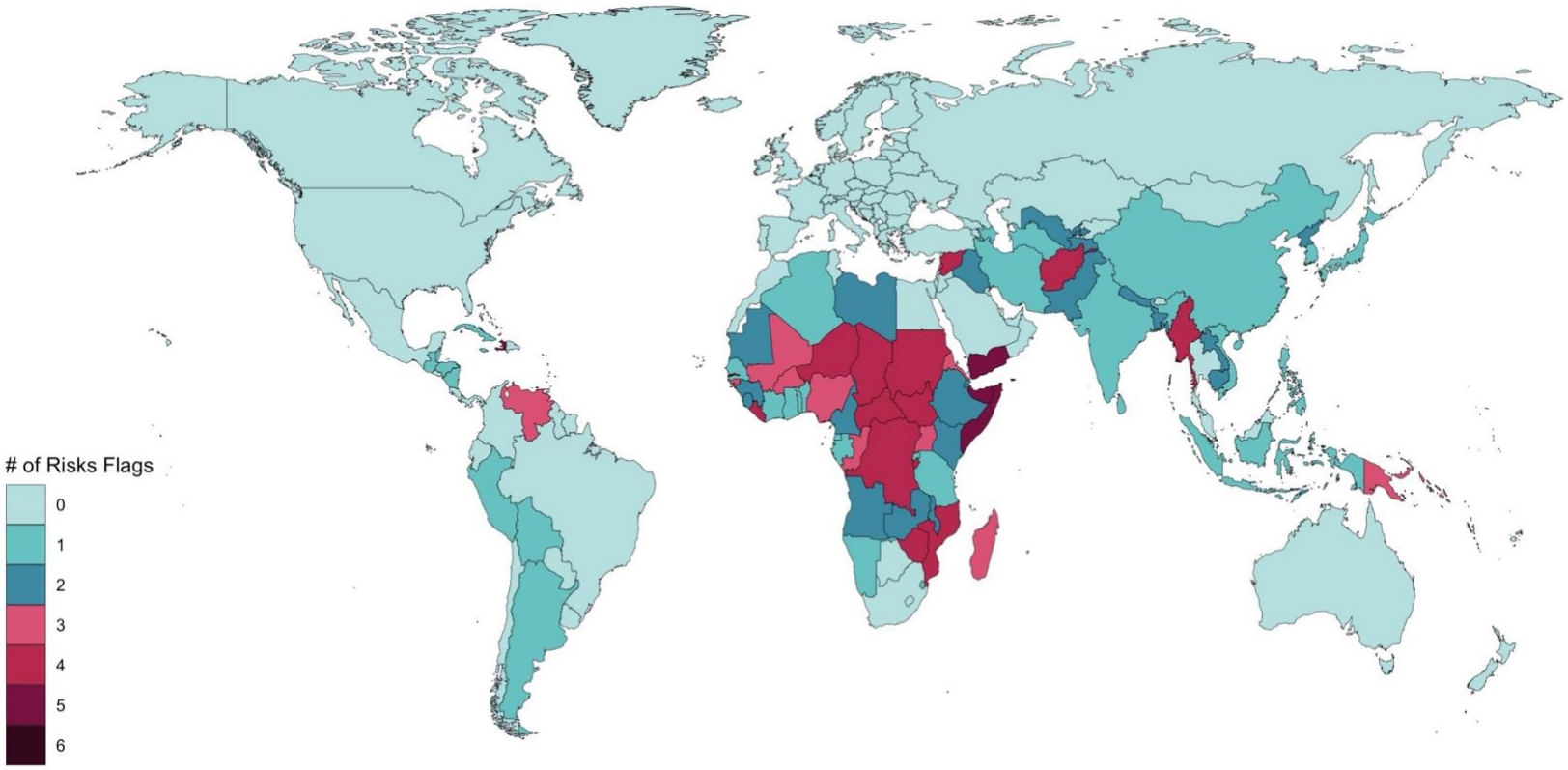
While the CRM's measure of Underlying Vulnerability provides a gradually evolving perspective on a country's predisposition to compound risk, understanding how current and/or future risk dynamics are materializing in real-time is often just as relevant to operational decision making. Figure 5 showcases levels of Emerging Threat across countries using the CRM's flagging system.[18] While the map reveals a similar concentration of risk in SSA, two wider observations are worth noting. Firstly, the spread of Emerging Threat flags appears more geographically diverse than for Underlying Vulnerability. In particular, North America and Latin America and the Caribbean regions have a number of countries with three risks of higher. Secondly, there are considerably more countries with a least two Emerging Threat flags compared with Underlying Vulnerability. Both traits reflect the fact that the ongoing COVID-19 pandemic is exacerbating wider socio-economic and political threats globally. Other global signals affecting CRM outcomes include the implications of an ongoing La Niña for regional weather patternsas well as heightened food insecurity concerns for much of Sub-Saharan Africa, further compounded by desert locust outbreaks across the Horn of Africa, MENA and South Asia. An annotated summary of regional risk highlights is provided in Annex Figure 7.

As a reminder, the Emerging Threat outlook is a measure of a country's *deviation from baseline risk conditions* (rather than an assessment of Overall Compound Risk). This explains why countries like the United States can be seen as having a higher number of risk flags compared to countries across SSA, MENA and other region

[18] Figures are accurate as of 14th May 2021

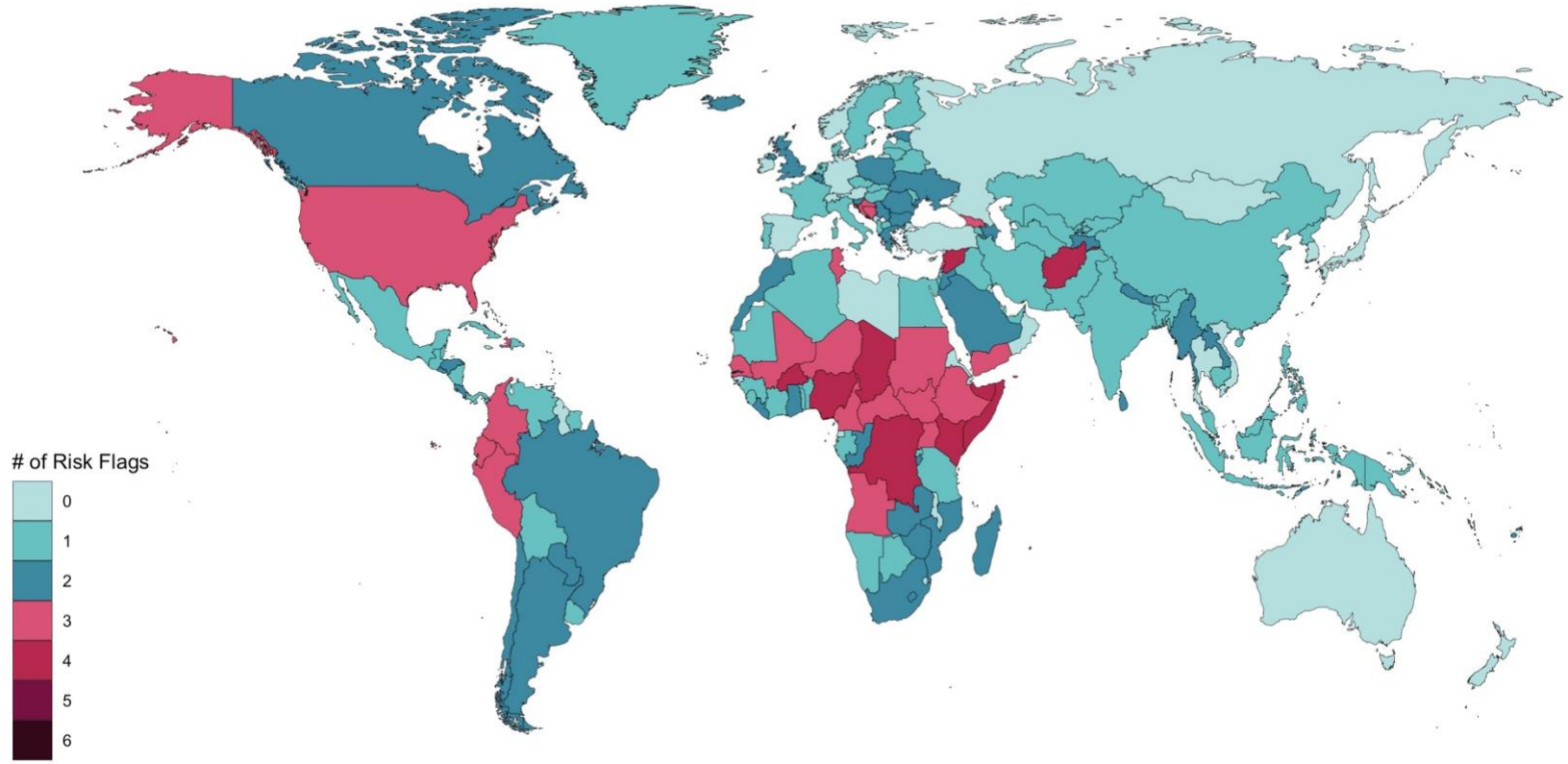
Global overview

Figure 4: Profile of UNDERLYING VULNERABILITY (i.e. snapshot of historic predisposition to risk)



Notes: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer for ease of viewing. Values in the figure updated as of 05/14/21.

Figure 5: Profile of EMERGING THREAT (i.e. dynamic assessment of changing risk conditions[19])



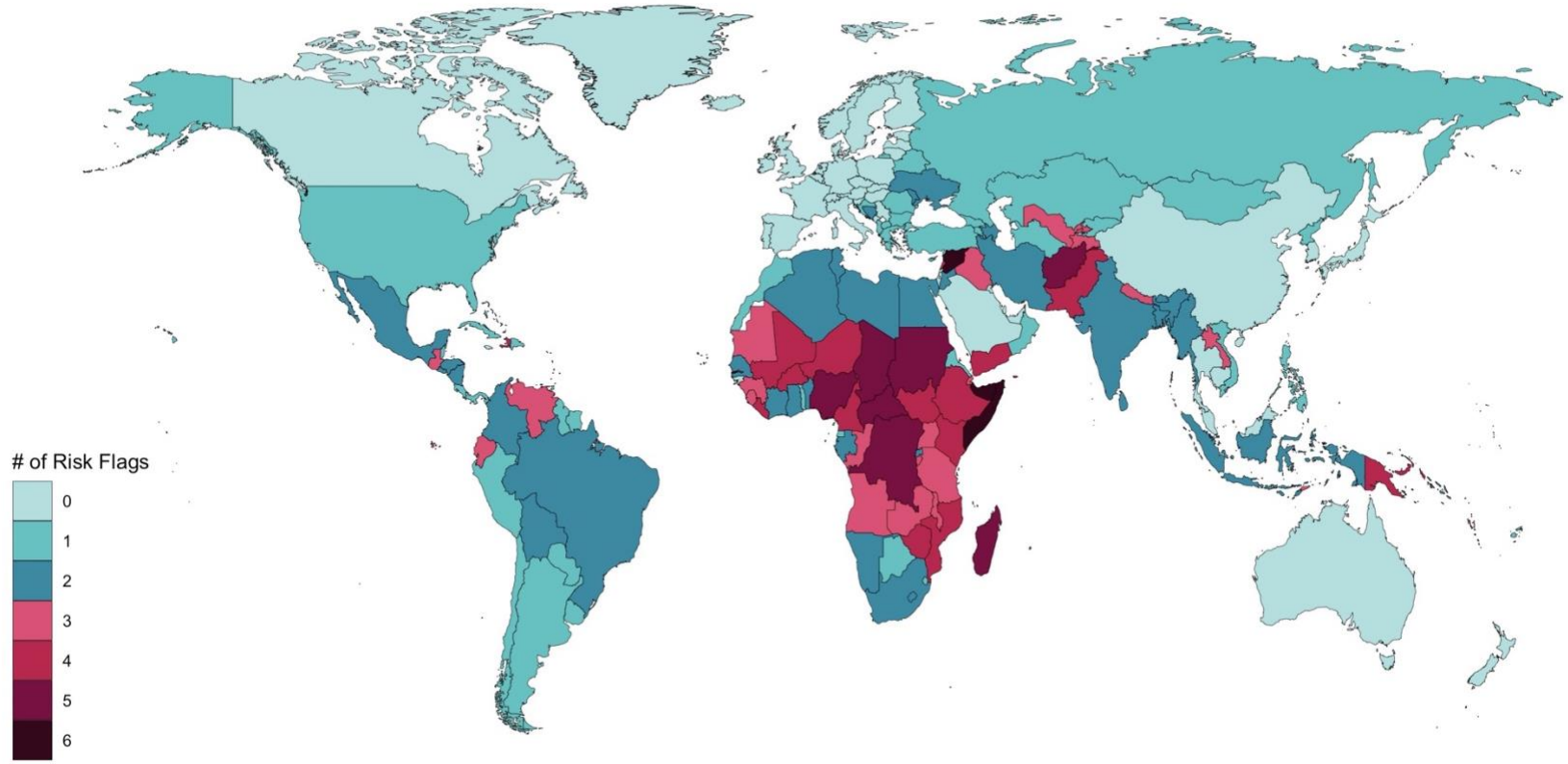
Notes: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer for ease of viewing. Values in the figure updated as of 05/14/21.

[19] Dynamic refers to the fact that underlying indicators are updated in real time at higher frequency (weekly to monthly depending on the indicators)

In addition to the Underlying Vulnerability and Emerging Threat outlooks, the CRM provides a measure of Overall Compound Risk. This third measure combines dimensions-level inputs from Underlying Vulnerability and Emerging Threat (using a geometric mean), and can be seen as a high-level approximation of a country's overall risk of being affected by multiple drivers of compound risk in the coming ahead (see Annex Supplementary Text 1 for details). In essence, it seeks to weigh the scale of ongoing changes in risk conditions against a country's capacity and predisposition to deal with the various risk dimensions tracked under the CRM.

Figure 6 reveals the geographic spread of Overall Compound Risk. As with the previous two outlooks, most countries with more than four high-risk flags are located in SSA. However, the map also points to distinct clusters in MENA (namely Yemen, Syria and Lebanon), SA (Afghanistan and Pakistan), EAP (Papua New Guinea, and Lao PDR) and LAC (Haiti). While Overall Compound Risk levels must be interpreted with caution, for reasons outlined above, the distribution of countries displaying high numbers of compound risk flags does provide an insightful snapshot of key hotspots. A combined metric is also better situated to operational decision making given that changing levels of exposure (i.e. Emerging Threat) are weighed against a country's predisposition in responding to given risk (i.e. Underlying Vulnerability).

Figure 6: Profile of OVERALL COMPOUND RISK Flags (i.e. level of alertness needed in monitoring multiple overlapping risks[20])



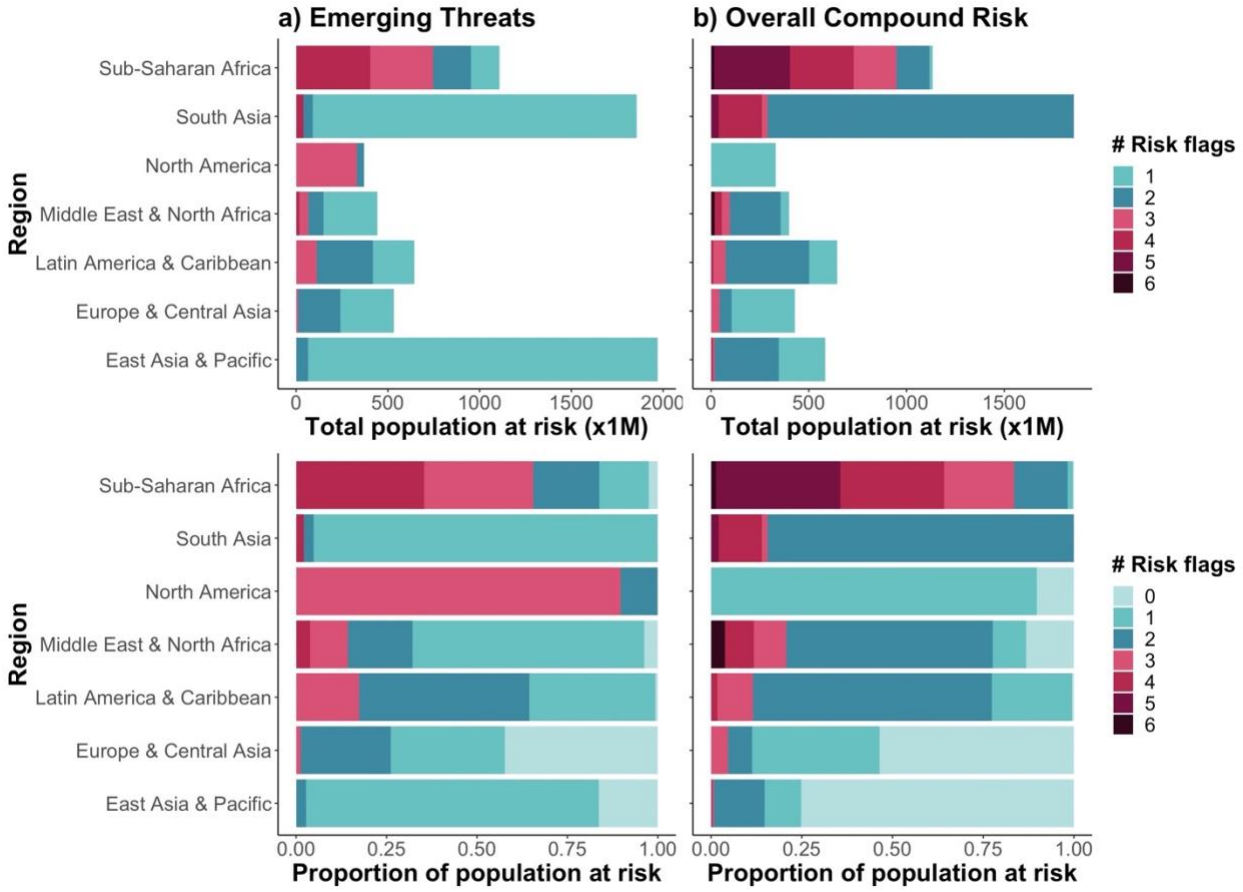
Note: Overall Compound Risk is devised using a geometric mean of Underlying Vulnerability and Emerging Threat scores for each risk dimension. The number of country-level flags is calculated as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer. Values in the figure updated as of 05/14/21.

[20] underlying indicators are updated in real time at higher frequency (weekly to monthly depending on the indicators)

Population under high alert

Alongside country and global-level risk outlooks, the CRM can also be of use in providing broad regional-level insights on the magnitude of risk conditions in the months ahead. For example, Figure 7 showcases the total regional population and proportion of individuals affected by different risk flags, by WB regions. This is done by summing populations in each country in each region, assuming for simplicity that all those within a country are affected uniformly.

Figure 7: Population living under different high-risk flags for Emerging Threat & Overall Compound Fisk



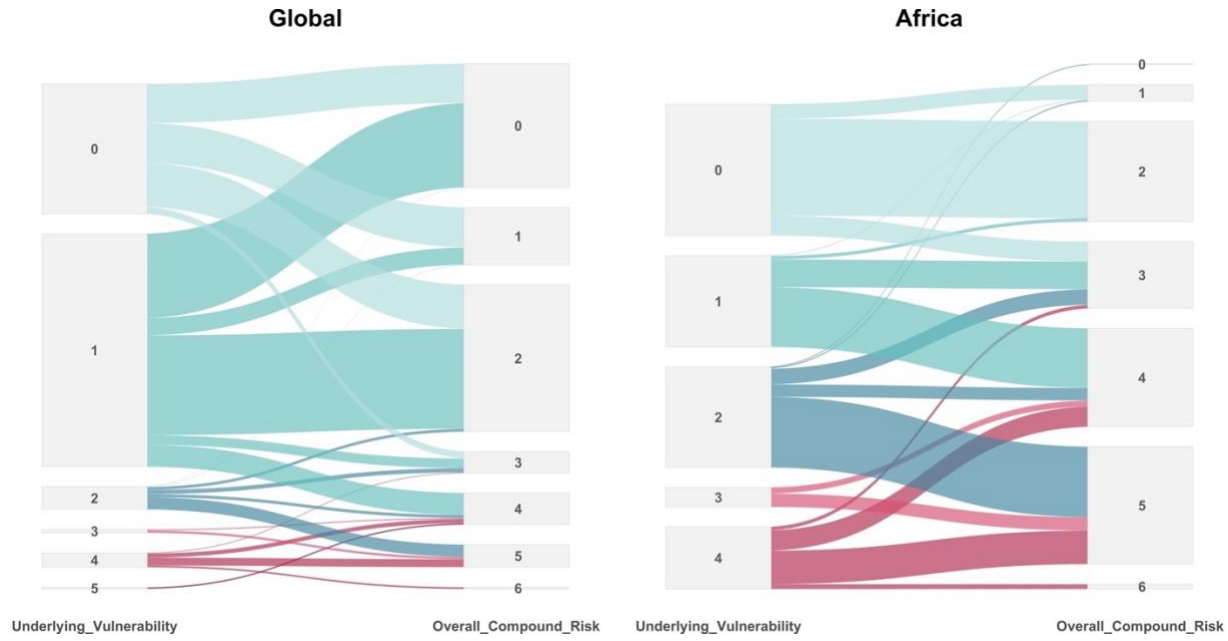
Note: This is NOT meant as a projection of total number of people affected by compound crises. Numbers correspond to the total population of each country in given risk flag categories. Levels of Emerging Threat are calculated as the sum of high and medium risk flags (max score = 6). Medium risk flags are assigned a ½, while high risk flags are assigned a 1. Risk scores are rounded down to the nearest integer for ease of viewing. All individuals within a country are assumed to be affected in the same way. Figure updated as of 05/14/2021

Regional-level insights also provide a wide range of geographic variation in the spread of compound risk, depending on the angle of interest. SSA clearly has the highest number of people covered under four of more emerging threat flags, both in terms of total population and proportion. However, it is interesting to note that MENA has the highest proportion of people classed under the maximum number of flags for the Overall Compound Risk (combing Underlying Vulnerability with Emerging Threat). Despite this, SSA

has a far higher proportion of people with four flags of more, signaling that the vast majority of compound risk conditions can be found in the region.

A further break-down of the distribution of risk profiles can be seen in the Sankey diagram depicted in Figure 8. This provides a break-down of the number of people exposed to different high-risk flags between Underlying Vulnerability and Overall Compound Risk outlooks. More importantly, it shows what proportion of each risk flag category in one outlook end up with different flag counts in the other outlook. Globally, it is apparent that large shifts can occur between the two respective outlooks. Many people that typically do not experience compound risk threats (i.e. 0 Underlying Vulnerability flags) currently seem to be experiencing conditions to compound risk (with a sizeable number of people transitioning from 0 vulnerability flags to 3 Overall Compound Risk flags). Many of the phase transitions appear to be driven by an intensification of risk in Africa. Much of the continent's population is living under conditions with high numbers of Overall Compound Risk flags compared with pre-existing levels of Underlying Vulnerability.

Figure 8: Number of people living under different high-risk flags using different risk outlooks (comparison between Underlying Vulnerability v Overall Compound Risk)



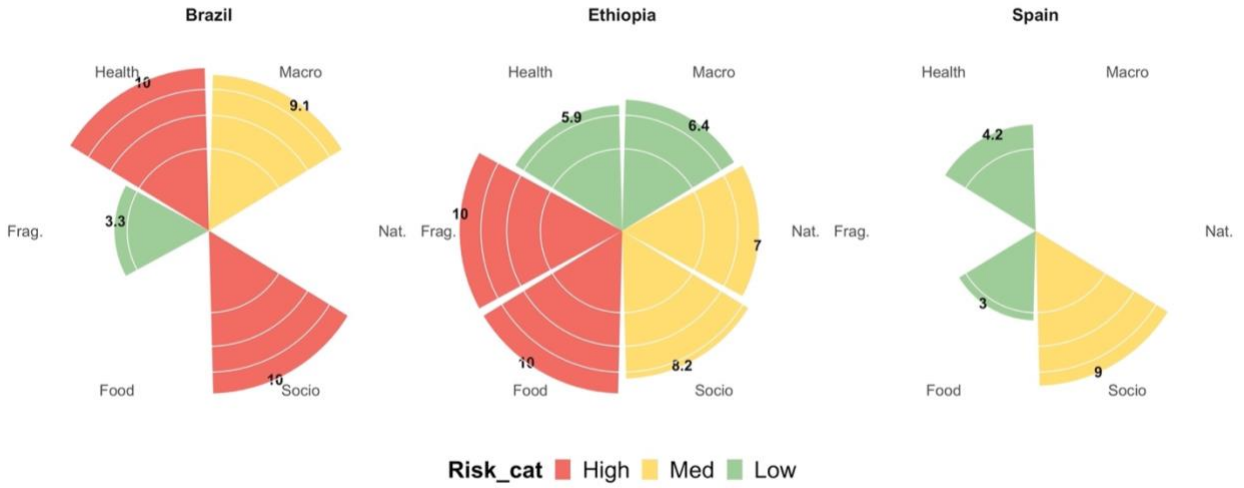
Note: Sankey diagram shows the total population in each risk category between vulnerability and emerging time periods. To calculate total populations, all individuals are assigned the same risk categories for respective countries in the Monitor. Figure updated as of 05/14/2021

Disaggregated view of risk

Alongside presentations of Overall Compound Risk, there is a wealth of relevant information on risk profiles across individual dimensions. These reveal the detail and nuance of why a given country may be considered highly prone to compound risk and can support tailored sectoral interventions. Figure 9 showcases three countries taken from the CRM, with scores for each of the six emerging dimensions of risk visible. Mozambique stands out as a country with a large number of high-risk signals (five high risk flags and one medium risk). While conditions are comparatively not as bad in Brazil, clear emerging threats can be seen with regards to the country's health system and pandemic response as well as socio-economic

vulnerabilities—both of which driven by the widespread impacts of COVID-19 that have ravaged the country in recent months. Spain similarly has a high flag relating to its health system and macro-fiscal conditions—again reflecting toll of high COVID exposure. However, this does not imply that overall risk levels in Spain are comparable to Mozambique or Brazil. Instead, it implies that risk conditions facing Spain's health system are similarly deteriorating relative to the normal condition—whatever the 'normal' of any given country may be, as defined by the measures defined in Table 1. In addition, while the expected impacts on socio-economic vulnerability in Spain are marked (largely driven by high levels of expected unemployment), risk profiles for the remain three dimensions remain low for the time being.

Figure 9: Comparing emerging threat scores across the six dimensions of compound risk



Note: Polar diagram shows risk levels for a range of multi-dimensional threats used in the CRM. Scores range from 0-10 for each dimension and are colored according to assigned risk categories (<7 = low risk, 7-9.9 = medium risk and 10 = high). The area under each risk score in the chart is equivalent, meaning that higher scores appear thinner. Figure updated as of 05/14/2021

4. AREAS FOR FURTHER CONSIDERATION

Given that the CRM is intended to be a live resource, source inputs are likely to evolve over time, particularly as new sources of risk information emerge. For further details on diagnostics of the CRM and its outputs, see Supplementary Text 3 in the Annex. While efforts have been made to ensure that methodological inputs are a robust reflection of Underlying Vulnerability and Emerging Threat conditions, a number of design options should be considered.

In the following, we highlight priority areas for further development of the CRM.

4.1. Indicator selection

i. **Aligning indicators with ongoing WB monitoring tools.** Where possible, the team chose indicators and thresholds aligned with (or sourced from) existing WB risk monitoring initiatives. This includes data from the Food Price Monitor (Food security), Global Economic Prospects (Macro-fiscal), DSSI (Macro-fiscal), and the FCS list (Fragility), amongst others. Going forward, the team will continue to coordinate with relevant teams to ensure that planned WB risk monitoring systems will feed directly into the CRM once launched—including, for example, outputs from FCV's Conflict Risk Monitoring Initiative and AGF's Food Security Monitoring Hub. In doing so, the hope is to provide a holistic view of risk and minimize different country-level warnings issued across the Bank's various risk monitoring efforts.

ii. **Identify suitable forward-looking indicators for dimensions of compound risk, particularly those with fewer source indicators.** Ongoing consideration of the selection of suitable source indicators will continue as the CRM evolves, in close conjunction with relevant sectoral experts across WB units and external partners. Notably, robust sources of information have yet to be identified for a number of emerging dimensions of compound risk. Household-level socio-economic vulnerability is one example where globally-applicable real-time information of changing risk remains scant (despite availability of country-specific and regional databases). In addition, a range of other dimensions are reliant on proxies with limited scope. Efforts will continue in seeking suitable indicators to improve the Monitor. Indeed, the CRM is tailored to easily accommodate new sources of information as they come online. Should no viable proxies be found for some dimensions of compound risk, Emerging Threat scores will reflect solely the number of dimensions with adequate sources.

iii. **Refine risk threshold values:** The designation of risk thresholds plays a large role in determining the rank of countries across the CRM. At present, most of the thresholds are determined by percentiles. However, choice of the cut-off is subjective (typically above the 80th percentile). It also does little to recognize any systematic changes in risk conditions, such as insights from FEWSNET suggesting that medium-term food insecurity is likely to worsen for all monitored countries—which would imply that the food security threshold may need to be lowered compared to other dimensions of compound risk. One alternative is to assign thresholds in accordance with critical values rather than percentiles. This could be done via expert elicitation, drawing on insights from a range of technical specialists within the Bank as well as outside partners.

   In most cases, thresholds in the CRM are aligned to classifications used internally by relevant units or programs in the Bank (such as the CRW ERF thresholds) or where there are established external high-risk thresholds used widely. In some cases, neither internal nor external thresholds are available or readily applicable to the CRM's methodology. If so, inputs are sought from relevant

sectoral teams within the Bank in gauging suitable levels of risk as a guide. Related to issue of compatibility and comparability of indicators and thresholds within each risk component, a number of steps are typically taken in selection.

The selection of thresholds will be subject to continued consultation with the relevant internal teams for further refinement.

4.2. Outputs and user interface

i. **Isolate countries in active crisis.** To facilitate the identification of countries that warrant increased vigilance among the universe of countries flagged by the CRM, the team is considering isolating countries in active crisis. This could increase the informational value of the CRM by clearly focusing on countries not currently in crisis but that warrant heightened vigilance going forward.

ii. **Link to interactive dashboard and horizon scanning exercise.** A digital dashboard will be used to visualize the data-driven outputs of the CRM (see Annex Figures 15-18 for screenshots of the existing prototype). Through this dashboard, the CRM will bring value added as an aggregator of risk information produced by different Bank teams and external partners, directing users to relevant data and resources on different aspects of compound risk. In addition, inputs from the CRM will be combined with a qualitative assessment. Through regular horizon scanning meetings, this will help ground-truth the CRM's outputs, reflect latest developments not captured in the data (such as political economy developments), and explore the different likelihood and potential impacts of key risk dimensions.

iii. **Consultative engagements on uptake and use of the CRM.** A critical next step will be to engage in a range of consultative exercises focused on launching and promoting uptake of the CRM with relevant end-users, including regional focal points, GPs, OPCS, DFi other relevant steakholders. The CRM team with also continue toengage with the GCRP in deciding on use and access proceedures relating to the CRM's dashboard, data and horizon scanning exercises within wider World Bank Group activities.

4.3. Opportunities and next steps

Beyond the methodological refinements described above, there are a number of opportunities that the team will consider in future iterations to expand the scope and value of the CRM. These include:

i. **Model and weight interactions between dimensions of compound risk.** The CRM currently models each dimension separately. This is done to promote transparency and simplicity, given the considerable complexities associated with predicting interactions across different threats. Future iterations of the CRM may wish to consider the use of functions that express how two or more dimensions of compound risk are likely to interact—whether they are increasing or diminishing overall levels of risk.

ii. **Factor in sub-national risk information.** The CRM is currently focused on country-level risks. With that in mind, most of the indexes and indicators are based on studied carried out at the national level. However, this does not account for potential heterogeneity within a country and does notrecognize that risk factors may differ from one region to the next. It also makes it difficult to use data collected at high spatial resolutions, such as satellite data, of information focused solely on urban environments. One option may be to combine the CRM with sub-national data using the Dashboard (as an added map layer). A similar approach is used by WFP's Hungermaps live.

iii. **Factor in seasonality and intra-annual components.** Issues of compounding risk are often affected by seasonality or factors that vary within a year. For example, the impacts of above and below average rainfall are especially relevant during growing seasons in countries highly reliant on agriculture, and the socio-economic impacts of COVID are pronounced during the timing of peak exposure (and stages of policy response). While it is difficult to factor these into the CRM holistically, it is important to consider how issues of seasonality can be incorporated. At present, this is being trialed in calculating future natural hazard risks and conflict risk, though there may be opportunities to add temporal dimensions to other dimensions of compound risk.

ANNEX

Table 1: Indicator selection of each compound risk dimension: How underlying vulnerability is reflected in the CRM

Quality of indicators (Q)	GOOD
	ACCEPTABLE
	POOR

INDICATOR NAME	INDICATOR DESCRIPTION	NORM. BOUNDS AND THRESHOLDS	SOURCE INDICATORS	AGGREGATION	Q
FOOD SECURITY RISK					
F_Proteus_Score_norm	*WFP Proteus composite index, measuring multidimensional aspects of food security*	*Normalised using a min/max procedure with an upper bound of 90th pct and lower bound of 10th pct*	Multidimensional index made up of grouped indicators for: Availability; Access; Utilization; and Stability	*N/A* *Single Index*	
NOTES: Index only runs till 2017. The CRM may want to consider updating WFP's methodology using data gathered through 2020, as well as assigning thresholds on the basis of expert derived values (rather than percentiles). Alternatives include the Global Food Security Index, as well as metrics on the prevalence of undernourishment and food consumption					
CONFLICT FRAGILITY AND INSTITUTIONAL RISK					
Fr_FCV_normalised	World Bank's Fragile and Conflict-affected Situations list	*Assigned values in consultation with FCV.* *10 = If on FCS list* *0 = If not on FCS list* *(based on FCS thresholds)*	Multidimensional index including information on the following: Country Policy and Institutional Assessment (CPIA) scores, whether a UN peacekeeping operation is present, the severity of border flight, and conflict-related deaths.	*MAX(Fr_FCV_normalised, FR_FSI_norm)*	

Fr_FSI_norm	Fund for Peace's Fragile States Index	*Normalised using a min/max procedure with an upper bound of 98th pct and lower bound of 40th pct*			
NOTES. CRM team will continue to liaise with FCV's ongoing conflict risk monitoring initiative to ensure consistency in indicator selection and thresholds.					

MACRO-FISCAL

M_EIU_Score_12m_norm	Economist Intelligence Unit's Country-level Operational Risk Score: a multi-dimension index tracking macro-fiscal conditions updated on a monthly basis Values are derived as an average of EIU scores in macroeconomic risk, financial risk, and foreign trade & payments risk for the previous 12 months (in order to be compatible with other risk dimensions)	*Normalised using a min/max procedure with an upper bound of 95 and lower bound of 10.*	A multidimensional index comprised of grouped indicators relating to: financial risk, foreign trade & payments risk, infrastructure risk, labour market risk, legal & regulatory risk, macroeconomic risk, and tax policy risk.	*N/A* *Single Index*	
Alternatives: An alternative index is currently under development together with MTI, FCI, CROCR and the Prospects Group					

HEALTH-SYSTEMS, DISEASE OUTBREAKS AND RESPONSE

H_HIS_Score_norm	Global Health Score Index, a composite index made up of a variety of health-related indicators	*Normalised using a min/max procedure with an upper bound of 20 and lower bound of 70*	GHS is made up of six categories (comprised of 34 indicators, 85 sub-indicators). The categories include: prevention; detection and reporting; rapid response; health system; compliance with international norms; and risk environment. For more details see link.	*N/A* *Single Index*	

NATURAL HAZARD RISK

NH_Hazard_Score_norm	Natural multi-hazard rating (INFORM) – 2022 data	*Normalised using a min/max procedure with an upper bound of 7 and lower bound of 1*	Historical rates of exposure and sensitivity to earthquake, tsunami, flood, cyclone, storm surge and drought risk. For more details see link.	*N/A* *Single Index*	
NOTES: The CRM team will continue to consult with sector experts to assign designated thresholds rather than percentiles					

SOCIOECONOMIC VULNERABILITY RISK

S_INFORM_vul_norm	*Composite index comprised of a range of socio-economic variables compiled by INFORM*	*Normalised using a min/max procedure with an upper bound of 7 and lower bound 0*	Comprised of grouped indicators relating to: development and deprivation (50%); inequality (25%) and economic dependence (25%).	N/A Single Index	

Table 2: How forward-looking risk is reflected in the CRM

Quality of indicators (Q)	GOOD
	ACCEPTABLE
	POOR

INDICATOR NAME	INDICATOR DESCRIPTION	NORMALISED BOUNDS	AGGREGTION	Q
FOOD SECURITY RISK				
F_fews_crm_norm	FEWSNET IPC classification (near term) adjusted. Thresholds chosen to align with CRW ERF trigger.	*Assigned values based on CRW threshold:* *10 = CRW threshold* *9 = Below CRW & IPC5* *8 = Below CRW & IPC4* *7 = Below CRW & IPC3* *5 = Below CRW & IPC2* *3 = Below CRW & IPC1* *0 = Below CRW & no IPC*	*Max of three indicators*	
F_fao_wfp_warning	Food security early warning released jointly by FAO and WFP. Thresholds chosen to align with FAO/WFP classification.	*10 = on FAO/WFP list of early warning countries* *0 = if not on FAO/WFP list*		
F_fpv_rating	Food price inflation from WB microdata for monthly food prices Thresholds chosen to align with FRM classification.	*Assigned values based on IPA threshold:* *7 = FPV above 30%* *5 = FPV between 5-30%* *3 = FPV between 2-5%* *1 = FPV below 2%*		
NOTES Primary challenge in finding robust information for non FEWSNET covered countries. CRM team will seek to draw food price data and additional FS indicators from the WB's Food Security Monitoring Hub. Alternatives: NDVI / GIEWS / WB Food Security Monitoring Hub				

MACRO-FISCAL

M_EIU_12m_change_norm	Point change in the average of Economist Intelligence Unit's Country-level Operational Risk scores for macroeconomic risk, financial risk, and foreign trade & payments risk. The EIU Operational Risk is a multi-dimension index tracking macro-fiscal conditions updated on a monthly basis. Values are based on the difference between the latest EIU monthly score and an average of scores over the past 12 months.	*Normalised using a min/max procedure with an upper bound of 95th pct and lower bound of 10th pct*	*Max of two indicators*	
M_MFR	Aggregate of Macro Fiscal Review's macroeconomic risk, monetary and financial conditions and risk appetite	*10 = Marked red (high risk)* *7 = Marked yellow (medium risk)* *0 = Marked green (low risk)*		
NOTES: An alternative index is currently under development together with MTI, FCI, CROCR and the Prospects Group				

FRAGILITY AND CONFLICT RISK

Fr_BRD_Normalised	Fatalities related to violent events, demonstrations or non-violent actions (ACLED). Indicator is calculated as 3-month running Z-scores using 3-month means and standard deviations for the past three years. Thresholds assigned by FCV	*Normalised using a min/max procedure with an upper bound of 1 and lower bound of 0; if there are fewer than 26 deaths in 3-month period, indicator is set to 0*	*Max of four indicators*	
Fr_REIGN_Normalised	Political disturbance (REIGN) Indicator is formed by summing results from 4 REIGN binary variables, including: successful coup; attempted coup; delayed election; and irregular election. Inputs from election variables are only considered in FCS countries.	*10 = at least one event across the REIGN indicators* *0 = no events across the REIGN indicators*		

	*REIGN is currently inactive; it is currently replicated using election data from the International Foundation for Electoral Systems, and coup data from the Global Instances of Coups dataset. Thresholds assigned by FCV			
ACAPS Risk List	Events related to conflict and fragility recorded by ACAPS	*10* = High risk 7 = Medium risk 3 = Low risk		
EIU Security Risk	Point change in Economist Intelligence Unit's Country-level Operational Risk scores for Security Risk, excluding hostility to foreign. The EIU Operational Risk is a multi-dimension index tracking macro-fiscal conditions updated on a monthly basis. Values are based on the difference between the latest EIU monthly score and an average of scores over the past 12 months.	*Normalised using a min/max procedure with an upper bound of 95th pct and lower bound*		
NOTES: To be updated based on coordination with FCV's Conflict Risk Monitoring Initiative.				

SOCIOECONOMIC VULNERABILITY

S_change_unemp _norm	Percentage point change in proportion of people unemployed between 2022-2021 and 2021-2020[21] (IMF forecast)	*Normalised using a min/max procedure with an upper bound of 1 percentage point and lower bound of 0*	*Max of four indicators*	

[21] Percentage point differences for both 2020 and 2021 are used in the current iteration, recognising that the knock-on implications of increased unemployment (and poverty) on household-level vulnerability can persist for long periods of time. Continued use of 2020-2019 figures will be actively considered in consultation with Poverty GP and the

S_pov_comb_norm	Percentage point change in the proportion of people below $2.05 poverty line 2023-2022 and 2020-2019[22] (WB/MPO)	*Normalised using a min/max procedure with an upper bound of 0.5 percentage points and lower bound of 0*		
S_Household.risks	Measure of household debt-to-GDP ratios and unemployment rates during the previous quarter	*10 = Marked red (high risk)* *7 = Marked yellow (medium risk)* *0 = Marked green (low risk)*		
ACAPS Risk List	Events related to socioeconomic vulnerability recorded by ACAPS	*10* = High risk 7 = Medium risk 3 = Low risk		

NATURAL HAZARD RISK

NH_seasonal_risk_norm	Measure of the proportion of a country projected to experience above or below average rainfall (with 60+ likelihood and above) using Columbia IRI's seasonal forecast. To be updated based on ongoing research and collaboration with IRI	*10 = if a critical proportion of the country is wet or if a critical proportion is dry. Critical proportion is determined by country size.*	***MAX**(NH_seasonal_risk_norm, NH_GDAC_Hazard_Score_Norm, NH_INFORM_Crisis_Norm, NH_locust_norm)*	

Development Data Group (and likely to drop in the later quarters of 2021). Thresholds in percentage point differences are different for the periods 2021-2020 and 2020-2019 owing to the differential impacts of the COVID crisis on socio-economic vulnerability. While large increases in unemployment (and poverty) are expected during the latter period, the former is characterised by lower growth rates as most countries are assumed to experience a relative rebound in conditions.

[22] Ibid.

NH_natural_acaps	INFORM Crisis monitor with live tracking of natural hazard events	*Normalised using a min/max procedure with an upper bound of 7 and a lower bound of 1*		
NH_GDAC_Hazard_Score_Norm	GDACS live natural hazard tracker	*Assigned value:* *10 = if ongoing Natural Hazard* *0 = no ongoing Natural Hazard*		
NH_locust_norm	FAO desert locust outbreak risk	*Assigned value:* *10 = High risk based on FAO thresholds* *7 = Medium risk based on FAO tresholds* *0 = Low risk based on FAO thresholds*		
ACAPS Risk List	Events related to conflict and fragility recorded by ACAPS	*10* = High risk 7 = Medium risk 3 = Low risk		
NOTES: Thresholds for seasonal precipitation are temporary and will be updated based on ongoing research together with IRI. Alternatives: Flood outlook (GLOFAS) – 4 month seasonal outlook + 10-day forecast. Drought monitor/outlook (IRI Global SPI Index / SPEI / CHIRPS / EDO). Live cyclone tracks (Cyclocane) – 1-10 day. Live natural hazard trackers –USGS / RSOE / GDACS / Reliefweb / Copernicas / PDC				

HEALTH-SYSTEMS, DISEASE OUTBREAKS AND RESPONSE

H_ifrc_epidemics	Epidemics announced by IFRC	*10: On list* *NA: Not on list*	*Max of two indicators*	

H_who_don_alert	WHO Disease Outbreak News (DON) Alert	*Assigned value:* *10 = if country if on WMO DON list* *0 = if county not on WMO DON list*	

NOTES May benefit from clustering indicators into different aspects of risk rather than max value across all. Use of USC projections done on the basis of comparison amongst a number of COVID projections. Will require careful consideration of thresholds

TABLE 3: Methods for aggregating Overall Compound Risk

AGGREGATION METHOD	DESCRIPTION	METHOD
Max score	Count of the total number of compound risk dimensions flagged as high-risk flag (i.e. score of 10)	***COUNT(IF** Risk Dimension = 10)*
Max + medium scores	Count of the total number of compound risk dimensions flagged are high-risk (i.e. score of 10), as well as medium-risks (i.e. score 7-10)	***COUNT(IF** Risk Dimension = 10) * 1 + **COUNT(IF** Risk Dimension > 7) * 0.5*
Geometric scores	Count of the total number of compound risk dimensions flagged high risk flags a geometric average (i.e. score 7-10)	***COUNT(IF** Geometric Risk Dimension > 7)*

NOTES Geometric method can use either the max score or max+medium approaches as source inputs for Emerging Threat. Threshold values may also vary depending on whether indicators are aggregated using a max value or geometric method (in which case high risk is likely to be <7 rather than =10.

Supplementary Text 1

Alternative aggregation option 1: Mean

An alternative method of aggregation is to use an average across all source indicators. This can be done in a number of ways. The simplest is to use a regular arithmetic mean, which assigns an equal weight to all source indicators.

$$RiskDriverAv_r = \frac{1}{N}\sum_{i=1}^{N} IndicatorNorm_i$$

Here, $RiskComponentAv_r$ relates to the average risk score for a given dimension *r,* taken as the average of all normalized indicators *(i = 1…n).*

PROS
Similar to the max value method, an arithmetic mean is simple to calculate. It also allows for any divergence in the suite of source indicators to be factored in (especially important where there may be outliers).
CONS
The main disadvantage is that the meanings of averaged scores are harder to interpret. Unlike with the max value (where a score of 10 meant that at least one indicator threshold has been exceeded), averaged scores have to be interpreted as a combination of all source indicators. Moreover, use of an average score result in far fewer countries with scores of 10. This requires a subjective choice in assigning lower thresholds for each of the risk characteristics.

A second related option is to take an average of grouped indicators. Here, source indicators are assigned in relation to whether they reflect changes in underlying risk capacities (represented by $CapacityNorm_c$) or outcomes ($OutcomeNorm_o$). The maximum value in each group is then selected, with an average taken between the two groups.

Averaging can either be done via a simple arithmetic mean:

$$RiskDimensionMaxAv_r = \frac{1}{2}\left(\max_{c=1\ldots n}\{CapacityNorm_c\} + \max_{o=1\ldots n}\{OutcomeNorm_o\}\right)$$

Or using a geometric mean, as recommended by Guillaumont (2009) for risk analysis where grouped outcomes are likely to multiply.

$$RiskDimensionMaxGeo_r = \sqrt[2]{\max_{c=1\ldots n}\{CapacityNorm_c\} \cdot \max_{o=1\ldots n}\{OutcomeNorm_o\}}$$

PROS
Grouping of the two allows for dimensions of compound risk with different types of indicators to be assessed (while diminishing the influence of indicators that have strong overlaps). For example, in the case of 'Health-systems, disease outbreaks and response', an average of max group values allows for closely-aligned outcome-based measures (such as COVID deaths, cases, growth rates etc.) to be compared alongside the tracking of changes in countries' sensitivity (such as a Government's preparatory measures and lockdown procedures)—see Table 2. In addition, choice of geometric mean takes into account the fact that capacity and outcome related measures are likely to compound (i.e.,

they have a multiplicative relationship rather than an additive one). A similar approach is adopted by a number of other multi-dimensional risk indexes, including INFORM.
CONS
In many ways, Underlying Vulnerability and Emerging Threat are not directly comparable, as their respective source indicators cover different underlying capacities and outcomes. However, efforts are made to ensure that grouped indicators overlap and provide valuable information (with some degree of caution needed in in interpreting outputs). In addition, and as outlined throughout, any averaging method is likely to be less interpretable than a simple max value method.

Given that the CRM is designed as a flagging system, signaling potential changes in emerging threats conditions rather than generating a precise risk index, use of a max value system is chosen as a default. However, users will be able to access and download all data inputs within the CRM and apply their own aggregation methods if appropriate to their needs. In addition, the CRM team will use the initial phase of implementation to review and validate the choice of default aggregation method.

Supplementary Text 2

Filtering methodology for calculating Overall Compound Risk

An alternative to the aggregation method for calculating Overall Compound Risk flags is to apply a filter. In this way, instead of calculating a combined average of Emerging Threat and Underlying Vulnerability, Overall Compound Risk is flagged on the basis of whether both of the two source inputs are considered high or medium risk. For example, the most basic filtering system for Overall Compound Risk designates a given dimension as high risk if both Emerging Threat and Underlying Threat scores are scored as 10 (i.e., high risk). All remaining values would be classified as 'not high risk'.

$$OverallCompoundRisk_r = \begin{cases} HighRisk & EmThreat_r = 10 \ \boldsymbol{AND} \ UnderVul_r = 10 \\ NothighRisk & EmThreat_r < 10 \ \boldsymbol{OR} \ UnderVul_r < 10 \end{cases}$$

While the method above is simple and clear to understand, it results in far fewer risk dimensions being flagged compared to the aggregate method—largely because it requires thresholds to be breached both in relation to Underlying Vulnerability and Emerging Threat. A more practical measure may involve lowering the critical threshold for designating dimensions as high risk (similar to the use of 7 rather than 10 as that threshold in the aggregation method). While this provides greater comparability with the aggregate method, as well as a broader spread of high-risk countries, it inherently involves some degree of subjectivity given that there is no empirical rationale for the selection of 7 as a cut-off (as opposed to 10 which implies that source indicators are above expert-derived thresholds).

$$OverallCompoundRisk_r = \begin{cases} HighRisk & EmThreat_r > 7 \ \boldsymbol{AND} \ UnderVul_r > 7 \\ NothighRisk & EmThreat_r < 7 \ \boldsymbol{OR} \ UnderVul_r < 7 \end{cases}$$

A final measure seeks to add further nuance by recognizing dimensions that that are just below the threshold for high risk. In this way, the filtering system separates alert levels according to high, medium, and low risk – without the need to aggregate Underlying Vulnerability and emerging threat. The system is very similar to designations listed under the quadrant (i.e., filter) heatmap shown in Annex Figure 10.

$$OverallCompRisk_r = \begin{cases} HighRisk & EmThreat_r > 7 \ \boldsymbol{AND} \ UnderVul_r > 7 \\ MediumRisk & (EmThreat_r < 7 \ \boldsymbol{AND} \ UnderVul_r > 7) \ \boldsymbol{OR} \ (EmThreat_r > 7 \ \boldsymbol{AND} \ UnderVul_r < 7) \\ LowRisk & EmThreat_r < 7 \ \boldsymbol{AND} \ UnderVul_r < 7 \end{cases}$$

This is much closer to the general approach adopted by the CRM. It is worth noting, however, that all filtering approaches result in categorical alert levels (rather than numeric scores ranging from 0-10). For this reason, we use the aggregation method as a default for calculating Overall Compound Risk in the CRM, while allowing users to choose alternative methods using the online interactive dashboard (including filtering) based on preferences.

Supplementary Text 3

Diagnostics and comparisons

Aside from the global risk maps, there are a wide range of descriptive analyses that can be used to unpack findings from the CRM. Heatmaps are an example of visual tool that helps to convey a holistic picture of risk conditions for countries and risk dimensions. As a reminder, the CRM provides three country-level risk profiles for each of the six risk dimensions. These include measures of, Underlying Vulnerability, Emerging Threat, and Overall Compound Risk. All three metrics are broadly related. In particular, Overall Compound Risk metrics are made up of a combination of the Vulnerability and Emerging Threat metrics, acting as a gauge of the vigilance required in monitoring ongoing risk conditions in the coming months. Having said that, each score can be viewed as a stand-alone, covering different aspects of risk of relevance to decision makers. As such, the CRM is designed to provide information for range of different user-needs, whether highlighting countries predisposed to compound crises (Underlying Vulnerability), identifying countries where risk conditions are likely to deteriorate rapidly (Emerging Threat), or gaining a general sense of upcoming compound risk hotspots in the months ahead (Overall Compound Risk).

Perhaps the easiest way to understand the relationship between the three measures is to plot heatmaps for each risk dimension (and country). Annex Figure 1 shows country-level profiles for all six risk dimensions by plotting Underlying Vulnerability on the X-axis against Emerging Threat on the Y-axis. Dots represent individual country scores (in instances where multiple countries have the same score dots are scaled according to the number of countries). A selection of random countries is highlighted to showcase where different types of countries fall within the heatmap. Shaded regions denote Overall Compound Risk, showcasing which risk category a country falls under, ranging from high-alert in red (representing Alert Level scores between 7-10), medium-alert in orange (scores of 5-7), to low-alert (0-5). Regions are shaded according to the default procedure used in aggregating Overall Compound Risk: a geometric average of Underlying Vulnerability and Emerging Risk. Alternative aggregation procedures are shown in supplementary heatmaps found in Annex Figures 9 and 10.

The heatmaps in Annex Figure 1 show a number of interesting traits. Firstly, the distribution of scores varies considerably across the six risk dimensions. This largely reflects the different nature of underlying indicators and thresholds used. For example, most risk dimensions feature country scores that are evenly scattered across the heatmap as indicators used to calculate Vulnerability and Emerging Threat elements are continuous (both in relation to raw data and normalized thresholds). However, some appear more segmented. For example, the wide horizontal spread between dots in the Conflict dimension reflects the fact that Underlying Vulnerability for conflict risk is represented by a binary variable (i.e., whether a country is on the FCS list or not). While there are good reasons for limiting the conflict risk to the FCS variable (further outlined in Table 1), this results in a stark spread of values in the heatmap and highlights the limitations of the current approach. It is for this reason that aggregation of Overall Compound Risk is carried out using an arithmetic mean as opposed to a geometric mean (as can be seen by the different risk classification shadings in the Conflict heat map). This accounts for the fact that countries not included on the FCS list (and therefore with an Underlying Vulnerability score of 0) would only ever be classified as a low alert status—irrespective of the country's Emerging Threat score. As such, the arithmetic mean allows for non-FCS country with an Emerging Threat score of 10 to be classified as medium-alert status instead (note that it is not possible for a non-FCS country to be grouped as high alert).

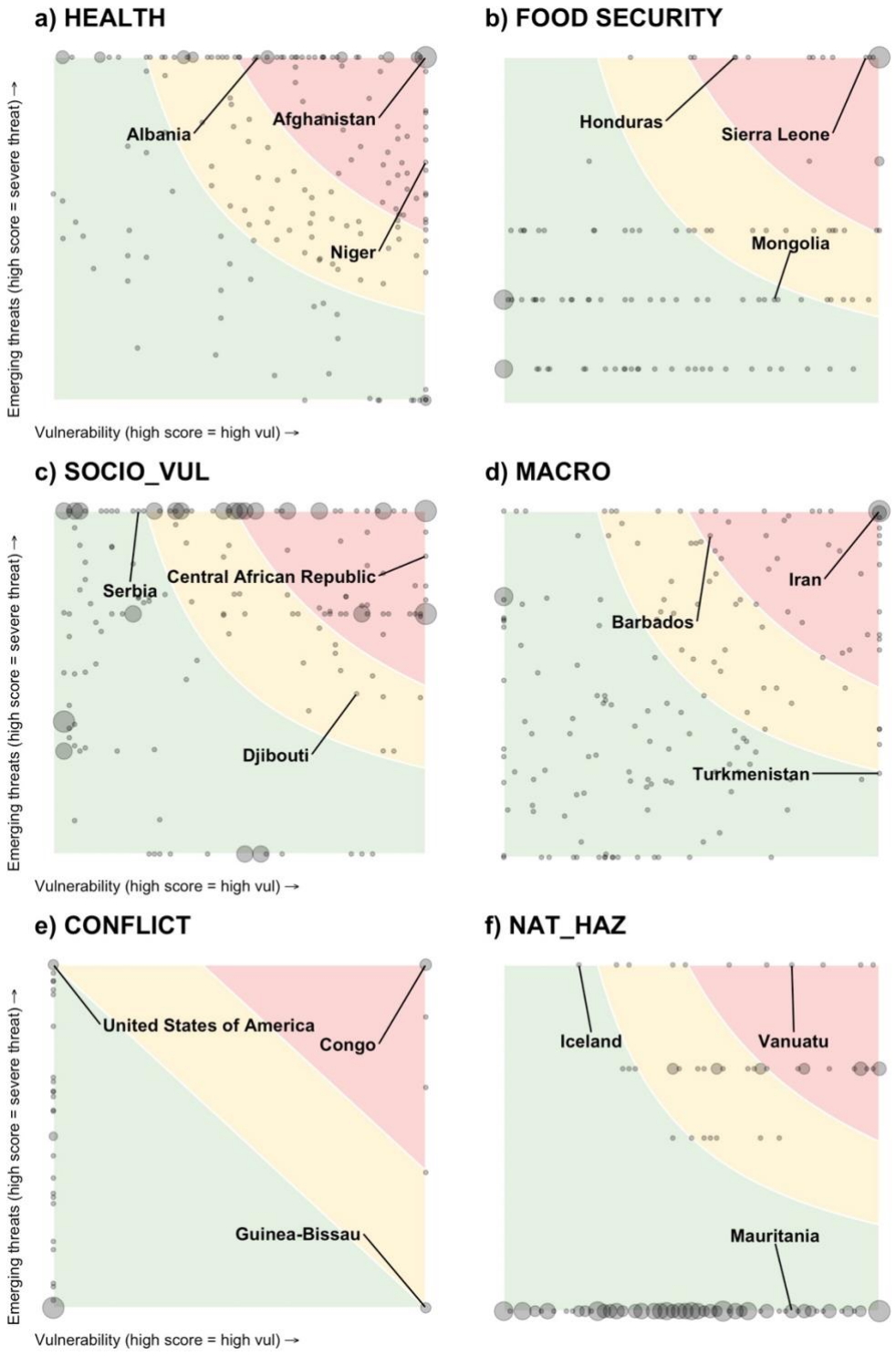
The heatmaps are also useful in revealing implications of aggregation in determining Overall Compound Risk. The default in the CRM is to use a geometric mean using values for Underlying Vulnerability and Emerging Threat. The shaded regions in the heatmap reveal how different combinations of scores result

in high, medium, and low alert outcomes. For example, countries classified as high alert tend to be those that have generally had high scores on both Vulnerability and Emerging Threat elements of the CRM. Looking closer to the boundary, countries can also be classified high alert if they score a 10 in one of the axes (Threat or Vulnerability) and 5 in the other.

It is these boundary cases that are of most interest when it comes to classifying countries. In using a geometric mean as the CRM's default, clear judgement calls are apparent in looking at the shaded regions of the heatmap. For example, a country that scores a 10 on one of the axes and a 0 on the other would be classified under a low alert level. This is done to reflect the fact that the CRM is an early warning system pointing to overall levels of vigilance needed in responding to changing risk conditions. With that in mind, a country that has very high levels of vulnerability to fragility (such as Guinea-Bissau) but currently experiencing a fall in conflict-related deaths would be placed under low alert—recognizing that conflict related risks are likely to be reduced in the coming months compared to expected norms. With the same example in mind, use of a different aggregation procedure, such as an arithmetic mean (show in Annex Figure 9) would mean that no matter what current conditions are being experienced, a highly vulnerability country (i.e., an Underlying Vulnerability score of 10) would always be classified under the medium or high alert bracket. Returning to use of a geometric mean, a country that has experienced a recent uptick in disease outbreaks (such as doubling of COVID-19 deaths from 20 to 40), but has had a highly effective health care system, would similarly be placed under low alert. This is done to recognize the country's high levels of resilience in dealing with the threat—though it is worth pointing out the limitations of this approach if the threat is exceedingly large.

While choice of aggregation procedure can have important implications for designating Overall Compound Risk flags, it is important is important to note that all three scores will be shown under the CRM database and dashboard, allowing users to get a holistic picture of threat conditions and to make judgements based on their own needs. Similarly, users will be able to choose between different aggregation procedures (such as geometric and arithmetic means) allowing them to tailor the CRM to given preferences.

Annex Figure 1: Heatmap showing relationship between the CRM's three outputs

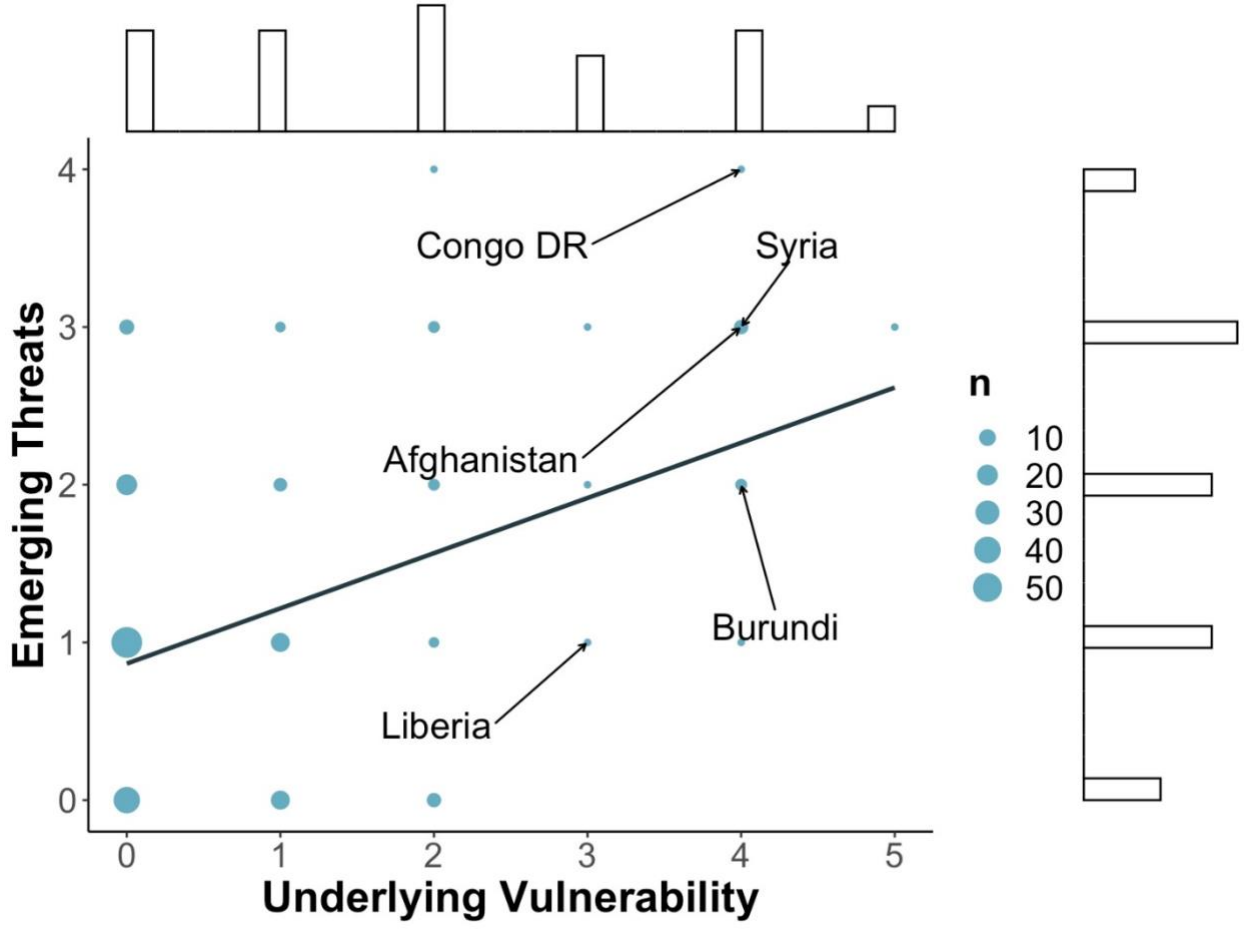


Heatmaps present information from three metrics related to Underlying Vulnerability score (X-axis), Emerging Threat score (Y-Axis) and Overall Compound Risk alert levels (shaded areas). Shaded areas relate to high-alert status (red), medium-alert status (yellow) and low-alert status (green). All shaded areas are derived according to a geometric mean, aside from conflict which is devised using an arithmetic mean. Figure updated as of 05/14/2021.

In order to further probe key outputs and methodological options within the CRM we analyse the large amount of analytical data produced by the early warning system. As mentioned above, the main focus of the analysis is on the CRM's Underlying Vulnerability and Emerging Threat outlooks – though comparisons are also drawn to the overall risk measure where relevant (alongside more detailed descriptions in Annex Supplementary Text 1 and Annex Table 6).

A first step in uncovering insights from the CRM is to compare how levels of Underlying Vulnerability correlate with Emerging Threat. Annex Figure 2 shows a count plot comparing scores from the two outlooks. The plot suggests that the relationship between the two variables is modest (with a correlation coefficient of 0.32). In general, countries that are historically predisposed to multi-dimensional threats are often those likely to be affected by numerous emerging threats. However, there relationship differs across continents. Interestingly, while the relationship is positive in Africa, Europe and to a certain extent Asia, trends are somewhat negative for the Americas and Oceania. The latter implying that many countries with low Emerging Threat flags are currently experience high emerging threats conditions (and vice versa).

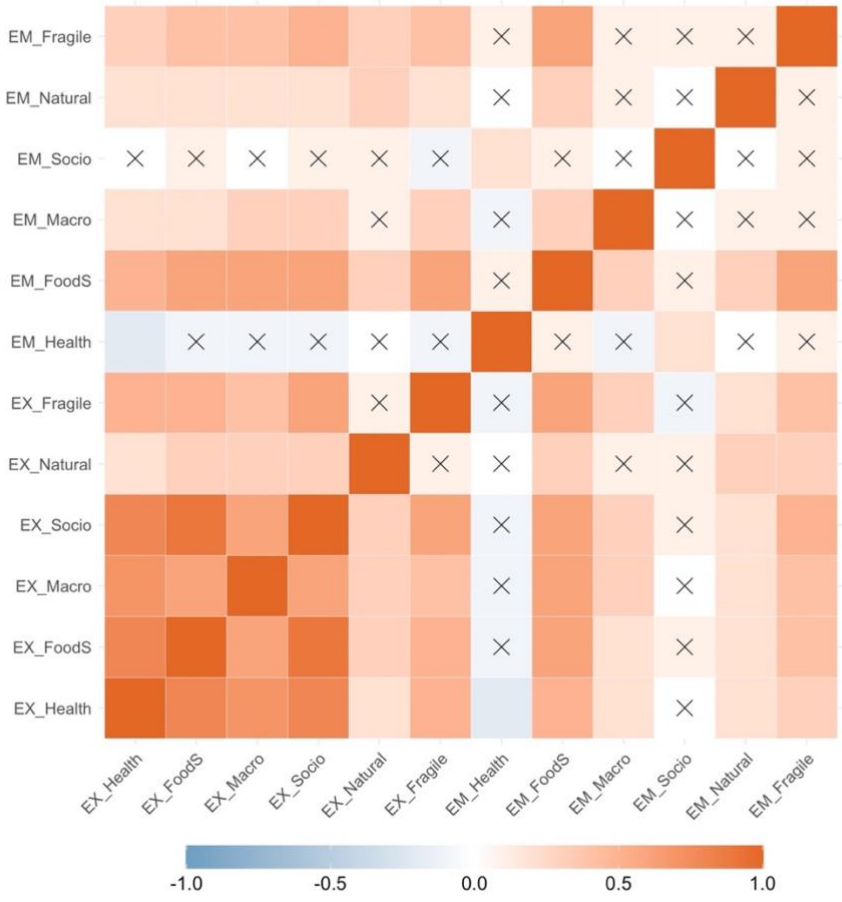
Annex Figure 2: Comparison of Emerging Threat and Underlying Vulnerability Flags under the CRM



Note: Count plot shows the frequency of different risk combinations split according to five continents (each colored differently). The size of each dot corresponds to the number of countries assigned the respective score. Histograms for Emerging Threat and Underlying Vulnerability are shown on the outside.

We can probe this further by looking at correlations between Emerging Threat and Underlying Vulnerability dimensions (Annex Figure 3). Here we see two important factors. Firstly, most risk dimensions appear to be positive correlated. Clear exceptions can be seen with regards to emerging Health risk. This may be suggestive of the fact that Health threats are currently experienced in countries that are otherwise less-affected by other multi-dimensional threats (and vice versa) – a trend that appears consistent with the current spread of COVID risk, as many countries in Europe and North America struggle to contain the virus. A second clear observation is that scores across the six Underlying Vulnerability dimensions are more highlight correlated than for Emerging Threat dimensions. While this may reflect the nature of current risk conditions, it may also be partly due to fact that Underlying Vulnerability dimensions tend to feature a heavy use of multi-dimensional indexes (that are likely to overlap slightly across different dimensions). This is one of the reasons why case should be taken in direct comparisons between Underlying Vulnerability and Emerging Threat (particularly as it relates to the combined Overall Compound Risk).

Annex Figure 3: Correlation plot between Emerging Threat and Underlying Vulnerability dimension scores



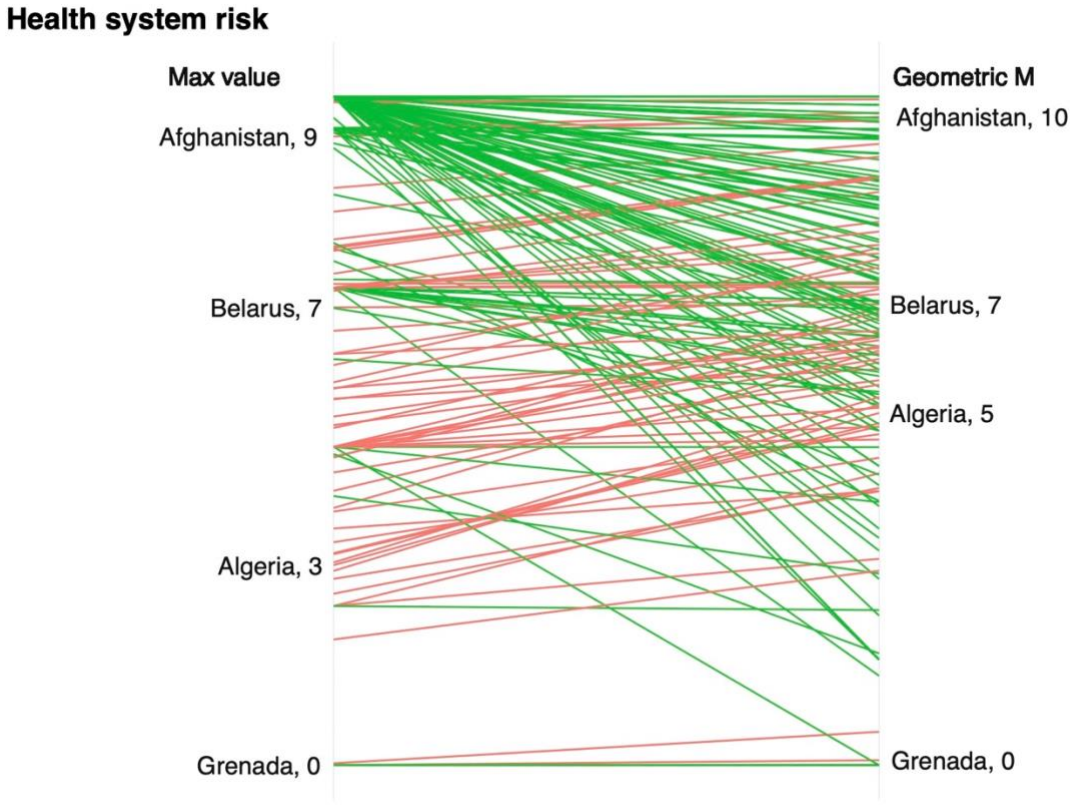
Note: Plot displays correlation coefficients between Emerging Threat and Underlying Vulnerability dimensions of compound risk. Red boxes correspond to a positive correlation, while blue boxes reflect negative associations. Box marked with an X are not statistically significant. Dimensions with an 'ET' relate to Emerging Threat while those labelled 'EV' relate to Underlying vulnerabilities. Figure updated 05/14/21.

Another important point of comparison is to look at different risk outcomes using the various methodological options for aggregation outlined in the methodology (Section 2). As highlighted above, the current default in the CRM is to aggregate country-level risk dimension scores by taking the maximum value across the series of source indicators. This method is chosen because it provides decision makers with a conservative estimate of compound risk. It is also simple to understand and transparent, particularly when calculating overall levels of compound risk.

However, a number of alternatives were laid out in Section 2.1. One notable option is in calculating compound risk dimension scores as an average of all grouped indicators within each risk dimension. This can either be done use an arithmetic or geometric mean – the latter of which tends to be favored in other multi-dimension risk indexes such as INFORM, especially when indicators are gathered across aspects of exposure, sensitivity and response capacity.

Annex Figure 4 plots country-level changes in scores and ranks between max value and geometric means for the Health risk dimension. Left hand columns show country rankings using the default max value system, while right hand columns show rankings with a geometric mean (i.e. mean values across all grouped indicators for Health risk). As is clear from the plot, mean values tend to be somewhat lower than the max value approach—perhaps unsurprisingly given the bread of indicators used. A similar feature can be seen when comparing histograms between max value and mean approaches across the other risk dimensions (as seen in Annex Figure 8). This is one of the reasons why classification levels using means are far lower (and somewhat subjective) when compared with the simplicity of max value classifications (as all values of 10 simply meant that at least one of the grouped indicators is above the designated threshold). Rankings can also differ considerably, especially as many high-risk countries under the max value approach are prone to dropping down significantly when using means. As a reminder, the strengths and limitations of the two approaches is discussed in Section 2.5.

Annex Figure 4: Rank Comparison of max value and geometric mean options used in calculating compound risk dimension scores



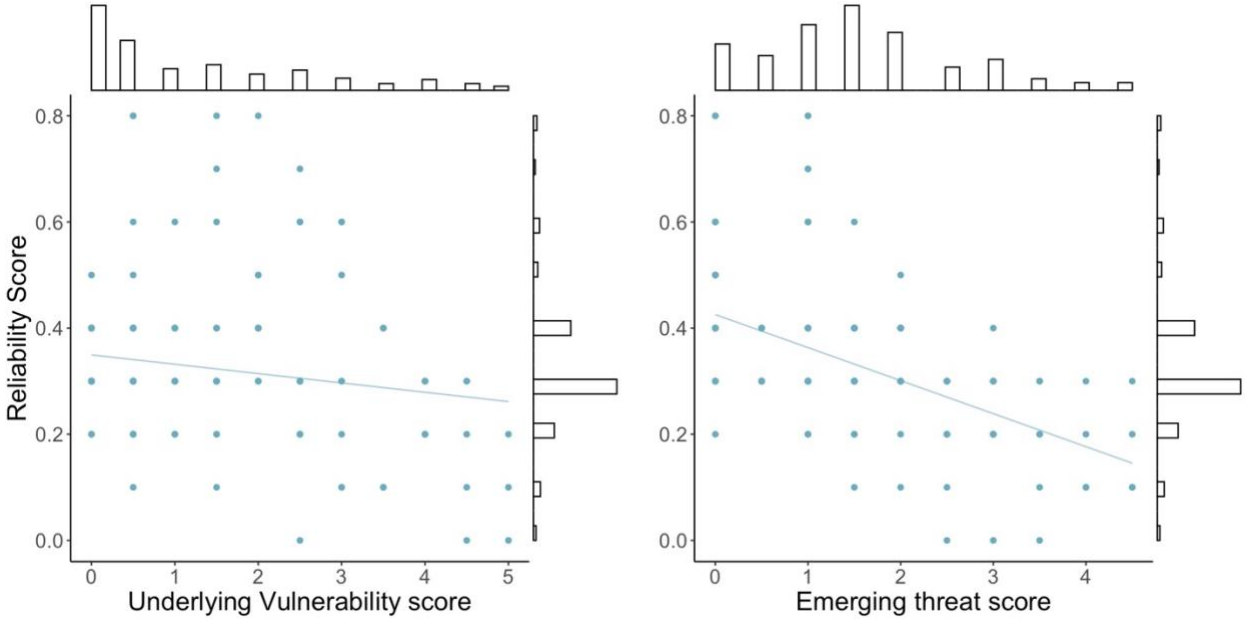
Note: Graphs compare country rankings for two different methods of calculating Health risk using a max value and geometric mean of Underlying Vulnerability and Emerging Threat. Labels for a subset of countries are included for illustrative purposes. Green lines indicate countries that have a reduction in score when moving from max to geometric approaches, while red lines showcase countries with increased scores.

Another important diagnostic is to consider the role of missing values. As mentioned previously, a large number of source indicators are geographically concentrated (whith decent coverage in some regions and none in others). To look at the influence of missing values on risk scores we devise an additional metric (termed a 'Reliability Score') that calculates the proportion of missing values used in constructing both Emerging Threat and Underlying Vulnerability scores. A reliability score of 1 implies that 100% of source indicators consist of missing values. The reliability scores will be made accessible in accompanying the main CRM outputs allowing users to gauge the quality of data inputs through the dashboard.

Annex Figure 5 shows that reliability scores drop relatively sharply as the number of multi-dimensional risks increase. In other words, countries that are at higher risk of compounding threats tend to have greater availability of source indicators, while those at lower risk of compounding threats have poorer data availability. The effect is far more pronounced in the Emerging Threat score, with a negative trend witness across all five continents. This reflects that fact that risk monitoring databases are typically concentrated on coverage in high-risk areas (such as FEWS NET). While this presents a challenge for robust

measurement of risk in lower-risk countries, it is at least reassuring that the trend does not run in the opposite direction (i.e., poor coverage in riskier countries).

Annex Figure 5: Count plot showing the relationship between reliability scores and Overall Compound Risk flags per region



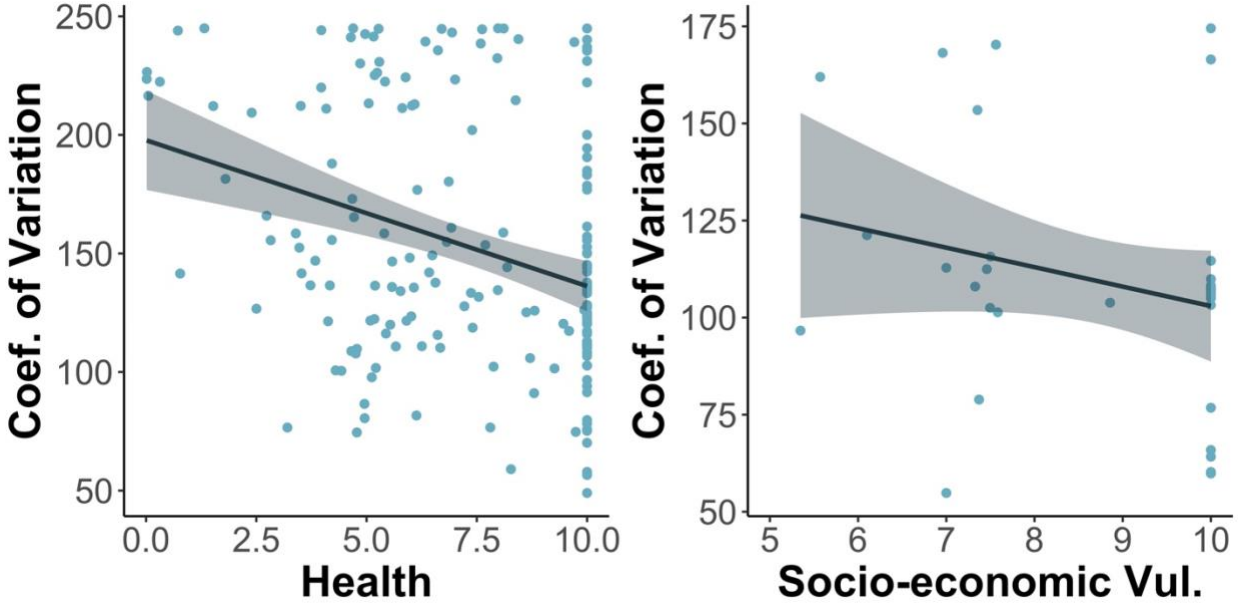
Note: Count plot shows the frequency of different risk combinations for Underlying Vulnerability and Emerging Threat. The size of each dot corresponds to the number of countries assigned the respective score. Histograms for reliability and Overall Compound Risk flag scores are shown on the outside.

Finally, we consider whether variation in scores across source indicators may result in skewed classification of high-risk threats. In doing so, we calculate the coefficient of variation for each country and each dimension of compound risk. This is done by dividing the standard deviation of all source indicators in a given dimension by the mean. Essentially, this tells us whether indicators are consistent when assigning risk dimension scores. A high score implies that the indicators are less likely to agree and/or point in the same general direction (a lower score shows greater consistency across source indicators).

Annex Figure 6 reveals the distribution of country-level cofficients of variation across three emerging dimensions of compound risk[23]. In most cases, there doesn't appear to be a strong trend – implying that variation amongst source indicators across the spectrum of risk scores is relatively consistent. If anything, trends are somewhat negative, suggesting that high risk scores have lower variation across source indicators. It is also important to note that considerable variation exists, particularly in relation to high-risk scores (i.e. 10).

[23] Note that Food Security, Natural Hazard and Socio-economic vulnerability are omitted owing to high dependence on binary source indicators.

Annex Figure 6: Comparing country-level coefficients of variation across emerging compound risk dimension scores



Plots show country-level coefficients of variation on the y-axis as the standard deviation of all source indicators divided by the mean. Results are presented for two dimensions of compound risk.

Supplementary Text 4

An Alternative Macro-Fiscal Emerging Risk Index: Toward an In-house Solution

Context

The Compound Risk Monitor (CRM) is an early warning system designed to flag countries experiencing an intensification of risk conditions across six dimensions of compound risk. One of its dimensions is macro-financial and fiscal risk which refers to the general status of a country's economy and the sustainability of fiscal measures. The current approach to the macro-fiscal dimension uses a modified version of the EIU's Risk Briefing score after existing inhouse metrics proved too limited including the macro-financial risk index (covers [39] emerging market and developing economies), and Debt Sustainability Analysis (focused on low-income countries).

Approach

To address the shortcomings of existing in-house measures, a new approach is proposed which leverages the World Bank's existing Macro Poverty Outlook (MPO) process. Ten indicators are used which provide some degree of early warning to the possibility of crisis, contribute to rising vulnerability in EMDEs, and can amplify and propagate shocks.

For an extensive review of early warning indicators, see Frankel and Saravelos (2012). The ten indicators are provided in Table 4. These variables are normalized following the same method used for the wider CRM and three indexes are created:

1. **Underlying Vulnerability**: The ten indicators are normalized using thresholds defined in Table 4 and combined using an unweighted average. Forecast observations for 2021 are used with the year of focus shifted with each round of MPO.
2. **Emerging Threat**: This index is a combination of the change in the underlying indicators calculated between 2022 and 2020 (for all debt related indicators, interest expense, and current account) and the outcomes of inflation, the output gap, real exchange rate gap, and general government primary balance for 2022. Change variables are normalized using thresholds at the 5th and 95th percentile of the underlying distribution while inflation, the output gap, real exchange rate gap and primary balance thresholds are based on Table 4. Overall index is the unweighted average.
3. **Overall Compound Risk**: Using normalized scores from the Underlying Vulnerability and Emerging Threat combined using a geometric mean.

Advantages:

Using the alternative inhouse measure has the following advantages:

- Forecasts are based on the World Bank's assessment of economic conditions and used as part of the bank's operational decisions.
- The MPO covers all 147 emerging and developing economies, of which 130 have sufficient coverage of selected variables to create the macro-fiscal risk index.
- Forecasts provide a forward-looking perspective on the variables of interest allowing for a more appropriate definition of emerging risk.

Disadvantages:
Using the alternative in-house measure has the following disadvantages:

- Unlike the EIU's Risk Briefing score, there is no qualitative data to leverage. Future work could look at how to survey country economists at the same time of the MPO to create additional indicators of a qualitative nature.
- The MPO process only covers emerging market and developing economies, limiting the global dimension of the alternative option. Excluding advanced economies also means that the underlying distribution of indicators will be different. However, it may be better aligned to the realities of EMDEs.
- MPO data is only updated twice a year for the World Bank's Spring and Annual meetings making the alternative approach less frequent than the monthly frequency of the current implemented measure.
- Forecasts for economies affected by fragility and conflict (Libya, Lebanon) generally do not have forecasts and when available may only exist for one-year ahead.
- The focus is heavily skewed to fiscal measures and may require additional information to be added to get more balanced economic picture.

Missing dimensions
The available indicators to construct a macro-fiscal risk index, however, do not include economic structure and financial market considerations that can impact on a country's perceived and actual vulnerability but are difficult to quantify. Economic structure considerations are broad and include diversification, policy frameworks, institutional arrangements, and governance. Economies that are not well diversified in production and exports hamper their ability to grow, lower their resilience to shocks, and expose themselves to limited and volatile revenue streams to cover foreign liabilities (Hesse 2008; Hausmann, Hwang and Rodrik 2007). EMDEs also have diverse governance and policy frameworks, and histories of crises, which can impact their perceived and actual vulnerability.

Financial sector vulnerabilities missing from the index can cover several dimensions including funding sources, interconnectedness, maturity transformation, and the role and size of shadow banking. The development of macroprudential tools to manage liquidity and financing risks, contain excessive credit growth, limit excessive exposure concentrations and mitigate moral hazard highlight the need to manage specific systemic risk in the banking sector. Turkey, for example, recently faced financial stress related in part to the importance of banks in financial intermediation (banks account for 90 percent of the financial system by assets) and most of their funding being held in foreign currency and at short maturities.

Annex Table 4: Macro-fiscal variables

Variable	Description	Thresholds		Country coverage
		Upper	Lower	
Output gap	Real GDP deviation from an Hodrick-Prescott filter	-3	3	130
Primary balance	General government primary balance to GDP	-3	3	130
Debt-to-Revenue	General government gross debt as a ratio to general government revenue	200	0	130
Debt-to-Exports	General government gross debt as a ratio to exports	140	0	121
Debt-to-GDP	General government gross debt as a ratio to GDP	50	0	130
External Debt-to-GDP	General government gross external debt as a ratio to GDP	15	0	99
Real exchange rate gap	Real exchange rate deviation from Hodrick-Prescott filter	5	-5	130
Interest-to-Exports	General government interest payments to exports	10	0	120
Inflation	Annual percent change	10	2	129
Current account	Current account to GDP	-3	3	130

Supplementary Text 5: Summary of related indexes

INFORM Risk Index

The INFORM Risk Index is a multi-dimensional index aimed at supporting the humanitarian sector. It is a collaboration of the Inter-Agency Standing Committee (IASC) Reference Group on Risk, Early Warning and Preparedness and the European Commission. Results are released on a bi-annual basis.

INFORM's Risk index is split into six 'categories' (natural, human, socio-economic, vulnerable groups, institutional, and infrastructure). Indicators are selected to populate each of the six categories and aggregated to form on overall composite index.

In addition to the Risk Index, INFORM has a number of satellite products that are of relevance to the CRM. In particular, the INFORM Severity index tracks the status of ongoing crises using a combination of quantitative and qualitative insights. More recently, the INFORM COVID-19 index has been tracking a range of real-time metrics gauging exposure and impact of the pandemic.

The CRM draws on a selection of indicators from across the Risk, Severity and COVID indexes used to populate a number of existing vulnerability dimensions, including natural hazards and socio-economic vulnerability. The CRM differs from the INFORM Risk Index in that it explicitly includes information on emerging and ongoing threats, factoring in real-time information across a range of risk dimensions alongside assessments of baseline capacities. In addition, unlike the INFORM Severity index, which focuses primarily on unidimensional threats, the CRM seeks to factor in aggregate compounding effects by tracking the number of risks above a given threshold.

For further details on INFORM's methodology and scope see: https://drmkc.jrc.ec.europa.eu/inform-index/INFORM-Covid-19

FAO-WFP Hunger Hotspots

Developed by Food and Agriculture Organization of the United Nations (FAO) and the World Food Programme (WFP), the Hunger Hotspots is an early-warning analysis of countries and situations (called hotspots) where acute food insecurity is likely to deteriorate over the coming months. These hotspots are identified through a consensus-based analysis of key drivers of food insecurity, and their likely combination and evolution across countries and regions

The hotspot countries are selected based on forward-looking analysis underpinned by a strict set of methodological parameters (food insecurity and malnutrition, COVID-19 impacts, natural hazard, economic and conflict risks, population-at-risk, macro-economic stability, agricultural planning, and operational and humanitarian access constraints). However, compound assessments within the Hunger Hotspots analysis are limited only to countries considered to be at risk of food insecurity, whereas the CRM has a global outlook.

The main sources of data on acute food insecurity (current and projections) are the Integrated Food Security Phase Classification and the Cadre Harmonisé. For countries where IPC/CH analyses were not conducted and where no recent analyses were available, estimates of the number of people in acute food insecurity were primarily derived from the Famine Early Warning Systems Network (FEWS NET) IPC-compatible analysis, WFP assessments using the Consolidated Approach for Reporting Indicators of Food Security, or CARI, as well as from humanitarian needs overviews. WFP's open-access Hunger Map actual data on insufficient food consumption was used to inform trend analysis and as a triangulation tool during the assessment phase.

For further details see: https://www.wfp.org/publications/hunger-hotspots-fao-wfp-early-warnings-acute-food-insecurity-march-july-2021-outlook

ND-GAIN

The ND-GAIN Country Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help governments, businesses, and communities better prioritize investments for a more efficient response to the immediate global challenges ahead.

ND-GAIN measures six 'sectors' of vulnerability(food, water, health, ecosystem services, human habitat, and infrastructure) as well asthree 'components' of readiness(economic readiness, governance readiness, and social readiness). Overall, ND-GAIN collates over 74 variables to form 45 core indicators to measure vulnerability and readiness of 192 UN countries from 1995 to the present. Due to data availability, ND-GAIN measures vulnerability of 182 countries and readiness of 184 countries. The underlying data is freely available in conjunction with a country-level rankings system.

For further details see: https://gain.nd.edu/our-work/country-index/

EIU Operational Risk Score

The EIU Operational Risk Score (ORS) measures a country's overall business operating risk across 180 markets via data analysis, forecasts, alerts, and background studies. The score summarises overall ratings based on risk scores across 10 dimensions (security, political stability, government effectiveness, legal and regulatory, macroeconomic, foreign trade and payments, financial, tax policy, labour market, and infrastructure) and 70 subcategories of risk. The model is updated daily enabling financial institutions, corporations, governments, and academic institutions to compare, rank and track countries operational risks over time.

Few holistic measures of exposure and sensitivity to macro-fiscal shocks exist— especially considering the CRM's need for global coverage. With that in mind, the CRM makes use of the EIU's Operational Risk Score as an interim measure (to be supplanted by an in-house index currently under development with support from various units across the Bank). For the purposes of the CRM, ORS categories relating to security, political stability, and government effectiveness are removed from the raw measure owing to duplication with other risk dimensions within the CRM.

Unlike many alternative risk metrics (such as the WB's Macro-Financial Review index), the ORS is global in nature, profiling risk scores across 180 countries. In order to reflect levels of Underlying Vulnerability, the CRM makes use a 12-month ORS average. Use of an average of prior scores provides a (relatively) static assessment of the overall status of macro-fiscal conditions. Inclusion of past values may also help smooth out some of the forward-looking elements of the EIU. This is also consistent with source indicators for Underlying Vulnerability across other risk dimensions in the CRM, most of which update on an annual basis.

For further details see: https://www.eiu.com/n/solutions/risk-briefing/

EIU's Global Health Score Index

The Global Health Security (GHS) Index assesses and benchmarks health security and related capabilities across 195 countries to help decision makers to improve country preparedness for preventing and mitigating epidemics and pandemics as well as other globally catastrophic biological events.

The index is based on a framework of 140 questions, organized across 6 'categories' (prevention detection and reporting, rapid response, health system, compliance with international norms, and risk environment), 34 indicators, and 85 sub indicators. All inputs into the GHS Index are open-source and based on data a country has published itself or has reported to or from an international entity. Direct comparisons, rankings, and correlations between scores and other data sets and indexes are made possible through the index which is based on a normalised scale of 0 to 100

The GHS Index was developed via a joint collaboration between the Nuclear Threat Initiative (NTI), the Johns Hopkins Center for Health Security (JHU), and The Economist Intelligence Unit (EIU).

For further details see: https://www.ghsindex.org/

The Famine Early Warning Systems Network (FEWSNET)

FEWSNET is an early warning system on acute food insecurity based on evidence-based analysis to governments and relief agencies who plan for and respond to humanitarian crises. The forward-looking analysis is based on four fundamental factors that influence food security: markets and trade, agroclimatology, livelihoods, and nutrition. A five-level scale and flagging system is designed to help governments and other humanitarian actors quickly understand a crisis (or potential crisis) and support decision making via monthly reports as well as maps, alerts, and other special reports.

While FEWSNET provides a comprehensive assessments of food security conditions in the 30 countries it covers, outside of this, analysts are typically reliant on alternative proxies to assess real-time conditions, many of which are far less reliable.

For further details see: https://fews.net/

ThinkHazard!

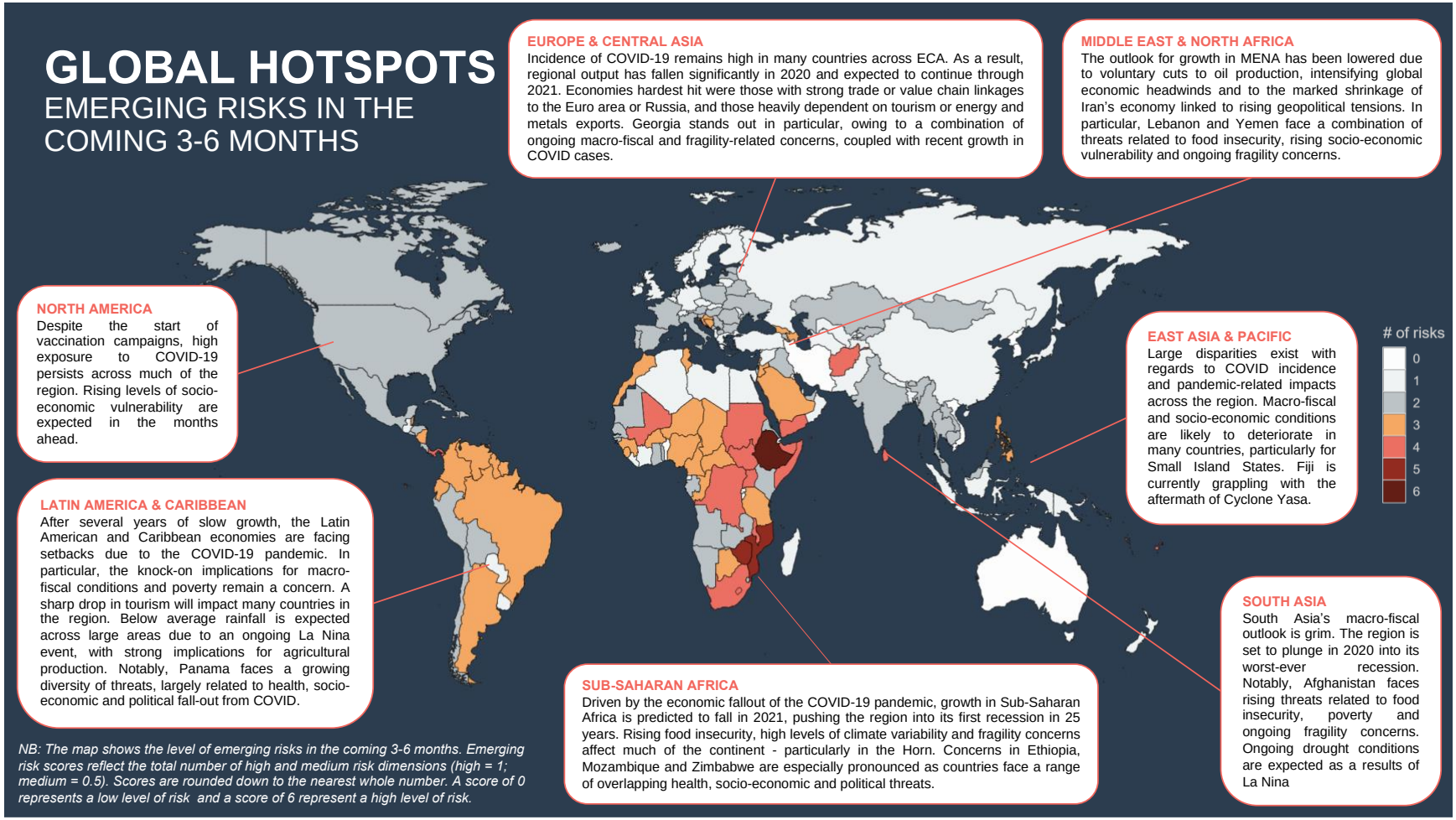
ThinkHazards! is an analytical tool for enhancing knowledge and understanding of natural hazards by assessing the level of river flood, earthquake, drought, cyclone, coastal flood, tsunami, volcano, and landslide hazard and assessing the impact of these events on new development projects.

Developed and maintained by the Global Facility for Disaster Reduction and Recovery (GFDRR), the tool enables users to review hazard-specific information relevant in project planning for a given location (country, region, or district). Outputs from the tool include risk management guidance, relevant contact information, and reference to further information, websites, and reports for the selected hazard and location.

The CRM makes use of extensive information on exposure from the WB's ThinkHazard! Database. For instance, the hazards thresholds are classified based on the hazard frequency/intensity, associated exceedance probabilities, and expert judgement.

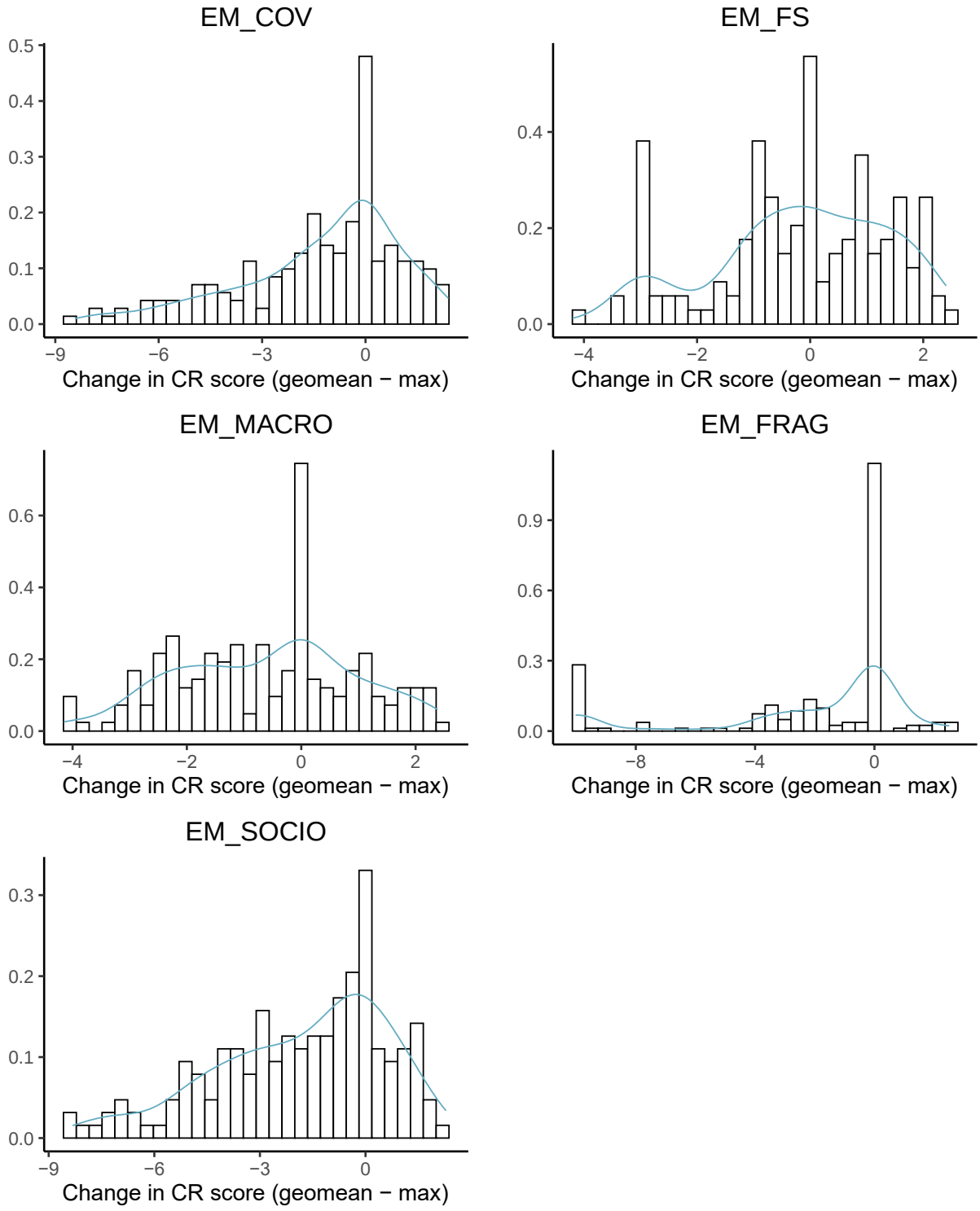
For further details see: https://thinkhazard.org/en/

Annex Figure 7: Annotated map of emerging compound risk with regional summaries (i.e. dynamic snapshot of changing risk conditions)



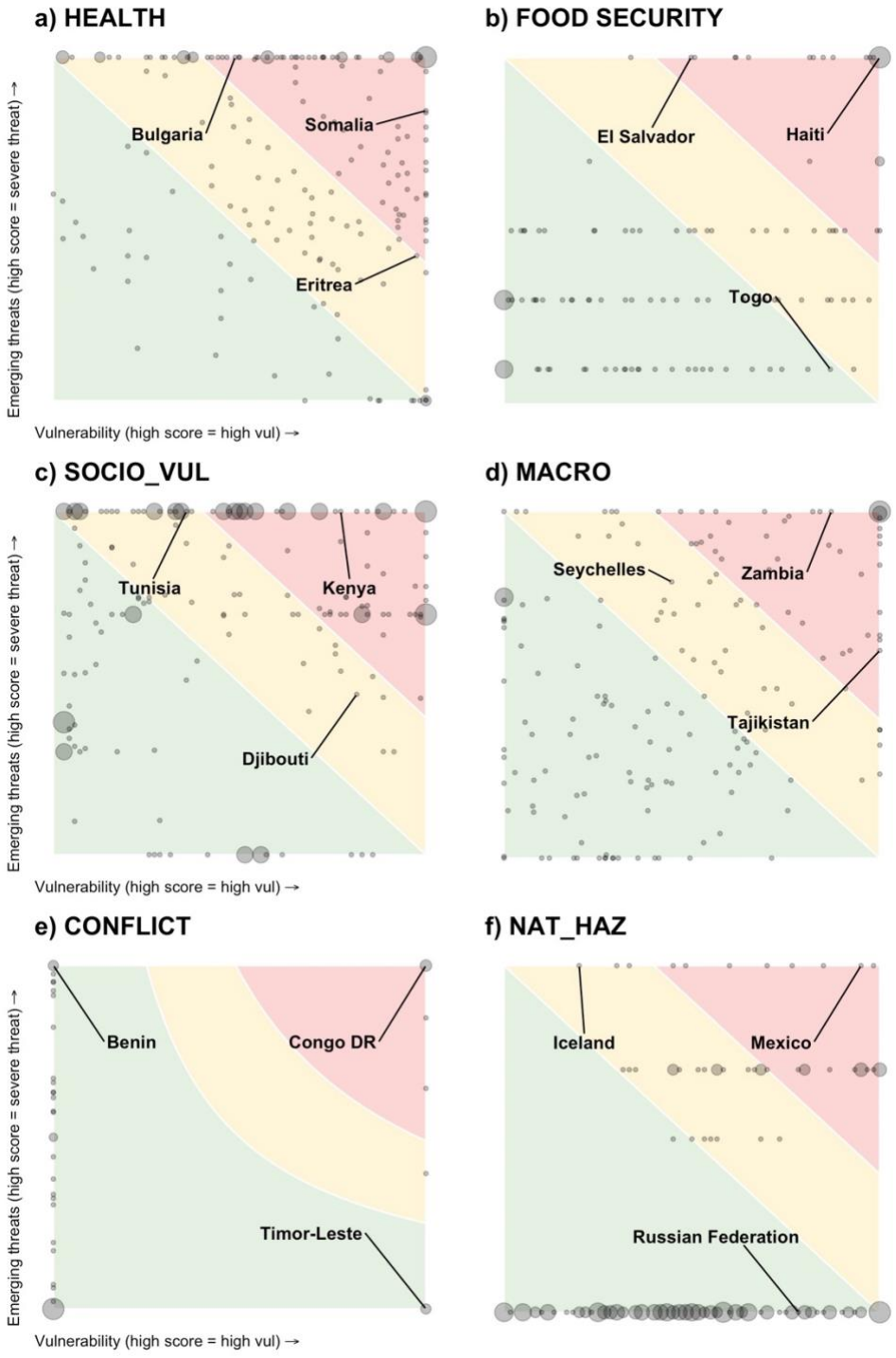
Note: The scale highlights countries with scores of 3 and above in order to emphasize higher risk countries and regions.

Annex Figure 8: Distribution of change in scores between max value and geometric average methods



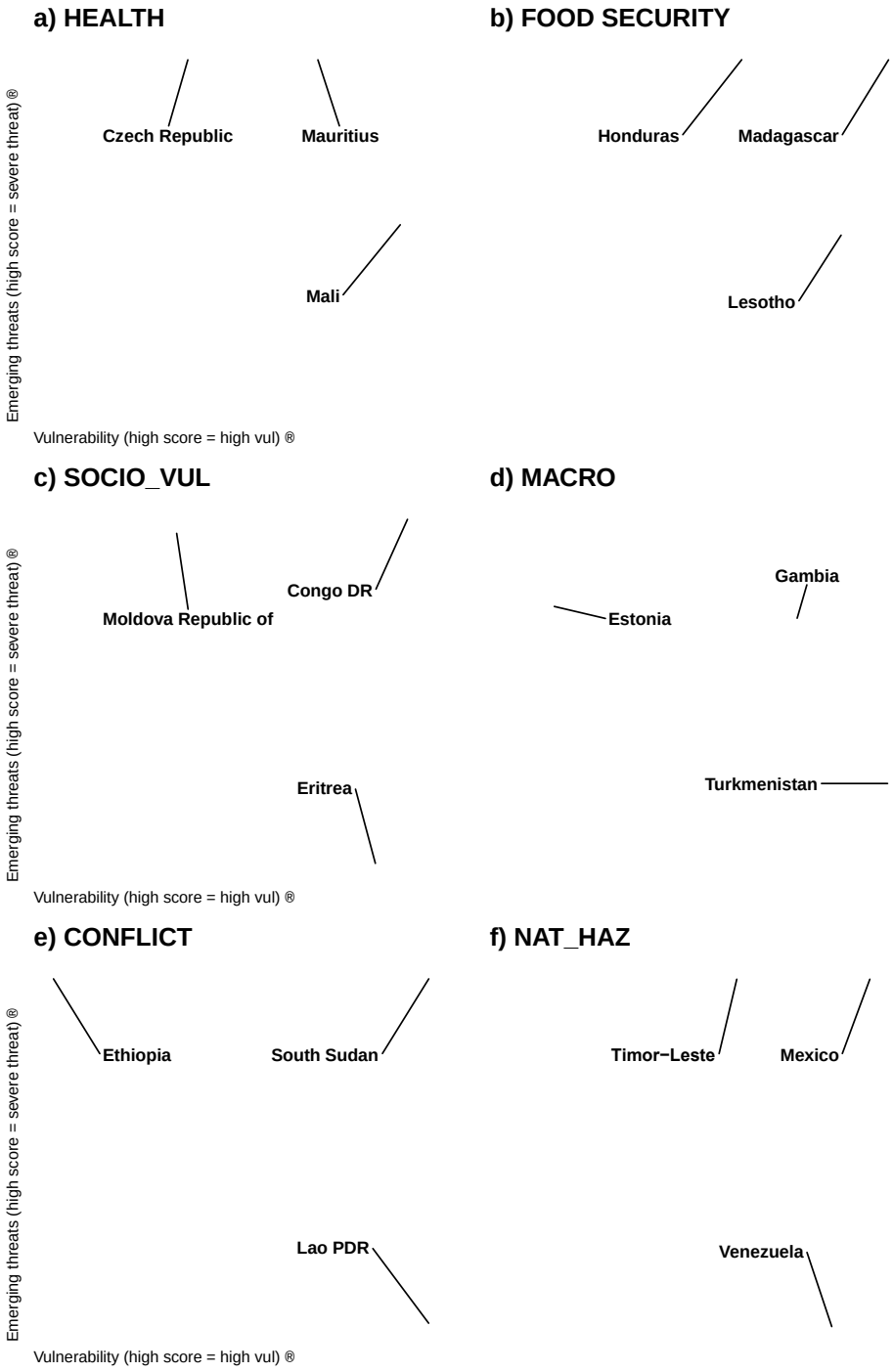
NOTES Figure show histograms of the difference between mean and geometric approaches (calculated as mean – geometric), showing how scores in the latter tend to lower than the former. Scores solely relate to Emerging Threat.

Annex Figure 9: Early Warning Heatmaps using an Arithmetic Mean to Calculate Overall Compound Risk Flags



Heatmaps present information from three metrics related to Underlying Vulnerability score (X-axis), Emerging Threat score (Y-Axis) and Overall Compound Risk alert levels (coloured zones). Shaded areas relate to high-alert status (red), medium-alert status (yellow) and low-alert status (green). All shaded areas are derived according to an arithmetic mean.

Annex Figure 10: Early Warning Heatmaps Using a Filtering System to Calculate Overall Compound Risk Flags



Heatmaps present information from three scores related to Underlying Vulnerability (X-axis), Emerging Threat (Y-Axis) and Overall Compound Risk alert levels (shaded areas). Shaded areas relate to high-alert status (red), medium-alert status (yellow) and low-alert status (green).

Annex Table 5: Emerging Compound Risk Scores (Top 28)

HEALTH	FOOD	MACRO	S.VUL	NATURAL	CONFLICT	TOTAL	TOTAL(+MEDIUM)	RELIABILITY
AFG 10	SDN 10	SDN 10	HRV 10	LBN 10	SDN 10	**HND 4**	**SOM 4.5**	PLW 0.8
HRV 10	AFG 10	SSD 10	BLR 10	SOM 10	AFG 10	**COD 4**	**COD 4.5**	FSM 0.8
LBN 10	MOZ 10	TCD 10	PER 10	MUS 10	MOZ 10	**NGA 4**	**NGA 4.5**	NRU 0.8
MDV 10	NER 10	HRV 10	YEM 10	TLS 10	NER 10	**SDN 3**	**AFG 4**	TUV 0.8
UKR 10	ETH 10	BRA 10	IRN 10	FJI 10	ETH 10	**AFG 3**	**TCD 4**	KIR 0.7
BRA 10	SSD 10	HND 10	ZMB 10	MDG 10	IRQ 10	**SSD 3**	**LBN 4**	TON 0.7
CPV 10	CAF 10	PER 10	MMR 10	MEX 10	SSD 10	**HRV 3**	**HND 4**	MDV 0.6
HTI 10	LBN 10	SRB 10	SYR 10	NRU 10	TCD 10	**LBN 3**	**KEN 4**	SLB 0.6
HND 10	ZWE 10	ARM 10	BIH 10	TUV 10	ZWE 10	**HTI 3**	**BFA 4**	PRK 0.6
PER 10	HTI 10	COL 10	ECU 10	VUT 10	HTI 10	**PER 3**	**SYR 4**	WSM 0.6
SRB 10	HND 10	COD 10	BTN 10	ISL 10	HND 10	**SOM 3**	**HTI 3.5**	TKM 0.6
COL 10	SOM 10	KEN 10	KHM 10	AFG 7	SOM 10	**YEM 3**	**YEM 3.5**	VUT 0.6
COD 10	YEM 10	MLI 10	LUX 10	NER 7	YEM 10	**COL 3**	**MLI 3.5**	MHL 0.6
GIN 10	CMR 10	NGA 10	CUB 10	ETH 7	CMR 10	**KEN 3**	**SEN 3.5**	COM 0.5
KEN 10	COD 10	ROU 10	PRT 10	TCD 7	COL 10	**MLI 3**	**USA 3.5**	STP 0.5
MNE 10	KEN 10	ZAF 10	FIN 10	IRN 7	COD 10	**BFA 3**	**SDN 3**	KNA 0.5
NGA 10	MLI 10	ZMB 10	GHA 10	KEN 7	MLI 10	**GEO 3**	**NER 3**	GNB 0.5

ALB 10	NGA 10	BRB 10	TUR 10	PNG 7	NGA 10	**MUS 3**	**ETH 3**	LIE 0.5
ARG 10	BFA 10	BOL 10	LBN 10	ROU 7	ZAF 10	**SYR 3**	**SSD 3**	LBY 0.4
BFA 10	SLV 10	EGY 10	NGA 10	TJK 7	BFA 10	**BIH 3**	**CAF 3**	UKR 0.4
GEO 10	GTM 10	GEO 10	COG 9.9	BFA 7	GEO 10	**MDG 3**	**HRV 3**	GRD 0.4
LSO 10	SYR 10	MUS 10	VEN 9.8	GTM 7	MMR 10	**SEN 3**	**PER 3**	IRN 0.4
MUS 10	VEN 10	TLS 10	AZE 9.7	PAK 7	SYR 10	**USA 3**	**CMR 3**	PNG 0.4
SYC 10	AGO 10	TUN 10	CAF 9.7	SYR 7	UGA 10	**MOZ 2**	**COL 3**	ROU 0.4
TTO 10	MDG 10	UGA 10	GUY 9.6	ECU 7	AZE 10	**NER 2**	**GEO 3**	TJK 0.4
TUN 10	SLE 10	AGO 10	SOM 9.5	OMN 7	COG 10	**ETH 2**	**MUS 3**	ATG 0.4
BIH 10	LBR 10	BHS 10	BRB 9.3	AZE 7	GMB 10	**TCD 2**	**AGO 3**	BRB 0.4
BGR 10	TCD 7	BLZ 10	AGO 9.3	KIR 7	PRK 10	**ZWE 2**	**BIH 3**	DMA 0.4

NOTES: Table presents the highest ranked countries for each respective dimension. 'Reliability' relates to the proportion of missing values used in calculating emerging overall risk scores. All compound risk dimension scores are calculated using max value. 'Total' is the sum of all high-risk dimensions (i.e. number of risk dimensions with a score of 10). 'Total(+Medium)' is the sum of high and medium risk dimensions (with dimensions rated as high assigned 1 and those rated medium assigned 0.5).

Annex Table 6: Underlying Vulnerability Scores (Top 28)

HEALTH	FOOD	MACRO	SOCIO_VUL	NATURAL	CONFLICT	TOTAL	TOTAL(+MEDIUM)	RELIABILITY
AFG 10	SDN 10	SDN 10	AFG 10	HTI 10	LBY 10	**YEM 5**	**HTI 5**	FSM 0.3
MOZ 10	AFG 10	LBN 10	MOZ 10	PER 10	SDN 10	**AFG 4**	**SOM 5**	GRD 0.2
NER 10	MOZ 10	ZWE 10	NER 10	MMR 10	AFG 10	**MOZ 4**	**YEM 5**	ATG 0.2
SSD 10	NER 10	SOM 10	SSD 10	PAK 10	MOZ 10	**NER 4**	**AFG 4.5**	PLW 0.2
CAF 10	ETH 10	YEM 10	CAF 10	BGD 10	NER 10	**SSD 4**	**MOZ 4.5**	LCA 0.2
TCD 10	SSD 10	COD 10	TCD 10	CHN 10	IRQ 10	**CAF 4**	**COD 4.5**	NRU 0.2
HTI 10	CAF 10	IRN 10	YEM 10	IND 10	SSD 10	**TCD 4**	**SYR 4.5**	TUV 0.2
SOM 10	TCD 10	NGA 10	MLI 10	JPN 10	CAF 10	**HTI 4**	**BDI 4.5**	LIE 0.2
YEM 10	ZWE 10	TJK 10	SYR 10	PHL 10	TCD 10	**SOM 4**	**SDN 4**	MHL 0.2
COD 10	HTI 10	ARG 10	BDI 10	IDN 10	LBN 10	**COD 4**	**NER 4**	LBY 0
GIN 10	SOM 10	SYR 10	LBR 10	VNM 10	ZWE 10	**SYR 4**	**SSD 4**	SDN 0
ZMB 10	YEM 10	VEN 10	MWI 9.9	SOM 9.8	HTI 10	**BDI 4**	**CAF 4**	AFG 0
BFA 10	COD 10	AGO 10	SLE 9.9	ECU 9.8	SOM 10	**SDN 3**	**TCD 4**	MOZ 0
LSO 10	KEN 10	BDI 10	GNB 9.9	IRN 9.7	YEM 10	**ZWE 3**	**ZWE 4**	NER 0
SYR 10	MWI 10	PRK 10	HTI 9.7	AFG 9.5	CMR 10	**LBR 3**	**MMR 4**	DZA 0
UGA 10	PNG 10	TKM 10	BFA 9.7	COL 9.5	COD 10	**LBN 2**	**LBR 4**	ETH 0
GNQ 10	ERI 10	UZB 10	KIR 9.7	PNG 9.5	MLI 10	**MLI 2**	**NGA 3.5**	IRQ 0

BDI 10	UGA 10	CUB 10	GMB 9.6	GTM 9.5	NGA 10	**NGA 2**	**PNG 3.5**	SSD 0
COM 10	COG 10	LBY 10	COD 9.4	MEX 9.5	PNG 10	**PNG 2**	**ERI 3.5**	CAF 0
GAB 10	MDG 10	ETH 9.7	SEN 9.1	DOM 9.5	BFA 10	**BFA 2**	**COG 3.5**	TCD 0
KIR 10	BDI 9.9	SUR 9.5	BEN 9.1	NIC 9.3	ERI 10	**ERI 2**	**MDG 3.5**	HRV 0
MDG 10	AGO 9.8	LBR 9.5	SOM 9	USA 9.3	MMR 10	**MMR 2**	**LBN 3**	LBN 0
STP 10	LBR 9.7	GIN 9.2	PRK 9	HND 9.2	SYR 10	**UGA 2**	**MLI 3**	MDV 0
SLE 10	TZA 9.7	ERI 9.1	ETH 8.9	SLV 9.2	TLS 10	**VEN 2**	**BFA 3**	MRT 0
LBR 10	SLE 9.6	PAK 9	PNG 8.9	ALB 9	VEN 10	**COM 2**	**UGA 3**	UKR 0
GNB 10	KHM 9.3	IRQ 8.9	ZMB 8.9	PAN 8.7	SLB 10	**COG 2**	**VEN 3**	ZWE 0
KOR 10	TLS 9.3	ZMB 8.7	LSO 8.9	TUR 8.7	BDI 10	**KIR 2**	**SLB 3**	BLR 0
MHL 10	NAM 9.3	UKR 8.6	RWA 8.9	CHL 8.7	COM 10	**MDG 2**	**COM 3**	BRA 0

NOTES: Table presents the highest ranked countries for each respective dimension. 'Reliability' relates to the proportion of missing values used in calculating emerging overall risk scores. All compound risk dimension scores are calculated using max value. 'Total' is the sum of all high-risk dimensions (i.e., number of risk dimensions with a score of 10). 'Total(+Medium)' is the sum of high and medium risk dimensions (with dimensions rated as high assigned 1 and those rated medium assigned 0.5).

Annex Table 7: Overall Compound Risk using a geometric averaging method - i.e. combining Underlying Vulnerability and Emerging Threat

HEALTH	FOOD	MACRO	S.VUL	NATURAL	CONFLICT	TOTAL
AFG 10	SDN 10	YEM 10	SSD 10	SOM 9.9	SDN 10	**SOM 6**
HTI 10	AFG 10	IRN 10	TCD 10	MEX 9.7	AFG 10	**SYR 6**
COD 10	MOZ 10	SYR 10	MLI 10	MDG 9.2	MOZ 10	**AFG 5.5**
GIN 10	NER 10	CUB 10	BDI 10	VUT 8.8	NER 10	**SDN 5**
BFA 10	ETH 10	LBN 10	LBR 10	LBN 8.4	IRQ 10	**CAF 5**
LSO 10	SSD 10	NGA 10	SLE 9.9	PAK 8.4	SSD 10	**TCD 5**
BDI 10	CAF 10	VEN 9.9	COD 9.7	IND 8.4	TCD 10	**LBN 5**
NGA 9.9	ZWE 10	SOM 9.8	SEN 9.6	IDN 8.4	ZWE 10	**COD 5**
TGO 9.9	HTI 10	AGO 9.6	ZMB 9.4	ECU 8.3	HTI 10	**NGA 5**
KIR 9.8	SOM 10	COD 9.5	RWA 9.4	IRN 8.2	SOM 10	**MDG 5**
KEN 9.5	YEM 10	ZMB 9.3	UGA 9.3	AFG 8.2	YEM 10	**NER 4.5**
TZA 9.5	COD 10	ARG 9.2	CAF 9.3	PNG 8.2	CMR 10	**ETH 4.5**
SLB 9.4	KEN 10	MMR 9.2	SDN 9.2	GTM 8.2	COD 10	**SSD 4.5**
HND 9.2	MDG 10	BLR 9.1	MDG 9.2	USA 8.1	MLI 10	**ZWE 4.5**
SOM 9.2	AGO 9.9	IRQ 8.9	AGO 9	CHL 7.8	NGA 10	**HTI 4.5**
VUT 9.2	LBR 9.9	UKR 8.8	GNB 8.9	TLS 7.7	BFA 10	**YEM 4.5**

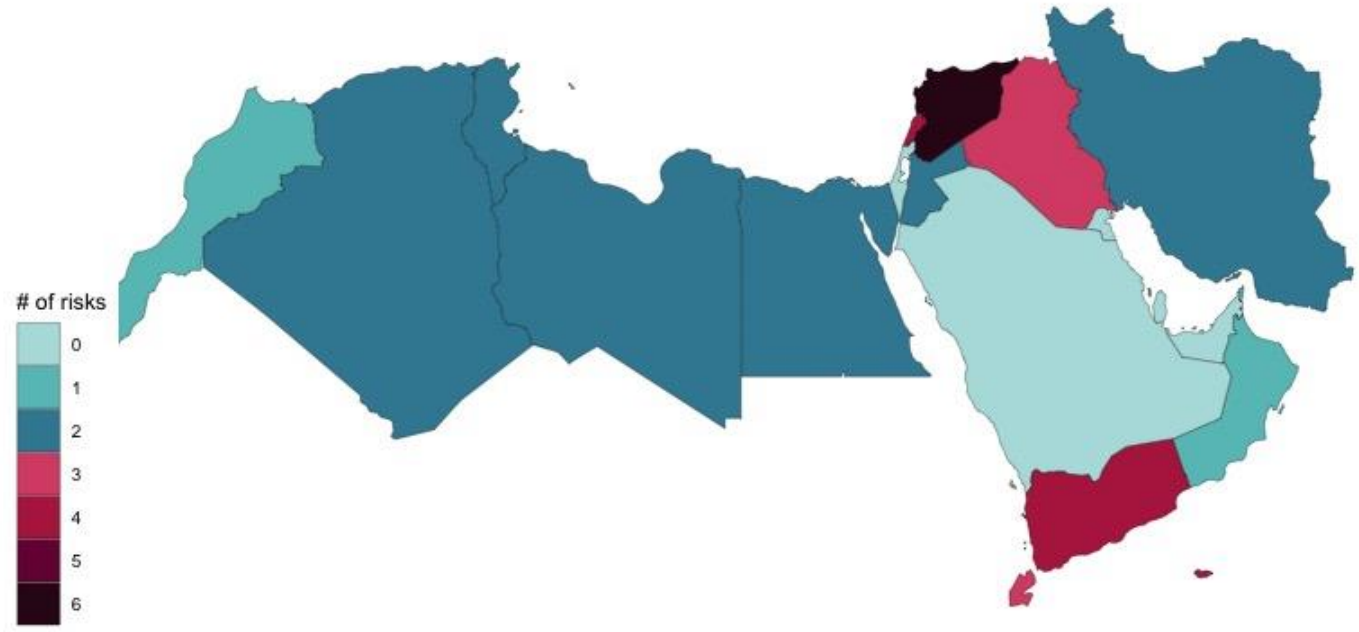
CAF 9.2	SLE 9.8	LBR 8.8	LSO 8.9	TJK 7.5	MMR 10	**CMR 4.5**
CPV 9	BFA 9.4	COG 8.6	ZWE 8.9	NPL 7.5	SYR 10	**KEN 4.5**
YEM 8.9	NGA 9.2	AZE 8.5	NAM 8.9	SYR 7.4	COG 10	**BFA 4.5**
TCD 8.8	MLI 9.1	UZB 8.4	HND 8.8	UZB 7	GMB 10	**GMB 4.5**
SEN 8.8	CMR 9	GHA 8.3	KEN 8.8	FJI 7	CAF 9.2	**MOZ 4**
NPL 8.8	TCD 8.4	KAZ 8.1	COG 8.8	KEN 6.9	LBY 8	**MLI 4**
SYC 8.7	UGA 8.4	PRK 8	HTI 8.7	KGZ 6.9	LAO 7.1	**PNG 4**
ZMB 8.7	GTM 8.1	ZWE 7.9	GHA 8.7	OMN 6.8	LBN 7	**PAK 4**
LBN 8.7	SYR 7.9	DZA 7.9	MOZ 8.6	AZE 6.7	DZA 0	**COG 4**
CMR 8.6	HND 7.8	ETH 7.9	SOM 8.6	MUS 6.7	ETH 0	**LBR 4**
TUN 8.5	MRT 7.5	TJK 7.7	TLS 8.5	NER 6.4	HRV 0	**LAO 4**
MDV 8.5	VEN 7.1	KEN 7.7	ETH 8.5	ETH 6.3	MDV 0	**GIN 3.5**

NOTES: Table presents the highest ranked countries for each respective dimension. Dimension of compound risk scores are calculated using a geometric mean (i.e., square root of Emerging Threat multiplied by Underlying Vulnerability). 'Total' is the sum of all high-risk dimensions (i.e., number of risk dimensions with a score of 7 or higher). 'Total(+Medium)' is the sum of high and medium risk dimensions (with dimensions rated as high assigned 1 and those rated medium assigned 0.5).

Figure 11: Profile of total number of Overall Compound Risk Flags in LAC region

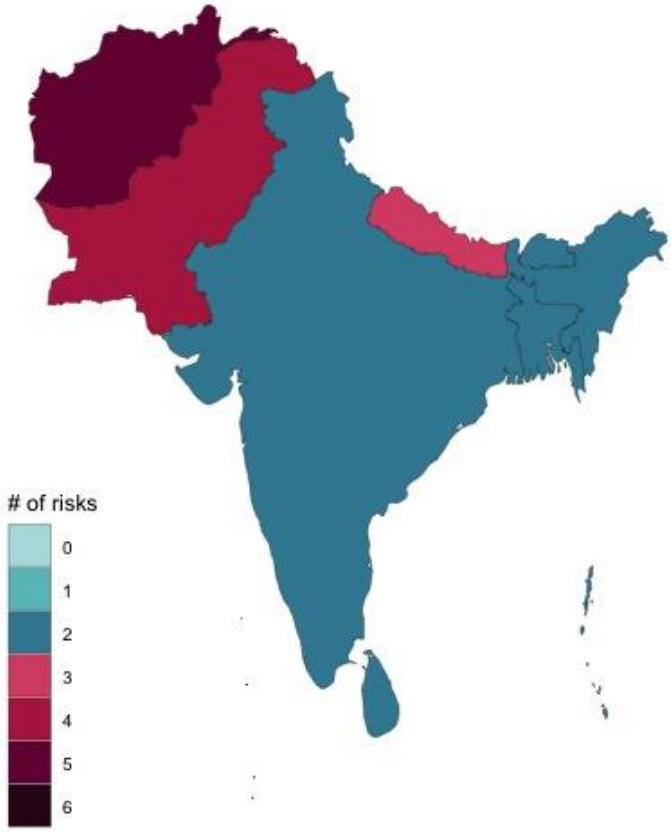
Note: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer.

Figure 12: Profile of total number of Overall Compound Risk Flags in MENA region



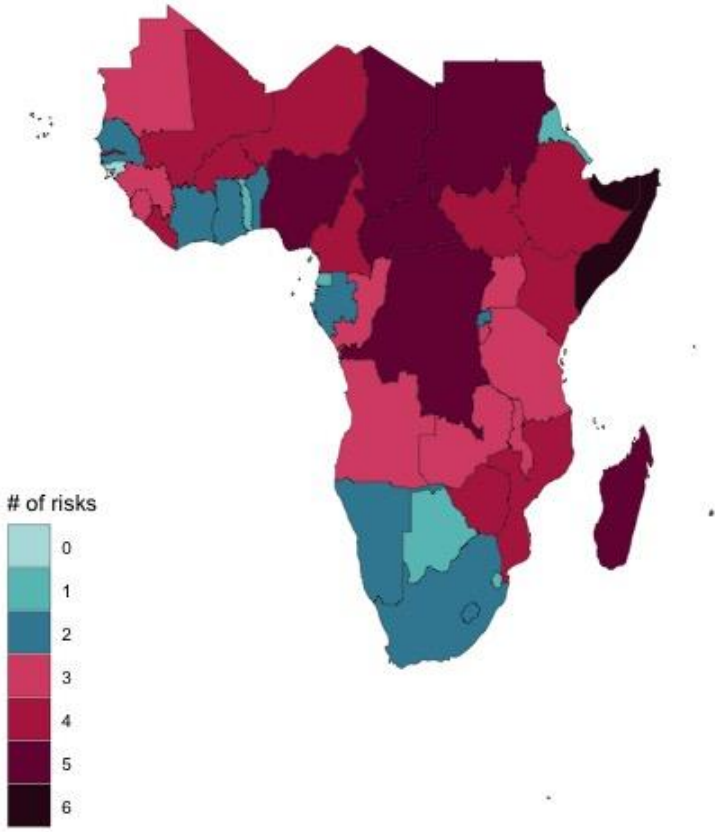
Note: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer.

Figure 13: Profile of total number of Overall Compound Risk Flags in SA region



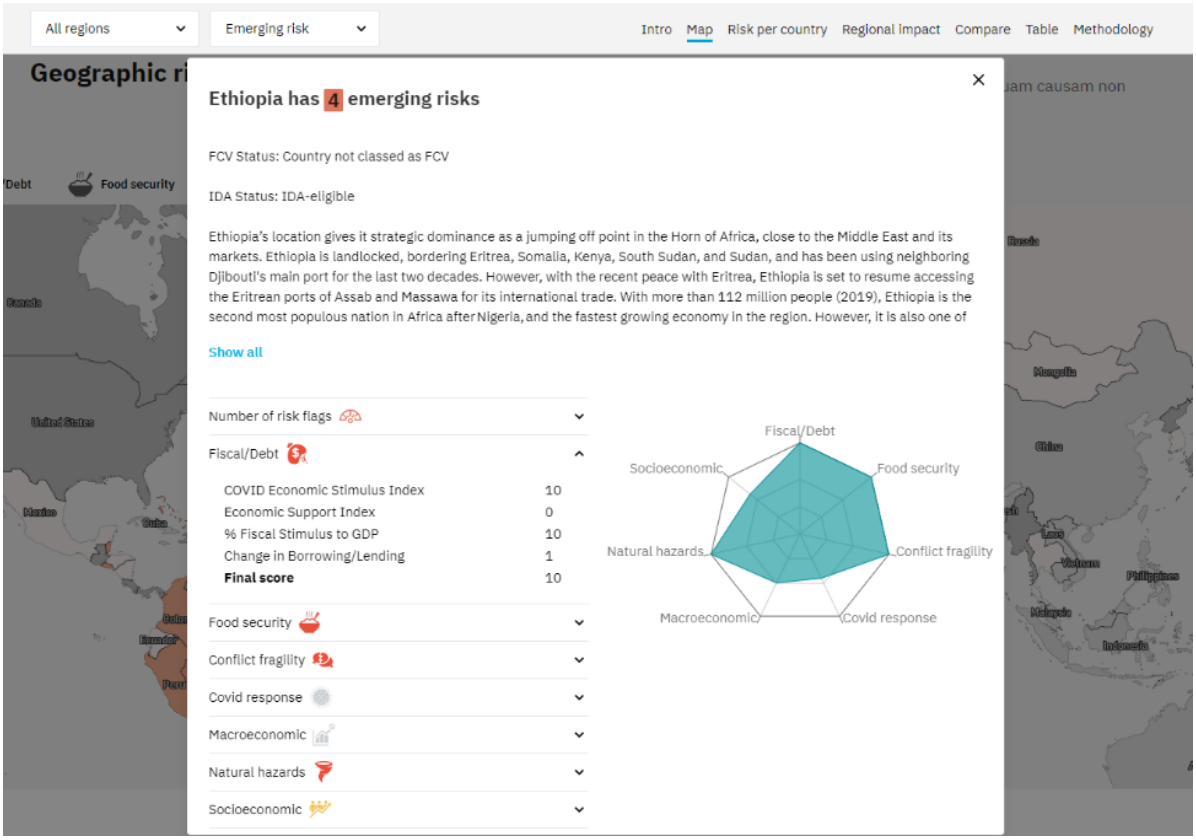
Note: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer.

Figure 14: Profile of total number of Overall Compound Risk Flags in SSA region



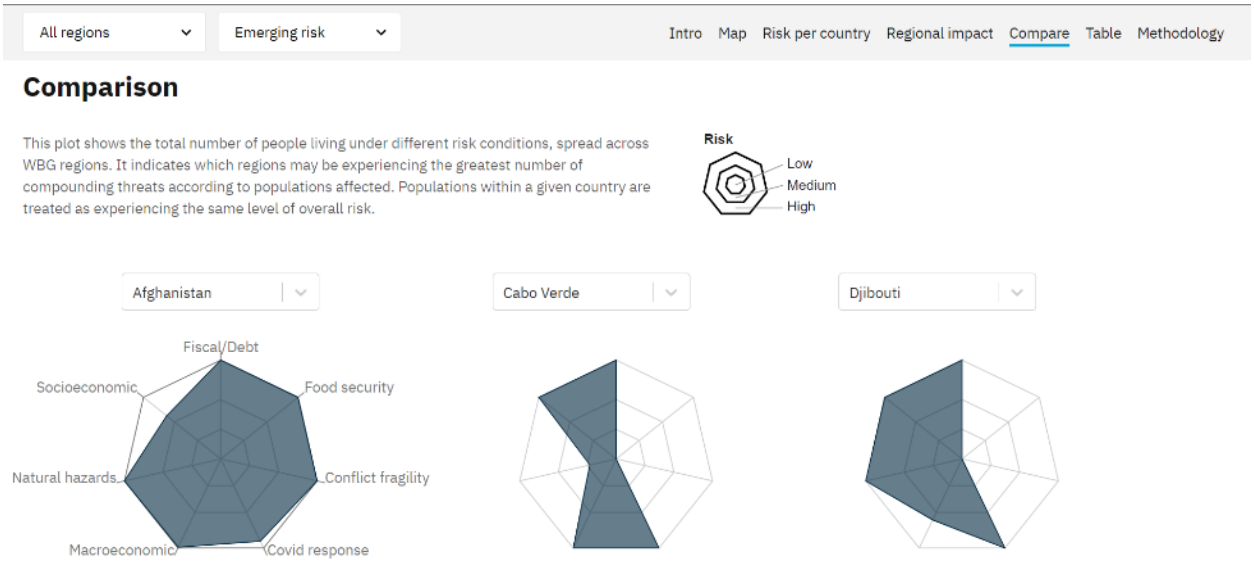
Note: Level of compound risk devised as the sum of high and medium-risk dimensions (max score = 6). Medium-risks are assigned a score of 0.5, high-risks are assigned a 1. Scores are rounded down to the nearest integer.

Figure 15: Screenshots from a prototype of the CRM's interactive Dashboard



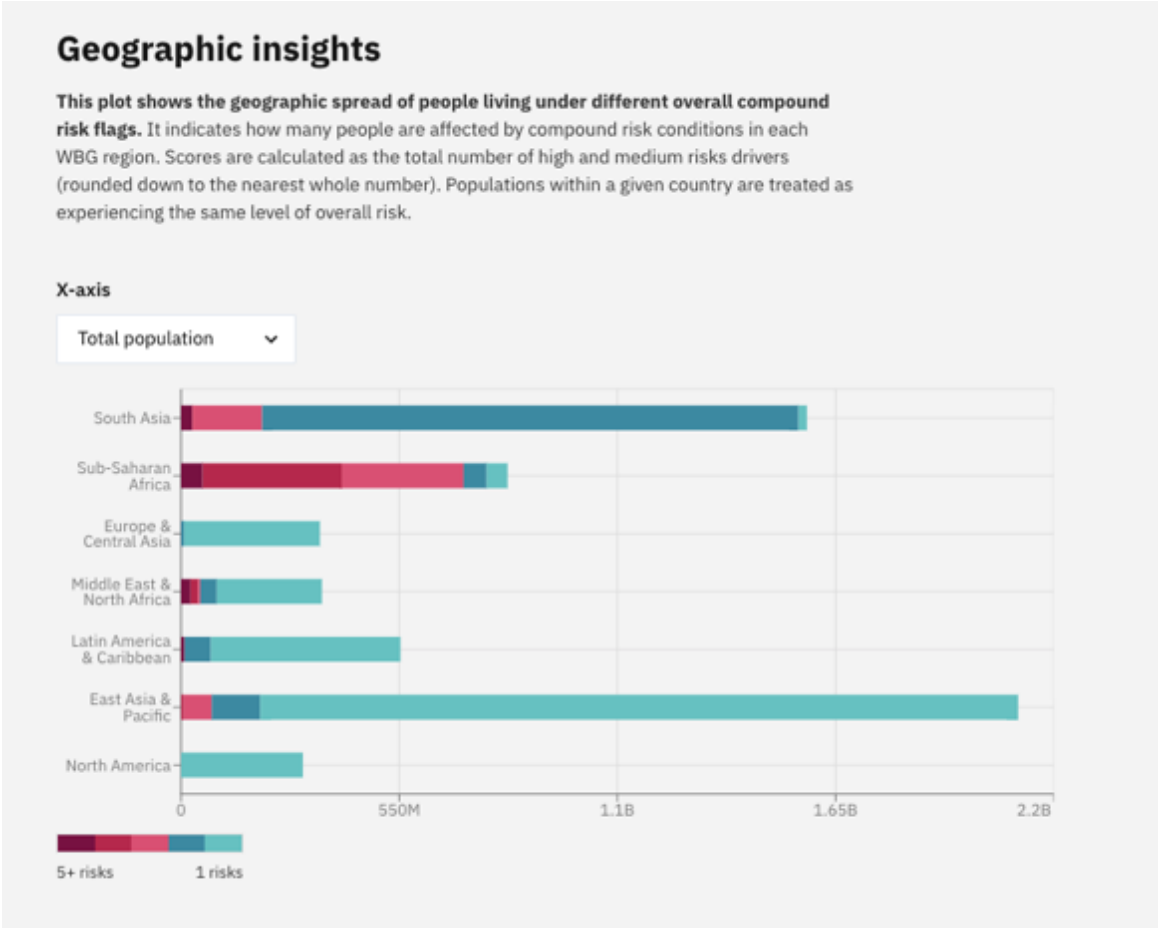
Screenshot of detailed country page included in the CRM Dashboard. Note that data is not up-to-date with the current version of the CRM.

Figure 16: Screenshots from a prototype of the CRM's interactive Dashboard



The above shows an interactive comparison of countries using radar charts. Users can select their countries of choice to allow like-for-like comparison. Note that data is not up-to-date with the current version of the CRM.

Figure 18: Screenshots from a prototype of the CRM's interactive Dashboard



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