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Measuring Climate Risks: A New Multidimensional Index for Global Vulnerability and Resilience

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Measuring Climate Risks: A New Multidimensional Index for Global Vulnerability and Resilience

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Abstract

As climate change intensifies, countries experience varying degrees of vulnerability and resilience that influence their capacity to withstand and recover from environmental, economic, and social shocks. This study introduces the Multidimensional Vulnerability and Lack of Resilience Index (MVLRI), a novel framework that goes beyond traditional vulnerability assessments by incorporating resilience as a critical component. The MVLRI synthesizes twenty-six key indicators across economic, environmental, and social dimensions, providing a comprehensive measure of how countries confront climate risks. Findings reveal that vulnerability and resilience are distinct yet complementary factors, each significantly contributing to the overall index. These contributions vary widely across countries, reflecting diverse climate risks and socioeconomic contexts. The importance of including resilience in policy frameworks is emphasized, as neglecting it could undermine the effectiveness of interventions aimed at reducing climate impacts. Furthermore, the MVLRI demonstrates strong correlations with institutional performance indicators, illustrating how governance, economic stability, and social equity shape a country's capacity to cope with climate adversity. By offering a multidimensional perspective, the MVLRI equips policymakers with a powerful tool to design targeted interventions that address both vulnerability and resilience. This approach enables more effective resource allocation and policy decisions, helping countries better anticipate, respond to, and recover from the growing threats posed by global climate change.

Keywords: climate change; vulnerability; resilience; composite index

JEL codes: Q54, Q56, C24, C43, C6

1 Introduction

Climate change presents unprecedented socioeconomic challenges. This study introduces the Multidimensional Vulnerability and Lack of Resilience Index (MVLRI), a new composite index designed to provide actionable insights into the impacts of climate change. The MVLRI integrates vulnerability with low resilience and examines the interplay among economic, environmental, and social dimensions. Adopting a macro perspective, the study employs a novel linear programming approach, a variant of nonparametric data envelopment

analysis (DEA), to generate mathematically flexible MVLRI indices. These indices offer a unique perspective on country-specific vulnerability and resilience across various climate change dimensions. This methodology overcomes significant limitations of existing composite indices, as the MVLRI is a pure quantity index that measures the magnitude, but not the drivers, of multidimensional vulnerability.

Focusing on an extensive dataset covering 142 low- and middle-income countries, the study employs DEA to synthesize vulnerability and lack of resilience indices from 26 indicators categorized as social, economic, and environmental. This comprehensive analysis suggests critical policy intervention areas, particularly in countries most vulnerable and least resilient to the impacts of climate change. The main contribution of this study is thus demonstrating that quantitative tools of economic analysis can provide a new composite index that enables countries to explore the complex relationship between climate risks and socioeconomic outcomes, while providing guidance to policymakers seeking to reduce vulnerability and promote resilience in an integrated way.

The study is structured as follows. Section 1 provides background and motivation for the study. Section 2 provides a critical overview of existing vulnerability indices. Section 3 details the DEA methodology used to estimate MVLRI and its two component indices as pure quantity indices. It also describes the data used in the study, comprising 13 vulnerability indicators described in Appendix Table 1 and 13 lack of resilience indicators described in Appendix Table 2. Section 4 reports estimated vulnerability, lack of resilience, and MVLRI indices for each country. It also reports for each country estimates of the relative importance of the two indices forming MVLRI and discusses their significance for policy making. Section 5 reports censored regression estimates of several important aggregate economic, social and governance performance correlates with MVLRI. Section 6 concludes with a discussion of the empirical findings and their policy implications.

2 An Overview of Existing Vulnerability Indices

Most climate change vulnerability indices rely on the Intergovernmental Panel on Climate Change (IPCC) risk framework. The IPCC's Special Report (2012) defines climate vulnerability as the degree to which a system is susceptible to or unable to cope with the adverse effects of climate change, including climate variability and extremes. This encompasses both vulnerability and resilience.

The IPCC's perspective on vulnerability has significantly shaped academic discourse on identifying suitable metrics to address human and environmental sources of climate vulnerability, as evidenced by the research of Adger (2006), Eakin and Luers (2006), and Gallopín (2006). The transition from understanding vulnerability to measuring it has sparked efforts to integrate multiple vulnerability indicators into a single climate vulnerability index. Notable examples include the Physical Vulnerability to Climate Change Index (PVCCI) by Guillaumont (2015), the Yale Environmental Performance Index (EPI) by Wendling et al. (2018), and the Global Adaptation Initiative Index (ND-GAIN) from the University of Notre Dame. However, these indices have significant limitations.

Criticism of climate vulnerability indices often centers on their mathematical structure, particularly regarding the weighting of variables during aggregation and the form of the aggregation function. For example, the ND-GAIN index is calculated as the arithmetic mean of six normalized sectoral vulnerability indicators, which has two main implications: (i) all sectoral weights are set at $1/6$, compelling all countries to treat the six sectors equally, regardless of their specific situations, and (ii) the linear aggregation implies perfect substitutability among all sectoral indicators across countries.

Other researchers have developed vulnerability indices in line with the definition of the UN Committee for Development Policy (CDP), which considers a country's risk of encountering external shocks, including climatic and economic factors. In this context, vulnerability is influenced by the magnitude and frequency of such shocks, the structural characteristics of the country, and its capacity to respond or its resilience. Based on this definition, the CDP created the Economic Vulnerability Index (EVI) to evaluate the vulnerability of least developed countries (LDCs) consistently (Guillaumont 2009). From 2005 to 2020, the EVI was calculated as a simple average of two sub-indices reflecting exposure to external shocks and the size of these shocks, each being a weighted average of several components. The EVI was revised in 2020 to separate economic and environmental vulnerability, utilizing principal component analysis (Assa and Meddeb 2021). However, the revised index does not encompass critical economic and social dimensions that newer multidimensional indices have sought to address.

In response to the impact of the COVID-19 pandemic on small island developing states (SIDS), the UNDP developed a multidimensional vulnerability index in 2021 (Assa and Meddeb 2021). This index expands on the CDP EVI by incorporating financial vulnerability indicators related to fluctuations in tourism revenues or remittances and sudden disruptions of external financial flows. Similarly, the United Nations Conference on Trade and Development (UNCTAD) introduced the Economic Vulnerability Plus Index (EVI+) (United Nations 2021) to assess barriers to the development of productive capacities across eight sectors and the structural changes necessary for transitioning from low- to high-productivity sectors. The Caribbean Development Bank (CDB) has been estimating a multidimensional vulnerability index for its members since the early 2000s (Crowards 1999), which informs the allocation of concessional financial resources. The 2021 update of this index includes a comprehensive array of indicators measuring exposure and volatility across economic, social, and environmental dimensions.

The Multidimensional Vulnerability Index (UN MVI) was introduced in 2023 by the UN General Assembly to guide concessional finance and multidimensional assessments for countries such as LDCs and SIDS (United Nations 2024). Unlike traditional income-based metrics, the MVI incorporates various vulnerability dimensions, assigning weights through a quadratic mean structure. This approach allows the index to account for differing levels of importance across these dimensions, distinguishing it from fixed-weight models typically used in multidimensional indices.

The MVLRI proposed in this study and implemented with DEA significantly advances vulnerability research by providing a flexible and data-driven approach to assessing countries' vulnerability and lack of resilience. Unlike previous approaches, this method estimates aggregation weights from the data rather than specifying them independently.¹ DEA's ability to determine weights endogenously allows it to reflect different countries' unique characteristics and priorities. Using DEA, MVLRI offers a flexible analytical framework, enabling policymakers to identify and prioritize the most effective interventions for a specific context. This approach helps to reveal the interconnections among the economic, environmental, and social dimensions of climate change impacts, ultimately enhancing the development of targeted, evidence-based strategies for reducing vulnerability and building resilience.

3 Methodology and Data

The objective is to develop and implement a nonparametric frontier framework within which to estimate the relative vulnerability of countries to climate change as a function of multiple

¹ In a previous study, Edmonds et al. (2020) used DEA to construct a Climate Change Vulnerability Index CCVI whose aggregation weights are endogenously generated, and thus free to vary across sectors and countries.

vulnerability indicators, to estimate the lack of resilience of countries to climate change as a function of multiple lack of resilience indicators, and to aggregate these two indices. To this end, Section 3.1 reviews the use of DEA to construct composite indices. Section 3.2 develops a novel variant of the DEA methodology to estimate vulnerability and lack of resilience frontiers, and to estimate countries' vulnerability and lack of resilience relative to these frontiers. It then aggregates countries' vulnerability and lack of resilience indicators into aggregate vulnerability and lack of resilience indices, which are then aggregated to create a multidimensional vulnerability index for each country. Each of these three indices is a pure quantity index. Section 3.3 describes the empirical data used to implement the analysis.

3.1 Data Envelopment Analysis and Composite Indices

DEA is a linear programming methodology introduced by Charnes et al. (1978) that envelops, rather than intersects, data as regression analysis does. In doing so, it creates a best practice frontier, the envelopment surface, and evaluates the performance of each observation relative to the estimated frontier. Thore and Tarverdyan (2022) summarize the construction of a typical DEA model as a process of four steps: (1) determining the input and output variables; (2) choice of optimization orientation, input minimization or output maximization; (3) possible use of weight restrictions; and (4) the use of cross-sectional data or longitudinal data. Furthermore, Thore and Tarverdyan explain that DEA is well-suited for policy impact assessment at the national level because it reveals frontier rather than central tendencies and does not require explicit assumptions about functional forms or relative weights to obtain its results. DEA establishes best practice observations on the frontier and quantifies for observations not on the frontier the potential output gains or the potential input savings they could achieve by adopting the best practices of their peers.

In a climate change context, observations are countries, best practice countries are the least vulnerable or most resilient countries, and the vulnerability or lack of resilience of other countries is measured by their relative distance from the least vulnerable or most resilient frontiers established by the best practice countries. In this context, vulnerability and lack of resilience indicators act as inputs to be minimized.

The application of DEA, formulated initially as a business management tool, has expanded from measuring business and economic performance to creating composite indices, most notably as alternatives to the Human Development Index HDI (Despotis 2005, Cherchye et al. 2008). It has been employed to create environmental composite indices on both micro (Zhou et al. 2006, Bellenger and Herlihy 2009, Edmonds et al. 2015, Zhou et al. 2017, Liu et al. 2019, Gómez-Limón et al. 2020) and macro (Färe et al. 2004, Zhou et al. 2007, Lo 2010, Wiréhn et al. 2015, Edmonds et al. 2017, 2020, Huang et al. 2018, Tsaples and Papathanasiou 2020) levels. Camanho et al. (2024) provide a comprehensive survey of DEA applications, a few of which examine climate issues.

In this climate change study, observations are countries whose vulnerability indicators are aggregated into a vulnerability index and whose lack of resilience indicators are aggregated into a lack of resilience index. These two indices are subsequently aggregated to create a multidimensional vulnerability index. Each of these indices is a pure quantity index in the sense that each depends on the magnitudes of the component indicators being aggregated and is independent of all other variables.²

² Balk (2008) provides a thorough analysis of quantity and price indices. Eichhorn and Voeller (1976) would describe these aggregate quantity indices as quantity indices depending only on quantities, because they are independent of prices and any other variables.

Aggregation requires weights. In most business and economic applications, market prices are available to weight quantities to generate aggregate revenue (e.g., a country's gross domestic product) or aggregate expenditure (e.g., a country's gross domestic income). However, in most environmental applications quantities are not priced on markets and an alternative weighting procedure must be adopted to generate environmental composite indices.³ As noted above, most environmental composite indices use *exogenous fixed* weights such as arithmetic means to aggregate components. A virtue of DEA as an aggregation procedure is that it generates *endogenous variable* weights that vary across components for each country and, in important contrast to fixed weight aggregation procedures, vary across countries. Variation of aggregation weights across countries is both analytically and practically essential because countries have different vulnerabilities and resiliencies. Incorporating the endogeneity of aggregation weights into the analysis is an important contribution of this study. It enables these estimated weights to serve as *shadow prices*, proxies for missing market prices typically available in most business and economic applications, which can elicit country-specific policy actions to limit climate change vulnerability and enhance resilience.⁴

3.2 DEA Applied to Vulnerability, Lack of Resilience, and Multidimensional Vulnerability

DEA is applied to evaluate the relative performance of countries by quantifying their vulnerability and lack of resilience to climate change. Both vulnerability and lack of resilience describe adverse situations to be minimized. Hence, their linear programs have a minimizing orientation, with vulnerability and lack of resilience indicators serving as the variables to be minimized. The solutions to the programs provide vulnerability and lack of resilience indices for each country. All other variables that do not characterize vulnerability or lack of resilience do not appear in the programs.

Vulnerability is analyzed here; lack of resilience is analyzed similarly, with an appropriate terminology change. Let a sample of countries be indexed by $i = 1, \dots, I$, and let a country's vulnerability be tracked across N indicators labelled x_n and indexed by $n = 1, \dots, N$. The DEA program that evaluates the aggregate vulnerability to climate change of country "o" is given by the dual pair of linear programs below.

³ For example, greenhouse gas emissions are typically reported as CO₂ equivalents (CO₂E), calculated as a weighted sum of component gases including CO₂, methane, and nitrous oxide, with exogenous fixed weights provided by the estimated global warming potential GWP of each component gas over a certain time period.

⁴ Despotis (2005; 388) has argued that DEA scores "...cannot be used to rank countries...given that scores are not based on common weights". However, common weights conceal the scarcity and resource allocation signals that endogenous weights convey. For example, the use of common weights would evaluate the vulnerability of Nepal and Tuvalu based on a common aggregation weight for low elevated coastal zones, one of the environmental vulnerability indicators employed in this study.

Envelopment Program	Multiplier Program
$\min_{\theta, \lambda} \theta$	$\max_{\mu, \nu} \mu$
subject to	subject to
$\theta x_{n0} - \sum_{j=1}^I \lambda_j x_{nj} \geq 0$	$\sum_{n=1}^N \nu_n x_{n0} = 1$
$\lambda_i \geq 0$	$\mu - \sum_{n=1}^N \nu_n x_{ni} \leq 0$
$n = 1, \dots, N$	$i = 1, \dots, I \quad n = 1, \dots, N$
$i = 1, \dots, I$	$\mu, \nu_n \geq 0$
DEA Vulnerability Programs	

The envelopment program calculates the potential of country “o” to radially shrink its vector of vulnerability indicators \mathbf{x}_o as much as possible, subject to N constraints, one for each indicator, that bound the minimized vector $\theta \mathbf{x}_o$ below by a weighted sum of the least vulnerable countries in the sample, with weights given by optimal values of the $\lambda_i \geq 0$. The lower boundary defines the envelopment frontier, in this case a *vulnerability frontier*. The optimal value of $\theta \in (0, 1]$, with smaller values of θ indicating greater vulnerability to climate change, provides a ranking of countries based on their vulnerability to climate change. It also provides a measure of a country’s composite *vulnerability gap*, the difference between (or ratio of) its actual vulnerability \mathbf{x}_o and its potential vulnerability $\theta \mathbf{x}_o$. The reciprocal $\theta^{-1} \in [1, +\infty)$ is a scalar-valued *climate change vulnerability index*, with larger values of θ^{-1} indicating greater vulnerability to climate change. Expressing the reciprocal as $\theta^{-1} = \mathbf{x}_o / \theta \mathbf{x}_o$ shows that θ^{-1} is a vulnerability quantity index independent of all other variables.

The multiplier program calculates for country “o” a vector of non-negative endogenous weights $\nu_n \in (0, +\infty)$ that aggregate its N vulnerability indicators into its climate change vulnerability index. A relatively small aggregation weight for an indicator suggests that the marginal reduction in vulnerability from efforts to reduce that indicator is likely to be relatively small. Conversely, a relatively large aggregation weight for an indicator suggests that the marginal reduction in vulnerability from efforts to reduce that indicator is likely to be relatively large. By reflecting different degrees of vulnerability across indicators that, in turn, reflect different national circumstances, these endogenous aggregation weights serve as shadow prices that can assist in the allocation of development finance and the design of other resource allocation policies intended to reduce vulnerability. The Intergovernmental Panel on Climate Change (IPCC) (2022) refers to these policies as adaptation and mitigation *pathways*.

By the duality theorem of linear programming, at optimum $\mu = \theta \in (0, 1]$. This implies that a country’s θ can be expressed as an endogenously weighted sum of its sectoral vulnerability indicators, $\theta = \sum_{n=1}^N \nu_n x_{ni}$. The endogenous variable weights ν_n provide a considerable improvement over the exogenous fixed weights used in most composite indices because they are specific to each country. Exogenous fixed weights impose perfect substitutability among sectoral indicators, with rates of substitution being the same for all countries. The weights generated by DEA also impose perfect substitutability among sectoral indicators, but with the critical advantage that these weights and rates of substitution among sectoral indicators vary across countries according to their circumstances.

Both vulnerability and lack of resilience are defined over three sectors: economic, environmental, and social, each having multiple indicators. DEA is applied initially to the indicators within each vulnerability sector to estimate three vulnerability frontiers and three vulnerability indices for each country. DEA is applied subsequently to these three estimated indices to create an aggregate vulnerability frontier and an aggregate vulnerability index V for each country. Lack of resilience is analyzed similarly. DEA is applied to the indicators in each lack of resilience sector to estimate three lack of resilience frontiers and three lack of resilience indices for each country, and these indices are aggregated to create an aggregate lack of resilience frontier and an aggregate lack of resilience index LR for each country.

The aggregate vulnerability index V and the aggregate lack of resilience index LR are aggregated to create a multidimensional vulnerability and lack of resilience frontier and a multidimensional vulnerability and lack of resilience index MVLRI. This index is a scalar-valued, non-decreasing function of vulnerability and lack of resilience. Many aggregator functions satisfy these properties. A DEA minimization program provides a theoretically appealing aggregator function, having endogenous variable weights for two quantity indices, aggregate vulnerability V and aggregate lack of resilience LR . The optimal solution to this problem provides the MVLRI index.

It is important to note that the envelopment and multiplier programs in the DEA vulnerability and lack of resilience programs, as well as the programs used to calculate multidimensional vulnerability, contain vulnerability and lack of resilience indicators that can be influenced through resource allocation decisions of policymakers, both domestic and external. Unlike virtually all models of business and economic behavior to which DEA has been applied, these programs do not contain variables that might influence vulnerability or lack of resilience, such as geographic location, national income, or colonization history. The optimal solutions to these simplified DEA programs are pure quantity indices of vulnerability, lack of resilience, and multidimensional vulnerability. This novel abbreviation of conventional DEA programs to exclude all other variables is the contribution of Adolphson et al. (1991) and Lovell and Pastor (1999).

3.3 Data

Data are obtained from open sources, including the Emergency Events Database created by the Center for Research on the Epidemiology of Disasters (EMDAT-CRED), the Food and Agriculture Organization of the United Nations (FAO), the University of West Anglia, the United Nations Department of Economics and Social Affairs (UNDESA), the United Nations Conference on Trade and Development (UNCTAD), and the World Health Organization (WHO). The dataset contains 13 vulnerability indicators and 13 lack of resilience indicators for 142 low- and middle-income countries. Tables 1 and 2 describe the 26 indicators and the primary data source for each used to construct the MVLRI.⁵ The indicators capture the two pillars of MVLRI: (i) structural vulnerability, which is linked to a country's exposure to adverse external shocks and stressors, and (ii) lack of structural resilience, which is associated with the capacity of a country to withstand such shocks. In turn, each pillar has three sectors, economic, environmental, and social.

⁵ We follow the United Nations (2024) for the definitions and rationale for the inclusion of these indicators in the MVLRI. Details are available in the Online Supplementary Materials and upon request. The 26 x 142 data matrix has four empty cells, three for low years of schooling and one for lack of gross capital formation. These cells have been filled with the average value of the relevant indicator.

4. Estimating Multidimensional Vulnerability and its Component Indices

This section summarizes the results of using DEA to estimate quantity indices of low- and middle-income countries' vulnerability, lack of resilience, and multidimensional vulnerability.⁶

4.1 Vulnerability

The vulnerability data have three sectors, economic, environmental, and social, containing three, six, and four indicators, respectively. In the first stage, DEA is applied to sectoral indicators to estimate vulnerability indices of each sector. After estimation, countries are assigned to one of three vulnerability groups for each sector. Group 1 contains the most vulnerable quintile of countries, group 3 contains the least vulnerable quintile of countries, and group 2 contains countries in the middle three quintiles. Results of the first stage are summarized in Appendix Table 1, which reports countries' estimated vulnerability indices and groups for each sector.

Economic vulnerability indices and groups for each country appear in the first two columns, labelled EconV and EconVg, of Appendix Table 1. The wide range of countries' economic vulnerabilities is apparent; the most economically vulnerable countries have index values more than twice those of the least economically vulnerable countries. Economic vulnerability groups are used to map countries according to their economic vulnerability in Appendix Figure 1. The majority of the economically most vulnerable countries are SIDS, and the rest are African and Middle Eastern.⁷

Environmental vulnerability indices and groups appear in the third and fourth columns, labelled EnvV and EnvVg, of Appendix Table 1, and environmental vulnerability groups are mapped in Appendix Figure 2. Environmental vulnerability does not vary as widely among countries as economic vulnerability. Many of the environmentally most vulnerable countries are SIDS, with the rest being scattered around the world.

Each country's social vulnerability indices and groups appear in the fifth and sixth columns, labelled SocV and SocVg, of Appendix Table 1, and social vulnerability groups are mapped in Appendix Figure 3. Social vulnerability is by far the most volatile sector in terms of both magnitude and variability. Ten of the socially most vulnerable countries are SIDS, 11 are Central and South American, and five are African.

There is little overlap in the identity of the most vulnerable countries across the three sectors. Correlations between pairs of sector scores are low, with correlation coefficients between economic and environmental vulnerability indices of 0.2067, between economic and social vulnerability indices of -0.0835, and between environmental and social vulnerability indices of 0.0953. This suggests that the three sectors provide largely independent information about vulnerability, and that a vulnerability index would suffer from the omission of any of the three sectors.

In the second stage, DEA is applied to the three estimated sector vulnerability indices to calculate countries' aggregate vulnerability. Results appear in Appendix Table 2, which contains estimated aggregate vulnerability indices V and aggregate vulnerability groups Vg for each country. V has a smaller mean and standard deviation than any of its sectors because countries weight the three sectors differently depending on their circumstances. The correlations between sector vulnerability indices and aggregate vulnerability are positive, with values of 0.3476 for economic and aggregate vulnerability, 0.9083 for environmental and aggregate vulnerability, and 0.1363 for social and aggregate vulnerability. This highlights the

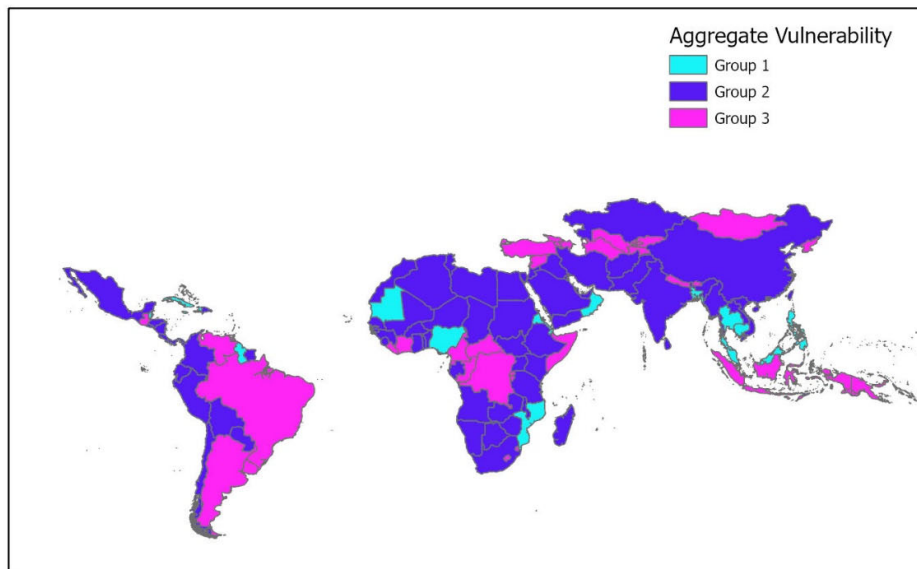
⁶ DEA models were estimated with R.

⁷ A list of SIDS is available at https://sdgs.un.org/topics/small-island-developing-states#list_of_sids

critical role of the environment, and the smaller role of the social sector, in influencing aggregate vulnerability to climate change.⁸

Initially DEA assigns 39 countries to the least vulnerable group. A novel application of dominance analysis is used to reduce the size of this group to a quintile of all countries. A country in the least vulnerable group dominates another country in this group if it is less vulnerable in the *strict* sense that it has lower values of all three sector vulnerability indices. A country is dominated by another country in this group if it is more vulnerable in the *strict* sense that it has larger values of all three sector vulnerability indices. The one-fifth of countries that dominate the most other countries in the least vulnerable group and are dominated by the fewest other countries in this group form the dominance-adjusted least vulnerable fifth quintile of countries reported in Appendix Table 2 and mapped in **Figure 1**. The remaining 11 countries are allocated to the middle group.⁹ The majority of the most vulnerable quintile of countries are SIDS, with most of the others from Africa and Southeast Asia. Aggregate vulnerability to climate change is a global phenomenon.

Figure 1. Aggregate Vulnerability Groups



⁸ Deleting the least influential social sector and re-estimating aggregate vulnerability generates a correlation coefficient between the two composite vulnerability indices of 0.97, suggesting that deletion of social indicators has little impact on an aggregate vulnerability index. However, deletion of the social sector has a large positive impact on the estimated vulnerability of several countries, most of them in the most vulnerable Group 1.

⁹ Tulkens (2006) provides an introduction to dominance analysis as an *alternative* to DEA as a performance assessment technique. In this climate change application, dominance analysis serves as a *complement* to DEA.

4.2 Lack of Resilience

Lack of resilience data have the same three sectors, with four, three, and six indicators, respectively. In the first stage, DEA is applied to sectoral indicators to estimate the lack of resilience indices for each sector. For each sector, countries are assigned to one of three resiliency groups. Group 1 contains the least resilient quintile of countries, group 3 includes the most resilient quintile of countries, and group 2 contains countries in the middle three quintiles. In the second stage, DEA is applied to the three estimated sector indices to calculate countries' aggregate lack of resilience indices.

The lack of economic resilience indices and groups for each country appear in the first two columns, labelled EconLR and EconLRg, of Appendix Table 3. Lack of economic resilience groups are used to map countries according to their lack of economic resilience in Appendix Figure 5. Half of the least economically resilient countries are SIDS, six are African, and the rest are geographically dispersed. Eight countries, six of them SIDS, are among the most economically vulnerable countries and the least economically resilient countries, highlighting the pervasive influence of economic health on both pillars of multidimensional vulnerability.

The lack of environmental resilience indices and groups for each country appear in the third and fourth columns, labelled EnvLR and EnvLRg, of Appendix Table 3. Lack of environmental resilience groups are used to map countries according to their lack of environmental resilience in Appendix Figure 6. Lack of environmental resilience is the most volatile of the three sectors, with the highest mean and standard deviation. The least environmentally resilient countries are distributed geographically among SIDS, North Africa, and the Middle East. Seven countries, five of them North African and Middle Eastern, are among the most environmentally vulnerable countries and the least environmentally resilient countries, highlighting the environment's pervasive influence on countries' multidimensional vulnerability.

Lack of social resilience indices and groups for each country appear in the fifth and sixth columns, labelled SocLR and SocLRg, of Appendix Table 3. Lack of social resilience groups are used to map countries according to their lack of social resilience in Appendix Figure 7. Lack of social resilience is the least volatile of the three sectors. Ten of the least socially resilient countries are SIDS, 14 are African, and three are from the Indian subcontinent. Only one country is among the most socially vulnerable and the least socially resilient countries.

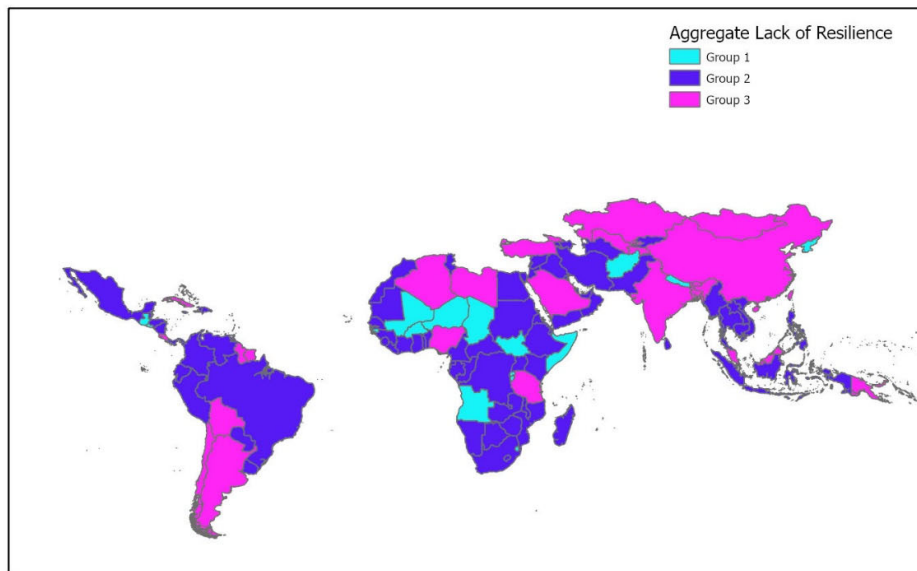
Correlations between pairs of sector indices are negative and small, with correlation coefficients between economic and environmental lack of resilience indices of -0.0534, between economic and social lack of resilience indices of -0.0085, and between environmental and social lack of resilience indices of -0.0294. As in the case of vulnerability, this suggests that the three sectors provide independent information about lack of resilience and that the omission of any sector would adversely affect a composite lack of resilience index.

The aggregate lack of resilience indices and groups for each country, labelled LR and LRg, appear in Appendix Table 4. Relationships between each sector and aggregate lack of resilience vary, with correlation coefficients of 0.4187 for economic and aggregate lack of resilience, 0.0904 for environmental and aggregate lack of resilience, and 0.6496 for social and aggregate lack of resilience. Thus, while the environment strongly influences aggregate vulnerability, it has a much weaker relationship with aggregate lack of resilience.¹⁰ Conversely,

¹⁰ Deleting the least influential environment sector and re-estimating aggregate lack of resilience generates a correlation coefficient of 0.92, suggesting that the environment has little impact on an

the social sector has a strong influence on aggregate lack of resilience, but it has much less influence on aggregate vulnerability. Countries are mapped according to their aggregate lack of resilience in **Figure 2**.¹¹ Twelve of the aggregate least resilient countries are SIDS, 11 are African, and five others are widely dispersed. Like vulnerability, lack of resilience to climate change is a global phenomenon.

Figure 2. Aggregate Lack of Resilience Groups



Source: Authors' calculations using data from EMDAT-CRET, FAO, The University of West Anglia, UNDESA, UNCTAD, WHO, and the World Bank.

4.3 Multidimensional Vulnerability

Multidimensional vulnerability indices and estimated aggregation weights of the two component indices, and multidimensional vulnerability groups for each country, labelled MVLRI, sV, sLR and MVLRIg, appear in Appendix Table 5.¹² The aggregate vulnerability and aggregate lack of resilience indices comprising MVLRI are essentially uncorrelated, with a correlation coefficient of -0.0040, implying that few of the most vulnerable countries are

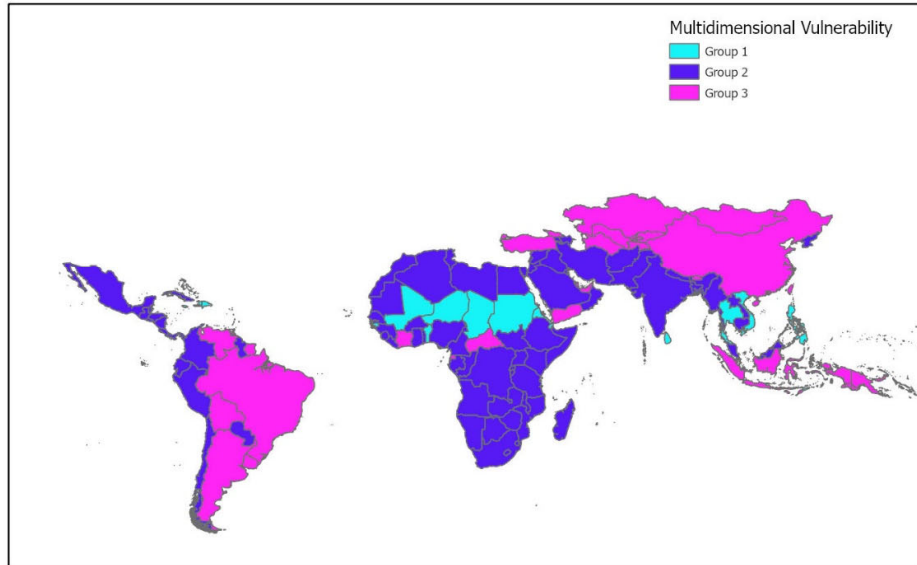
aggregate lack of resilience index. However, deletion of the environment sector has a large positive impact on several countries, most of them in the least resilient Group 1.

¹¹ As in the case of aggregate vulnerability, DEA also generates more than one-fifth of countries forming the aggregate most resilient group and the least multidimensionally vulnerable group. In each case, dominance analysis is used to reduce the size of these groups to a quintile.

¹² Aggregation weights have been estimated for all 142 countries at all three levels of aggregation and are reported for the V and LR pillars of MVLRI in Table 5. Estimated aggregation weights for the three sectors of V and the three sectors of LR convey important resource allocation information to policymakers but have been omitted to conserve space. They are available upon request.

among the least resilient. However, both indices are related to multidimensional vulnerability, with correlation coefficients 0.6701 and 0.4082, respectively, suggesting that the omission of either index would distort an index of multidimensional vulnerability. Countries are mapped in **Figure 3** according to their multidimensional vulnerability group. Sixteen of the most multidimensionally vulnerable countries are SIDS, eight are African, and four are Asian. MVLRI is also a global phenomenon, focused on SIDS.

Figure 3. Multidimensional Vulnerability Groups



Multidimensional vulnerability varies across countries by less than either of its component indices because countries attach different aggregation weights to the two indices in their efforts to minimize their multidimensional vulnerability. In Appendix Table 5, most countries have positive aggregation weights for LR, suggesting that they can achieve more significant reductions in MVLRI through marginal reductions in LR than via marginal reductions in V. However, most countries in the most multidimensionally vulnerable quintile have positive aggregation weights for V, implying that they can achieve more significant reductions in MVLRI through marginal reductions in V. Group 1 countries have structurally different, as well as greater, multidimensional vulnerabilities than other countries. This distinction is significant because policy and resources are likely to be directed toward countries in Group 1.

Appendix Table 6 summarizes the vulnerability and lack of resilience of the most multidimensionally vulnerable group of countries.

4.4 The Value of Aggregation Weights

A combined focus on countries' MVLRI indices and the aggregation weights countries attach to the V and LR indices and their sectors components has important policy implications for allocating adaptation resources. The analysis in Appendix Table 7 narrows the focus to Fiji

and Micronesia, two Pacific Ocean countries in the most multidimensionally vulnerable Group 1. The analysis takes a top-down approach, beginning with the two pillars V and LR of MVLRI, descending to the three sectors of V and of LR, and concluding with the indicators within each sector of V and of LR.

In Appendix Table 7.1 both Fiji and Micronesia attach zero aggregation weights to lack of resilience, signalling that marginal increases in resilience would have a relatively negligible impact on their multidimensional vulnerability. Their more pressing challenge is their vulnerability. Therefore, Appendix Table 7.2 focuses on the V pillar of MVLRI and its three sectors, where the two countries' relative vulnerabilities differ. Fiji attaches positive aggregation weights to its economic and social vulnerabilities and a zero weight to its environmental vulnerability. In contrast, Micronesia attaches zero aggregation weights to economic and social vulnerability and a positive weight to environmental vulnerability. The sources of the two countries' aggregate vulnerability differ. Appendix Table 7.3a breaks down Fiji's economic and social vulnerabilities. All three economic vulnerability indicators receive positive aggregation weights, with EconV2, instability of export revenue, receiving the largest weight. All four social vulnerability indicators also receive positive aggregation weights, with SocV2 and SocV4, regional conflict-related death and refugees from abroad, receiving the largest weights.¹³ Table 7.3b examines Micronesia's environmental vulnerability. Five indicators receive positive aggregation weights, with EnvV1, victims of natural hazards, receiving the largest weight.¹⁴

This analysis provides insights into how policymakers might follow a top-down strategy to allocating resources for climate change adaptation. The United Nations Environment Programme Adaptation Fund established under the Kyoto Protocol allocates resources based on a country's "...needs, views and priorities."¹⁵ The top-down strategy illustrated in Appendix Table 7 focuses on two of the neediest countries, and incorporates their views and priorities expressed in the estimated aggregation weights of their vulnerabilities and resilience inadequacies.

5 The Association between Multidimensional Vulnerability and Aggregate Measures of Economic Performance

The objective of this section is to investigate the extent to which aggregate indicators of economic, social, and governance performance influence estimated MVLRI. Since MVLRI is a pure quantity index, it is a function of 13 vulnerability indicators and 13 lack of resilience indicators. This index is not a function of institutional performance, but it can be influenced by institutional performance.

¹³ Much of Fiji's export revenue derives from sugar exports and tourism. Both are sensitive to tropical cyclones (tropical cyclone Winston in 2016 was the most intense on record in the Southern Hemisphere) and other impacts of climate change, and tourism was negatively impacted by the COVID-19 pandemic. Fiji is also a popular destination for migrants.

¹⁴ Micronesia is particularly vulnerable to typhoons, sea level rise, saltwater intrusion, and other impacts of climate change.

¹⁵Source:<https://www.unep.org/about-un-environment-programme/funding-and-partnerships/adaptation-fund>

Several cross-country regressions are estimated using Tobit specifications, given the censored nature of MVLRI (Greene 2018).¹⁶ MVLRI is rescaled between 0 and 1 to facilitate the interpretation of the estimates.¹⁷ The macroeconomic variables of interest include (1) GDP per capita; (2) growth in GDP per capita; (3) income inequality measured with the Gini index; (4) poverty rate using the international poverty line for extreme poverty (\$2.15 a day, 2017 PPP); (5) government effectiveness; and (6) control of corruption.¹⁸

The six panels in **Figure 4** suggest a potential negative link between MVLRI and variables measuring strong economic performance (GDP per capita) and good governance (government effectiveness and control of corruption) and a positive link with variables indicating less desirable distributional outcomes (poverty and inequality).

Appendix Table 8 presents the parameter estimates. The estimates reveal that *levels* of GDP per capita are negatively and significantly related to MVLRI, with the relationship working exclusively through the LR component. Countries with relatively high incomes have the resources to enhance their resilience, but these resources can do little to reduce their vulnerability. However, *growth* in GDP per capita is essentially uncorrelated with MVLRI, but positively correlated with its V component and negatively correlated with its LR component. This suggests that faster-growing countries are more vulnerable, perhaps due to their greater exposure to external shocks, and more resilient.

There is no significant statistical link between MVLRI and either inequality or poverty. However, poverty is positively correlated with the LR component, suggesting that higher poverty rates can cause a larger share of the population to suffer from economic hardships and make it more challenging for them to respond to unexpected shocks.¹⁹

Neither governance indicator is correlated with MVLRI, although both are strongly and negatively correlated with its LR component. This finding aligns with the intuition that more robust government capabilities in policy formulation, public service delivery, regulatory quality, and control of corruption can increase a country's resilience to the shocks and stresses of climate change.²⁰

¹⁶ The widespread practice of regressing DEA-based *efficiency scores* against explanatory variables has been criticized on statistical grounds; see Simar and Wilson (2007). However, DEA-based *quantity indices depending only on quantities* are immune to this criticism because they are functions of quantities only. A country's multidimensional vulnerability to climate change is a function of its vulnerability and lack of resilience indicators. It is not a function of its institutional performance, although its multidimensional vulnerability can be influenced by its institutional performance. Similarly, a country's GDP is not a function of its weather, but the magnitude of its GDP can be influenced by it.

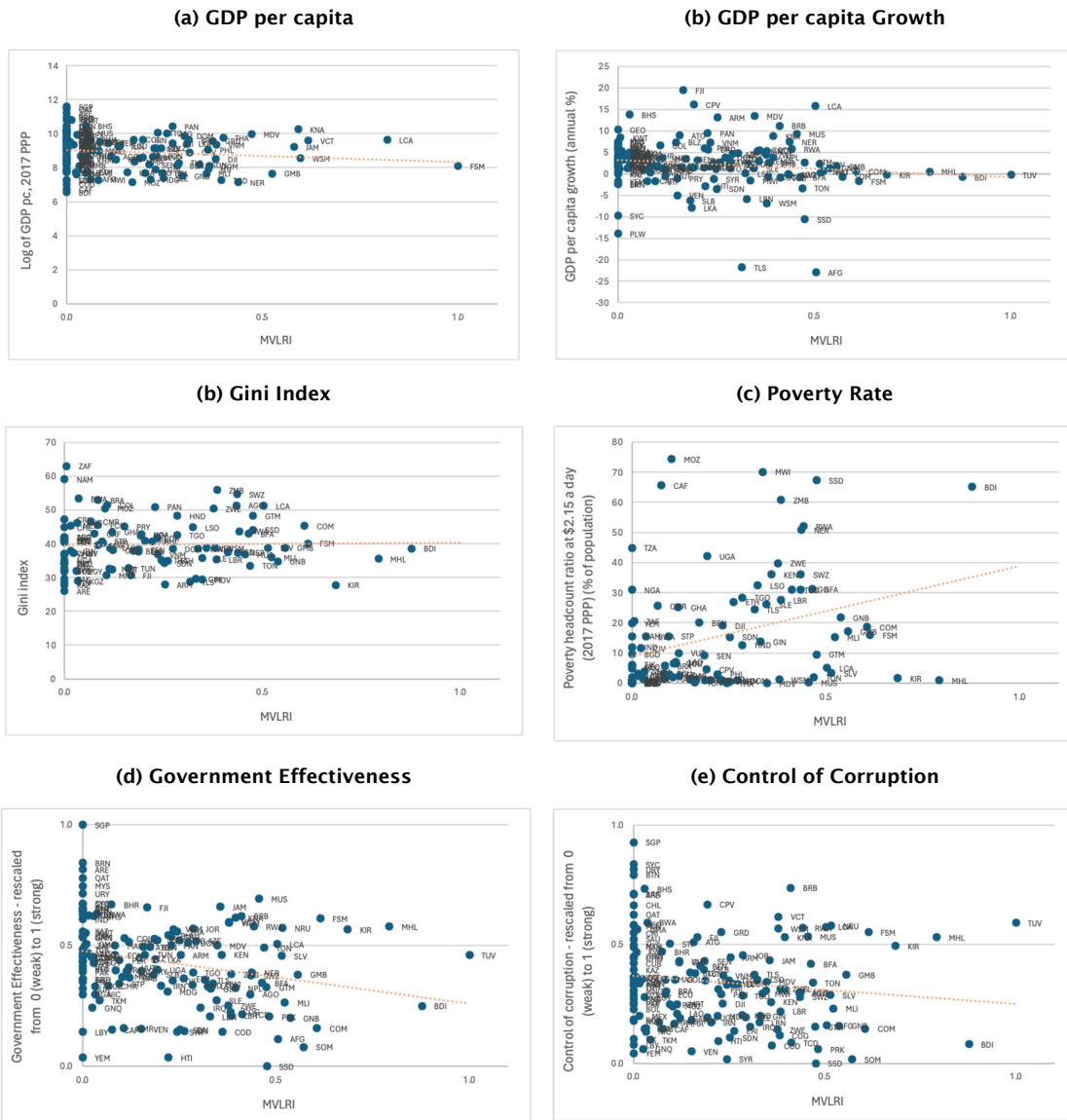
¹⁷ Tobit estimates were obtained using Stata.

¹⁸ This study uses data on GDP and distributional outcomes from the World Development Indicators. The governance indicators come from the Worldwide Governance Indicators. See Kaufmann and Kraay (2023).

¹⁹ Hallegatte et al. (2018) reach similar conclusions regarding the association of poverty with climate change.

²⁰ Additional information on the linkage between government performance and climate change is available at <https://www.worldbank.org/en/businessready>

Figure 4. MVLRI and Aggregate Measures of Economic Performance



Source: Authors' calculations using data from EMDAT-CRET, FAO, The University of West Anglia, UNDESA, UNCTAD, WHO, and the World Bank.

6 Summary and Conclusions

The contribution of this study is to demonstrate the significance of incorporating lack of resilience LR with vulnerability V to create a more encompassing index of vulnerability to climate change MVLRI. This has been achieved by employing DEA to aggregate V and LR indices to create a multidimensional vulnerability index MVLRI. This approach highlights the value of the endogenous aggregation weights generated by DEA (which function as shadow prices in economics applications) and emphasizes their advantage over exogenous aggregation weights used in most composite indices. The study illustrates these features by applying DEA to a data set of 142 low- and middle-income countries to estimate their multidimensional vulnerability to climate change, and by associating their estimated MVLRI

indices with aggregate indicators of institutional performance. Each of the following empirical findings of the study can inform policy making and resource allocation, both within and among countries.

Empirical findings of the study highlight several important points for policymaking and resource allocation. There is considerable variation in multidimensional vulnerability among low- and middle-income countries. Fiji, Micronesia, and several other SIDS, and several African (North as well as sub-Saharan) countries are identified as the most multidimensionally vulnerable. However, vulnerability and lack of resilience measure different national characteristics. For instance, Pakistan and Palau are vulnerable but resilient, while Rwanda and Tuvalu are less vulnerable and less resilient. Jamaica and Samoa are vulnerable and not very resilient. The indices V and LR are essentially uncorrelated, but each correlates with MVLRI, underscoring the importance of including both components in a multidimensional index.

Countries place different emphasis on V and LR based on their unique circumstances. For example, Palau attaches greater importance to reducing vulnerability by assigning a positive weight to V and zero to LR. In contrast, Tuvalu prioritizes increasing resilience, assigning a positive weight to LR and zero to V. A deeper examination of the three sectors comprising V and LR reveals similar patterns in values and aggregation weights. These findings underscore the benefit of using endogenous aggregation weights, which can adapt to the specific needs of different countries. This approach enables an assessment that reflects each country's unique conditions and priorities, thereby overcoming the limitations of fixed-weight indices.

These empirical findings also suggest that policymaking and resource allocation might proceed in multiple stages. In the first stage, the most multidimensionally vulnerable countries are identified. Most are SIDS and African, although a few are Asian and Latin American. Their more pressing needs are either vulnerability reduction or resilience enhancement. Accordingly, in the second stage, attention turns to these countries' vulnerability indices and aggregation weights or their lack of resilience indices and aggregation weights. Once these countries with the greatest vulnerability or least resilience are identified, in the third stage, policy attention is directed to the economic, environmental, and social sectors of vulnerability and lack of resilience respectively, using index values and aggregation weights to guide resource allocation. Finally, resource allocation is further directed toward specific indicators within each sector of vulnerability and lack of resilience, ensuring that interventions are effectively targeted to address specific national contexts.

In summary, this study demonstrates that DEA can be effectively used to estimate indices of countries' vulnerability, lack of resilience, and multidimensional vulnerability. The inclusion of lack of resilience is essential for a comprehensive understanding of multidimensional vulnerability. This study illustrates how DEA creates a multi-level analytical structure that can guide policymaking and resource allocation towards the most vulnerable countries and the most critical areas within these countries. Further research could expand the MVLRI framework by incorporating additional indicators and exploring its applicability to multidimensionally vulnerable high-income countries. Additionally, longitudinal studies could provide insights into how vulnerability and resilience evolve over time, informing more dynamic and adaptive policy responses. Finally, the analysis is not inherently aggregate and can be disaggregated to the regional level within a country.

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Statements and Declarations

The authors declare no financial or non-financial interests that are directly or indirectly related to this work. The findings, interpretations, and conclusions expressed in this paper are those of the authors and do not necessarily represent the views of the World Bank, its affiliated organizations, or those of the executive directors of the World Bank or the governments they represent. No funding was received for conducting this work. All authors contributed equally to this work.

Table 1. Vulnerability Indicators

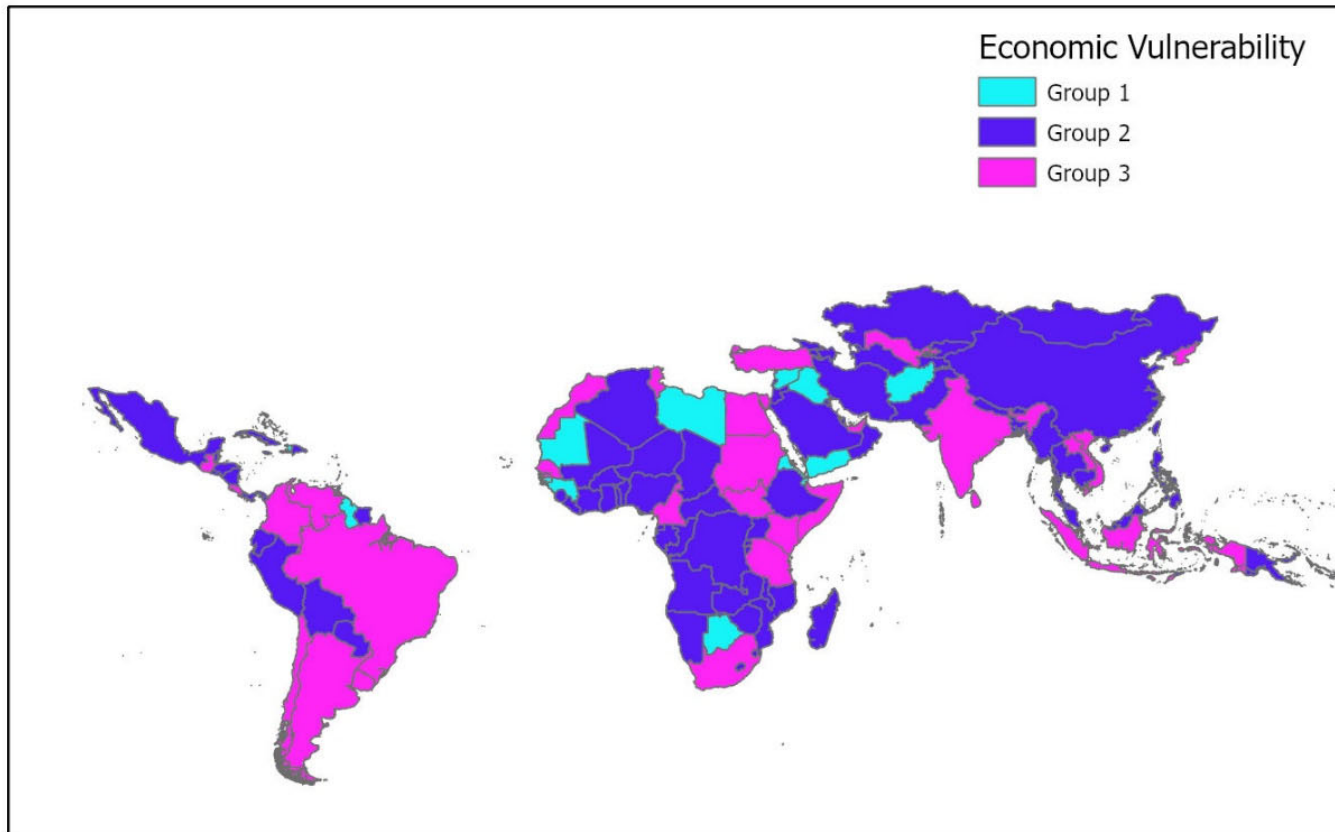
Economic Vulnerability		
Indicator	Measured by	Primary data source
Merchandise and services export concentration	Share of the three highest export categories in total exports of goods and services (in %)	UNCTAD
Instability of export revenue	Defined as the standard deviation of the difference between the value of annual export earnings and its 20-year (quadratic) trend (in \$)	UNDESA Statistics Division
Food and fuel import dependency	Share of food and fuel imports over total consumption expenditure (in % of total consumption expenditure)	UNCTAD
Environmental Vulnerability		
Indicator	Measured by	Primary data source
Victims of natural hazards	The share of the population who have been killed or affected by natural hazards (in % of total population)	EMDAT- CRED
Damages related to natural hazard	Share of damages over GDP (in % of GDP)	EMDAT- CRED
Rainfall shocks	The magnitude of rainfall shocks is measured as the square root of the square deviation of rainfall series from their long-term trend. Inverse level of rainfall is measured by the average level of precipitation over a long period (since 1950). Magnitude of shocks and level are combined to produce the indicator. (in millimeters)	CRU TS (University of East Anglia)
Temperature shocks	The magnitude of temperature shocks is measured as the square root of the square deviation of temperature series from their long-term trend. Level of temperature is measured by the average of temperature over a long period (since 1950). Magnitude of shocks and level are combined to produce the indicator. (in degrees Celsius)	CRU TS (University of East Anglia)
Low elevated coastal zones	Share of areas contiguous to the coast below five meters to total land areas of countries (in % of territory)	CoastalDEM (Climate Central)
Drylands	Share of drylands over the country's area (excluding deserts). (in % of territory)	CRU TS (University of East Anglia)
Social vulnerability		
Indicator	Measured by	Primary data source
Victims of epidemics	Share of victims of epidemics over the total population (in % of total population)	EMDAT- CRED
Regional Conflict- related death (excluding own country's data)	Quadratic mean of battle-related death deaths per 100,000 inhabitants due to internal conflicts in neighboring countries. Neighborhood is defined by contiguity for countries that are not isolated islands. However, for isolated islands, the neighborhood is defined according to UN regions. (per 100,000 populations)	ACLED
Regional Homicide (excluding own country's data)	Quadratic mean of homicide rates per 100,000 inhabitants in neighboring countries. Neighborhood is defined by contiguity for countries that are not isolated islands. However, for isolated islands, the neighborhood is defined according to UN regions. (per 100,000 populations)	UNODC/ WHO / IHME Burden of Disease
Refugees from abroad	Share of refugee population in the country over total population (per 100,000populations)	UNHCR

Table 2. Lack of Resilience Indicators

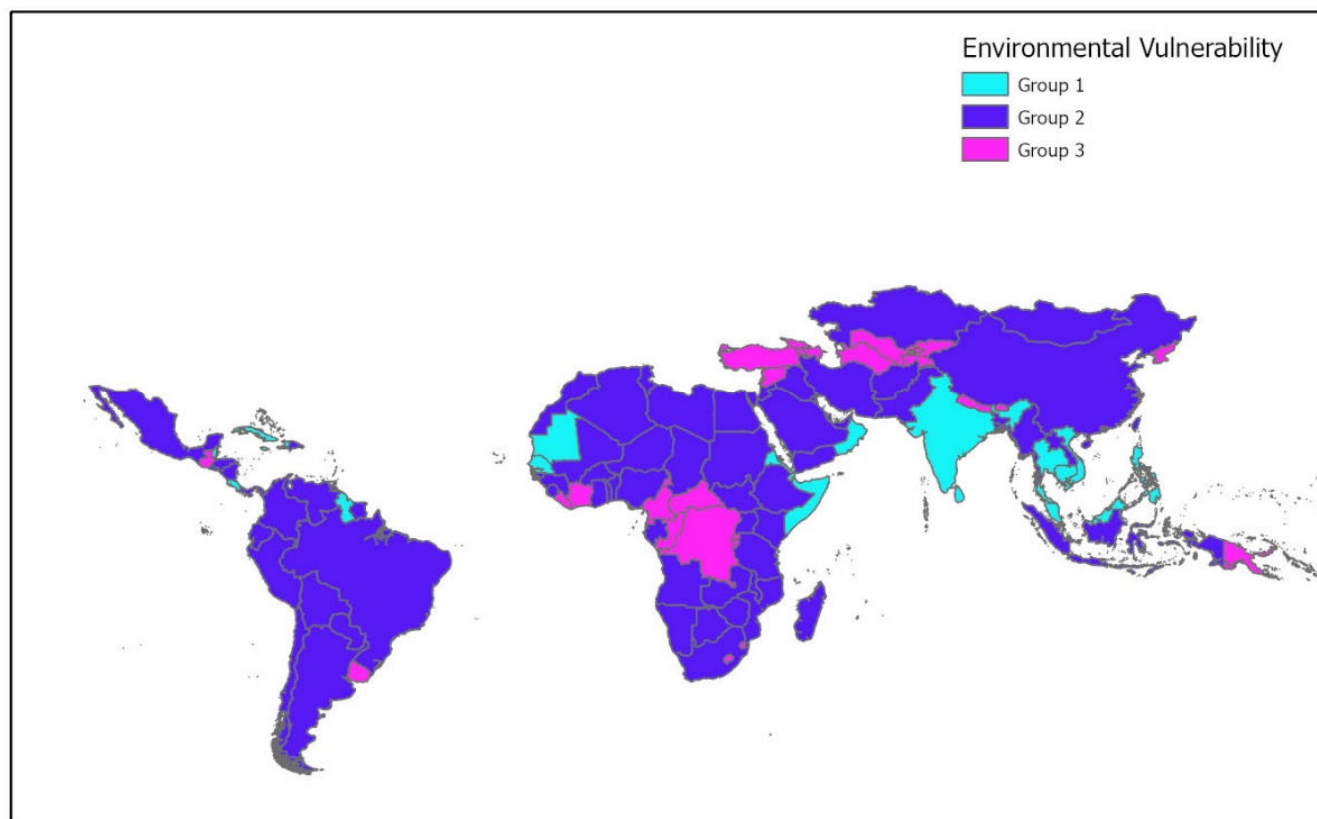
Economic Lack of Resilience		
Indicator	Measured by	Primary data source
Low connectivity	Weighted average distance from the nearest trading partners with a cumulative share in world trade of 50 per cent, with market shares as weights and adjusted for landlockedness (in km)	UNDESA
Population size	Total population in logarithm (in number of individuals)	UNDESA
Low gross fixed capital formation	Gross fixed capital formation over GDP (in % of GDP)	UNCTAD
High production concentration	Herfindahl-Hirschman concentration index of product export (between 0 and 1, being 1 more concentrated)	UNCTAD
Environmental Lack of Resilience		
Indicator	Measured by	Primary data source
Lack of renewable internal freshwater resources	Ratio of renewable internal freshwater resources over total population (cubic meters per capita)	FAO
Lack of crop land	Ratio of cropland over total population (in 1,000 hectares per capita)	FAO
Lack of tree cover	Ratio of tree cover over country size (in 1,000 hectares per capita)	FAO
Social Lack of Resilience		
Indicator	Measured by	Primary data source
Dependency ratio	Ratio of non-working age population over working age population (per hundred persons aged 15-64)	UNDESA
Population density	Total population divided by land area in square kilometers (people per sq. km)	UNDESA
Lack of basic sanitation services	Share of population using at least basic sanitation services over total population) (in % of population)	WHO
Under-5 mortality	Probability per 1,000 that a newborn baby will die before reaching age five (deaths per 1,000 live births)	UNDESA
Low years of schooling	Average number of completed years of education of a country's population aged 25 years and older (in years)	UNDP
Low proportion of seats held by women in national parliaments	Proportion of seats held by women in national parliaments (% of total number of seats)	Inter-Parliamentary Union (IPU)

Appendix Figures

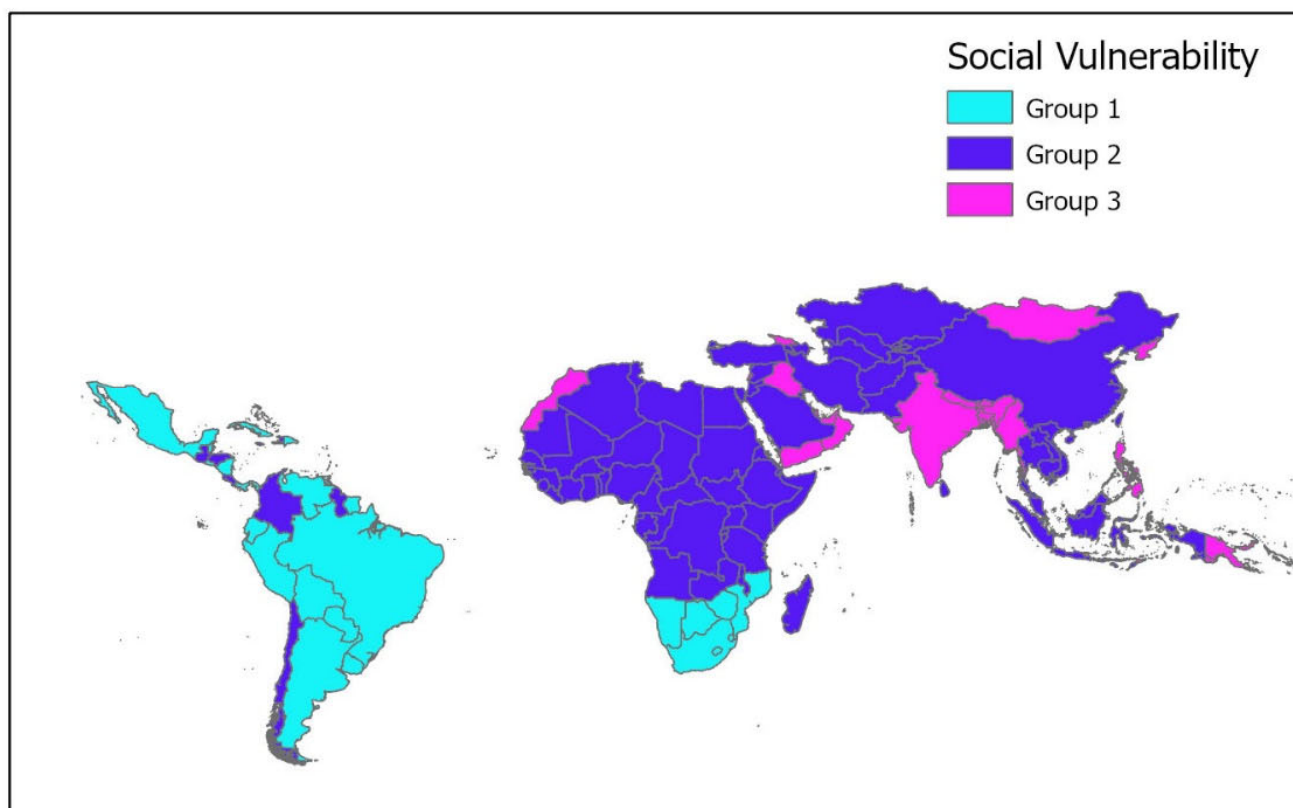
Appendix Figure 1 Economic Vulnerability Groups



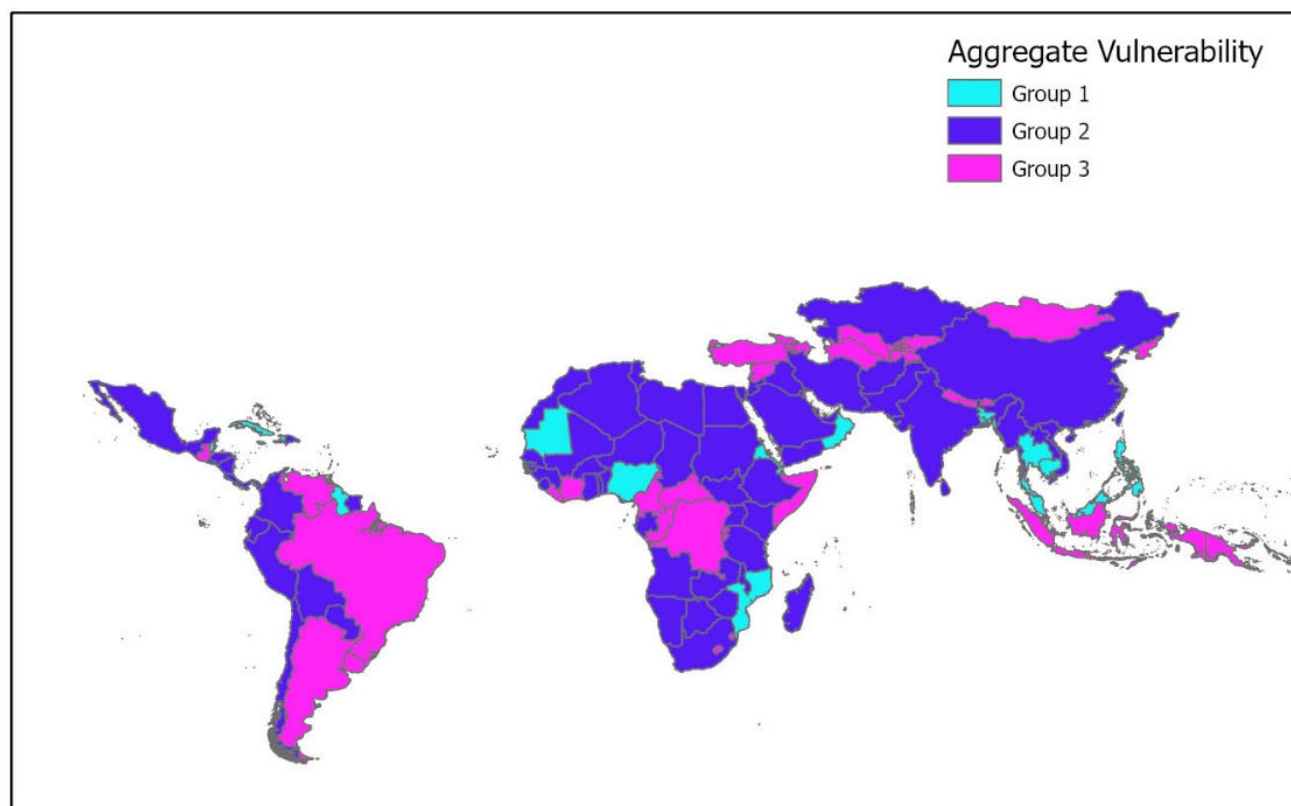
Appendix Figure 2 Environmental Vulnerability Groups



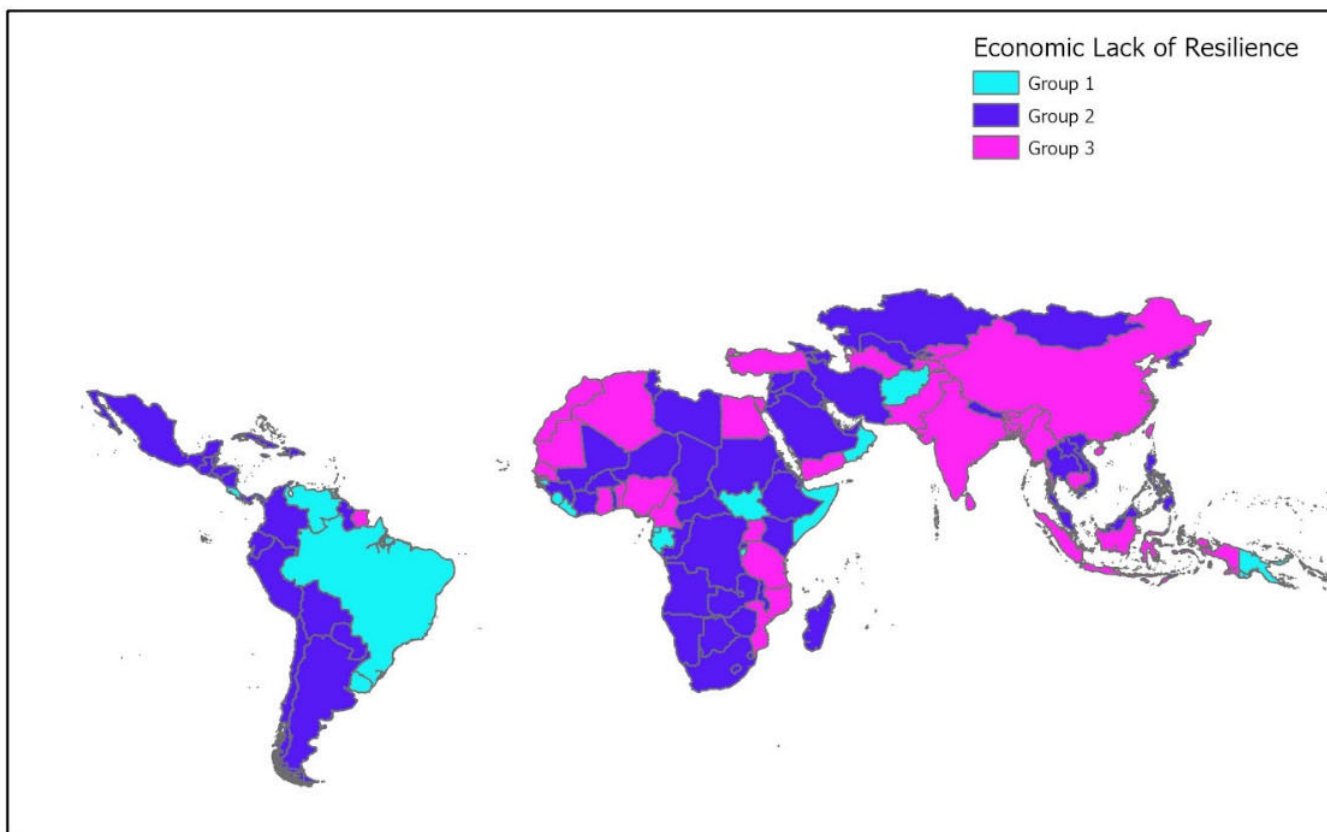
Appendix Figure 3 Social Vulnerability Groups



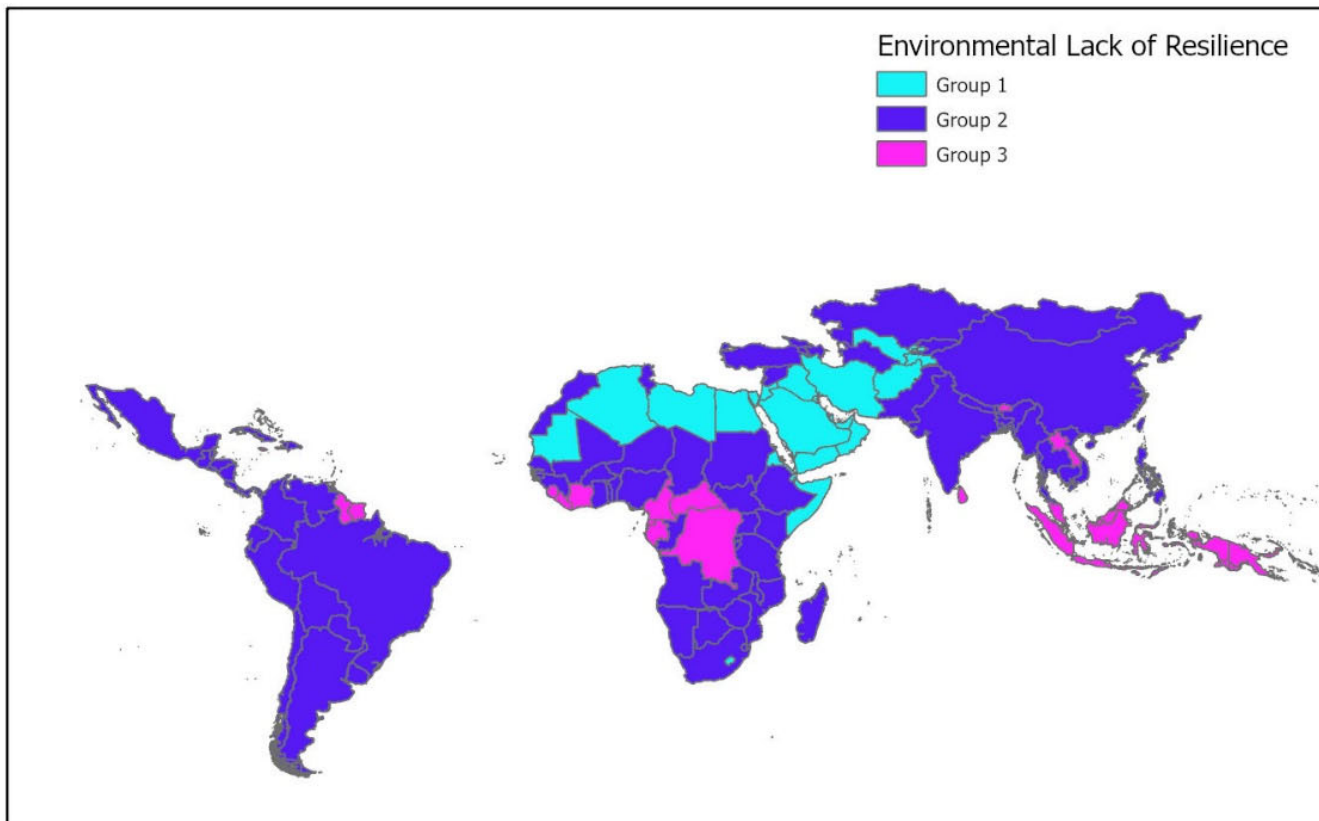
Appendix Figure 4 Aggregate Vulnerability Groups



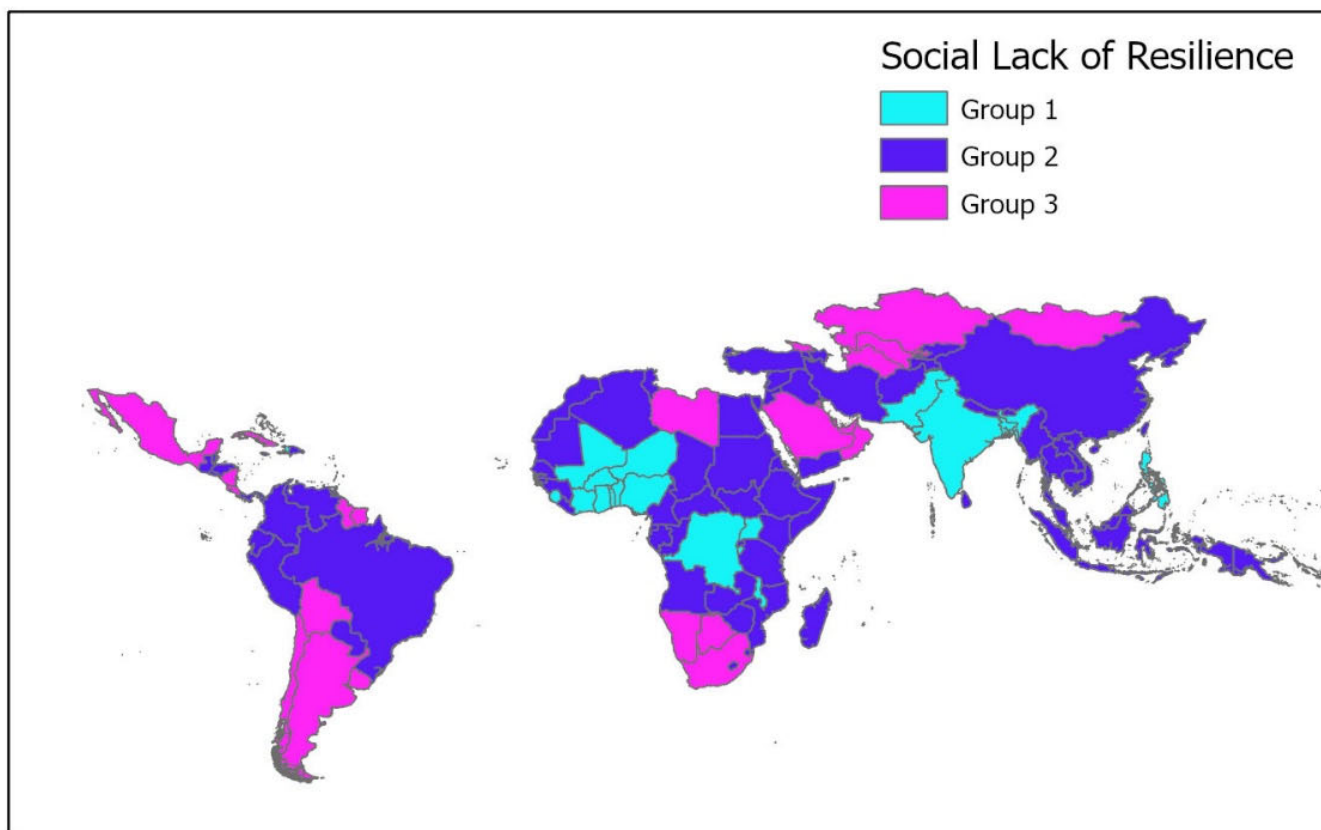
Appendix Figure 5 Lack of Economic Resilience Groups



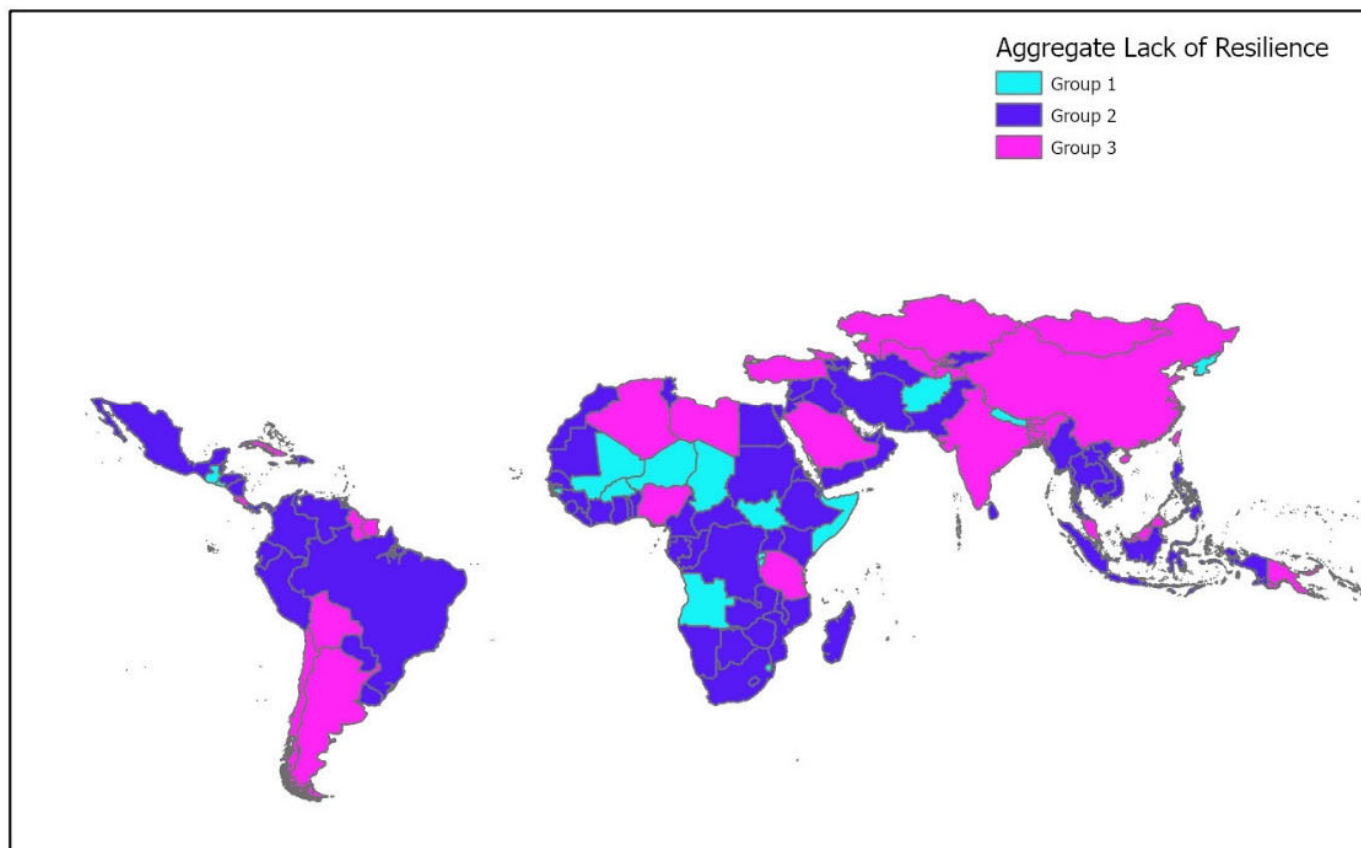
Appendix Figure 6 Lack of Environmental Resilience Groups



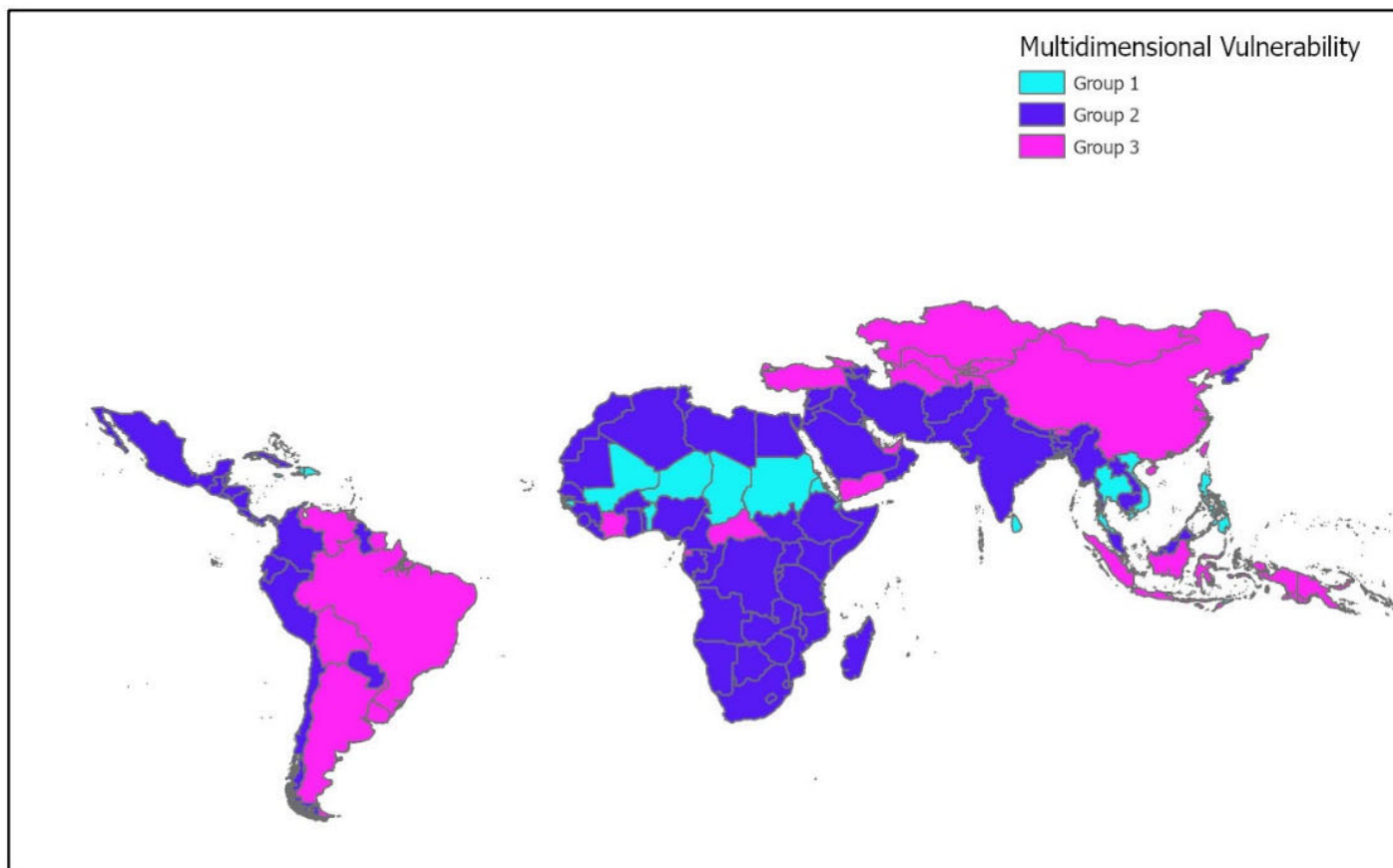
Appendix Figure 7 Lack of Social Resilience Groups



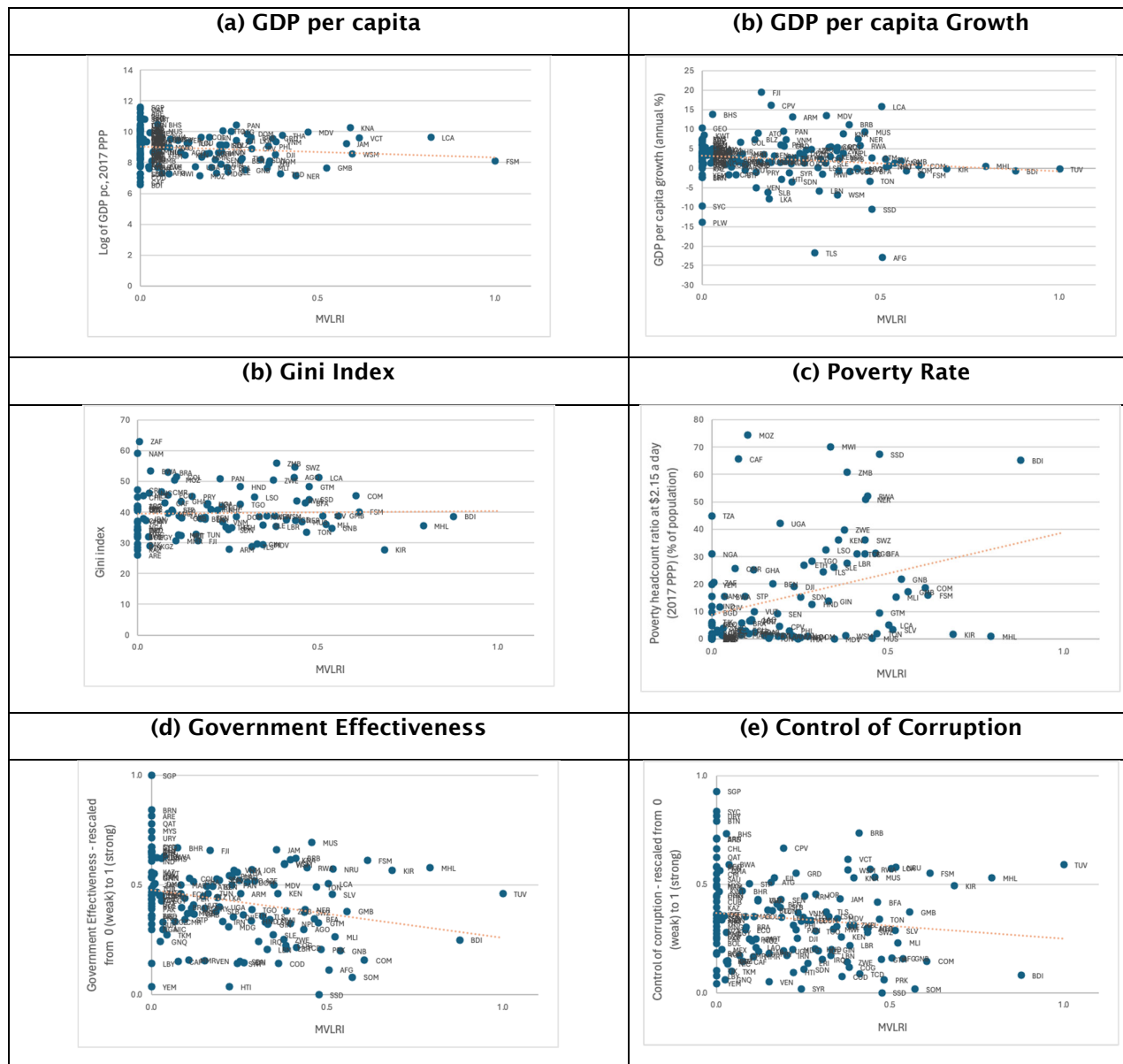
Appendix Figure 8 Aggregate Lack of Resilience Groups



Appendix Figure 9 Multidimensional Vulnerability Groups



Appendix Figure 10. MVLRI and Aggregate Measures of Economic Performance



Source: Authors' calculations using data from EMDAT-CRET, FAO, The University of West Anglia, UNDESA, UNCTAD, WHO, and the World Bank.

Appendix Tables

Table 1 Sector Vulnerability Results							
Country	ISO	EconV	EconVg	EnvV	EnvVg	SocV	SocVg
Afghanistan	AFG	4.3253	1	1.0885	2	4.3165	2
Angola	AGO	2.7430	2	1.1657	2	15.3555	2
United Arab Emirates	ARE	1.5571	3	1.6468	2	1.0532	3
Argentina	ARG	1.0000	3	1.0531	2	19.4521	1
Armenia	ARM	3.2502	2	1.0000	3	3.5739	2
Antigua and Barbuda	ATG	4.5943	1	2.4101	1	35.1124	1
Azerbaijan	AZE	3.2692	2	1.0000	3	6.1159	2
Burundi	BDI	3.7216	2	1.0000	3	7.5246	2
Benin	BEN	3.7509	2	1.6495	2	13.6275	2
Burkina Faso	BFA	2.9710	2	1.3573	2	12.3178	2
Bangladesh	BGD	2.4782	2	1.7025	2	3.5137	3
Bahrain	BHR	2.5088	2	1.0060	2	7.2030	2
Bahamas	BHS	3.3842	2	2.0019	1	22.7304	1
Belize	BLZ	3.6462	2	2.2649	1	30.5659	1
Bolivia (Plurinational State of)	BOL	1.7364	2	1.1511	2	18.4090	1
Brazil	BRA	1.0000	3	1.5936	2	28.7987	1
Barbados	BRB	2.4044	2	1.4547	2	5.6631	2
Brunei Darussalam	BRN	2.5002	2	1.2803	2	1.0000	3
Bhutan	BTN	3.7025	2	1.0000	3	1.1367	3
Botswana	BWA	4.5000	1	1.1057	2	32.3081	1
Central African Republic	CAF	3.6915	2	1.0000	3	9.5884	2
Chile	CHL	1.4260	3	1.4289	2	9.1744	2
China	CHN	1.8064	2	1.2666	2	7.2758	2
Côte D'Ivoire	CIV	2.2986	2	1.0000	3	10.4080	2
Cameroon	CMR	1.2322	3	1.0002	3	14.3152	2
Democratic Republic of the Congo	COD	3.1900	2	1.0000	3	13.3004	2
Congo	COG	3.1189	2	1.0000	3	12.7054	2
Colombia	COL	1.2486	3	1.2822	2	14.4525	2
Comoros	COM	3.3549	2	1.5301	2	10.1233	2
Cabo Verde	CPV	5.4649	1	1.7269	2	2.0664	3
Costa Rica	CRI	1.4479	3	1.8319	1	15.2197	2
Cuba	CUB	2.0894	2	1.9824	1	17.9630	1
Djibouti	DJI	4.8911	1	2.1174	1	16.5131	2
Dominica	DMA	4.4108	1	1.6318	2	5.6631	2
Dominican Republic	DOM	2.3142	2	1.4389	2	33.4017	1
Algeria	DZA	2.1681	2	1.4134	2	10.7699	2
Ecuador	ECU	1.7772	2	1.3742	2	27.3501	1
Egypt	EGY	1.2850	3	1.3834	2	9.4799	2
Eritrea	ERI	6.3852	1	1.9988	1	10.4676	2
Ethiopia	ETH	2.2708	2	1.0760	2	14.3177	2
Fiji	FJI	3.8541	2	2.4563	1	4.7806	2
Micronesia (Federated States of)	FSM	4.3089	1	2.4739	1	11.9514	2
Gabon	GAB	2.2980	2	1.0872	2	5.8606	2
Georgia	GEO	3.0862	2	1.0000	3	3.3508	3
Ghana	GHA	2.3059	2	1.3687	2	11.9619	2
Guinea	GIN	4.3840	1	1.3308	2	9.9423	2
Gambia	GMB	4.9425	1	1.7652	2	1.9988	3
Guinea-Bissau	GNB	4.3659	1	1.4303	2	9.0850	2
Equatorial Guinea	GNQ	2.6854	2	1.0000	3	5.7857	2
Grenada	GRD	6.6167	1	2.0692	1	5.6631	2
Guatemala	GTM	1.0000	3	1.0000	3	15.0223	2
Guyana	GUY	4.9122	1	1.8696	1	14.5334	2
Honduras	HND	2.2921	2	1.3209	2	17.5251	2

Haiti	HTI	4.4004	1	2.3240	1	12.5937	2
Indonesia	IDN	1.0000	3	1.2736	2	9.5573	2
India	IND	1.5507	3	1.8069	1	3.2997	3
Iran (Islamic Republic of)	IRN	2.0921	2	1.2828	2	9.5710	2
Iraq	IRQ	4.0706	1	1.3266	2	2.9934	3
Jamaica	JAM	2.8927	2	2.2586	1	7.2456	2
Jordan	JOR	2.2053	2	1.0051	2	10.8492	2
Kazakhstan	KAZ	1.8445	2	1.0351	2	3.8043	2
Kenya	KEN	1.1828	3	1.7060	2	15.1934	2
Kyrgyzstan	KGZ	2.6951	2	1.0000	3	6.0203	2
Cambodia	KHM	2.6489	2	2.3541	1	9.3014	2
Kiribati	KIR	5.2130	1	1.0357	2	1.7745	3
Saint Kitts and Nevis	KNA	3.2037	2	1.8612	1	26.7874	1
Kuwait	KWT	2.2838	2	1.6135	2	13.0911	2
Lao PDR	LAO	1.5933	3	1.1199	2	4.8914	2
Lebanon	LBN	3.2372	2	1.0000	3	3.2197	3
Liberia	LBR	2.9585	2	1.0000	3	11.2070	2
Libya	LBY	6.6852	1	1.3959	2	7.6001	2
Saint Lucia	LCA	5.5507	1	2.4197	1	28.7893	1
Sri Lanka	LKA	1.4974	3	1.8566	1	4.7856	2
Lesotho	LSO	3.5699	2	1.0000	3	25.4601	1
Morocco	MAR	1.3189	3	1.0989	2	1.9600	3
Madagascar	MDG	2.9814	2	1.3120	2	7.0059	2
Maldives	MDV	5.2358	1	1.6885	2	4.7856	2
Mexico	MEX	1.7027	2	1.5025	2	35.1124	1
Marshall Islands	MHL	1.6638	2	1.0510	2	1.4839	3
Mali	MLI	3.1616	2	1.5202	2	9.9927	2
Myanmar	MMR	3.1686	2	1.5196	2	2.5143	3
Mongolia	MNG	3.0339	2	1.5801	2	1.0000	3
Mozambique	MOZ	2.9064	2	1.7178	2	26.7661	1
Mauritania	MRT	4.8236	1	2.0942	1	9.5641	2
Mauritius	MUS	3.0744	2	1.0699	2	7.7306	2
Malawi	MWI	2.6136	2	1.1173	2	11.2981	2
Malaysia	MYS	1.7567	2	1.9971	1	5.4413	2
Namibia	NAM	2.3128	2	1.6458	2	30.2670	1
Niger	NER	2.0946	2	1.6383	2	12.7334	2
Nigeria	NGA	2.7045	2	1.7923	2	10.5290	2
Nicaragua	NIC	1.7210	2	1.2927	2	35.5058	1
Nepal	NPL	3.0533	2	1.0000	3	3.4620	3
Nauru	NRU	5.1724	1	1.0000	3	9.9542	2
Oman	OMN	2.6193	2	1.8374	1	3.1850	3
Pakistan	PAK	2.2485	2	1.5698	2	7.5240	2
Panama	PAN	2.1083	2	1.3937	2	29.1589	1
Peru	PER	1.7338	2	1.1552	2	24.4599	1
Philippines	PHL	2.3278	2	1.8786	1	2.3350	3
Palau	PLW	4.3331	1	1.5690	2	1.5884	3
Papua New Guinea	PNG	1.9527	2	1.0000	3	1.4175	3
Democratic People's Republic of Korea	PRK	1.0000	3	1.0000	3	1.0000	3
Paraguay	PRY	2.7421	2	1.1224	2	22.5500	1
Qatar	QAT	2.2663	2	1.0257	2	1.3954	3
Rwanda	RWA	2.3175	2	1.0000	3	9.9668	2
Saudi Arabia	SAU	2.0648	2	1.3383	2	6.3804	2
Sudan	SDN	1.4948	3	1.7340	2	15.2674	2
Senegal	SEN	1.3085	3	2.1220	1	10.8938	2
Singapore	SGP	1.7542	2	1.0000	3	1.1686	3
Solomon Islands	SLB	3.8633	2	1.0332	2	11.5008	2
Sierra Leone	SLE	2.6235	2	1.3608	2	9.4085	2
El Salvador	SLV	1.7596	2	1.3325	2	18.9011	1

Somalia	SOM	1.0000	3	2.0321	1	11.0427	2
South ?Sudan	SSD	1.6502	3	1.2525	2	13.5146	2
Sao Tome and Principe	STP	4.6831	1	1.0000	3	10.7408	2
Suriname	SUR	3.4549	2	1.0890	2	27.1657	1
Eswatini	SWZ	3.5111	2	1.0000	3	35.1124	1
Seychelles	SYC	3.5922	2	1.5386	2	3.6979	2
Syrian Arab Republic	SYR	4.1482	1	1.0000	3	9.7050	2
Chad	TCD	3.7662	2	1.5754	2	14.9647	2
Togo	TGO	1.9243	2	1.2922	2	9.0285	2
Thailand	THA	1.7810	2	2.3908	1	6.9093	2
Tajikistan	TJK	3.5026	2	1.0000	3	7.2023	2
Turkmenistan	TKM	1.9425	2	1.0000	3	4.7136	2
Timor-Leste	TLS	3.6419	2	1.4432	2	1.4175	3
Tonga	TON	3.8115	2	1.4957	2	1.3323	3
Trinidad and Tobago	TTO	3.8146	2	1.3383	2	35.1124	1
Tunisia	TUN	1.4307	3	1.1910	2	9.3371	2
Turkey	TUR	1.2581	3	1.0000	3	8.1323	2
Tuvalu	TUV	4.1043	1	1.0000	3	1.0000	3
United Republic of Tanzania	TZA	1.2712	3	1.6877	2	9.1021	2
Uganda	UGA	2.2478	2	1.2250	2	10.0599	2
Uruguay	URY	1.6111	3	1.0000	3	26.3052	1
Uzbekistan	UZB	1.2077	3	1.0000	3	3.8133	2
Saint Vincent and the Grenadines	VCT	4.5683	1	2.1955	1	15.8007	2
Venezuela (Bolivarian Republic of)	VEN	1.0000	3	1.2212	2	33.7622	1
Viet Nam	VNM	1.5845	3	1.8082	1	3.5416	2
Vanuatu	VUT	4.3710	1	1.0000	3	1.2887	3
Samoa	WSM	1.8708	2	1.9948	1	6.4473	2
Yemen	YEM	4.6515	1	1.8042	2	1.0889	3
South Africa	ZAF	1.3783	3	1.4784	2	30.9603	1
Zambia	ZMB	3.5791	2	1.0466	2	16.3454	2
Zimbabwe	ZWE	2.8777	2	1.0700	2	31.6891	1
Mean		2.8493		1.4264		11.7984	
Standard Deviation		1.29278		0.415478		9.45302	

Table 2 Aggregate Vulnerability Results			
Country	ISO	V	Vg
Afghanistan	AFG	1.0885	2
Angola	AGO	1.1657	2
United Arab Emirates	ARE	1.0532	2
Argentina	ARG	1.0000	3
Armenia	ARM	1.0000	3
Antigua and Barbuda	ATG	2.4101	1
Azerbaijan	AZE	1.0000	3
Burundi	BDI	1.0000	3
Benin	BEN	1.6495	2
Burkina Faso	BFA	1.3573	2
Bangladesh	BGD	1.7025	1
Bahrain	BHR	1.0060	2
Bahamas	BHS	2.0019	1
Belize	BLZ	2.2649	1
Bolivia (Plurinational State of)	BOL	1.1511	2
Brazil	BRA	1.0000	3
Barbados	BRB	1.4547	2
Brunei Darussalam	BRN	1.0000	3
Bhutan	BTN	1.0000	3
Botswana	BWA	1.1057	2
Central African Republic	CAF	1.0000	3
Chile	CHL	1.4260	2
China	CHN	1.2666	2
Côte D'Ivoire	CIV	1.0000	3
Cameroon	CMR	1.0002	3
Democratic Republic of the Congo	COD	1.0000	3
Congo	COG	1.0000	3
Colombia	COL	1.2486	2
Comoros	COM	1.5301	2
Cabo Verde	CPV	1.7269	1
Costa Rica	CRI	1.4479	2
Cuba	CUB	1.9824	1
Djibouti	DJI	2.1174	1
Dominica	DMA	1.6318	2
Dominican Republic	DOM	1.4389	2
Algeria	DZA	1.4134	2
Ecuador	ECU	1.3742	2
Egypt	EGY	1.2850	2
Eritrea	ERI	1.9988	1
Ethiopia	ETH	1.0760	2
Fiji	FJI	2.4563	1
Micronesia (Federated States of)	FSM	2.4739	1
Gabon	GAB	1.0872	2
Georgia	GEO	1.0000	3
Ghana	GHA	1.3687	2
Guinea	GIN	1.3308	2
Gambia	GMB	1.7652	1
Guinea-Bissau	GNB	1.4303	2
Equatorial Guinea	GNQ	1.0000	3
Grenada	GRD	2.0692	1
Guatemala	GTM	1.0000	3
Guyana	GUY	1.8696	1
Honduras	HND	1.3209	2

Haiti	HTI	2.3240	1
Indonesia	IDN	1.0000	3
India	IND	1.5507	2
Iran (Islamic Republic of)	IRN	1.2828	2
Iraq	IRQ	1.3266	2
Jamaica	JAM	2.2586	1
Jordan	JOR	1.0051	2
Kazakhstan	KAZ	1.0351	2
Kenya	KEN	1.1828	2
Kyrgyzstan	KGZ	1.0000	3
Cambodia	KHM	2.3541	1
Kiribati	KIR	1.0357	2
Saint Kitts and Nevis	KNA	1.8612	1
Kuwait	KWT	1.6135	2
Lao PDR	LAO	1.1199	2
Lebanon	LBN	1.0000	3
Liberia	LBR	1.0000	3
Libya	LBY	1.3959	2
Saint Lucia	LCA	2.4197	1
Sri Lanka	LKA	1.4974	2
Lesotho	LSO	1.0000	3
Morocco	MAR	1.0989	2
Madagascar	MDG	1.3120	2
Maldives	MDV	1.6885	1
Mexico	MEX	1.5025	2
Marshall Islands	MHL	1.0510	2
Mali	MLI	1.5202	2
Myanmar	MMR	1.5196	2
Mongolia	MNG	1.0000	3
Mozambique	MOZ	1.7178	1
Mauritania	MRT	2.0942	1
Mauritius	MUS	1.0699	2
Malawi	MWI	1.1173	2
Malaysia	MYS	1.7567	1
Namibia	NAM	1.6458	2
Niger	NER	1.6383	2
Nigeria	NGA	1.7923	1
Nicaragua	NIC	1.2927	2
Nepal	NPL	1.0000	3
Nauru	NRU	1.0000	3
Oman	OMN	1.8374	1
Pakistan	PAK	1.5698	2
Panama	PAN	1.3937	2
Peru	PER	1.1552	2
Philippines	PHL	1.8786	1
Palau	PLW	1.5690	2
Papua New Guinea	PNG	1.0000	3
Democratic People's Republic of Korea	PRK	1.0000	3
Paraguay	PRY	1.1224	2
Qatar	QAT	1.0257	2
Rwanda	RWA	1.0000	3
Saudi Arabia	SAU	1.3383	2
Sudan	SDN	1.4948	2
Senegal	SEN	1.3085	2
Singapore	SGP	1.0000	3
Solomon Islands	SLB	1.0332	2
Sierra Leone	SLE	1.3608	2
El Salvador	SLV	1.3325	2

Somalia	SOM	1.0000	3
South ?Sudan	SSD	1.2525	2
Sao Tome and Principe	STP	1.0000	3
Suriname	SUR	1.0890	2
Eswatini	SWZ	1.0000	3
Seychelles	SYC	1.5386	2
Syrian Arab Republic	SYR	1.0000	3
Chad	TCD	1.5754	2
Togo	TGO	1.2922	2
Thailand	THA	1.7810	1
Tajikistan	TJK	1.0000	3
Turkmenistan	TKM	1.0000	3
Timor-Leste	TLS	1.4175	2
Tonga	TON	1.3323	2
Trinidad and Tobago	TTO	1.3383	2
Tunisia	TUN	1.1910	2
Turkey	TUR	1.0000	3
Tuvalu	TUV	1.0000	3
United Republic of Tanzania	TZA	1.2712	2
Uganda	UGA	1.2250	2
Uruguay	URY	1.0000	3
Uzbekistan	UZB	1.0000	3
Saint Vincent and the Grenadines	VCT	2.1955	1
Venezuela (Bolivarian Republic of)	VEN	1.0000	3
Viet Nam	VNM	1.5845	2
Vanuatu	VUT	1.0000	3
Samoa	WSM	1.8708	1
Yemen	YEM	1.0889	2
South Africa	ZAF	1.3783	2
Zambia	ZMB	1.0466	2
Zimbabwe	ZWE	1.0700	2
Mean		1.3633	
Standard Deviation		0.3962	

Table 3 Sector Lack of Resilience Results							
County	ISO	EconLR	EconLRg	EnvLR	EnvLRg	SocLR	SocLRg
Afghanistan	AFG	3.0101	1	14.2954	1	2.1982	2
Angola	AGO	2.4834	2	5.7993	2	2.0300	2
United Arab Emirates	ARE	2.6365	2	14.9816	1	1.0000	3
Argentina	ARG	2.5904	2	11.7582	2	1.0000	3
Armenia	ARM	1.7891	2	12.5408	2	1.6009	2
Antigua and Barbuda	ATG	2.7645	2	7.2612	2	1.3728	2
Azerbaijan	AZE	2.9647	2	12.0205	2	1.6947	2
Burundi	BDI	3.0818	1	11.8192	2	3.6796	1
Benin	BEN	1.4130	3	8.1644	2	2.7197	1
Burkina Faso	BFA	2.1028	2	12.9558	2	2.5960	1
Bangladesh	BGD	1.0000	3	10.7467	2	2.5966	1
Bahrain	BHR	2.7812	2	15.0117	1	1.1772	2
Bahamas	BHS	4.4316	1	11.7407	2	1.0705	3
Belize	BLZ	2.8070	2	4.5816	2	1.3529	2
Bolivia (Plurinational State of)	BOL	2.3396	2	5.8197	2	1.0000	3
Brazil	BRA	3.1934	1	5.5497	2	1.2009	2
Barbados	BRB	3.8649	1	10.7484	2	1.9761	2
Brunei Darussalam	BRN	3.8061	1	1.0000	3	1.4287	2
Bhutan	BTN	1.0000	3	3.0709	3	1.1806	2
Botswana	BWA	2.7009	2	13.2273	2	1.0848	3
Central African Republic	CAF	2.2081	2	1.1786	3	2.3527	2
Chile	CHL	2.7947	2	11.3576	2	1.0000	3
China	CHN	1.0000	3	11.0777	2	1.4811	2
Côte D'Ivoire	CIV	1.5015	2	1.5328	3	2.4422	1
Cameroon	CMR	1.1571	3	3.0922	3	2.0627	2
Democratic Republic of the Congo	COD	2.3708	2	3.0736	3	2.5880	1
Congo	COG	1.9072	2	3.9336	2	2.0009	2
Colombia	COL	2.2977	2	4.2904	2	1.2555	2
Comoros	COM	3.3082	1	3.7729	2	4.0042	1
Cabo Verde	CPV	1.4580	3	13.9231	2	1.7684	2
Costa Rica	CRI	3.3959	1	5.5756	2	1.0000	3
Cuba	CUB	2.4674	2	6.6019	2	1.0000	3
Djibouti	DJI	2.9765	2	15.0799	1	1.5548	2
Dominica	DMA	2.8615	2	1.0255	3	1.4311	2
Dominican Republic	DOM	1.6475	2	5.3748	2	2.2218	2
Algeria	DZA	1.0000	3	14.3579	1	1.2456	2
Ecuador	ECU	1.8081	2	3.8387	2	1.1994	2
Egypt	EGY	1.0692	3	14.9468	1	1.8545	2
Eritrea	ERI	1.6246	2	14.4540	1	1.9641	2
Ethiopia	ETH	1.6199	2	11.2348	2	2.1247	2
Fiji	FJI	2.2720	2	2.0294	3	1.4839	2
Micronesia (Federated States of)	FSM	4.5832	1	14.5916	1	2.4577	1
Gabon	GAB	3.2448	1	1.2902	3	1.4585	2
Georgia	GEO	1.9308	2	7.3414	2	1.0000	3
Ghana	GHA	1.2839	3	7.0388	2	2.4835	1
Guinea	GIN	1.7973	2	3.6220	2	2.2078	2
Gambia	GMB	2.3216	2	10.9137	2	3.4674	1
Guinea-Bissau	GNB	3.1860	1	4.1248	2	2.2774	2
Equatorial Guinea	GNQ	3.2748	1	1.0591	3	1.9470	2
Grenada	GRD	4.3206	1	3.4721	3	1.5448	2
Guatemala	GTM	2.1296	2	5.5789	2	2.3407	2
Guyana	GUY	2.3268	2	1.0000	3	1.0000	3
Honduras	HND	1.7817	2	4.4328	2	1.6755	2

Haiti	HTI	1.5273	2	7.8354	2	3.6316	1
Indonesia	IDN	1.0448	3	2.0997	3	1.8731	2
India	IND	1.0000	3	11.6501	2	2.9975	1
Iran (Islamic Republic of)	IRN	1.5690	2	14.2539	1	1.4805	2
Iraq	IRQ	1.7256	2	14.5942	1	1.8438	2
Jamaica	JAM	2.2866	2	3.1494	3	2.2465	2
Jordan	JOR	1.8331	2	14.9783	1	1.6808	2
Kazakhstan	KAZ	1.9801	2	13.5041	2	1.0000	3
Kenya	KEN	1.8527	2	12.9003	2	2.1508	2
Kyrgyzstan	KGZ	1.0778	3	13.8915	2	1.3390	2
Cambodia	KHM	1.0686	3	7.1649	2	1.6938	2
Kiribati	KIR	4.1352	1	14.2889	1	2.6261	1
Saint Kitts and Nevis	KNA	2.8947	2	4.3187	2	1.9402	2
Kuwait	KWT	2.7673	2	15.0569	1	1.0171	3
Lao People's Democratic Republic	LAO	1.7629	2	2.0912	3	1.3492	2
Lebanon	LBN	1.7803	2	12.4029	2	2.0632	2
Liberia	LBR	3.1713	1	2.3829	3	2.2838	2
Libya	LBY	1.8604	2	14.2341	1	1.0000	3
Saint Lucia	LCA	4.1033	1	2.7007	3	2.3875	1
Sri Lanka	LKA	1.4455	3	3.5157	3	1.8720	2
Lesotho	LSO	2.8136	2	14.5251	1	1.7702	2
Morocco	MAR	1.1975	3	13.4033	2	1.6051	2
Madagascar	MDG	1.5202	2	9.9819	2	2.0110	2
Maldives	MDV	2.9262	2	14.8109	1	1.8261	2
Mexico	MEX	1.8412	2	9.1803	2	1.0378	3
Marshall Islands	MHL	3.6244	1	14.6785	1	2.8818	1
Mali	MLI	2.2417	2	13.3852	2	2.4378	1
Myanmar	MMR	1.2517	3	4.2598	2	1.6179	2
Mongolia	MNG	2.2356	2	13.0245	2	1.0000	3
Mozambique	MOZ	1.2431	3	3.7517	2	1.9221	2
Mauritania	MRT	1.2691	3	14.8279	1	1.6097	2
Mauritius	MUS	3.1939	1	9.2817	2	2.0818	2
Malawi	MWI	1.8010	2	9.5369	2	3.0176	1
Malaysia	MYS	1.7567	2	1.0000	3	1.3160	2
Namibia	NAM	2.9773	2	13.3650	2	1.0000	3
Niger	NER	2.0386	2	13.7225	2	2.5222	1
Nigeria	NGA	1.0000	3	9.8696	2	3.4412	1
Nicaragua	NIC	1.7529	2	7.5022	2	1.0764	3
Nepal	NPL	1.9389	2	6.8338	2	2.0849	2
Nauru	NRU	2.2253	2	14.9874	1	3.9355	1
Oman	OMN	3.2459	1	15.0014	1	1.0000	3
Pakistan	PAK	1.0000	3	14.0217	2	3.0343	1
Panama	PAN	1.5984	2	4.1457	2	1.5432	2
Peru	PER	2.0234	2	5.7234	2	1.2274	2
Philippines	PHL	1.5254	2	4.2379	2	2.5046	1
Palau	PLW	4.4669	1	4.6842	2	1.0000	3
Papua New Guinea	PNG	3.0373	1	1.0000	3	1.7341	2
Democratic People's Republic of Korea	PRK	2.4578	2	5.4613	2	2.1464	2
Paraguay	PRY	2.1726	2	5.7514	2	1.3589	2
Qatar	QAT	2.4067	2	15.0465	1	1.0000	3
Rwanda	RWA	2.0496	2	11.7139	2	2.1078	2
Saudi Arabia	SAU	2.3968	2	14.7866	1	1.0000	3
Sudan	SDN	1.5996	2	13.3462	2	1.8702	2
Senegal	SEN	1.4425	3	11.5221	2	1.9045	2
Singapore	SGP	2.4064	2	11.3065	2	1.0000	3
Solomon Islands	SLB	2.6707	2	1.4360	3	1.9714	2
Sierra Leone	SLE	3.8839	1	1.8237	3	2.4762	1
El Salvador	SLV	2.5428	2	7.3927	2	2.2211	2

Somalia	SOM	3.9947	1	14.2629	1	2.3574	2
South Sudan	SSD	3.9540	1	8.9865	2	2.1302	2
Sao Tome and Principe	STP	2.0915	2	1.3105	3	2.8406	1
Suriname	SUR	1.0000	3	2.0329	3	1.0000	3
Eswatini	SWZ	2.9058	2	7.4536	2	2.0337	2
Seychelles	SYC	2.7924	2	12.8959	2	1.0000	3
Syrian Arab Republic	SYR	1.5789	2	13.9816	2	2.2208	2
Chad	TCD	1.9797	2	13.2132	2	2.3252	2
Togo	TGO	1.6771	2	7.3098	2	2.6683	1
Thailand	THA	1.6593	2	6.8054	2	1.5822	2
Tajikistan	TJK	1.0000	3	14.5508	1	1.5974	2
Turkmenistan	TKM	1.4935	3	14.1507	2	1.1033	3
Timor-Leste	TLS	2.6978	2	2.7167	3	1.8253	2
Tonga	TON	2.5728	2	10.7116	2	2.1141	2
Trinidad and Tobago	TTO	2.7477	2	3.5654	3	1.5949	2
Tunisia	TUN	1.5974	2	13.1203	2	1.3842	2
Turkey	TUR	1.0000	3	10.6291	2	1.5999	2
Tuvalu	TUV	5.1280	1	14.6629	1	3.3736	1
United Republic of Tanzania	TZA	1.0000	3	7.1010	2	2.1158	2
Uganda	UGA	1.4597	3	10.4904	2	2.8565	1
Uruguay	URY	3.2601	1	11.9451	2	1.0000	3
Uzbekistan	UZB	1.5077	2	14.6639	1	1.0000	3
Saint Vincent and the Grenadines	VCT	3.0053	2	2.3546	3	2.5474	1
Venezuela (Bolivarian Republic of)	VEN	3.1438	1	5.6442	2	1.3593	2
Viet Nam	VNM	1.5573	2	4.9880	2	2.1239	2
Vanuatu	VUT	2.7123	2	1.2857	3	2.0944	2
Samoa	WSM	3.1430	1	14.3975	1	1.9006	2
Yemen	YEM	1.0000	3	14.8750	1	2.3372	2
South Africa	ZAF	2.8621	2	13.0843	2	1.0125	3
Zambia	ZMB	1.9136	2	4.4775	2	2.1219	2
Zimbabwe	ZWE	2.2727	2	7.4549	2	1.8944	2
Mean		2.2751		8.7449		1.8644	
Standard Deviation		0.91034		4.84017		0.68961	

Table 4 Aggregate Lack of Resilience Results

County	ISO	LR	LRg
Afghanistan	AFG	2.1982	1
Angola	AGO	2.0300	1
United Arab Emirates	ARE	1.0000	2
Argentina	ARG	1.0000	3
Armenia	ARM	1.6009	2
Antigua and Barbuda	ATG	1.3728	2
Azerbaijan	AZE	1.6947	2
Burundi	BDI	3.0818	1
Benin	BEN	1.4130	2
Burkina Faso	BFA	2.1028	1
Bangladesh	BGD	1.0000	3
Bahrain	BHR	1.1772	2
Bahamas	BHS	1.0705	2
Belize	BLZ	1.3529	2
Bolivia (Plurinational State of)	BOL	1.0000	3
Brazil	BRA	1.2009	2
Barbados	BRB	1.9761	1
Brunei Darussalam	BRN	1.0000	3
Bhutan	BTN	1.0000	3
Botswana	BWA	1.0848	2
Central African Republic	CAF	1.1786	2
Chile	CHL	1.0000	3
China	CHN	1.0000	3
Côte D'Ivoire	CIV	1.0543	2
Cameroon	CMR	1.1571	2
Democratic Republic of the Congo	COD	1.8570	2
Congo	COG	1.9072	2
Colombia	COL	1.2555	2
Comoros	COM	2.4393	1
Cabo Verde	CPV	1.4580	2
Costa Rica	CRI	1.0000	3
Cuba	CUB	1.0000	3
Djibouti	DJI	1.5548	2
Dominica	DMA	1.0255	2
Dominican Republic	DOM	1.6475	2
Algeria	DZA	1.0000	3
Ecuador	ECU	1.1994	2
Egypt	EGY	1.0692	2
Eritrea	ERI	1.6246	2
Ethiopia	ETH	1.6199	2
Fiji	FJI	1.3952	2
Micronesia (Federated States of)	FSM	2.4577	1
Gabon	GAB	1.2902	2
Georgia	GEO	1.0000	3
Ghana	GHA	1.2839	2
Guinea	GIN	1.7880	2
Gambia	GMB	2.3216	1
Guinea-Bissau	GNB	2.2774	1
Equatorial Guinea	GNQ	1.0591	2
Grenada	GRD	1.5448	2
Guatemala	GTM	2.1296	1
Guyana	GUY	1.0000	3
Honduras	HND	1.6755	2

Haiti	HTI	1.5273	2
Indonesia	IDN	1.0377	2
India	IND	1.0000	3
Iran (Islamic Republic of)	IRN	1.4805	2
Iraq	IRQ	1.7256	2
Jamaica	JAM	1.8454	2
Jordan	JOR	1.6808	2
Kazakhstan	KAZ	1.0000	3
Kenya	KEN	1.8527	2
Kyrgyzstan	KGZ	1.0778	2
Cambodia	KHM	1.0686	2
Kiribati	KIR	2.6261	1
Saint Kitts and Nevis	KNA	1.9402	1
Kuwait	KWT	1.0171	2
Lao People's Democratic Republic	LAO	1.2710	2
Lebanon	LBN	1.7803	2
Liberia	LBR	1.9117	2
Libya	LBY	1.0000	3
Saint Lucia	LCA	2.1937	1
Sri Lanka	LKA	1.4455	2
Lesotho	LSO	1.7702	2
Morocco	MAR	1.1975	2
Madagascar	MDG	1.5202	2
Maldives	MDV	1.8261	2
Mexico	MEX	1.0378	2
Marshall Islands	MHL	2.8818	1
Mali	MLI	2.2417	1
Myanmar	MMR	1.2517	2
Mongolia	MNG	1.0000	3
Mozambique	MOZ	1.2431	2
Mauritania	MRT	1.2691	2
Mauritius	MUS	2.0818	1
Malawi	MWI	1.8010	2
Malaysia	MYS	1.0000	3
Namibia	NAM	1.0000	2
Niger	NER	2.0386	1
Nigeria	NGA	1.0000	3
Nicaragua	NIC	1.0764	2
Nepal	NPL	1.9389	1
Nauru	NRU	2.2253	1
Oman	OMN	1.0000	2
Pakistan	PAK	1.0000	2
Panama	PAN	1.5432	2
Peru	PER	1.2274	2
Philippines	PHL	1.5254	2
Palau	PLW	1.0000	3
Papua New Guinea	PNG	1.0000	3
Democratic People's Republic of Korea	PRK	2.1464	1
Paraguay	PRY	1.3589	2
Qatar	QAT	1.0000	2
Rwanda	RWA	2.0496	1
Saudi Arabia	SAU	1.0000	3
Sudan	SDN	1.5996	2
Senegal	SEN	1.4425	2
Singapore	SGP	1.0000	3
Solomon Islands	SLB	1.4360	2
Sierra Leone	SLE	1.8237	2
El Salvador	SLV	2.2211	1

Somalia	SOM	2.3574	1
South Sudan	SSD	2.1302	1
Sao Tome and Principe	STP	1.2259	2
Suriname	SUR	1.0000	3
Eswatini	SWZ	2.0337	1
Seychelles	SYC	1.0000	3
Syrian Arab Republic	SYR	1.5789	2
Chad	TCD	1.9797	1
Togo	TGO	1.6771	2
Thailand	THA	1.5822	2
Tajikistan	TJK	1.0000	3
Turkmenistan	TKM	1.1033	2
Timor-Leste	TLS	1.7506	2
Tonga	TON	2.1141	1
Trinidad and Tobago	TTO	1.5949	2
Tunisia	TUN	1.3842	2
Turkey	TUR	1.0000	3
Tuvalu	TUV	3.3736	1
United Republic of Tanzania	TZA	1.0000	3
Uganda	UGA	1.4597	2
Uruguay	URY	1.0000	2
Uzbekistan	UZB	1.0000	3
Saint Vincent and the Grenadines	VCT	1.9003	2
Venezuela (Bolivarian Republic of)	VEN	1.3593	2
Viet Nam	VNM	1.5573	2
Vanuatu	VUT	1.2857	2
Samoa	WSM	1.9006	2
Yemen	YEM	1.0000	2
South Africa	ZAF	1.0125	2
Zambia	ZMB	1.9136	2
Zimbabwe	ZWE	1.8944	2
Mean		1.5004	
Standard Deviation		0.49759	

Table 5 Multidimensional Vulnerability Results							
Country	ISO	V	LR	MVLRI	sV	sLR	MVLRig
Afghanistan	AFG	1.0885	2.1982	1.0885	0	0.9187	2
Angola	AGO	1.1657	2.0300	1.1657	0	0.8579	2
United Arab Emirates	ARE	1.0532	1.0000	1.0000	1	0	3
Argentina	ARG	1.0000	1.0000	1.0000	0	1	3
Armenia	ARM	1.0000	1.6009	1.0000	0	1	2
Antigua and Barbuda	ATG	2.4101	1.3728	1.3728	0.7284	0	2
Azerbaijan	AZE	1.0000	1.6947	1.0000	0	1	2
Burundi	BDI	1.0000	3.0818	1.0000	0	1	2
Benin	BEN	1.6495	1.4130	1.4130	0.7077	0	1
Burkina Faso	BFA	1.3573	2.1028	1.3573	0	0.7368	2
Bangladesh	BGD	1.7025	1.0000	1.0000	1	0	2
Bahrain	BHR	1.0060	1.1772	1.0060	0	0.9941	2
Bahamas	BHS	2.0019	1.0705	1.0705	0.9342	0	2
Belize	BLZ	2.2649	1.3529	1.3529	0.7392	0	2
Bolivia (Plurinational State of)	BOL	1.1511	1.0000	1.0000	1	0	3
Brazil	BRA	1.0000	1.2009	1.0000	0	1	3
Barbados	BRB	1.4547	1.9761	1.4547	0	0.6874	1
Brunei Darussalam	BRN	1.0000	1.0000	1.0000	0	1	3
Bhutan	BTN	1.0000	1.0000	1.0000	0	1	3
Botswana	BWA	1.1057	1.0848	1.0848	0.9219	0	2
Central African Republic	CAF	1.0000	1.1786	1.0000	0	1	3
Chile	CHL	1.4260	1.0000	1.0000	1	0	2
China	CHN	1.2666	1.0000	1.0000	1	0	3
Côte D'Ivoire	CIV	1.0000	1.0543	1.0000	0	1	3
Cameroon	CMR	1.0002	1.1571	1.0002	0	0.9998	2
Democratic Republic of the Congo	COD	1.0000	1.8570	1.0000	0	1	2
Congo	COG	1.0000	1.9072	1.0000	0	1	2
Colombia	COL	1.2486	1.2555	1.2486	0	0.8009	2
Comoros	COM	1.5301	2.4393	1.5301	0	0.6536	1
Cabo Verde	CPV	1.7269	1.4580	1.4580	0.6859	0	1
Costa Rica	CRI	1.4479	1.0000	1.0000	1	0	2
Cuba	CUB	1.9824	1.0000	1.0000	1	0	2
Djibouti	DJI	2.1174	1.5548	1.5548	0.6432	0	1
Dominica	DMA	1.6318	1.0255	1.0255	0.9752	0	2
Dominican Republic	DOM	1.4389	1.6475	1.4389	0	0.695	1
Algeria	DZA	1.4134	1.0000	1.0000	1	0	2
Ecuador	ECU	1.3742	1.1994	1.1994	0.8337	0	2
Egypt	EGY	1.2850	1.0692	1.0692	0.9353	0	2
Eritrea	ERI	1.9988	1.6246	1.6246	0.6155	0	1
Ethiopia	ETH	1.0760	1.6199	1.0760	0	0.9294	2
Fiji	FJI	2.4563	1.3952	1.3952	0.7167	0	1
Micronesia (Federated States of)	FSM	2.4739	2.4577	2.4577	0.4069	0	1
Gabon	GAB	1.0872	1.2902	1.0872	0	0.9198	2
Georgia	GEO	1.0000	1.0000	1.0000	0	1	3
Ghana	GHA	1.3687	1.2839	1.2839	0.7789	0	2
Guinea	GIN	1.3308	1.7880	1.3308	0	0.7514	2
Gambia	GMB	1.7652	2.3216	1.7652	0	0.5665	1
Guinea-Bissau	GNB	1.4303	2.2774	1.4303	0	0.6991	1
Equatorial Guinea	GNQ	1.0000	1.0591	1.0000	0	1	3
Grenada	GRD	2.0692	1.5448	1.5448	0.6473	0	1
Guatemala	GTM	1.0000	2.1296	1.0000	0	1	2
Guyana	GUY	1.8696	1.0000	1.0000	1	0	2
Honduras	HND	1.3209	1.6755	1.3209	0	0.757	2

Haiti	HTI	2.3240	1.5273	1.5273	0.6548	0	1
Indonesia	IDN	1.0000	1.0377	1.0000	0	1	3
India	IND	1.5507	1.0000	1.0000	1	0	2
Iran (Islamic Republic of)	IRN	1.2828	1.4805	1.2828	0	0.7795	2
Iraq	IRQ	1.3266	1.7256	1.3266	0	0.7538	2
Jamaica	JAM	2.2586	1.8454	1.8454	0.5419	0	1
Jordan	JOR	1.0051	1.6808	1.0051	0	0.9949	2
Kazakhstan	KAZ	1.0351	1.0000	1.0000	1	0	3
Kenya	KEN	1.1828	1.8527	1.1828	0	0.8454	2
Kyrgyzstan	KGZ	1.0000	1.0778	1.0000	0	1	3
Cambodia	KHM	2.3541	1.0686	1.0686	0.9358	0	2
Kiribati	KIR	1.0357	2.6261	1.0357	0	0.9655	2
Saint Kitts and Nevis	KNA	1.8612	1.9402	1.8612	0	0.5373	1
Kuwait	KWT	1.6135	1.0171	1.0171	0.9832	0	2
Lao PDR	LAO	1.1199	1.2710	1.1199	0	0.8929	2
Lebanon	LBN	1.0000	1.7803	1.0000	0	1	2
Liberia	LBR	1.0000	1.9117	1.0000	0	1	2
Libya	LBY	1.3959	1.0000	1.0000	1	0	2
Saint Lucia	LCA	2.4197	2.1937	2.1937	0.4559	0	1
Sri Lanka	LKA	1.4974	1.4455	1.4455	0.6918	0	1
Lesotho	LSO	1.0000	1.7702	1.0000	0	1	2
Morocco	MAR	1.0989	1.1975	1.0989	0	0.91	2
Madagascar	MDG	1.3120	1.5202	1.3120	0	0.7622	2
Maldives	MDV	1.6885	1.8261	1.6885	0	0.5922	1
Mexico	MEX	1.5025	1.0378	1.0378	0.9636	0	2
Marshall Islands	MHL	1.0510	2.8818	1.0510	0	0.9515	2
Mali	MLI	1.5202	2.2417	1.5202	0	0.6578	1
Myanmar	MMR	1.5196	1.2517	1.2517	0.7989	0	2
Mongolia	MNG	1.0000	1.0000	1.0000	0	1	3
Mozambique	MOZ	1.7178	1.2431	1.2431	0.8044	0	2
Mauritania	MRT	2.0942	1.2691	1.2691	0.788	0	2
Mauritius	MUS	1.0699	2.0818	1.0699	0	0.9347	2
Malawi	MWI	1.1173	1.8010	1.1173	0	0.895	2
Malaysia	MYS	1.7567	1.0000	1.0000	1	0	2
Namibia	NAM	1.6458	1.0000	1.0000	1	0	2
Niger	NER	1.6383	2.0386	1.6383	0	0.6104	1
Nigeria	NGA	1.7923	1.0000	1.0000	1	0	2
Nicaragua	NIC	1.2927	1.0764	1.0764	0.929	0	2
Nepal	NPL	1.0000	1.9389	1.0000	0	1	2
Nauru	NRU	1.0000	2.2253	1.0000	0	1	2
Oman	OMN	1.8374	1.0000	1.0000	1	0	2
Pakistan	PAK	1.5698	1.0000	1.0000	1	0	2
Panama	PAN	1.3937	1.5432	1.3937	0	0.7175	2
Peru	PER	1.1552	1.2274	1.1552	0	0.8656	2
Philippines	PHL	1.8786	1.5254	1.5254	0.6556	0	1
Palau	PLW	1.5690	1.0000	1.0000	1	0	2
Papua New Guinea	PNG	1.0000	1.0000	1.0000	0	1	3
Democratic People's Republic of Korea	PRK	1.0000	2.1464	1.0000	0	1	2
Paraguay	PRY	1.1224	1.3589	1.1224	0	0.891	2
Qatar	QAT	1.0257	1.0000	1.0000	1	0	3
Rwanda	RWA	1.0000	2.0496	1.0000	0	1	2
Saudi Arabia	SAU	1.3383	1.0000	1.0000	1	0	2
Sudan	SDN	1.4948	1.5996	1.4948	0	0.669	1
Senegal	SEN	1.3085	1.4425	1.3085	0	0.7643	2
Singapore	SGP	1.0000	1.0000	1.0000	0	1	3
Solomon Islands	SLB	1.0332	1.4360	1.0332	0	0.9679	2
Sierra Leone	SLE	1.3608	1.8237	1.3608	0	0.7348	2
El Salvador	SLV	1.3325	2.2211	1.3325	0	0.7505	2

Somalia	SOM	1.0000	2.3574	1.0000	0	1	2
South ?Sudan	SSD	1.2525	2.1302	1.2525	0	0.7984	2
Sao Tome and Principe	STP	1.0000	1.2259	1.0000	0	1	3
Suriname	SUR	1.0890	1.0000	1.0000	1	0	3
Eswatini	SWZ	1.0000	2.0337	1.0000	0	1	2
Seychelles	SYC	1.5386	1.0000	1.0000	1	0	2
Syrian Arab Republic	SYR	1.0000	1.5789	1.0000	0	1	2
Chad	TCD	1.5754	1.9797	1.5754	0	0.6347	1
Togo	TGO	1.2922	1.6771	1.2922	0	0.7739	2
Thailand	THA	1.7810	1.5822	1.5822	0.632	0	1
Tajikistan	TJK	1.0000	1.0000	1.0000	0	1	3
Turkmenistan	TKM	1.0000	1.1033	1.0000	0	1	3
Timor-Leste	TLS	1.4175	1.7506	1.4175	0	0.7054	1
Tonga	TON	1.3323	2.1141	1.3323	0	0.7506	2
Trinidad and Tobago	TTO	1.3383	1.5949	1.3383	0	0.7472	2
Tunisia	TUN	1.1910	1.3842	1.1910	0	0.8396	2
Turkey	TUR	1.0000	1.0000	1.0000	0	1	3
Tuvalu	TUV	1.0000	3.3736	1.0000	0	1	2
United Republic of Tanzania	TZA	1.2712	1.0000	1.0000	1	0	2
Uganda	UGA	1.2250	1.4597	1.2250	0	0.8163	2
Uruguay	URY	1.0000	1.0000	1.0000	0	1	3
Uzbekistan	UZB	1.0000	1.0000	1.0000	0	1	3
Saint Vincent and the Grenadines	VCT	2.1955	1.9003	1.9003	0.5262	0	1
Venezuela (Bolivarian Republic of)	VEN	1.0000	1.3593	1.0000	0	1	3
Viet Nam	VNM	1.5845	1.5573	1.5573	0.6421	0	1
Vanuatu	VUT	1.0000	1.2857	1.0000	0	1	3
Samoa	WSM	1.8708	1.9006	1.8708	0	0.5345	1
Yemen	YEM	1.0889	1.0000	1.0000	1	0	3
South Africa	ZAF	1.3783	1.0125	1.0125	0.9876	0	2
Zambia	ZMB	1.0466	1.9136	1.0466	0	0.9555	2
Zimbabwe	ZWE	1.0700	1.8944	1.0700	0	0.9346	2
Mean		1.3633	1.5004	1.1893			
Standard Deviation		0.3962	0.49759	0.26889			

Table 6 The Most Multidimensionally Vulnerable Nations

Country	ISO	V	Vg	LR	LRg	MVLRI	MVLRig
Benin	BEN	1.649541	2	1.413007	2	1.413007	1
Barbados	BRB	1.454712	2	1.976063	1	1.454712	1
Comoros	COM	1.530059	2	2.439336	1	1.530059	1
Cabo Verde	CPV	1.726922	1	1.457985	2	1.457985	1
Djibouti	DJI	2.117407	1	1.554806	2	1.554806	1
Dominican Republic	DOM	1.438917	2	1.647547	2	1.438917	1
Eritrea	ERI	1.998806	1	1.624633	2	1.624633	1
Fiji	FJI	2.456276	1	1.395248	2	1.395248	1
Micronesia (Federated States of)	FSM	2.473855	1	2.457668	1	2.457668	1
Gambia	GMB	1.765193	1	2.321628	1	1.765193	1
Guinea-Bissau	GNB	1.430333	2	2.27739	1	1.430333	1
Grenada	GRD	2.06918	1	1.544835	2	1.544835	1
Haiti	HTI	2.324017	1	1.527252	2	1.527252	1
Jamaica	JAM	2.258585	1	1.845446	2	1.845446	1
Saint Kitts and Nevis	KNA	1.8612	1	1.940191	1	1.8612	1
Saint Lucia	LCA	2.419722	1	2.193665	1	2.193665	1
Sri Lanka	LKA	1.497404	2	1.445499	2	1.445499	1
Maldives	MDV	1.688508	1	1.826089	2	1.688508	1
Mali	MLI	1.520156	2	2.241687	1	1.520156	1
Niger	NER	1.638336	2	2.038614	1	1.638336	1
Philippines	PHL	1.878551	1	1.525424	2	1.525424	1
Sudan	SDN	1.49482	2	1.599612	2	1.49482	1
Chad	TCD	1.575436	2	1.979683	1	1.575436	1
Thailand	THA	1.780982	1	1.582218	2	1.582218	1
Timor-Leste	TLS	1.417549	2	1.75064	2	1.417549	1
Saint Vincent and the Grenadines	VCT	2.195549	1	1.900257	2	1.900257	1
Viet Nam	VNM	1.584478	2	1.557323	2	1.557323	1
Samoa	WSM	1.870765	1	1.900585	2	1.870765	1

Table 7 An Illustration of the Use of Shadow Values														
Table 7.1														
Country	ISO	V	LR	MVI	sV	sLR	MVlg							
Fiji	FJI	2.4563	1.3952	1.3952	0.7167	0	1							
Micronesia (f FSM		2.4739	2.4577	2.4577	0.4069	0	1							
Table 7.2														
Country	ISO	EconV	EnvV	SocV	V	sEconV	sEnvV	sSocV						
Fiji	FJI	3.8541	2.4563	4.7806	2.4563	0.4071	0	0.4071						
Micronesia (f FSM		4.3089	2.4739	11.9514	2.4739	0	0.4042	0						
Table 7.3a														
Country	ISO	EconV1	EconV2	EconV3	EconV	sEconV1	sEconV2	sEconV3						
Fiji	FJI	30.6875	51.5049	61.0415	3.8541	0.0033	0.0145	0.0025						
Country	ISO	SocV1	SocV2	SocV3	SocV4	SocV	sSocV1	sSocV2	sSocV3	sSocV4				
Fiji	FJI	0	0	29.0129	0.1173	4.7806	0.0212	0.7918	0.0118	5.5943				
Table 7.3b														
Country	ISO	EnvV1	EnvV2	EnvV3	EnvV4	EnvV5	EnvV6	EnvV	sEnvV1	sEnvV2	sEnvV3	sEnvV4	sEnvV5	sEnvV6
Micronesia (f FSM		91.9724	22.3953	78.4188	77.2755	0	22.6173	2.4739	0.4042	0.0003	0	0.0073	0.0052	0.0137

**Appendix Table 8. Tobit Estimates of the Relationship between MVLRI and
Aggregate Measures of Economic Performance**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	MVLRI	VI	LRI	MVLRI	VI	LRI	MVLRI	VI	LRI	MVLRI	VI	LRI	MVLRI	VI	LRI	MVLRI	VI	LRI
Log of GDP per capita, PPP (constant 2017 international \$)	-0.077** (0.031)	-0.000 (0.036)	-0.144*** (0.027)															
GDP per capita growth				0.059 (0.413)	0.912** (0.356)	-0.508* (0.292)												
Gini index							-0.027 (0.418)	0.063 (0.438)	-0.253 (0.419)									
Poverty headcount ratio at \$2.15 a day (2017 PPP)										-0.102 (0.162)	-0.227 (0.202)	0.314* (0.184)						
Government Effectiveness													0.005 (0.151)	0.244 (0.188)	-0.449*** (0.129)			
Control of corruption																-0.000 (0.142)	0.190 (0.173)	-0.268** (0.122)
Constant	0.761** (0.293)	0.231 (0.337)	1.500*** (0.260)	0.073 (0.067)	0.226*** (0.080)	0.213*** (0.066)	0.192 (0.147)	0.296* (0.176)	0.332** (0.161)	0.187** (0.078)	0.329*** (0.086)	0.229*** (0.067)	0.058 (0.094)	0.079 (0.119)	0.457*** (0.092)	0.061 (0.081)	0.129 (0.106)	0.334*** (0.073)
No. Countries	135	135	135	140	140	140	96	96	96	96	96	96	142	142	142	142	142	142
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses clustered at the country level

Significance at 1%***, 5%** , and 10%*

Note: The indices MVLRI, VI and LRI, and the indicators for government effectiveness and control of corruption are rescaled between 0 and 1.

