# A Synthetic Assessment of the Global Distribution of Vulnerability to Climate Change from the IPCC Perspective that Reflects Exposure and Adaptive Capacity

Gary Yohe[a], Elizabeth Malone[b], Antoinette Brenkert[b], Michael Schlesinger[c], Henk Meij[d] , Xiaoshi Xing[e], Daniel Lee[a]

a[1]. Department of Economics, Wesleyan University, Middletown, CT 06459 USA
b. Joint Global Change Research Institute, College Park, MD 20740 USA
c. The Climate Research Group, Department of Admospheric Sciences, University of Illinois at Urbana-Champaign, Urbana, IL 61801 USA
d. Information Technology Services, Wesleyan University, Middletown, CT 06459 USA
e. Center for International Earth Science Information Network, Columbia University, Palisades, NY 10964, USA

**Motivation:**

IPCC (2001) expressed "high confidence" in the conclusion that "developing countries will be more vulnerable to climate change than developed countries (pg. 916)". This pronouncement has framed subsequent discussions despite concern raised elsewhere in Chapter 18 of the same assessment that "current knowledge of adaptation and adaptive capacity is insufficient for reliable prediction of adaptations (pg. 880)" because "the capacity to adapt varies considerably among regions, countries and socioeconomic groups and will vary over time (pg. 879)". In an attempt to reconcile this apparent contradiction, we employ the IPCC (2001) framework that vulnerability is a function of exposure, sensitivity and adaptive capacity to organize a synthetic assessment of new knowledge and available tools to produce geographically explicit qualitative portraits of vulnerability designed explicitly to incorporate both exposure to climate change (across a range of futures as reflected in temperature change) and subjective judgments of national capacities to adapt.

**Background:**

Several national level indices of environmental vulnerability exist. The "Environmental Sustainability Index" (ESI) was jointly created by the Yale Center for Environmental Law and Policy located at Yale University and the Center for International Earth Science Information Network (CIESIN) located at Columbia University in collaboration with the World Economic Forum and the Joint Research Center. It has global coverage; see http://www.yale.edu/esi or http://sedac.ciesin.columbia.edu/es/esi for details. The "Environmental Vulnerability Index" (EVI) of the South Pacific Applied Geosciences Commission is a second with global coverage; see http://sopac.org/tiki/tiki-index.php?page=EVI for details. Both of these indices are widely cited. Both build from exposure to environmental stress and a wide range of social, economic, and political factors, but neither explicitly reflects the extra stress of climate change. Indeed, climate concerns are registered only through national participation in mitigation.

Antoinette Brenkert and Elizabeth Malone, working in collaboration with Richard Moss, have applied their Vulnerability-Resilience Indicator Model (VRIM) to produce a third index for 100 countries wherein more than 80% of the world's population resides; see Brenkert and Malone (2005) for a complete description of the model and coverage of an early application to a more limited set of countries. Their index is also moot on sensitivity to climate change stresses, *per se*, but their approach does have the advantage of dividing their indicator into two major components – one that reflects sensitivity and a second that reflects adaptive capacity. Moreover, the underlying factors from which the strength of the adaptive capacity component is estimated conform well to the determinants of adaptive capacity highlighted in IPCC (2001, Chapter 18) and subsequent literature; see, for example Yohe and Tol (2002). These are, as well, the same determinants that serve as the building blocks for much of the discussion of adaptation found in Chapter 17 and 18 of the Fourth Assessment Report.

[1] Corresponding author: Gary Yohe (gyohe@wesleyan.edu)

**Method:**

Given the commonality of their approach to the IPCC work, we chose to offer mapping portraits of relative vulnerability to climate change derived from combinations of the national Brenkert and Malone adaptive capacity indices and ranges of possible temperature change at the national level for 2050 and 2100. These temperature ranges, drawn from Country Specific Model for Intertemporal Climate (COSMIC) downscaling described in Schlesinger and Williams (2000), have been chosen to "bracket" much of the published distribution of plausible climate change over the next century. To that end, A2 and B2 scenarios were considered for two climate sensitivities – one at the low end of the range of current estimates (1.5$^{o}$C) and one at the lower bound of the high end of recent work (5.5$^{o}$C); see Andronova and Schlesinger (2001), for example, as well as the contribution of WGI to the AR4. For the lower sensitivity, COSMIC reports A2 and B2 producing increases in global mean temperature of 2.81$^{o}$C and 1.16$^{o}$C, respectively, from 2000 through 2100. For the higher sensitivity, COSMIC shows A2 and B2 increasing global mean temperature by 4.86$^{o}$C and 3.33$^{o}$C, respectively, over the same time frame. Local manifestations of these global trends vary, of course, from location to location

The Vulnerability-Resilience Indicator Model (VRIM) takes a hierarchical approach in constructing a vulnerability index as the geometric mean of various measures of sensitivity (how systems could be negatively affected by environmental stresses) and adaptive capacity (the capability of a society to maintain, minimize loss of, or maximize gains in welfare). Sensitivity and adaptive capacity are composed, in turn, by underlying determinants that include, for adaptive capacity, human resources (dependency ratios and literacy rates), economic capacity (market GDP per capita and income distribution), and environmental capacity (population density, sulfur dioxide emissions, percentage of unmanaged land). For sensitivity, they include settlement/infrastructure, food security, ecosystems, human health, and water resources. Table 1 divides their sample of 102 countries into thirds according to their VRIM estimates of vulnerability. Discrepancies against the ESI rankings for the same countries are highlighted there by a color code, and the strong (though not perfect) correlation between the two is displayed in Figure 1. Indeed, this correlation was employed to add ten countries to global sample when the maps are drawn to achieve improved coverage in Africa and northern Asia.[2]

COSMIC converts the transient outputs of various global circulation models into national averages for annual and monthly precipitation and temperature in a way that assures internal consistency with underlying scenarios for changes in global mean temperature along specific emissions trajectories for climate sensitivities between 1.0$^{o}$C and 9.5$^{o}$C. We tracked national temperature change in terms of annual means (computed from a small ensemble of the global circulation models referenced in COSMIC that range from least to most sensitive to increases in atmospheric concentrations of greenhouse gases) as well as the usual seasonable dichotomies (December, January and February versus June, July and August) for two years (2050 and 2100) using population weights for the averaging process. The two emissions trajectories and the two climate sensitivities that we chose offered national glimpses at exposure to relatively modest and potentially severe climate change. Despite the differences across scenarios, all of these portraits of future climate change are "not-implausible" depictions of changes in global mean temperature over the course of this century.

A series of maps was created to portray the geographical distribution of combined national indices of exposure and sensitivity. These indices were, for each year and each combination of underlying parameters, defined as the quotient of modified national VRIM adaptive capacity indices (anchored to unity for the global average) and projected temperature change. To be more specific, we converted each national VRIM index to a number anchored at unity by dividing each by the world average; values below 1 are therefore indicative of countries with low adaptive capacity while values above 1 suggest higher than average adaptive capacity.

The maps suggest vulnerability by color schemes that were calibrated to three areas of concern highlighted in the "burning ember" diagram of IPCC (2001, Figure TS-12). Figure 2 replicates that diagram to show the color scale for concern about "Aggregate Impacts"; it also displays roughly the same color scale for "Risks from Extreme Weather Events" and "Risks to Unique and Threatened Systems". In all cases, a country with adaptive capacity near the global average that would see temperature changes that closely follow the global mean as the future unfolds

[2] The countries added are: Germany, Russia, Mauritania, Mali, Niger, Chad, Zambia, Namibia, Georgia and Cuba.

were assigned colors on the maps that were coincident with the original burning embers diagram. Countries with lower adaptive capacity and/or countries that would confront higher than average temperature change were assigned colors further to the right on the "burning embers" scale to indicate more pronounced reasons for concern; and countries with higher adaptive capacity and/or countries facing lower than average temperature change were assigned colors further to the left to indicate diminished concern.

The various panels of Figure 3 displays preliminary results for three countries chosen to represent the three categories depicted in Table 1 (i.e., Kenya with low adaptive capacity indexed at 0.47; Costa Rica with higher adaptive capacity that is still below the world average with an index value 0.91; and the Netherlands with high adaptive capacity index estimated to be 1.30). Four combinations of SRES storyline and climate sensitivity are noted for annual mean temperature as well as the DJF and JJA averages; moreover, two alternative color calibrations are also offered. More specifically, the values identified as Maps 1 and 4 display vulnerabilities based on increased annual mean temperature along A2 with climate sensitivities of 1.5$^{o}$C and 5.5$^{o}$C, respectively. Designations for Maps 2 and 5 do the same for increased annual mean temperature along B2. Maps 3 and 6 meanwhile offer a glimpse at the value of mitigation by displaying vulnerabilities for the two climate sensitivities with along a least-cost mitigation trajectory that limits atmospheric concentrations from an A2 baseline to 550 ppm. Maps 7 through 12 reflect comparable results with exposure reflected in changes in the average temperature during the months of December, January and February; and Maps 13 through 18 repeat the process for average temperatures during the months of June, July and August.

It was already evident from these representative countries that the value of high adaptive capacity could be undermined by exaggerated climate change (the Netherlands case), at least in comparison with a more average adaptive capacity being exercised in the face of more modest climate change (the Costa Rica case). It is also clear that vulnerability to the "Risks from Extreme Climate Events" and "Risks to Unique and Threatened Species" are more severe in all cases. The "burning embers" reflect this increased concern for changes in the global mean temperature, but the maps hold the promise of assessing the geographic distribution of the relative intensities of these concerns.

**Results – Discussing a Representative Sample of the Maps:**

*Vulnerability in the Medium Term – 2050:*

Figure 4 offers the first glimpse at the geographic distribution of vulnerability calibrated to aggregate impacts along the B2 and A2 emissions scenarios for climate sensitivities of 1.5$^{o}$C and 5.5$^{o}$C; note in passing that areas colored light green indicate countries for which data were not available. Vulnerability is relatively modest across the globe for the two scenarios portrayed on the left panel maps for a climate sensitivity of 1.5$^{o}$C; the light yellow tint (that reflects concern in burning embers consistent with something like 2$^{o}$C of further warming since the year 2000) materializes only in southern South America and southern Africa. Increased vulnerability is portrayed on the right panel maps for a climate sensitivity of 5.5$^{o}$C, particularly for China, northern and southern Africa, central South America. This is the beginning of a suggestive confirmation that developing countries are among the most vulnerable to climate change, but they may not be alone. It is important to note yellow and pale orange coloration assigned to countries across Europe and North America. They might not be most vulnerable, but it would appear that they are not immune climate risks, either.

Figure 7 replicates the synthesis portrayed in Figure 4 using a color calibration tied to the risk of extreme events line of evidence recorded in the burning ember. The left panel scenarios, again characterized by setting the climate sensitivity equal to 1.5$^{o}$C, distributes significant vulnerability across the globe, this time quiet even-handedly. Regional differentiation reappears in the right hand panels, though, when the climate sensitivity equals 5.5$^{o}$C. Notice, in particular, that much of South America, southern Asia, and most of the African nations included in the sample show the dark red coloration of significant vulnerability. So, too, do China and some of Eastern Europe. High sensitivity brings exposure to high temperatures that cannot, at least against a metric of concern calibrated to the risk of extreme events, be ameliorated significantly by exercising even significant stores of adaptive capacity. Indeed, North America and Europe are shown to be extremely vulnerable. Calibrating vulnerability to climate change against the risk of extreme events therefore seems to undermine the conclusion that developing countries are most vulnerable in the sense that it offers a portrait of widespread vulnerability across the globe where adaptive capacity is overwhelmed by climate change even over the next 40 years of so.

*Vulnerability in the Longer Term – 2100:*

Figures 5 and 8 repeat the exercise described above for the year 2100 for the two alternative color calibrations. Low climate sensitivity continues to support the notion that China along with developing countries in Africa, southern Asia and South America are most vulnerable regardless of the color calibration. The high sensitivity scenarios, however, again overwhelm differences in adaptive capacity in every case except the one in which the vulnerability along the B2 emissions scenario is calibrated by aggregate impacts. There, the now familiar geographical pattern persists.

*Vulnerability with Mitigation along A2-550 in 2050 and 2100:*

Figures 6 and 9 offer a glimpse at the possible geographical distribution of the complementary benefits of mitigation (a concentration cap) cast into a world that tries to exploit an uneven allocation of adaptive capacity. Again, vulnerability is reflected by two alternative color calibrations. Looking first at the maps coded to aggregate impacts, notice by comparing the left panels of Figure 6 with the lower left panels of Figures 4 and 5 that holding concentrations of greenhouse gases below a 550 ppm cap in a low climate sensitivity world reduces modest vulnerability worldwide through 2050. Moreover, the concentration *limit reduces vulnerability through 2100 most significantly in Africa, southern Asia, and South America.* These are, of course, the most vulnerable regions to begin with, so this is a comforting geographical distribution of complementary policies.

Comparing the right panels of Figure 6 with the lower right panels of Figures 4 and 5 suggests that this fortuitous complementarity could even hold for higher sensitivities through 2050, but geographical correlation seems to be reversed by 2100. Rapid and persistent climate change supported by high climate sensitivities would apparently produce enough exposure to higher temperatures in countries all over the world to overwhelm the modest adaptive capacities of developing nations even if concentrations of greenhouse gases were effectively held below a 550 ppm cap.

The same patterns, including the reversal in the geographical distribution of complementary synergies between adaptation and mitigation, are also evident in the Figures 7, 8, and 9 where vulnerability is calibrated to the risk of extreme events. Time is more pressing in those maps, though, because the risk of extreme events is more pressing for lower temperature change in the burning embers. As a result, changes in vulnerability occur earlier in the coming century – to the point that fixing concentrations at 550 ppm is completely ineffective in lowering vulnerability anywhere in the world along the high sensitivity future.

Table 2 describes the complete set of maps from which these representative offerings were drawn. They include reflections of exposure in terms of DJF and JJA temperatures as well as the annual means. They include all three emissions scenarios. And they include representations of the effect of enhanced adaptive capacity in 2050 and 2100 (the adaptive capacity indices increasing to either the current global mean or to a value that is 25% higher than the current value – whichever is higher).

**Table 1: Rankings of the 100 Countries in the Brenkert and Malone (2005) Sample by Descending Vulnerability.**

| Lowest Third | Middle Third | Highest Third |
|---|---|---|
| Sierra-Leone | Cambodia | Trinidad-and-Tobago |
| Bangladesh | Iran | Papua-New-Guinea |
| Somalia | Iraq | Ukraine |
| Mozambique | Viet-Nam | Iceland |
| Ethiopia | Peru | Romania |
| Rwanda | Bolivia | Poland |
| Benin | Tunisia | Hungary |
| Yemen | Mexico | Albania |
| Angola | Paraguay | Israel |
| Kenya | Algeria | Greece |
| Senegal | Philippines | Portugal |
| Nigeria | Brazil | UK |
| Uganda | Jordan | Bulgaria |
| Madagascar | Sri-Lanka | S-Korea |
| Sudan | Lebanon | Ireland |
| Nepal | China | Belarus |
| Haiti | Egypt | Spain |
| Guatemala | Gabon | New-Zealand |
| Syria | Saudi-Arabia | Australia |
| Kuwait | Libya | Netherlands |
| Swaziland | Kyrgyzstan | United Arab Emirates |
| Zimbabwe | Ecuador | Italy |
| Pakistan | Indonesia | Belgium |
| S-Africa | Uruguay | Denmark |
| Ghana | Jamaica | USA |
| Nicaragua | Thailand | France |
| India | Colombia | Austria |
| Congo | Chile | Japan |
| Morocco | Panama | Canada |
| Honduras | Turkey | Switzerland |
| El-Salvador | Costa-Rica | Sweden |
| Cameroon | Malaysia | Finland |
| Dominican-Republic | Argentina | Norway |
| | Venezuela | |

Note: Countries whose categories are significantly different according the ESI estimates are highlighted by color – blue indicates location in the next higher category; red indicates location in the next lower category.

**Table 2: Identification of the Various Maps.** Four versions are provided for each – combinations of alternative calibrations to "Aggregate Impacts" and "Risk of Extreme Weather Events" with and without enhanced adaptive capacity.

| | |
|---|---|
| Map 1 | Scenario A2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 2 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 3 | Scenario B2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 4 | Scenario A2 2050 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 5 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 6 | Scenario B2 in 2050 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 7 | Scenario A2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 8 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 9 | Scenario B2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - Annual Mean Temperature |
| Map 10 | Scenario A2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 11 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 12 | Scenario B2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - Annual Mean Temperature |
| Map 13 | Scenario A2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 14 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 15 | Scenario B2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 16 | Scenario A2 2050 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 17 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 18 | Scenario B2 in 2050 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 19 | Scenario A2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 20 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 21 | Scenario B2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - DJF Mean Temperature |
| Map 22 | Scenario A2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 23 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 24 | Scenario B2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - DJF Mean Temperature |
| Map 25 | Scenario A2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 26 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 27 | Scenario B2 in 2050 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 28 | Scenario A2 2050 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |
| Map 29 | Scenario A2-550 in 2050 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |
| Map 30 | Scenario B2 in 2050 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |
| Map 31 | Scenario A2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 32 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 33 | Scenario B2 in 2100 with Climate Sensitivity equal to 1.5 degrees C - JJA Mean Temperature |
| Map 34 | Scenario A2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |
| Map 35 | Scenario A2-550 in 2100 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |
| Map 36 | Scenario B2 in 2100 with Climate Sensitivity equal to 5.5 degrees C - JJA Mean Temperature |

**Figure 1: A Graphical Comparison of the Brenkert-Malone Adaptive Capacity Indices (VRIM) and the Environmental Sustainability Index (ESI), 2005, for the VRIM Sample**

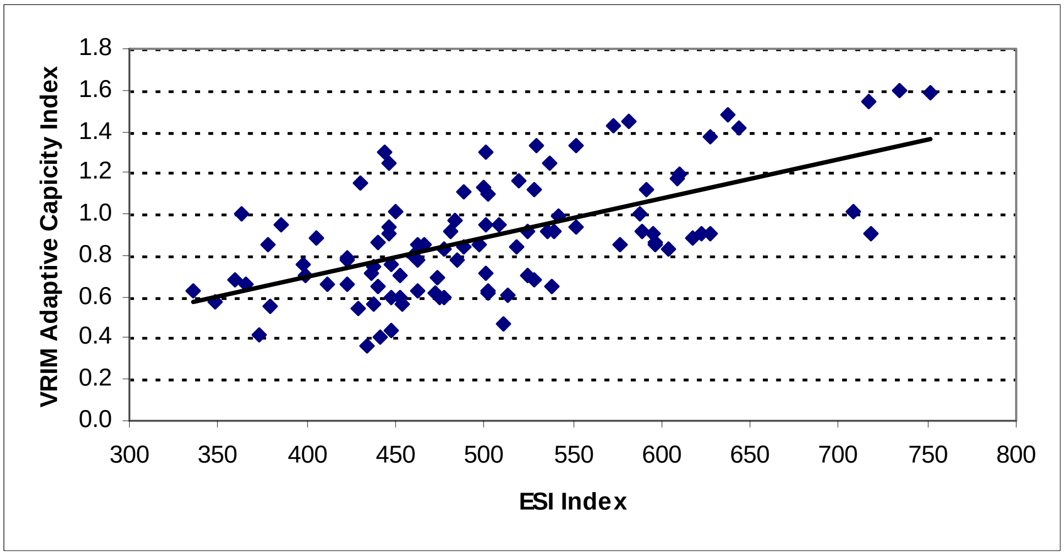
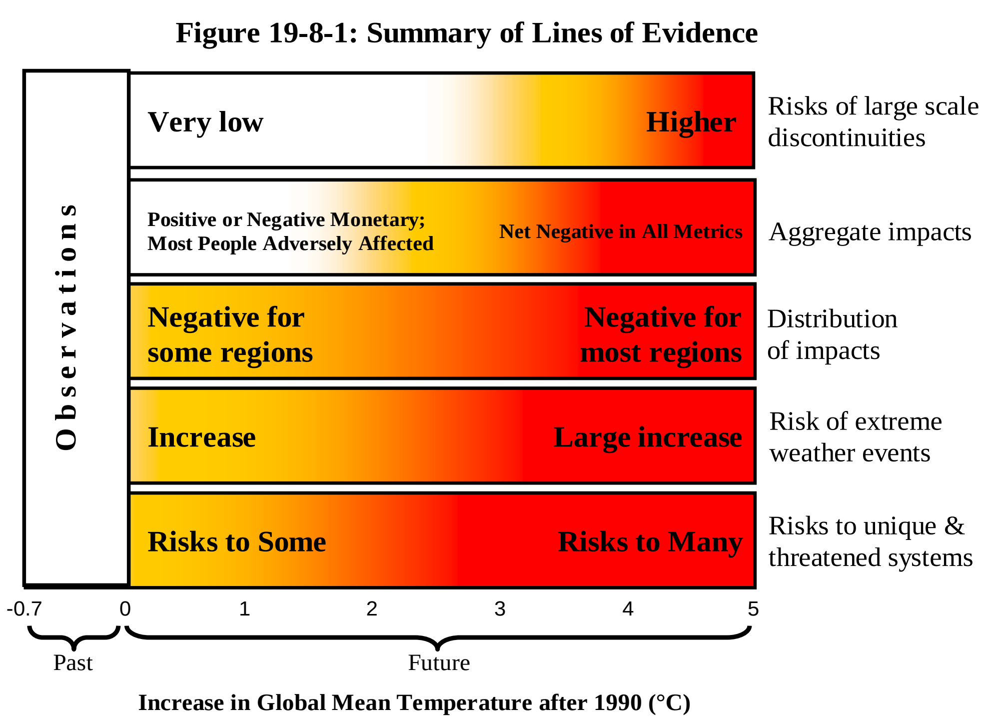



**Figure 2: Color Calibration from the "Burning Embers" (IPCC, 2001, also Figure TS-12)**



## Figure 3: Assessment Results for Three Representative Countries

**PANEL A: VULNERABILITY INDICES & COLOR CODES WITH EXPOSURE IN TERMS OF ANNUAL MEAN TEMPERATURE**

**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF AGGREGATE GLOBAL IMPACTS - TAR Chapter 19**

| | | Year | A2<br>1.5 Degrees<br>Map 1 | B2<br>1.5 Degrees<br>Map 2 | A2 - 550<br>1.5 Degrees<br>Map 3 | A2<br>5.5 Degrees<br>Map 4 | B2<br>5.5 Degrees<br>Map 5 | A2 - 550<br>5.5 Degrees<br>Map 6 |
|---|---|---|---|---|---|---|---|---|
| **Netherlands** | **High AC** | **2050** | 0.48 | 0.56 | 0.37 | 1.20 | 1.48 | 0.96 |
| **Costa Rica** | **Mid AC** | **2050** | 0.38 | 0.46 | 0.28 | 0.70 | 0.91 | 0.56 |
| **Kenya** | **Low AC** | **2050** | 0.79 | 0.93 | 0.64 | 1.97 | 2.38 | 1.60 |
| **Netherlands** | **High AC** | **2100** | 1.57 | 1.01 | 0.97 | 4.07 | 2.85 | 2.64 |
| **Costa Rica** | **Mid AC** | **2100** | 1.26 | 0.61 | 0.79 | 2.45 | 1.71 | 1.60 |
| **Kenya** | **Low AC** | **2100** | 2.53 | 1.63 | 1.54 | 6.48 | 4.56 | 4.22 |

**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF RISK FROM EXTREME EVENTS - TAR Chapter 19**

**Climate Exposure in Terms of Annual Temperature**

| | | Year | A2<br>1.5 Degrees<br>Map 1 | B2<br>1.5 Degrees<br>Map 2 | A2 - 550<br>1.5 Degrees<br>Map 3 | A2<br>5.5 Degrees<br>Map 4 | B2<br>5.5 Degrees<br>Map 5 | A2 - 550<br>5.5 Degrees<br>Map 6 |
|---|---|---|---|---|---|---|---|---|
| **Netherlands** | **High AC** | **2050** | 0.48 | 0.56 | 0.37 | 1.20 | 1.48 | 0.96 |
| **Costa Rica** | **Mid AC** | **2050** | 0.38 | 0.46 | 0.28 | 0.70 | 0.91 | 0.56 |
| **Kenya** | **Low AC** | **2050** | 0.79 | 0.93 | 0.64 | 1.97 | 2.38 | 1.60 |
| **Netherlands** | **High AC** | **2100** | 1.57 | 1.01 | 0.97 | 4.07 | 2.85 | 2.64 |
| **Costa Rica** | **Mid AC** | **2100** | 1.26 | 0.61 | 0.79 | 2.45 | 1.71 | 1.60 |
| **Kenya** | **Low AC** | **2100** | 2.53 | 1.63 | 1.54 | 6.48 | 4.56 | 4.22 |

**Figure 3 continued: Assessment Results for Three Representative Countries**

**PANEL B: VULNERABILITY INDICES & COLOR CODES WITH EXPOSURE IN TERMS OF MEAN TEMPERATURE IN DJF**

**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF AGGREGATE GLOBAL IMPACTS - TAR Chapter 19**

| | | Year | A2<br>1.5 Degrees<br>Map 7 | B2<br>1.5 Degrees<br>Map 8 | A2 - 550<br>1.5 Degrees<br>Map 9 | A2<br>5.5 Degrees<br>Map 10 | B2<br>5.5 Degrees<br>Map 11 | A2 - 550<br>5.5 Degrees<br>Map 12 |
|---|---|---|---|---|---|---|---|---|
| **Netherlands** | **High AC** | **2050** | 0.56 | 0.68 | 0.44 | 1.35 | 1.73 | 1.09 |
| **Costa Rica** | **Mid AC** | **2050** | 0.46 | 0.51 | 0.35 | 0.84 | 1.03 | 0.66 |
| **Kenya** | **Low AC** | **2050** | 1.42 | 1.52 | 1.24 | 2.55 | 2.84 | 2.16 |
| | | | | | | | | |
| **Netherlands** | **High AC** | **2100** | 1.83 | 1.21 | 1.15 | 4.72 | 3.31 | 3.09 |
| **Costa Rica** | **Mid AC** | **2100** | 1.41 | 0.71 | 0.88 | 2.86 | 1.94 | 1.83 |
| **Kenya** | **Low AC** | **2100** | 2.94 | 2.16 | 2.06 | 6.60 | 4.75 | 4.47 |

**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF RISKS FROM EXTREME EVENTS - TAR Chapter 19**

| | | | Climate Exposure in Terms of Temperature in DJF | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Year | A2<br>1.5 Degrees<br>Map 7 | B2<br>1.5 Degrees<br>Map 8 | A2 - 550<br>1.5 Degrees<br>Map 9 | A2<br>5.5 Degrees<br>Map 10 | B2<br>5.5 Degrees<br>Map 11 | A2 - 550<br>5.5 Degrees<br>Map 12 |
| **Netherlands** | **High AC** | **2050** | 0.56 | 0.68 | 0.44 | 1.35 | 1.73 | 1.09 |
| **Costa Rica** | **Mid AC** | **2050** | 0.46 | 0.51 | 0.35 | 0.84 | 1.03 | 0.66 |
| **Kenya** | **Low AC** | **2050** | 1.42 | 1.52 | 1.24 | 2.55 | 2.84 | 2.16 |
| | | | | | | | | |
| **Netherlands** | **High AC** | **2100** | 1.83 | 1.21 | 1.15 | 4.72 | 3.31 | 3.09 |
| **Costa Rica** | **Mid AC** | **2100** | 1.41 | 0.71 | 0.88 | 2.86 | 1.94 | 1.83 |
| **Kenya** | **Low AC** | **2100** | 2.94 | 2.16 | 2.06 | 6.60 | 4.75 | 4.47 |

**Figure 3 continued: Assessment Results for Three Representative Countries**

**PANEL C: VULNERABILITY INDICES & COLOR CODES WITH EXPOSURE IN TERMS OF MEAN TEMPERATURE IN JJA**

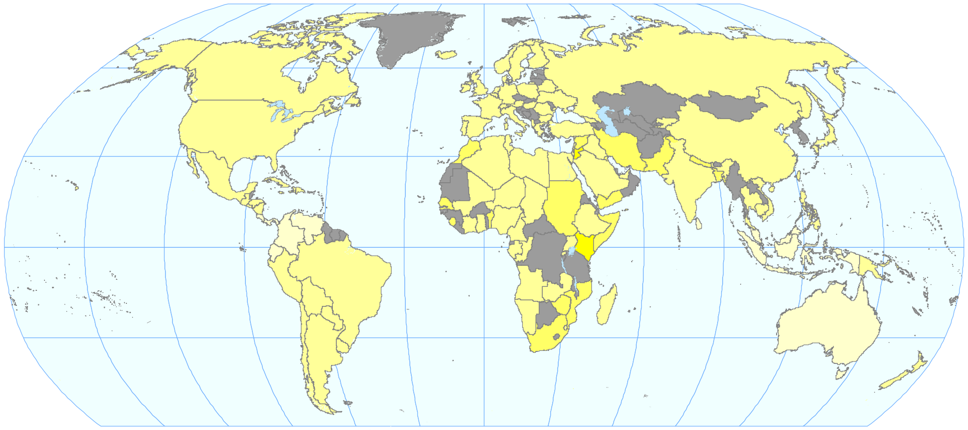
**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF AGGREGATE GLOBAL IMPACTS - TAR Chapter 19**

| | | Year | A2<br>1.5 Degrees<br>Map 13 | B2<br>1.5 Degrees<br>Map 14 | A2 - 550<br>1.5 Degrees<br>Map 15 | A2<br>5.5 Degrees<br>Map 16 | B2<br>5.5 Degrees<br>Map 17 | A2 - 550<br>5.5 Degrees<br>Map 18 |
|---|---|---|---|---|---|---|---|---|
| **Netherlands** | **High AC** | **2050** | 0.56 | 0.56 | 0.42 | 1.45 | 1.54 | 1.14 |
| **Costa Rica** | **Mid AC** | **2050** | 0.29 | 0.40 | 0.20 | 0.55 | 0.81 | 0.46 |
| **Kenya** | **Low AC** | **2050** | 0.82 | 1.06 | 0.67 | 2.13 | 2.73 | 1.77 |
| | | | | | | | | |
| **Netherlands** | **High AC** | **2100** | 1.62 | 1.03 | 0.95 | 4.32 | 2.95 | 2.68 |
| **Costa Rica** | **Mid AC** | **2100** | 1.15 | 0.55 | 0.71 | 2.29 | 1.56 | 1.47 |
| **Kenya** | **Low AC** | **2100** | 2.94 | 1.88 | 1.77 | 7.66 | 5.46 | 5.07 |

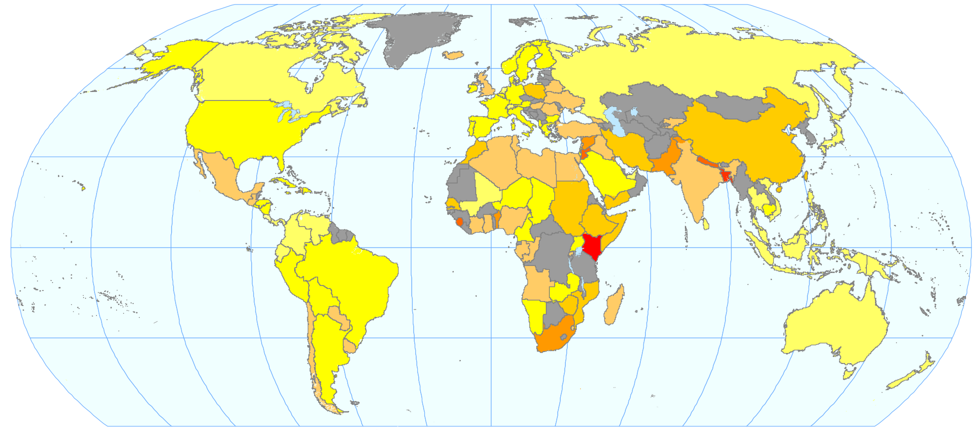
**CALIBRATED TO "CONCERN" EXPRESSED IN TERMS OF RISKS FROM EXTREME EVENTS - TAR Chapter 19**

| | | | Climate Exposure in Terms of Temperature in JJA | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Year | A2<br>1.5 Degrees<br>Map 13 | B2<br>1.5 Degrees<br>Map 14 | A2 - 550<br>1.5 Degrees<br>Map 15 | A2<br>5.5 Degrees<br>Map 16 | B2<br>5.5 Degrees<br>Map 17 | A2 - 550<br>5.5 Degrees<br>Map 18 |
| **Netherlands** | **High AC** | **2050** | 0.56 | 0.56 | 0.42 | 1.45 | 1.54 | 1.14 |
| **Costa Rica** | **Mid AC** | **2050** | 0.29 | 0.40 | 0.20 | 0.55 | 0.81 | 0.46 |
| **Kenya** | **Low AC** | **2050** | 0.82 | 1.06 | 0.67 | 2.13 | 2.73 | 1.77 |
| | | | | | | | | |
| **Netherlands** | **High AC** | **2100** | 1.62 | 1.03 | 0.95 | 4.32 | 2.95 | 2.68 |
| **Costa Rica** | **Mid AC** | **2100** | 1.15 | 0.55 | 0.71 | 2.29 | 1.56 | 1.47 |
| **Kenya** | **Low AC** | **2100** | 2.94 | 1.88 | 1.77 | 7.66 | 5.46 | 5.07 |

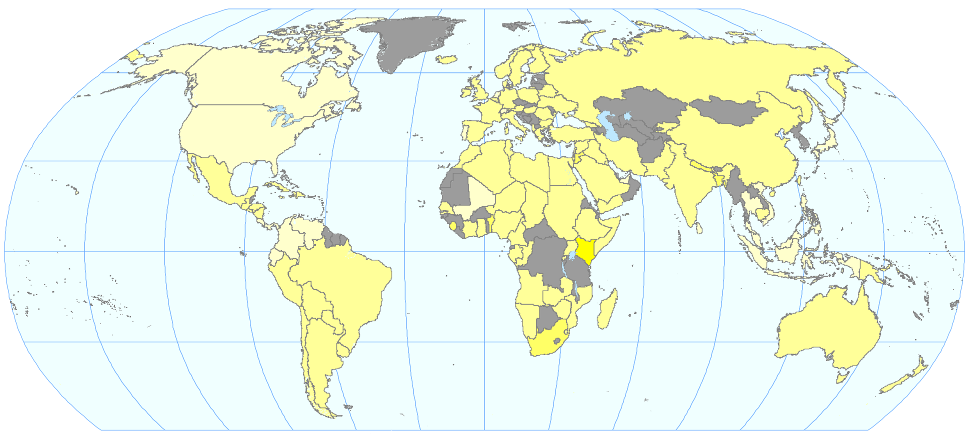
Figure 4: Geographical Distribution of Vulnerability in 2050 Calibrated to Aggregate Impacts



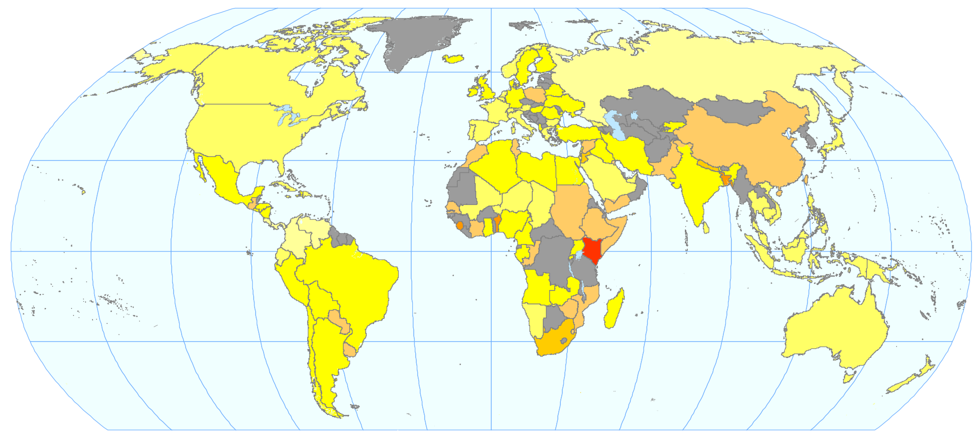
**Scenario B2 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



**Scenario B2 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



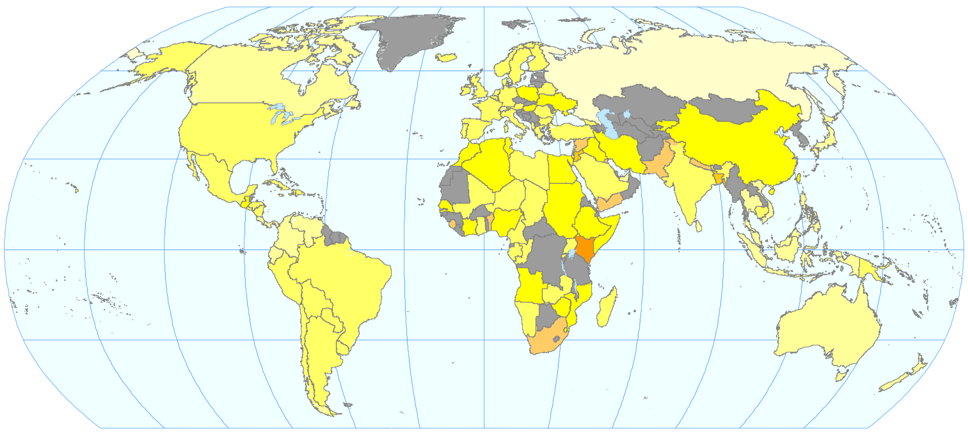
**Scenario A2 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



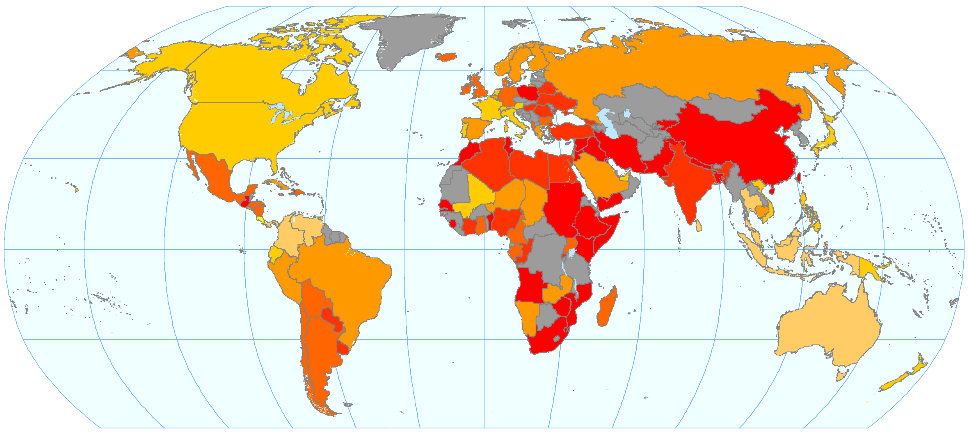
**Scenario A2 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**

**10 Extreme** · **8 Serious** · **6 Moderate** · **4 Modest** · **2 Little vulnerability** · **no data**
**9 Severe** · **7 Moderate** · **5 Modest** · **3 Little** · **1 No vulnerability**

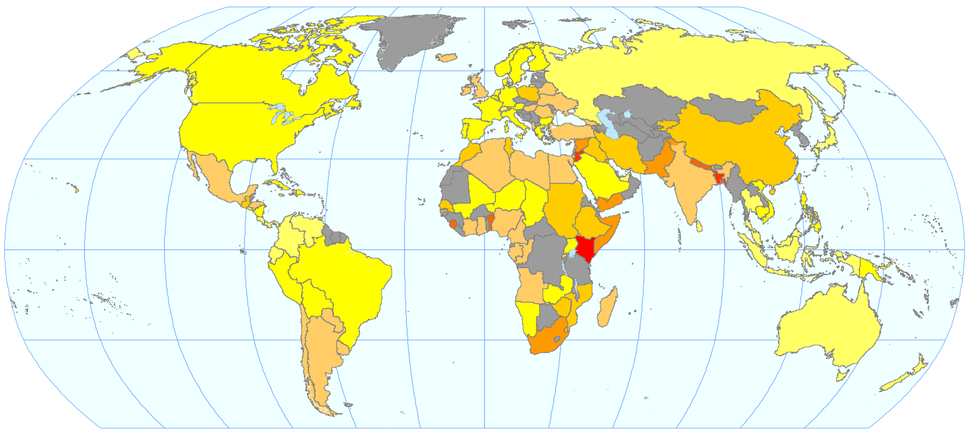
Figure 5: Geographical Distribution of Vulnerability in 2100 Calibrated to Aggregate Impacts



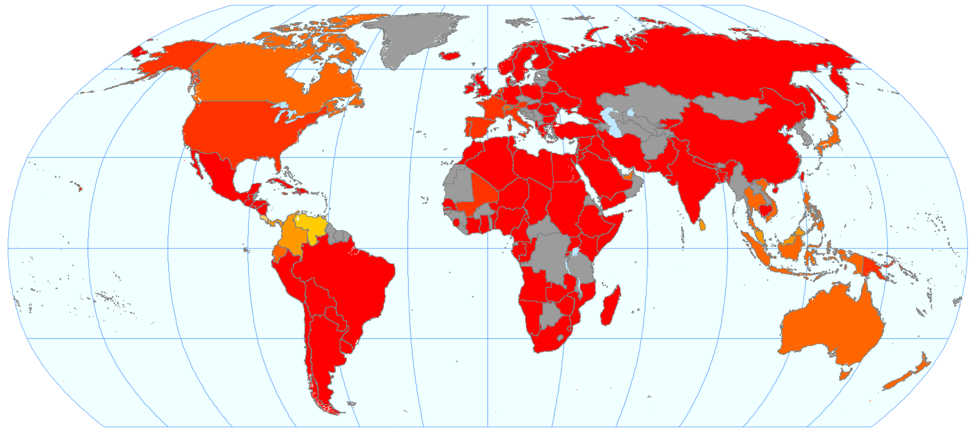
**Scenario B2 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



**Scenario B2 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



**Scenario A2 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



**Scenario A2 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**

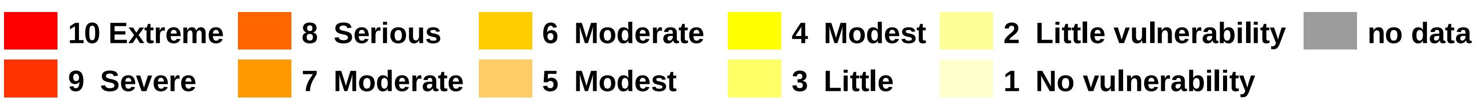
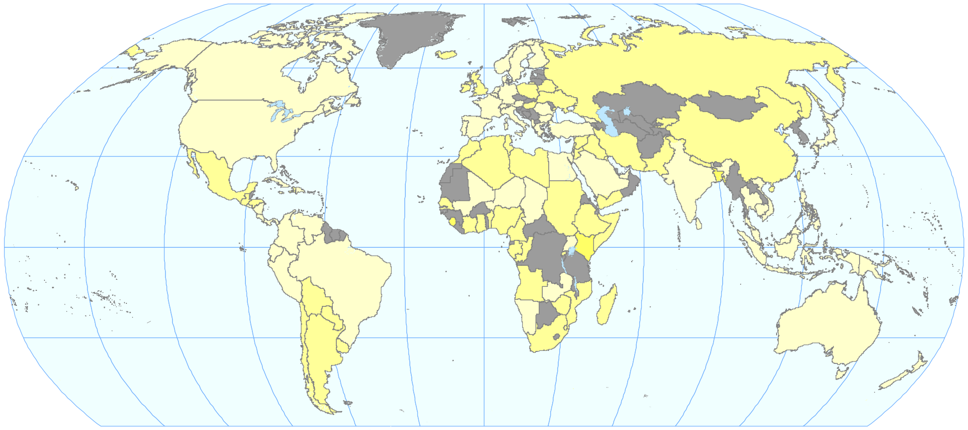
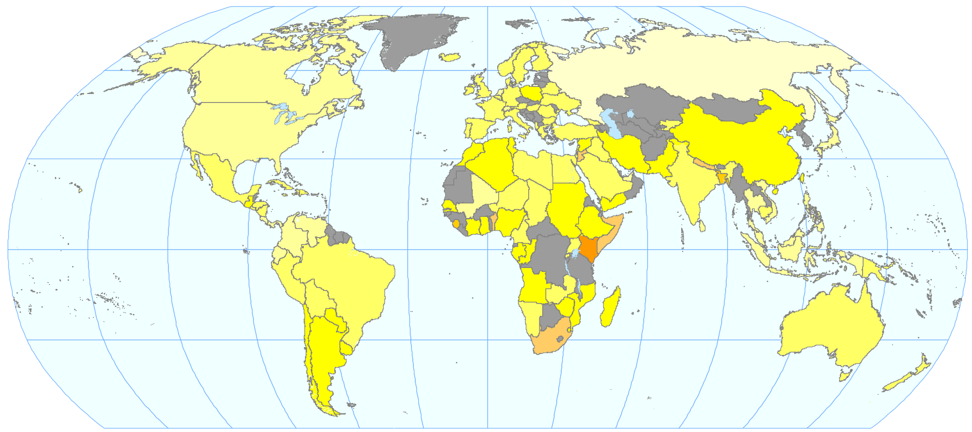


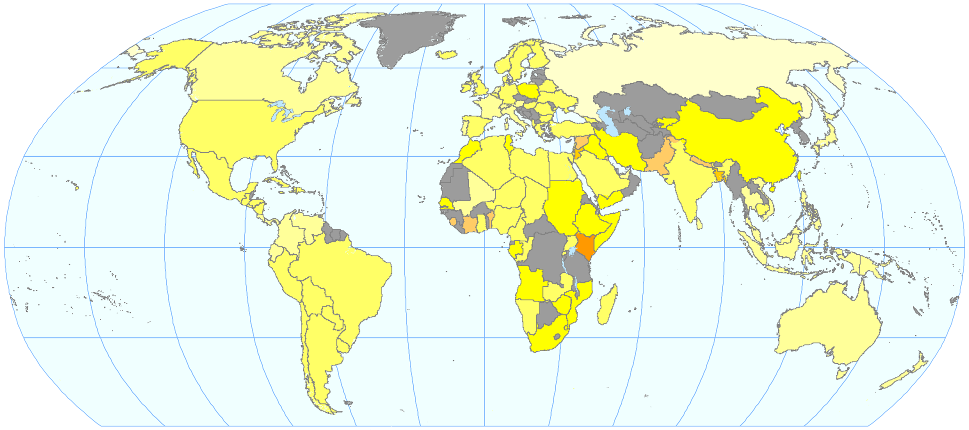
Figure 6: Geographical Distribution of Vulnerability with Mitigation along A2-550 Calibrated to Aggregate Impacts



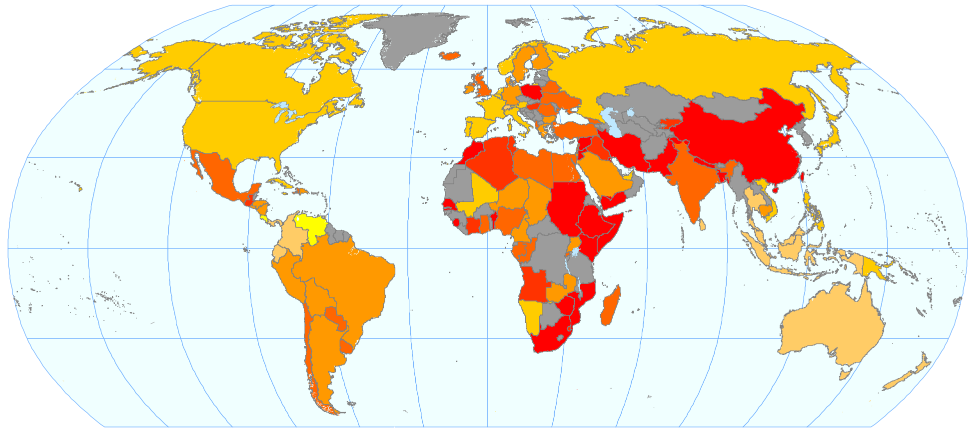
**Scenario A2-550 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**



**Scenario A2-550 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**

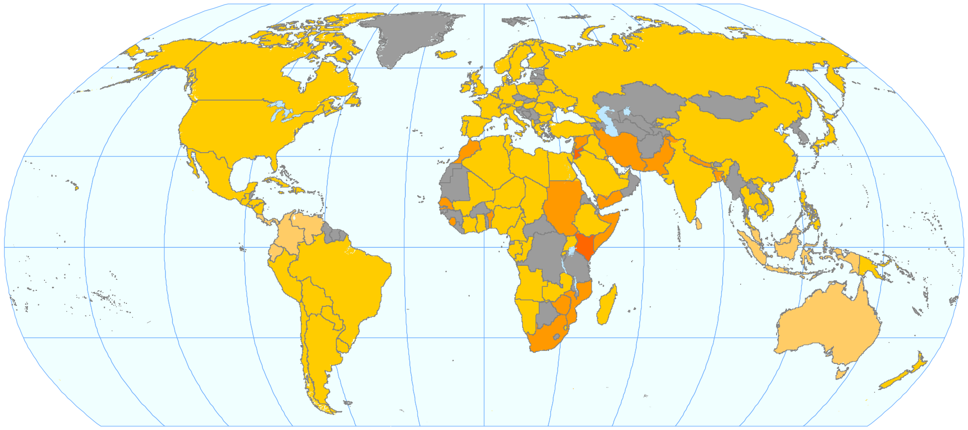


**Scenario A2-550 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**

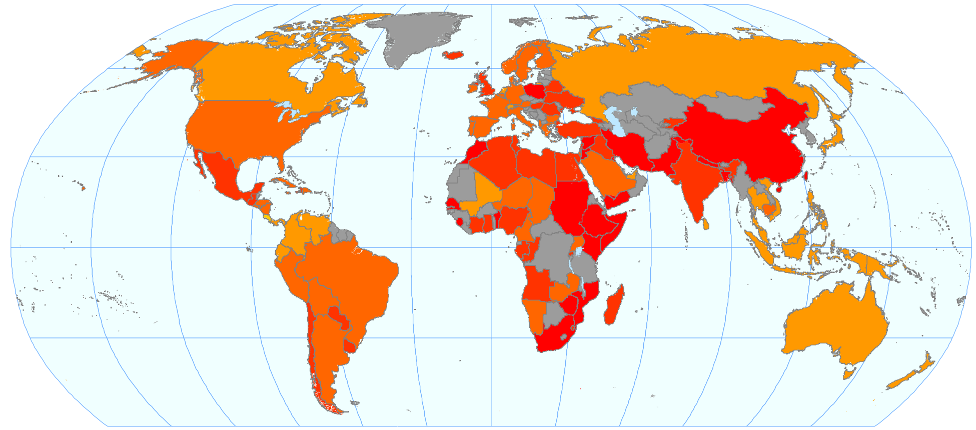


**Scenario A2-550 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Aggregate Impacts Calibration**

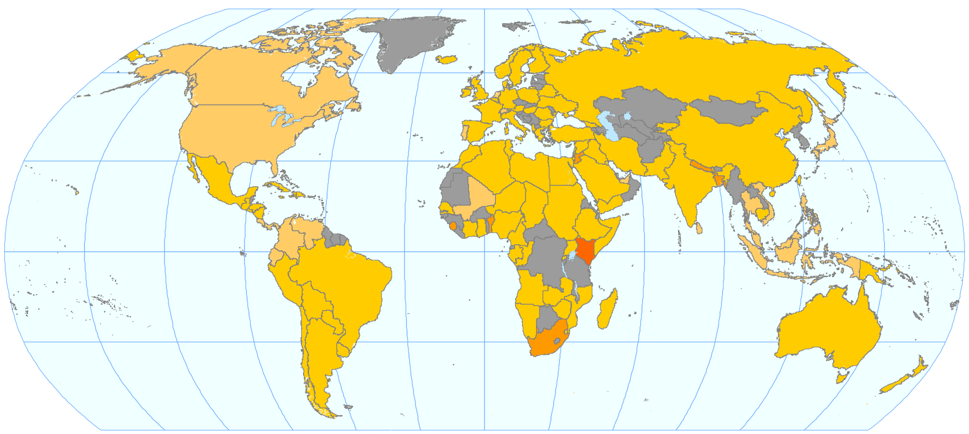
Figure 7: Geographical Distribution of Vulnerability in 2050 Calibrated to the Risk from Extreme Events



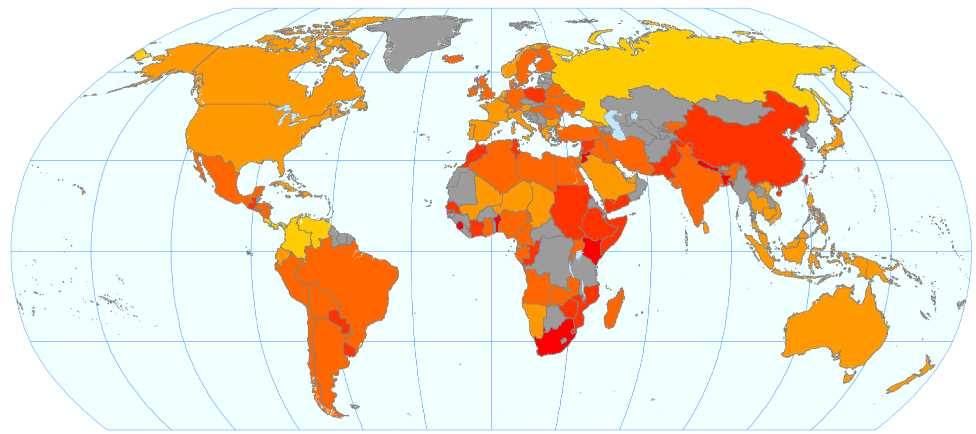
**Scenario B2 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



**Scenario B2 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



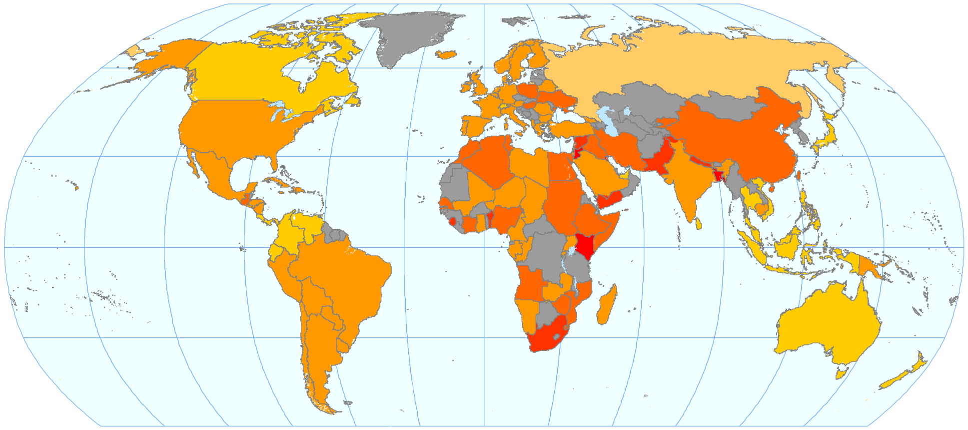
**Scenario A2 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



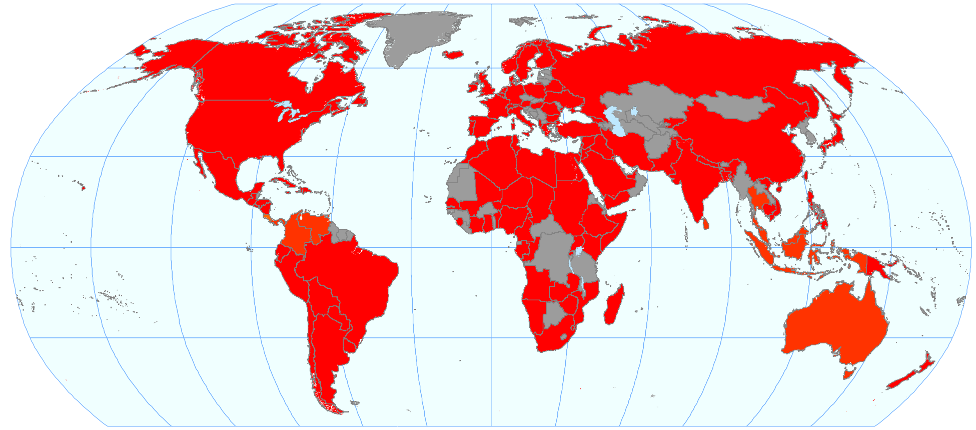
**Scenario A2 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**

**10 Extreme**
**9 Severe**
**8 Serious**
**7 Moderate**
**6 Moderate**
**5 Modest**
**4 Modest**
**3 Little**
**2 Little vulnerability**
**1 No vulnerability**
**no data**

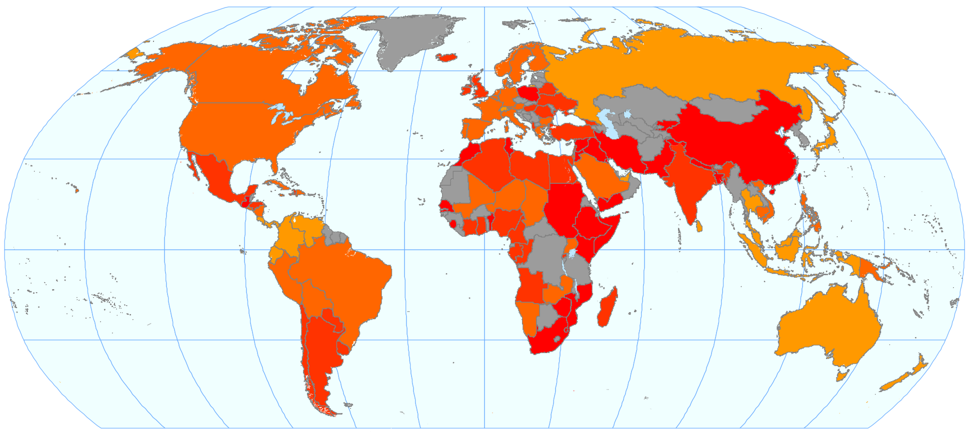
Figure 8: Geographical Distribution of Vulnerability in 2100 Calibrated to the Risk from Extreme Events



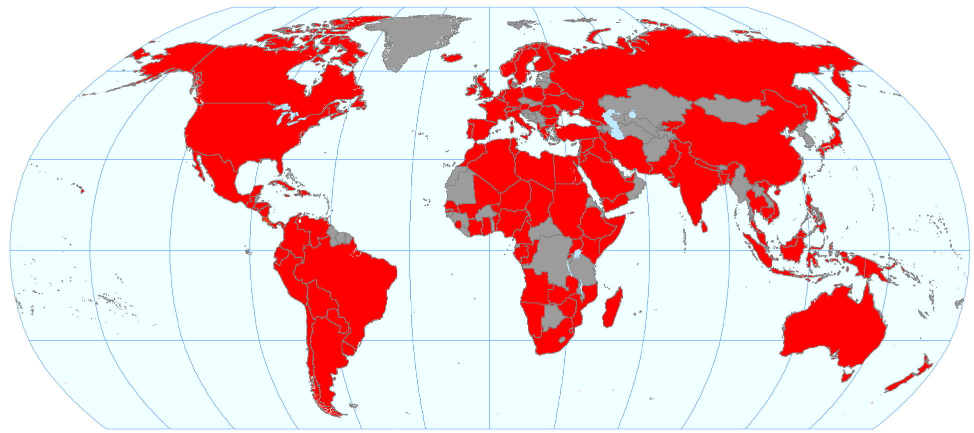
**Scenario B2 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



**Scenario B2 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



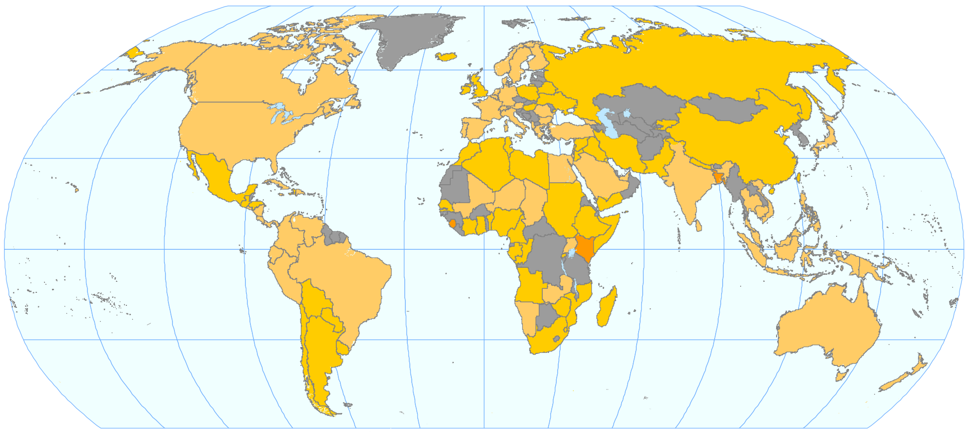
**Scenario A2 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



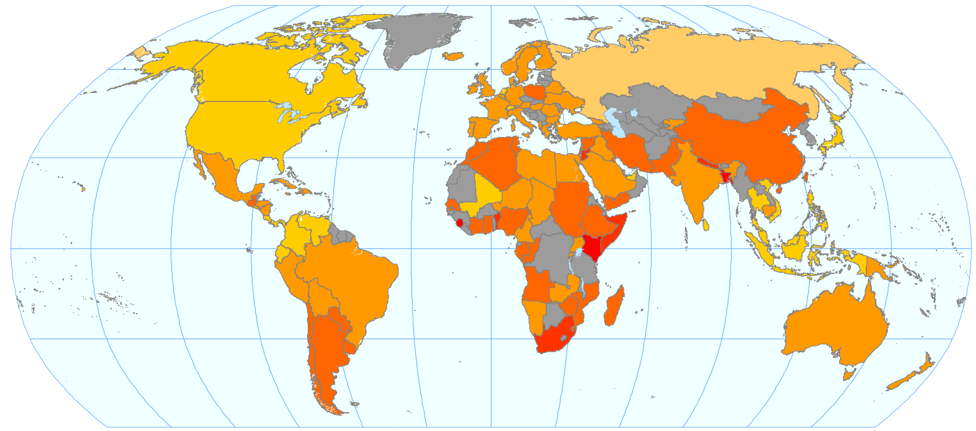
**Scenario A2 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**

**10 Extreme** | **8 Serious** | **6 Moderate** | **4 Modest** | **2 Little vulnerability** | **no data**
**9 Severe** | **7 Moderate** | **5 Modest** | **3 Little** | **1 No vulnerability**

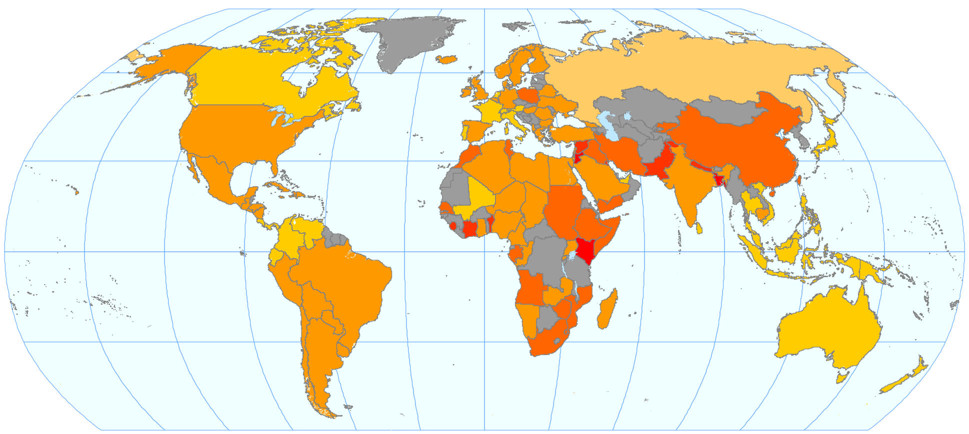
Figure 9: Geographical Distribution of Vulnerability with Mitigation along A2-550 Calibrated to the Risk from Extreme Events



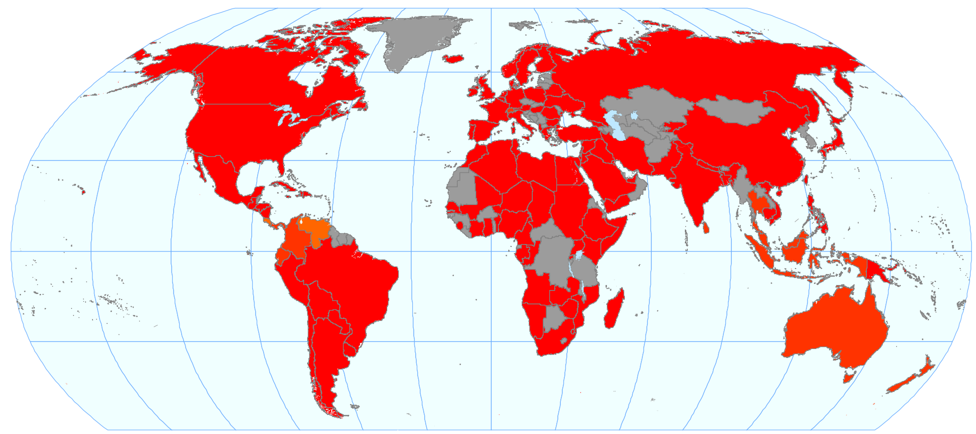
**Scenario A2-550 in Year 2050 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



**Scenario A2-550 in Year 2050 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



**Scenario A2-550 in Year 2100 with Climate Sensitivity Equal to 1.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**



**Scenario A2-550 in Year 2100 with Climate Sensitivity Equal to 5.5 Degrees C**
**Annual Mean Temperature with Extreme Events Calibration**

**10 Extreme** **8 Serious** **6 Moderate** **4 Modest** **2 Little vulnerability** **no data**
**9 Severe** **7 Moderate** **5 Modest** **3 Little** **1 No vulnerability**

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