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The Allocation of Adaptation Funding

Rhona Barr[a], Samuel Fankhauser[b] and Kirk Hamilton[c]

9 February 2010

Abstract

Providing additional finance for adaptation is a key element of the emerging international climate change framework. This paper discusses how adaptation funding may be allocated among developing countries in a transparent, efficient and equitable way. We propose an approach based on three criteria: the climate change impact experienced in a country, a country's adaptive (or social) capacity and its implementation capacity. Rough indicators are proposed for each of these three dimensions. Physical impact and adaptive capacity together determine a country's vulnerability to climate change. It seems both efficient and fair that countries which are more vulnerable should have a stronger claim on adaptation resources. The third dimension, implementation capacity, introduces a measure of adaptation effectiveness. It makes sense to focus adaptation finance on countries with the capacity to use these resources efficiently.

Keywords: adaptation finance, development effectiveness, vulnerability

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1. Introduction

Adaptation is a central part of the post-2012 climate change architecture. For least-developed countries, which contribute little to climate change but are hardest hit by its consequences, the adaptation debate is arguably more relevant than the question of emissions targets.

The returns from successful adaptation are substantial, but so is the scale of investment required. A recent World Bank estimate puts the funding requirements for adequate adaptation in developing countries at $75-100 billion a year (World Bank 2009a). Estimates by UNDP (2007) are of a similar order of magnitude, while the UNFCCC (2008) expects adaptation costs of $27-67 billion a year in developing countries and $44 – 166 billion a year worldwide (an underestimate, according to Parry et al. 2009; see also Agrawala and Fankhauser 2008 and Fankhauser 2010). Fankhauser and Schmidt-Traub (2010) estimate that climate change will increase the cost of meeting the Millennium Development Goals in Africa from $70 billion a year to $100 billion a year over the next decade.

It is widely agreed, and indeed enshrined in the Framework Convention on Climate Change, that developing countries will need financial and technical assistance from developed countries to help them implement appropriate adaptation strategies.[1] But the exact mechanisms through which this assistance is to be provided are still a matter of debate.

At the risk of simplification, that debate ultimately comes down to two basic questions: how can additional adaptation finance be raised and who should receive the additional funds. The need for extra funding itself is no longer disputed.[2] This paper is about the second question – how additional adaptation funds should be allocated.[3]

The allocation question is complex and pits ethical considerations of entitlement and need against economic concerns like delivery and effectiveness. Overlaying them are institutional issues related to governance, accountability and the link to the prevailing development aid framework. Adaptation and development are closely intertwined (McGray et al. 2007, Klein and Persson 2008) and the coordination between the two financial flows is crucial. At the same time, adaptation finance has to be, and has to be proven to be, additional to existing development assistance.

Given this complexity, and the potential magnitude of the flows involved, it is important that the allocation process is as *transparent*, *efficient* and *equitable* as possible. This in turn calls for a set of objective and empirically measurable

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[1] Article 4.4 of the UNFCCC states that "*developed country Parties …shall… assist the developing country Parties that are particularly vulnerable to the adverse effects of climate change in meeting costs of adaptation to those adverse effects*".

[2] The Copenhagen Accord promises additional financial assistance of $30 billion up to 2012, rising to $100 billion a year by 2020. This is for both adaptation and mitigation. (http://unfccc.int/resource/docs /2009 /cop15/eng/l07.pdf)

[3] The question of potential sources of adaptation finance is discussed by Harmeling et al. (2009) and Müller (2008).

benchmarks that can guide the allocation process. Allocation decisions will always be based on judgement, and are to some extent political, but objective data can help to put them on a better analytical footing.

This paper argues that these benchmarks should be centred around the concept of vulnerability. It seems reasonable that countries (or populations groups within countries) that are more vulnerable to climate change should, all else equal, have a stronger claim on adaptation resources. This is also the presumption of the UNFCCC, which emphasizes assistance to "particularly vulnerable" countries (see footnote 1 above).

The practical difficulty with a vulnerability-driven, indicator-based approach is that vulnerability is difficult to define and measure objectively. Typically, vulnerability to climate change is taken to be a function of *physical impact* and *adaptive capacity*, that is, the severity of change (which in turn is a function of exposure and sensitivity) and our ability to respond to it.[4] Neither component is straightforward to quantify, and little is known about the complicated pathways that translate potential impacts into vulnerability.

Vulnerability is also a dynamic concept and will evolve over time, as socio-economic characteristics change and climate change becomes more pronounced. As such vulnerability assessments must be iterative, have defined time periods and be reassessed under an allotted timeframe.

Another difficulty is aggregation. Even if the various aspects of vulnerability can be identified and measured, they will have to be compared with each other. For example, should coastal flooding be a higher priority than the loss of agricultural output? And should the answer to this question depend on the relative income of farmers and coastal dwellers and/or their ability to protect themselves? The process to answer these questions cannot be "mechanistic", based on a formula. It will be deliberative and judgmental, but the judgments have to be based on objective data.

Moreover, it is unlikely that vulnerability will be the only allocation criteria. The World Bank approach to the allocation of IDA resources, for example, complements measures of need with indicators of *implementation capacity* – that is, the ability to manage and use finance effectively. We argue that the capacity to implement is as important for adaptation as it is for development assistance. Adaptation funding will be scarce and has to be used effectively.

A low implementation capacity should not disqualify a country from receiving support. Fragile states, which are characterized by weak institutions and low implementation capacity are amongst the most vulnerable countries to climate change. However, insufficient implementation capacity will point to the need for different implementation arrangements, for example, the replacement of budgetary support with externally controlled project management.

This paper attempts to define a set of indicators that can guide the allocation of adaptation funding and meet the core criteria of transparency, efficiency and equity.

[4] Adaptive capacity is sometimes also referred to as social capacity (e.g., World Bank 2009b).

They are grouped around the three notions of *physical impact*, *adaptive capacity* (which together determine vulnerability) and *implementation capacity* (which promotes adaptation effectiveness). There is nothing unique to this structure, and the proposed indicators cannot answer all the questions, whether practical or conceptual. But they provide a starting point on which further discussions may be based.

The paper starts with a conceptual discussion and a review of earlier attempts to quantify and measure vulnerability (section 2). Sections 3 to 5 offer indicative benchmarks for the three concepts at the core of our indicator system: physical impact, adaptive capacity and implementation capacity. Section 6 discusses different methods of aggregation and section 7 concludes.

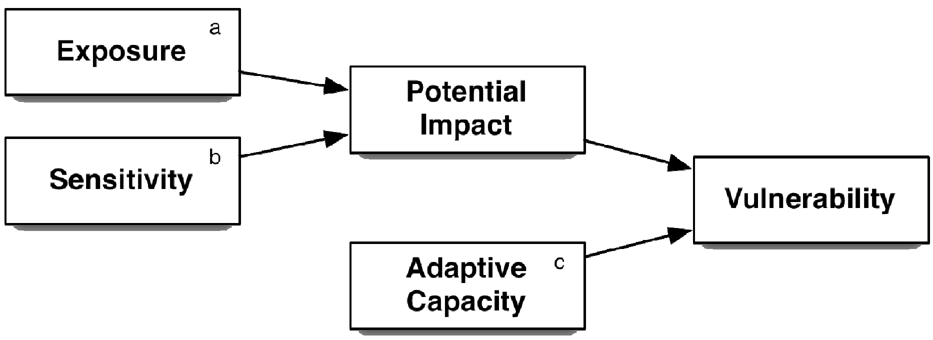
2. Measuring vulnerability

Although well established in other academic fields, the concept of vulnerability has only recently entered into the climatic change debate. Broadly defined, 'climatic vulnerability' refers to the degree to which a natural or social system is likely to experience damage or harm due as a result of climate change (Füssel 2007). The IPCC in its third Assessment Report (McCarthy et al. 2001) defines vulnerability as:

> *"The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate, including climatic variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity."*

Climate change vulnerability can, therefore, be seen as a function of three elements: exposure, sensitivity and adaptive capacity (Figure 1). Vulnerable systems are those that are highly exposed, sensitive to change and have limited ability to adapt.

Figure 1 Vulnerability and its components



Source: After Schröter (2004).
Notes: (a) defined as stimuli impacting upon a system, represents the background climate conditions within a system and any changes in those conditions;
(b) defined as the responsiveness of a system to climate influences, the degree to which outputs change in response to changes in climatic inputs;
(c) defined as the ability of a system to transform itself, so to be better equipped to deal with the new external stimuli.

Measuring vulnerability is not an exact science. Uncertainty about future climate change makes it difficult to determine physical impact with precision, particularly at the regional level. Multiple future scenarios and complex causal relationships make translating these impact uncertainties into human vulnerability even less clear.

There is nevertheless an emerging literature aiming to measure and assess vulnerability. Studies addressing vulnerability to climate change tend to have their origins in two different disciplines.

The first strand of literature is climate impact studies. There is a large number of national and global climate studies that attempt to quantify the potential extent and scale of climate change impacts. They focus on the physical and sometimes economic implications of climate change as they relate to specific sectors of the economy such as agriculture, health and coastal zones.

Projections of climate impacts have improved significantly over the last few years (Füssel 2008), but there are still substantial knowledge gaps, particularly when it comes to understanding the impact of adaptation (Agrawala and Fankhauser 2008). Another drawback of traditional impact studies is that they tend to ignore the human dimension required to translate impacts into human vulnerability.

The second strand of literature, vulnerability studies, aims to address this point. Vulnerability studies have long been used to identify those population groups most likely to be negatively affected by drought and other natural hazards. However, framing climate change impacts within a context of vulnerability is a fairly new endeavor. Most recent work on social vulnerability has tended to focus on the local to regional scale where the processes which shape vulnerability are better understood, often using a case-study approach (Ibarrarán et al 2009; Eriksen and Kelly 2007). Far fewer studies have attempted to address vulnerability at a national level.[5]

Most vulnerability studies do not specifically deal with the modelled impacts of climate change. Instead, they focus on the presence of environmental assets which may be affected by climatic changes, such as arable land or areas previously affected by climatic disasters (Brooke et al 2005; Lonergan 1999).

A notable exception is Moss et al (2001), who developed the Vulnerability-Resilience Impact Model (VRIM). Using indicators of sensitivity to climate change and indicators of coping-adaptive capacity Moss et al (2001) calculated an aggregate indicator of vulnerability for three alternative future climate scenarios.

Recent aggregated indices have combined measures of climate change severity with measures of socioeconomic capacity. However none of these have considered projections from climate impact models. Projected data such as precipitation and temperature are used to proxy the severity of regional climate change instead.[6]

3. Indicators of impact

[5] For examples of such social vulnerability studies see Brooks et al (2005) and Esty et al (2005).

[6] See Baettig et al. (2007); Diffenbaugh et al (2007) and Yohe et al (2006). For a further discussion of vulnerability indices see Füssel (2009) and Eriksen and Kelly (2007).

Exposure to, and sensitivity towards climatic change together decide the strength of an impact on a country or locality (see Figure 1 above). Since exposure and sensitivity are difficult to disentangle, we use their combined effect, physical impact, as the first pillar of our indicator system.

Ideally, an indicator of physical impact should include all aspects of climate change and cover all the main sectors. However, that level of information is not available, even if the effects of climate change are increasingly well understood (see Parry et al. 2007). The main constraint is the availability of internally consistent, global data, which are crucial to establish credible vulnerability scores at the global level. Making cross-country comparisons based on national-level studies would be difficult, given the high diversity in underlying assumptions and study methods.

There are much fewer global studies and they are inevitably less accurate than detailed local case studies. However, the main concern here is relative vulnerability across countries, rather than the absolute vulnerability of a particular place. The assumption is that country rankings may be relatively robust and not sensitive to the analytical shortcomings of global studies.

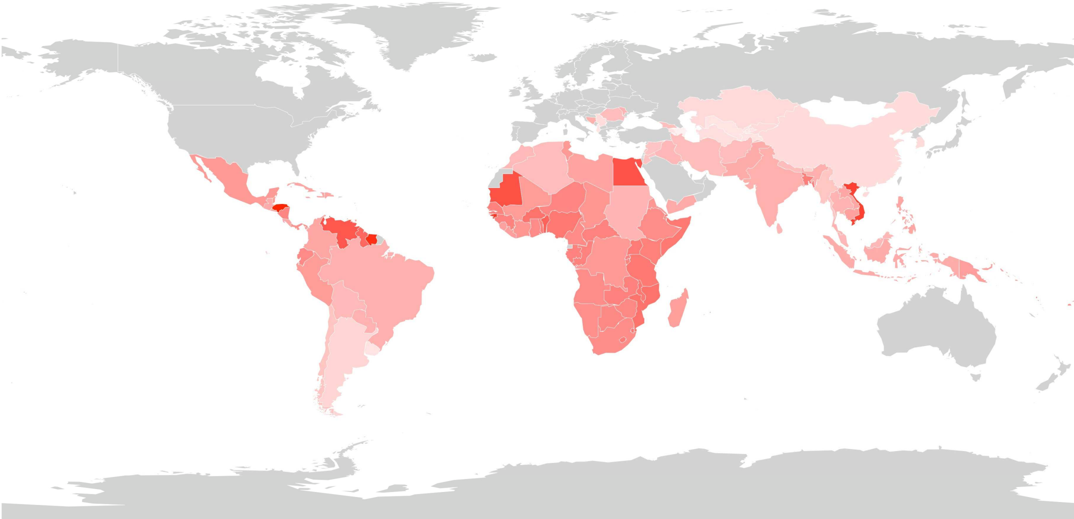
Suitable global studies are available for agriculture, health and coastal protection. In the case of extreme events, we use historic disaster statistics as a proxy for future vulnerability. Table 1 gives the details. The table shows that the impact metrics and climate assumptions differ widely across the four sectors. However, our main concern is consistency within a sector, rather than comparison across sectors. Future research may tell us more on how country rankings change as a function of different climate scenarios. The assumption here is that rankings are robust in this respect.

Table 1 Indicators of physical impact

Indicator	Metric	Source	Assumptions
Agriculture	Inverse percent crop yield change (wheat, rice, soybean) by 2050	Parry et al, (2004)	Yield change is representative of impact on producers and consumers.
Disasters	Percent population killed by disasters	EMDAT disaster database 1990-1999	Current disaster patterns representative of future impacts from climate change
Health	Percent additional deaths in 2050	Bosello et al, (2006)	Additional deaths representative of all heath impacts from climate change
Coastal zones	Percent population impacted by 1 m sea level rise	Dasgupta et al (2007)	Population at risk is a proxy of impacts on economies, assets and people

To obtain an aggregate score, all values were normalized to ensure all sectors had roughly equal weight and no one indicator biased the results. Regional averages were calculated for those countries where no data was available. The results were averaged across all four criteria to give a final ‘impact vulnerability’ score per country. Figure 2 and Table 2 summarize the result, grouping countries into impact quartiles. Methodology and detailed country scores are shown in Annex 1.

Figure 2 Country climate change impact rankings



Note: The darkest red indicates the countries with the highest impact vulnerability score, light pink the lowest. Grey countries were omitted from the analysis.

Table 2 Climate change impact rankings

Quartile	Countries
I (highest impact)	Benin, Burkina Faso, Burundi, Cape Verde, Central African Rep., Congo Rep., Gabon, Gambia, Guinea, Guinea Bissau, Kenya, Lesotho, Malawi, Mauritania, Mauritius, Mozambique, Nigeria, Rwanda, Senegal, Seychelles, Somalia, Swaziland, Tanzania, Togo, Uganda, Zambia, Bangladesh, Vietnam, Honduras, Egypt, Guyana, Suriname, Venezuela,
II	Angola, Botswana, Cameroon, Chad, Congo, Dem. Rep., Comoros, Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Ghana, Mali, Namibia, Niger, Sao Tomé and Principe, South Africa, Tunisia, Zimbabwe, Antigua and Barbuda, Grenada, Mexico, Nicaragua, Panama, St Kitts and Nevis, St Lucia, Fiji, Kiribati, Marshall Is., Samoa, Solomon Is., Tonga, Vanuatu, Ecuador
III	Liberia, Libya, Madagascar, Sierra Leone, Cambodia, India, Indonesia, Lao PDR, Maldives, Pakistan, Philippines, Thailand, Timor-Leste, Belize, Costa Rica, Cuba, Dominica, Dominican Rep, El Salvador, Guatemala, Haiti, Jamaica, St Vincent and the Grenadines, Trinidad and Tobago, Bosnia-Herzegovina, Moldova, Yemen, Micronesia, Papua New Guinea, Brazil, Colombia, Paraguay, Peru
IV (lowest impact)	Algeria, Morocco, Sudan, Afghanistan, Armenia, Azerbaijan, Bhutan, China, Georgia, Kazakhstan, Korea Rep., Kyrgyz Republic, Malaysia, Mongolia, Myanmar, Nepal, Sri Lanka, Tajikistan, Turkmenistan, Uzbekistan, Albania, Romania, Serbia, Iran, Iraq, Jordon, Lebanon, Syria, Argentina, Bolivia, Chile, Uruguay

Note: Data available for 131 countries.

4. Indicators of adaptive capacity

Besides physical impact, a country's vulnerability crucially depends on its ability to adapt (Figure 1 above). Unlike impact, which is defined by the kind, extent and vigor of climatic variability, adaptive capacity is mainly determined by socio-economic factors, such as income, demographic trends, institutional capacity, political stability and the quality of education, water and health facilities. It is in fact these socio-economic dimensions that drive much of the vulnerability of developing nations. Adaptive capacity is therefore the second pillar of our indicator system.

The adaptive capacity inherent in a system represents the assets available, and the ability to use these resources effectively in the pursuit of adaptation. In practical terms it is the ability to react to evolving hazards, which among other things requires the capacity to learn from previous experiences (Brooks and Adger 2004). Other factors that determine adaptive capacity include the quality of institutions and decision making processes, the availability of resources and technologies and the stock of human and social capital (Tol and Yohe 2007). Brooks et al (2005) highlight the importance of factors such as literacy, governance and health (which had to be omitted here for data reasons).

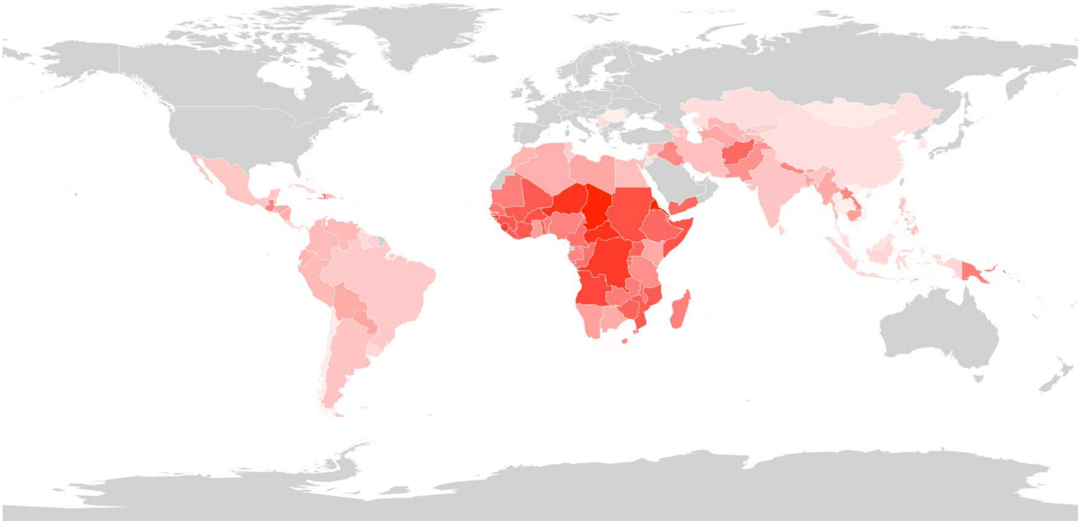
However, indicators for adaptive capacity are generally more difficult to identify than risk, as they are not directly measurable, and the way in which individual factors interact is difficult to ascertain. Table 3 lists the capacity measures used here.

Table 3 Indicators of adaptive capacity

Indicator	Metric	Source	Assumptions
Age dependency ratio	Ratio of dependent population to working population (2006)	World Bank (2007)	The lower the age dependency ratio, the higher the adaptive capacity
Domestic credit to private sector	Domestic credit to private sector, as a percentage of GDP (1998-2996)	World Bank (2007)	The better access to credit, the higher the adaptive capacity
Gini	Gini coefficient (latest available year)	World Bank (2007)	The lower the GINI coefficient the lower the inequality, the higher the adaptive capacity
Governance	WGI (World Governance Indicator) voice and accountability	Kaufman et al (2008)	The higher the WGI score, the lower the degree of in-country conflict and the higher the adaptive capacity
Literacy	Percent population, aged >15years, literate (1991-2005)	World Bank (2007)	The higher the literacy rate, the higher the adaptive capacity
Primary completion rate (female)	Percent female population completing primary education (1991-2006)	World Bank (2007)	The higher the female primary completion rate, the higher the adaptive capacity

Note: The WGI is a composite index that ranks countries according to six criteria: Voice and accountability; political stability and absence of violence; government effectiveness; rule of law; and control of corruption. Gini coefficients were unavailable for 27 countries. In order not to lose these countries, adaptive capacity was calculated as an average of the remaining five indicators.

Figure 3 Country adaptive capacity rankings



Note: The darkest red indicates the countries with the lowest adaptive capacity (associated with the highest vulnerability). Light pink denotes the countries with the highest adaptive capacity. Grey countries were omitted from the analysis.

Table 4 Adaptive capacity rankings

Quartile	Countries
I (lowest capacity)	Angola, Burkina Faso, Burundi, Cameroon, Central African Rep., Chad, Comoros, Congo Dem. Rep., Congo Rep., Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea Bissau, Liberia, Malawi, Mali, Mozambique, Niger, Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Togo, Uganda, Zambia, Zimbabwe, Afghanistan, Haiti, Yemen
II	Algeria, Benin, Botswana, Gabon, Ghana, Kenya, Lesotho, Libya, Madagascar, Mauritania, Namibia, Nigeria, Sao Tomé and Principe, Swaziland, Tanzania, Bangladesh, Bhutan, Cambodia, Lao PDR, Myanmar, Nepal, Pakistan, Timor-Leste, Turkmenistan, Guatemala, Honduras, Nicaragua, Iraq, Papua New Guinea, Solomon Is., Bolivia, Ecuador, Paraguay
III	Cape Verde, Seychelles, Tunisia, Armenia, Azerbaijan, Georgia, India, Kyrgyz Republic, Philippines, Tajikistan, Uzbekistan, Belize, Dominican Rep., El Salvador, Jamaica, Mexico, Egypt, Iran, Lebanon, Morocco, Syria, Fiji, Kiribati, Micronesia, Samoa, Tonga, Vanuatu, Argentina, Brazil, Colombia, Ecuador, Peru, Suriname, Venezuela
IV (highest capacity)	Mauritius, South Africa, China, Indonesia, Kazakhstan, Korea Rep., Malaysia, Maldives, Mongolia, Sri Lanka, Thailand, Vietnam, Antigua and Barbuda, Costa Rica, Cuba, Dominica, Grenada, Panama, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Albania, Bosnia-Herzegovina, Moldova, Romania, Serbia, Jordan, Marshall Is., Chile, Guyana, Uruguay

Note: Data available for 131 countries.

5. Indicators of implementation capacity

Decisions about adaptation spending may also be influenced by the ability of potential recipients to use funds effectively. Like development aid, adaptation finance will be more cost-effective when targeted at countries that are able to implement the required strategies, for example, those with relatively sound or improving policies and institutions (Kaufmann and Kraay 2004).

This is called a country's implementation capacity and forms the third pillar of our indicator system. Implementation capacity introduces *adaptation effectiveness* as an explicit concern into the decision making process. It complements vulnerability, which combines both equity and efficiency considerations, in the sense that allocating money according to vulnerability is both fair and targets the areas of highest need.

A number of performance indicators exist that can be used to address this country-specific risk factor. They include Country Performance and Institutional Assessments (CPIA), the worldwide governance indicators (WGI), the International Country Risk Guide (ICRG), the Corruption Perception Index (CPI), the Global Competitive Index (GCI), as well as the country assessments of credit rating agencies. They each assess different aspects of government performance – including fiscal management, institutional quality, the business environment, corruption and credit default risks – but each aspect contributes to, or is correlated with, the ability of governments to manage financial inflows effectively.

Note also that many of these indicators are correlated with adaptive capacity, the second pillar of our indicator framework. The WGI index, in particular, was used in Table 3 to assess institutional quality – a key factor of adaptive capacity. This creates a certain amount of double-counting.

Our index of implementation capacity is based on CPIA, an index used by the World Bank Group to inform the allocation of concessional funding from the International Development Association (IDA). The CPIA ranks countries according to 16 indicators grouped into four clusters as follows:

- *CPIA a*: economic management;
- *CPIA b*: structural policies;
- *CPIA c*: policies for social inclusion and equity; and
- *CPIA d*: governance (public sector management and institutions).

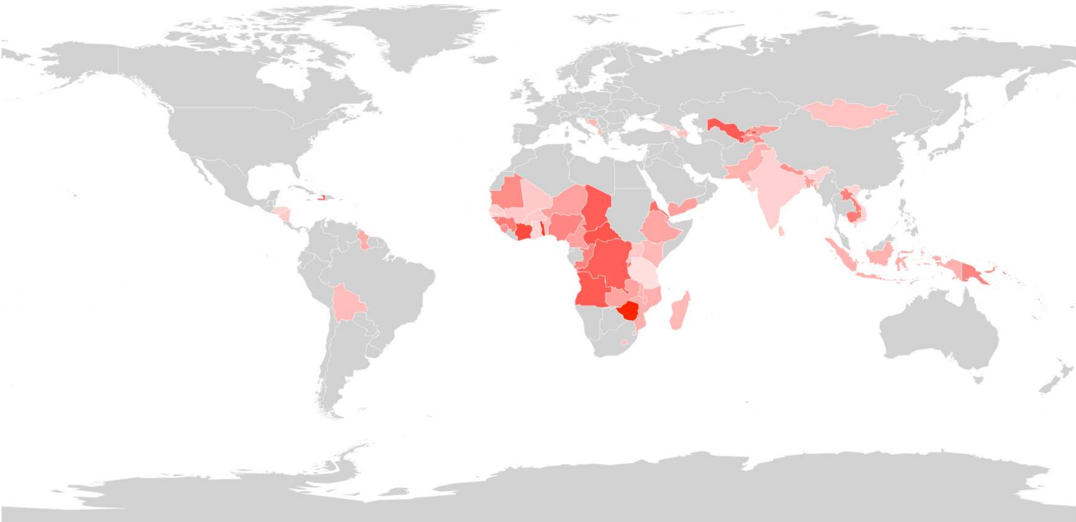
Policies are ranked from one (low) to six (high) based upon a combination of objective data and expert judgment by World Bank staff. The final component of the index measures a country's capacity to absorb finance. It is based on World Bank portfolio data from the Bank's Annual Review of Portfolio Performance (ARPP).

The five components were aggregated through the same formula the World Bank's uses for IDA allocation, which gives additional weight to governance and public sector management. The implementation capacity index combines central government capacity and ability to absorb finance in the following way:

*Implementation Capacity = 0.24*average of (CPIAa CPIAb CPIAc) + 0.68*CPIAd + 0.08* ARPP*

Figure 4 and Table 5 summarize the results by quartile, with the full results again given in Annex 1. Note that the sample size was reduced from 131 countries to 72 countries. The CPIA is not calculated for all developing countries.

Figure 4 Country implementation capacity rankings



Note: The darkest red indicates the countries with the lowest implementation capacity (associated with the lower adaptation efficiency). Light pink denotes the countries with the highest implementation capacity. Grey countries were omitted from the analysis.

Table 5 Implementation capacity rankings

Quartile	Countries
I (lowest capacity)	Angola, Burundi, Central African Rep., Chad, Comoros, Congo Dem Rep., Congo Rep., Cote d'Ivoire, Eritrea, Guinea, Guinea Bissau, Nigeria, Togo, Zimbabwe, Cambodia, Lao PDR, Uzbekistan, Haiti
II	Cameroon, Djibouti, Gambia, Mauritania, Niger, Sao Tomé and Principe, Sierra Leone, Zambia, Bangladesh, Kyrgyz Republic, Nepal, Tajikistan, Yemen, Kiribati, Papua New Guinea, Solomon Is., Tonga, Vanuatu
III	Benin, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Rwanda, Uganda, Azerbaijan, Indonesia, Mongolia, Pakistan, Dominica, Albania, Bosnia-Herzegovina, Bolivia, Guyana
IV (highest capacity)	Burkina Faso, Cape Verde Is., Ghana, Senegal, Tanzania Uni. Rep., Armenia, Bhutan, Georgia, India, Maldives, Sri Lanka, Vietnam, Grenada, Honduras, Nicaragua, St Lucia, St Vincent and the Grenadines, Samoa

Note: Data available for 72 countries.

It is worth re-emphasising that a low implementation capacity may not necessarily disqualify a country from receiving adaptation support. In fact, with their weak institutions and low adaptive capacity, fragile states are amongst the most vulnerable countries to climate change and as such most in need of support. However, insufficient implementation capacity may point to the need for different ways of providing support, with stricter monitoring arrangements and a stronger role for development agencies in project management. It also points to a need for capacity building as an adaptation (and development) priority.

6. An attempt at integration

Sections 3 to 5 have developed quantitative indicators for the three pillars of our indicator framework: physical impact, adaptive capacity and implementation capacity. The next step is to combine the three constituent indicators into a ranking system that helps prioritizing access to adaptation finance.

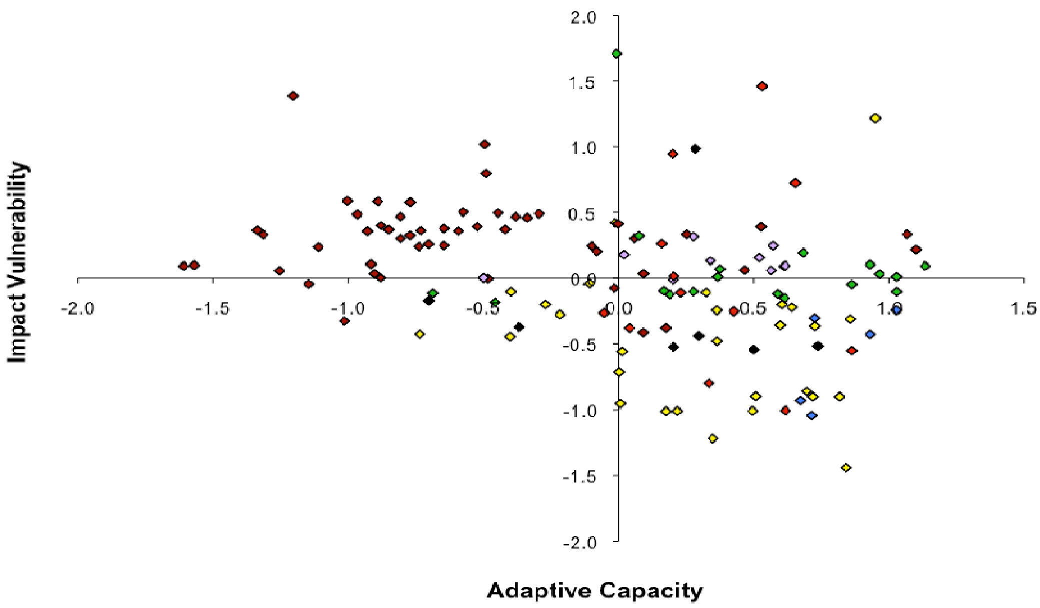
The degree to which the constituent indicators need to be aggregated for this purpose is open to debate. On the one hand, an aggregate score would have the advantage of simplicity. On the other hand, aggregation amplifies the uncertainties inherent in the constituent indicators. It also masks some important trade offs that perhaps ought to be made explicitly. We therefore start by analysing the constituent indicators separately.

Fund allocation will initially require identification of the countries most affected by climate change. As we have seen (Figure 1), vulnerability is a function of physical impact and adaptive capacity. The interaction between the two drivers is potentially complex, but as a starting point Figure 5 plots the indicators for adaptive capacity (x axis) and physical impact (y-axis) against each other.

Countries with high ‘impact vulnerability’ and low ‘adaptive capacity’ are located in the top left quartile. They are considered to be those most vulnerable and should therefore be at the forefront for fund allocation. Figure 5 shows that they are almost exclusively based within Africa. There are impact hotspots elsewhere, for example in Central and tropical South America, but adaptive capacity within many of the Central and South American countries is generally higher, which should reduce their long-term vulnerability. The same pattern holds for small island states. They have high impact scores, but their adaptive capacity is also higher.

To get a rough handle on the combined effect of impact vulnerability and adaptive capacity we merge the two scores into an indicator of overall vulnerability. The easiest way to do this is by subtracting the adaptive capacity score (where low capacity means high vulnerability) from the impact score (where high impact means high vulnerability).

Figure 5 Impact vulnerability (y axis) and adaptive capacity (x axis)



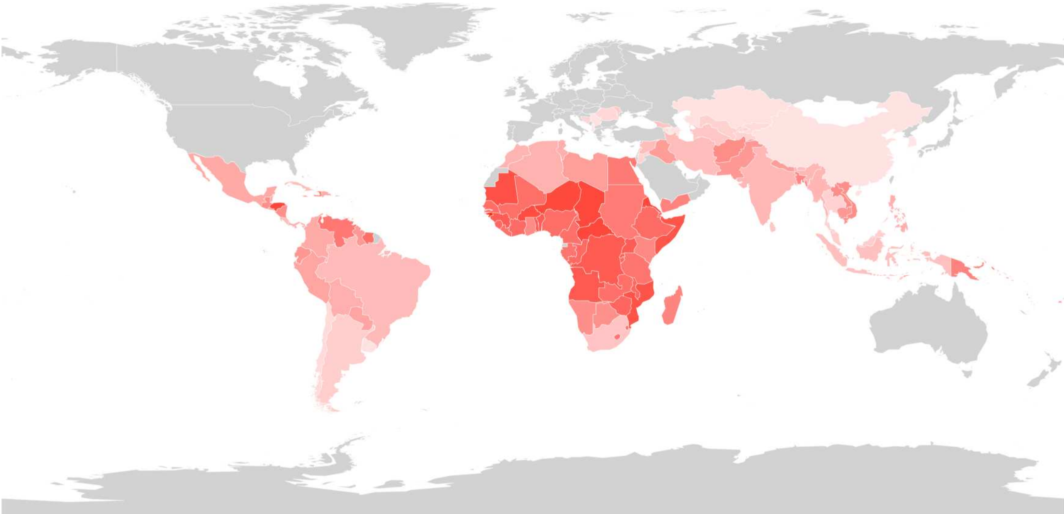
Key:	**Africa**	**Asia**	**Central America & Caribbean**
	Middle East	**Europe**	**South America**
	Oceania		

Figure 6 and Table 6 show the results by quartile. A quick comparison between Figure 6 (overall vulnerability) with Figure 2 (physical impact) underlines the central importance of adaptive capacity. Their poor capacity to adapt leads to a disproportionately high vulnerability among African nations, suggesting in turn a strong concentration of adaptation effort on Africa.

However, by their very nature, countries that are highly vulnerable to climate change may lack institutional capacity for implementing adaptation measures. Figure 7 demonstrates this by plotting the overall vulnerability scores (Table 6) against implementation capacity (Table 5). Implementation capacity is shown on the x axis, vulnerability on the y axis.

At one level this suggests a trade-off between considerations of fairness – which would favor adaptation spending in the most vulnerability countries – and adaptation effectiveness, which suggests prioritizing slightly less vulnerable but more effectively governed countries. However, in reality, the issue is less about fund allocation than implementation arrangements. Highly vulnerable countries should and will obtain the lion’s share of adaptation resources. However, their low implementation capacity may require adaptation agencies to take a more hands-on approach in project implementation than is generally assumed.

Figure 6 Overall vulnerability rankings



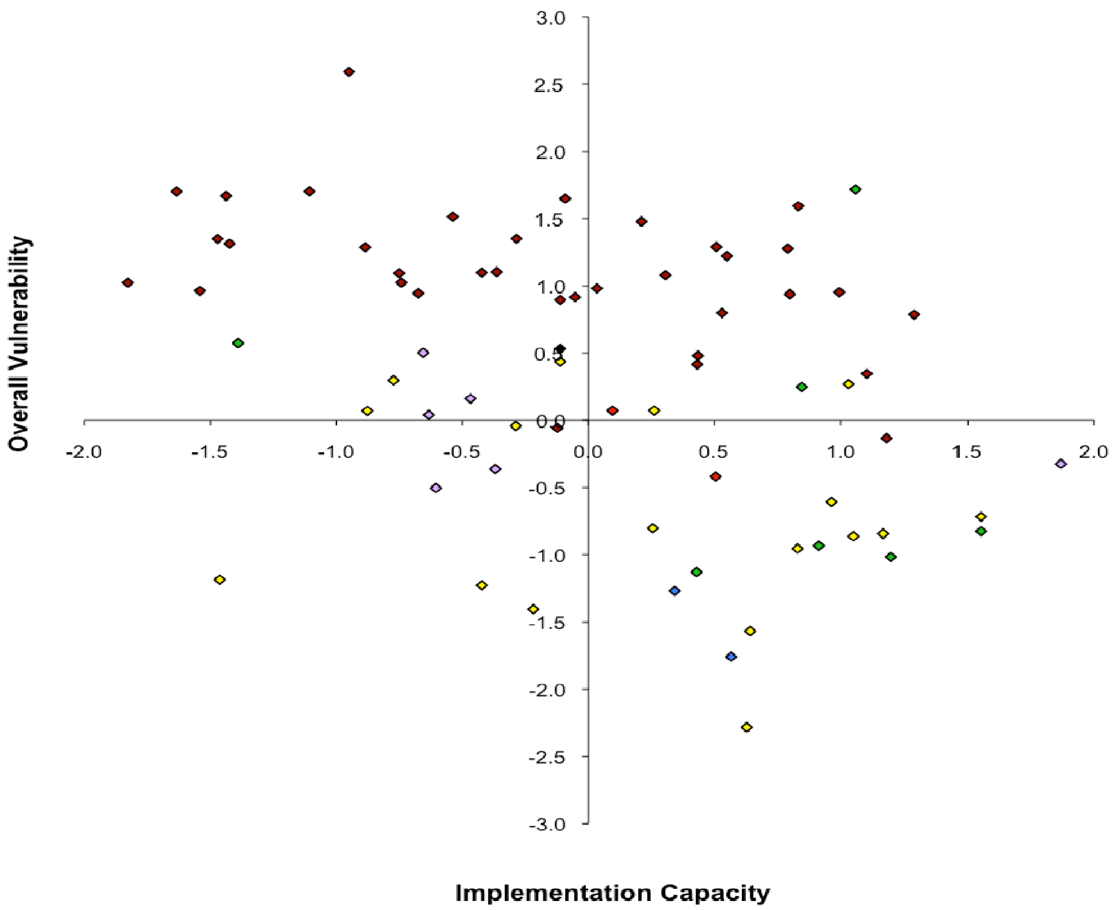
Note: The darkest red indicates the highest overall vulnerability scores. Light pink denotes the lowest vulnerability scores. Grey countries were omitted from the analysis.

Table 6 Overall vulnerability rankings

Quartile	Countries
I (highest impact)	Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Rep., Chad, Comoros, Congo, Congo Dem. Rep., Cote d'Ivoire, Djibouti, Eritrea, Ethiopia, Gambia The, Guinea, Guinea-Bissau, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, Togo, Uganda, Zambia, Zimbabwe, Honduras, Suriname
II	Botswana, Gabon, Ghana, Kenya, Lesotho, Liberia, Libya, Madagascar, Namibia, Sao Tomé and Principe, Seychelles, Sudan, Swaziland, Tanzania Uni. Rep., Afghanistan, Bangladesh, Cambodia, Lao PDR, Nepal, Pakistan, Vietnam, Guatemala, Haiti, Nicaragua, Egypt, Iraq, Yemen, Papua New Guinea, Solomon Is., Vanuatu, Ecuador, Guyana, Venezuela
III	Algeria, Cape Verde Is, Mauritius, Morocco, Tunisia, Bhutan, India, Indonesia, Myanmar, Philippines, Timor-Leste, Antigua and Barbuda, Belize, Costa Rica, Cuba, Dominican Rep., El Salvador, Jamaica, Mexico, Panama, Iran Islamic Rep., Syrian Arab Rep., Fiji, Kirbati, Marshall Is., Micronesia Fed Sts., Samoa, Tonga, Bolivia, Brazil, Colombia, Paraguay, Peru
IV (lowest impact)	South Africa, Armenia, Azerbaijan, China, Georgia, Kazakhstan, Korea Rep, Kyrgyz Republic, Malaysia, Maldives, Mongolia, Sri Lanka, Tajikistan, Thailand, Turkmenistan, Uzbekistan, Dominica, Grenada, St Kitts and Nevis, St Lucia, St Vincent and the Grenadines, Trinidad and Tobago, Albania, Bosnia-Herzegovina, Moldova Rep, Romania, Serbia, Jordan, Lebanon, Argentina, Chile, Uruguay

Note: Data available for 131 countries.

Figure 7 Overall vulnerability (y axis) and implementation capacity (x axis)



Key: **Africa** **Middle East** **Oceania** **Asia** **Europe** **Central America & Caribbean** **South America**

7. Conclusions

This paper proposes an analytical framework to inform the allocation of adaptation funding. An omniscient social planner would solve the problem by ranking all possible adaptation interventions in order of their benefit – cost ratio and financing them according to economic merit. Distributional issues would be accounted for explicitly, for example by using equity weighting (Fankhauser et al. 1997). Residual climate damages that cannot be adapted to cost-effectively (Parry et al. 2009) would be subject to compensation, as appropriate.

What we propose is a distant second best to the approach of the omniscient planner, but it may help to make allocation decisions more transparent, efficient and equitable. The approach is inspired by the World Bank's method of allocating concessional IDA resources among the world's poorest countries. It uses quantitative indicators to assess a country's vulnerability, as well as its ability to manage additional resources effectively.

The IDA approach is not without its critics. Kanbur (2005) has argued that since the formula is uniform across countries, the IDA approach essentially imposes the same development model on all countries. This is problematic already for standard development issues, and may be even more so for climate change, where much less is known about the right adaptation model.

Nevertheless, an empirical approach to allocating adaptation finance that aims to address these concerns could serve at least three purposes: it can reduce transaction costs if lobbying and negotiations (though inevitable) become a less prominent part of the allocation process, it can support the results agenda with an allocation process based on empirical measures, and it can support mutual accountability through transparency in allocations.

Moreover, we do not propose that allocation decisions are made mechanistically according to a formula. The indicators are there to aid decision making, to make it more transparent and objective. But ultimately wise spending decisions will always take into account a range of considerations and require a considerable amount of judgement.

Some of that judgement already enters into the indicator system. There are infinite ways in which the raw data on climate impacts, adaptive capacity and implementation capacity can be combined, scaled, normalized and added up. The choice of data sets and the disparity between the underlying distributions of the chosen indicators will inevitable have implications for the implicit weighting of each. The way we constructed our indicators is only one of many ways how this might be done. Criteria weighting will ultimately be a political decision, made by experts in consultation with stakeholders.

The quality of the indicators is also affected by data gaps and imperfect information. With limited knowledge of environment-system feedbacks and limited climate scenario projections, uncertainty is compounded at each step. Assessing country-level vulnerability requires aggregating impacts across a number of sectors, and uncertainties, scientific and modelled, are further escalated.

There is substantial scope to improve the method over time. New data series may be added, for example, on physical impacts, where many potentially severe impacts have been omitted (for example, water, the implications of ocean acidification) or are represented only through proxies (for example, extreme events). Over time we may also learn more about the way the different determinants of adaptive capacity interact, a strand of research initiated by Tol and Yohe (2007). Our static approach may be made more dynamic by recognizing feedback loops and the fact that interventions will reduce future vulnerability.

A key question that our indicator framework cannot answer is the magnitude of adaptation funding that will be required. Answering this question requires information about physical impacts and adaptation needs in absolute dollar terms, rather than the relative ranking of countries put forward in this paper. Information about this question is still sketchy, but it is clear that the adaptation bill will run into tens of billions of dollars. This makes it all the more important that available funds are allocated as transparently, efficiently and equitably as possible.

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Annex 1: Country-level results

Individual indicators by country, as documented in Tables 1 and 3 and in the description of the CPIA in Section 5, are normalized by converting to z-scores, and then taking the average of these z-scores for each of the adaptive capacity, impact vulnerability, and implementation capacity indicators shown in the table below. We use an unweighted average, although the normalization procedure creates implicit weights. The overall vulnerability score is derived by subtracting adaptive capacity from impact vulnerability.

Country indicators (ordered by overall vulnerability score)

	Country	Region	Overall Vulnerability	Adaptive Capacity	Impact Vulnerability	Implementation Capacity
1	Guinea Bissau	Africa	2.59	-1.20	1.39	-0.95
2	Honduras	Central America & Caribbean	1.72	-0.01	1.71	1.06
3	Eritrea	Africa	1.70	-1.61	0.09	-1.11
4	Central African Rep	Africa	1.70	-1.34	0.36	-1.63
5	Chad	Africa	1.67	-1.57	0.10	-1.44
6	Niger	Africa	1.65	-1.32	0.33	-0.09
7	Burkina Faso	Africa	1.59	-1.00	0.59	0.83
8	Mauritania	Africa	1.51	-0.50	1.02	-0.54
9	Mozambique	Africa	1.48	-0.89	0.59	0.21
10	Somalia	Africa	1.45	-0.97	0.49	
11	Gambia The	Africa	1.35	-0.77	0.58	-0.29
12	Angola	Africa	1.35	-1.11	0.24	-1.47
13	Zaire/Congo Dem Rep	Africa	1.31	-1.26	0.06	-1.42
14	Benin	Africa	1.29	-0.49	0.80	0.51
15	Guinea	Africa	1.29	-0.93	0.36	-0.89
16	Togo	Africa	1.28	-0.88	0.40	-2.20
17	Uganda	Africa	1.28	-0.81	0.47	0.79
18	Rwanda	Africa	1.22	-0.85	0.37	0.55
19	Zimbabwe	Africa	1.11	-0.81	0.30	-2.78
20	Sierra Leone	Africa	1.10	-1.15	-0.04	-0.36
21	Djibouti	Africa	1.10	-0.77	0.33	-0.42
22	Burundi	Africa	1.09	-0.73	0.36	-0.75
23	Malawi	Africa	1.08	-0.58	0.50	0.31
24	Congo	Africa	1.02	-0.65	0.38	-0.74
25	Cote d'Ivoire	Africa	1.02	-0.92	0.11	-1.83
26	Ethiopia	Africa	0.98	-0.74	0.24	0.03
27	Comoros	Africa	0.96	-0.70	0.26	-1.54
28	Senegal	Africa	0.95	-0.59	0.36	0.99
29	Nigeria	Africa	0.94	-0.45	0.50	-0.68
30	Mali	Africa	0.94	-0.90	0.03	0.80
31	Suriname	South America	0.93	0.53	1.46	
32	Zambia	Africa	0.92	-0.52	0.39	-0.05
33	Cameroon	Africa	0.89	-0.65	0.25	-0.11
34	Liberia	Africa	0.88	-0.88	0.00	
35	Swaziland	Africa	0.85	-0.38	0.47	

	Country	Region	Overall Vulnerability	Adaptive Capacity	Impact Vulnerability	Implementation Capacity
36	Lesotho	Africa	0.80	-0.34	0.46	0.53
37	Gabon	Africa	0.79	-0.42	0.37	
38	Tanzania Uni Rep	Africa	0.79	-0.29	0.49	1.29
39	Venezuela	South America	0.75	0.20	0.95	
40	Egypt	Middle East	0.70	0.28	0.98	
41	Sudan	Africa	0.69	-1.01	-0.33	
42	Haiti	Central America & Caribbean	0.57	-0.69	-0.12	-1.39
43	Yemen	Middle East	0.53	-0.70	-0.17	-0.11
44	Papua New Guinea	Oceania	0.50	-0.50	0.00	-0.66
45	Madagascar	Africa	0.48	-0.48	0.00	0.43
46	Bangladesh	Asia	0.44	-0.01	0.42	-0.11
47	Kenya	Africa	0.41	0.00	0.41	0.43
48	Ghana	Africa	0.35	-0.10	0.24	1.10
49	Afghanistan	Asia	0.31	-0.74	-0.42	
50	Lao P Dem Rep	Asia	0.30	-0.40	-0.10	-0.77
51	Namibia	Africa	0.28	-0.08	0.20	
52	Guatemala	Central America & Caribbean	0.28	-0.46	-0.18	
53	Viet Nam	Asia	0.27	0.95	1.22	1.03
54	Nicaragua	Central America & Caribbean	0.25	0.08	0.32	0.85
55	Botswana	Africa	0.24	0.06	0.30	
56	Solomon Is	Oceania	0.16	0.02	0.18	-0.47
57	Ecuador	South America	0.10	0.16	0.26	
58	Seychelles	Africa	0.08	0.25	0.33	
59	Pakistan	Asia	0.07	-0.27	-0.20	0.26
60	Guyana	South America	0.07	0.65	0.72	0.10
61	Cambodia	Asia	0.07	-0.11	-0.04	-0.88
62	Vanuatu	Oceania	0.04	0.28	0.32	-0.63
63	Iraq	Middle East	0.00	-0.37	-0.37	
64	Nepal	Asia	-0.04	-0.40	-0.44	-0.29
65	Sao Tome and Principe	Africa	-0.06	0.09	0.03	-0.12
66	Libyan Arab Jamah	Africa	-0.06	-0.02	-0.07	
67	East Timor	Asia	-0.06	-0.22	-0.28	
68	Cape Verde Is	Africa	-0.13	0.53	0.39	1.18
69	Peru	South America	-0.19	0.20	0.01	
70	Fiji	Oceania	-0.21	0.34	0.13	
71	Paraguay	South America	-0.21	-0.05	-0.26	
72	Micronesia Fed States	Oceania	-0.21	0.20	-0.01	
73	El Salvador	Central America & Caribbean	-0.26	0.17	-0.10	
74	Mexico	Central America & Caribbean	-0.30	0.37	0.07	
75	Dominican Rep	Central America & Caribbean	-0.31	0.19	-0.12	
76	Samoa	Oceania	-0.32	0.57	0.25	1.87
77	Colombia	South America	-0.34	0.23	-0.11	
78	Belize	Central America & Caribbean	-0.36	0.37	0.01	

	Country	Region	Overall Vulnerability	Adaptive Capacity	Impact Vulnerability	Implementation Capacity
79	Kiribati	Oceania	-0.36	0.52	0.16	-0.37
80	Jamaica	Central America & Caribbean	-0.38	0.28	-0.10	
81	Tunisia	Africa	-0.40	0.46	0.06	
82	Bolivia	South America	-0.42	0.04	-0.38	0.50
83	Philippines	Asia	-0.43	0.32	-0.11	
84	Panama	Central America & Caribbean	-0.49	0.68	0.19	
85	Algeria	Africa	-0.50	0.09	-0.41	
86	Tonga	Oceania	-0.50	0.56	0.06	-0.61
87	Marshall Is	Oceania	-0.52	0.62	0.10	
88	Antigua and Barbuda	Central America & Caribbean	-0.52	0.61	0.09	
89	Morocco	Africa	-0.55	0.17	-0.38	
90	Myanmar	Asia	-0.57	0.01	-0.56	
91	India	Asia	-0.61	0.36	-0.24	0.96
92	Brazil	South America	-0.68	0.43	-0.25	
93	Cuba	Central America & Caribbean	-0.71	0.59	-0.12	
94	Bhutan	Asia	-0.72	0.00	-0.72	1.55
95	Syrian Arab Rep	Middle East	-0.73	0.20	-0.52	
96	Mauritius	Africa	-0.73	1.07	0.34	
97	Iran Islam Rep	Middle East	-0.73	0.30	-0.44	
98	Costa Rica	Central America & Caribbean	-0.76	0.61	-0.15	
99	Indonesia	Asia	-0.80	0.60	-0.20	0.26
100	St Lucia	Central America & Caribbean	-0.83	0.93	0.10	1.55
101	Georgia	Asia	-0.84	0.36	-0.48	1.17
102	Maldives	Asia	-0.86	0.64	-0.22	1.05
103	South Africa	Africa	-0.88	1.10	0.22	
104	Trinidad and Tobago	Central America & Caribbean	-0.91	0.86	-0.05	
105	Grenada	Central America & Caribbean	-0.93	0.96	0.03	0.91
106	Sri Lanka	Asia	-0.95	0.60	-0.36	0.83
107	Turkmenistan	Asia	-0.96	0.01	-0.95	
108	St Vincent and The Grenadines	Central America & Caribbean	-1.02	1.03	0.01	1.20
109	Moldova Rep	Europe	-1.03	0.72	-0.30	
110	St Kitts and Nevis	Central America & Caribbean	-1.04	1.13	0.09	
111	Lebanon	Middle East	-1.04	0.50	-0.54	
112	Malaysia	Asia	-1.09	0.73	-0.36	
113	Dominica	Central America & Caribbean	-1.13	1.03	-0.10	0.43
114	Argentina	South America	-1.13	0.33	-0.80	
115	Thailand	Asia	-1.17	0.86	-0.31	
116	Uzbekistan	Asia	-1.19	0.17	-1.01	-1.46
117	Tajikistan	Asia	-1.23	0.22	-1.01	-0.42
118	Jordan	Middle East	-1.25	0.74	-0.52	
119	Bosnia-Hercegovenia	Europe	-1.27	1.03	-0.24	0.34
120	Romania	Europe	-1.36	0.93	-0.43	

	Country	Region	Overall Vulnerability	Adaptive Capacity	Impact Vulnerability	Implementation Capacity
121	Kyrgyzstan	Asia	-1.40	0.51	-0.90	-0.22
122	Chile	South America	-1.41	0.86	-0.55	
123	Armenia	Asia	-1.50	0.50	-1.01	2.06
124	Kazakhstan	Asia	-1.56	0.69	-0.86	
125	Azerbaijan	Asia	-1.57	0.35	-1.22	0.64
126	Serbia Montenegro	Europe	-1.60	0.67	-0.93	
127	China P Rep	Asia	-1.62	0.72	-0.90	
128	Uruguay	South America	-1.62	0.62	-1.01	
129	Korea Rep	Asia	-1.72	0.82	-0.90	
130	Albania	Europe	-1.76	0.71	-1.04	0.57
131	Mongolia	Asia	-2.28	0.84	-1.44	0.63