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DEFINING AND ASSESSING THE RISK OF A TERRITORY BEING HARMED BY CLIMATE CHANGE

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1. INTRODUCTION

Many definitions of vulnerability[1] and adaptation[2] do not clearly distinguish between inherent and self-inflicted realities, as is the case with the following IPCC definition "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate 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." In this case, there is no distinction between inherent (or natural) or man-made adaptation.

This paper argues that, in order to assess the risk of being harmed by climate change, it would be useful methodologically to (i) confine the concept of vulnerability to natural factors and (ii) the concept of adaptation (or resilience) to man-made or policy induced factors. In addition this distinction would render the discussion more useful for policy.

The remainder of this paper is organised as follows. Section 2 distinguishes between inherent and policy-induced realities, and presents four scenarios relating to these realities. Section 3 presents an attempt to measure the risk of being ahrmed by climate change on the basis of the distinction discussed in the previous sction. Section 4 concludes the paper with a summary of the methodological advantages relating to the approach proposed in the study.

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[1] For a discussion on the concept of vulnerability to climate change see Fussel (2005).

[2] For a discussion on the concept of adaptation see Levina and Tirpak (2006).

2. INHERENT AND POLICY-INDUCED REALITIES

The basic argument proposed in this paper is the following:

1. Risk depends positively on natural vulnerability and negatively on human adaptation;
2. Vulnerability depends on inherent features which exposes a territory to climate change effects – these features are therefore permanent or quasi-permanent;
3. Adaptation relates to the ability of humans in a given territory in taking measures to withstand, absorb or bounce back from the effects of climate change. Such ability can be anticipatory or reactive and can be policy-induced.[3]

2.1 Advantages of the Methodology

This method of defining risk in terms of inherent vulnerability and anthropogenic adaptation has a number of advantages, including:

(1) If the definition of vulnerability is restricted to refer to inherent features, it follows that the country or a territory having these features has practically no control over their incidence. In other words, highly vulnerable countries/territories cannot be accused of inflicting vulnerability on themselves. Examples of inherent vulnerability is the case of islands that are low lying since this renders them exposed to the harm caused by sea-level rise. Many countries located in the tropics are inherently exposed to hurricanes and cyclones.[4]

(2) If the definition of adaptation (or resilience) is constrained to refer to what humans have done, are doing, or can do to cope with (or exacerbate) natural vulnerability to climate change, it follows that such adaptation can be nurtured, and therefore can be policy-induced.[5]

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[3] This definition is very similar to that used by Briguglio et al. (2006) in their definition of economic resilience, which enables an economy to bounce back or absorb economic shocks.

[4] Vulnerability can also be self-inflicted because in many countries there are activities which exacerbate exposure to climate change, such as building on the coast, removal of mangrove cover, damage to coral reefs, etc. Self-inflicted vulnerability, in the methodological approach presented in this paper, would be considered as the obverse of nurtured adaptation/resilience.

[5] Adaptation (or resilience) can also be inherent, but in the context of this methodological approach inherent adaptation/resilience would be included with vulnerability or lack of it.

(3) the combination of the two factors would then refer to the **risk of being harmed by climate change**, due to inherent vulnerability features, counterbalanced to different extents, by nurtured resilience.

2.2 Diagrammatic Approach

The arguments developed above are summarised graphically in Figure 1.

Figure 1 about here

Figure 1 shows that risk of being harmed by climate change has two elements, the first being associated with the inherent conditions of the territory that is exposed and the second associated with conditions developed by humans to absorb, cope with or bounce back from external shocks. The risk of being adversely affected by climate change is therefore the combination of the two elements. The negative sign in front of the adaptationelement indicates that the risk is reduced as adaptation builds up. The scale parameter is intended to capture the amount of people or assets at risk.

2.3 Four Scenarios

On the basis of the relationship between inherent vulnerability and nurtured adaptation, shown in Figure 1, one can consider 4 possible territory scenarios as shown in Figure 2.

Figure 2 about here

The "lowest-risk" scenario applies to territories which are not inherently very vulnerable to climate change and which at the same time adopt effective adaptation measures, possibly as part of their normal way of doing things. For example, the infrastructure in developed countries, including that intended for flood control, tends to be of better quality than in poorer countries, even when the latter are more vulnerable to flooding. This scenario can also be labelled as the "best-case" scenario.

The “highest-risk” or “worst-case” scenario applies to territories that are inherently very vulnerable to climate change but do not or cannot adopt effective adaptation, possibly due to lack of resources. For example a deltaic port city located in a low-income country, exposed to high winds and experiencing natural subsidence will have a very high risk of being harmed by climate change, in line with the arguments relating to Figure 1.

Territories classified under the “managed-risk” category would be those with a high degree of inherent vulnerability to climate change, but which adopt or afford to adopt appropriate policies to enable them to cope with or withstand their inherent vulnerability. They can also be labelled “self-made” in the sense that they would have taken steps to make up for their disadvantage. These territories remain inherently vulnerable, but their adaptation measures reduce the risk associated with exposure to climate change effects.

Territories falling within the “mismanaged-risk” scenario are those with a relatively low degree of inherent vulnerability to climate change, but which do not or cannot adopt adaptation measures in the face of their exposure to climate change. At times they allow practices which exacerbate their vulnerability. This scenario can also be labelled “prodigal-son”, the analogically being that though “born in a good family”, the prodigal son mismanaged his riches.

It should be noted that given that vulnerability is considered to be natural and permanent or quasi permanent, movement from the lower quadrants to the upper quadrants is not possible. However, given that adaptation is policy-driven, movement from the left quadrants to the right quadrants is possible.

3. MEASURING RISK

3.1 Measuring Vulnerability

This section of the paper draws heavily on Nicholls et al (2008) for the data. This important work is essentially a global screening of the exposure of the world's large[6] port cities to coastal flooding due to storm surge, high winds and climate change. The authors found that most (about 38%) of the most vulnerable port cities are found in underdeveloped Asia and many of them located in deltas with a higher coastal flood risk as a result of their tendency to be at lower elevations and experience significant subsidence. This means that many millions of people in low-income countries are exposed to coastal flooding, with limited protection and absence of or underdeveloped early warning systems.

The authors rightly insist that exposure does not necessarily translate into impact. They argue that, in general, cities in high-income countries have (and are more likely to have in the future) much better protection levels than those in the developing world. This is in line with the methodological approach proposed above.

The results reported by Nicholls et al (2008) indicate that the most vulnerable cities in 2005 in terms of population exposure (including all environmental and socioeconomic factors)[7] were Mumbai, Guangzhou, Shanghai, Miami, Ho Chi Minh City, Calcutta, Greater New York, Osaka-Kobe, Alexandria and New Orleans. A high percentage of the exposed population is located in Asian developing countries.

3.2 Measuring Adaptation

Adaptation measures can take different forms (see UNFCCC, 2007; Burton 2005). According to Nicholls et al. (2008), the adaptation strategies with regard to climate change include a combination of :

1. Upgraded protection;

[6] The analysis by Nicholls et al. (2008) is confined to cities with a population greater than 1 million, so it excludes small island developing states, which as argued in the IPCC (2007) tend to be amongst the most vulnerable countries to climate change.

[7] This refers to the C scenario proposed by Nicholls et at (2008), which relates to 2005 conditions taking into account global sea-level rise, a storm enhancement factor and natural/anthropogenic subsidence. The index proposed by Nicholls et al. does not therefore measure natural vulnerability only, as it includes some anthropogenic factors. The index deltaic cities, for example, where assigned a slightly higher degree of vulnerability due to human-induced subsidence.

2. Managing subsidence (in susceptible cities);
3. Land use planning to reduce vulnerability, including focusing new development away from the floodplain, and preserving space for future infrastructure development;
4. Selective relocation away from existing city areas; and
5. Flood warning and evacuation.

It is not an easy task to measure policy induced adaptation measures. One possible approach is to assign a value on a mapping scale ranging from say 1 to 5 to the adaptation measures listed above for different territories, and on this basis, create a composite index by aggregating the adaptation measures through a simple or weighted average.

In this paper however we take a simpler route. It is assumed that the territory's economic situation enables it to have a higher degree of protection standards. As Nicholls et al (2007; 2008) argue, cities in rich countries have much better protection levels than cities in the developing world. This is due to the ability by richer territories to afford the cost of protection infrastructures. In addition, in richer countries there is a tendency for a higher degree of risk aversion due in part to the higher value of assets involved. Basing on these arguments, we have taken GDP per capita as a measure of the extent to which countries put in place adaptation measures. It is to be emphasized however, that this approach is somewhat of a rule of thumb method[8] and that further work is required to construct a more reliable adaptation index across countries.

3.3 Juxtaposing Vulnerability and Adaptation

As argued above, risk of being harmed by climate change is a function of two elements, namely inherent vulnerability and nurtured adaptation. Juxtaposing the two indices described above, namely the which captures inherent features derived from Nicholls et al.

[8] Nicholls et al (2008) note that " the relationship between wealth and protection is not automatic. Even though rich countries have a larger capacity to protect their cities, they may or may not choose to do so." The authors refer to, Amsterdam, Rotterdam, London and Tokyo, which are much better protected than New York, whereas Shanghai, has a better protection level than New York.

(2008)[9] and the GDP per capital index, assumed to proxy adaptation measures, one can therefore assess the extent of risk to the effects of climate change risk.

In order to do this the country scores were rescaled to take a value of between 0 and 1 using the following formula:

Xr = (Xi – Xmin)/(Xmax-Xmin)

where Xr is the rescaled score, Xi is the actual score, Xmin and Xmax are the minimum and the maximum of all scores of a given variable.

In addition the variables where measured in logs, so as to allow for decreasing marginal effects, in the sense that (a) with regard to adaptation, doubling the income per capita does less than doubles the adaptation possibilities (b) with regard to vulnerability, doubling exposure does less than double the harm.

The results are shown graphically in Figure 3. The thresholds between categories is taken to be the average of all scores of both variables. The scatter points represent the 136 port cities identified by Nicholls et al. (2008), which in Appendix 1, are named and classified according to the 4 scenarios described above.

It can be seen that 32 port cities are in the "lowest-risk" category – these are mostly port cities in high-income countries, 27 are in the "managed-risk" category, which are vulnerable cities mostly located in high-income countries. 38 are located in the "mismanaged-risk" category. These are low-vulnerability cities mostly in low-income countries. The remaining 39 cities are the "highest-risk" countries, with high-vulnerability cities located in low-income countries.

[9] The results pertain to Scenario C, relating to 2005 conditions. A similar exercise was worked out with the FAC scenario, where future (2070) climate change and subsidence in taken into account, with the results being very similar except that certain developing countries (eg China) are likely to grown faster than other countries and therefore would be able to afford better adaptation measures, leading them to move to the right in diagram 3.

3.4 Some Caveats

These results should be interpreted with some caution, due to the measurement weaknesses indicated above, including that (1) the vulnerability index does not only cover natural factors, as premised in the arguments presented above, and (2) the adaptation index is a very basic and needs to be refined.

In addition the thresholds dividing the four scenarios are set somewhat arbitrarily, and movements of these thresholds can result in the movement of marginal scores from one scenario to another.

However the methodological approach proposed in this study could be very useful, especially because it highlights the importance of adaptation policies. It also carries the message that territories that a vulnerable to climate change should not be complacent in the face of this reality but can and should take action to build up their adaptation capacity.

4. CONCLUSION

There are various advantages emanating from the methodological approach proposed in this study, based on the distinction between what is natural (inherent, permanent or quasi-permanent) and what is nurtured and subject to policy orientations.

The methodology emphasises the benefits of policies that promote adaptation, which is an important component of risk management. Nichols et al (2008) highlight the following adaptation strategies (1) upgraded protection/infrastructure (2) management of subsidence (in susceptible cities), (3) land-use planning (4) selective relocation away from vulnerable areas and (5) flood warning and evacuation.

These strategies do not reduce the natural vulnerability of the territories concerned, but they do serve to enable humans to withstand, bounce back from or absorb the effects of climate change.

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Figure 1. Conceptual Framework for Assessing the Risk of being affected by Climate Change

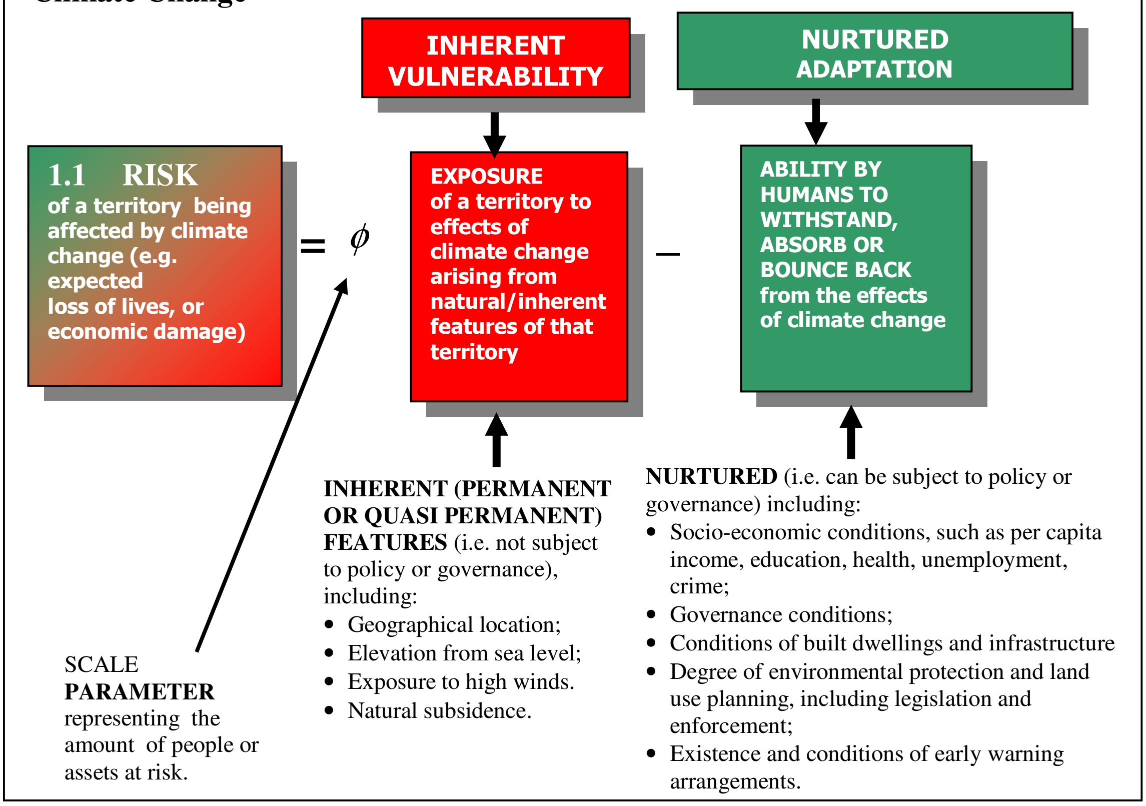
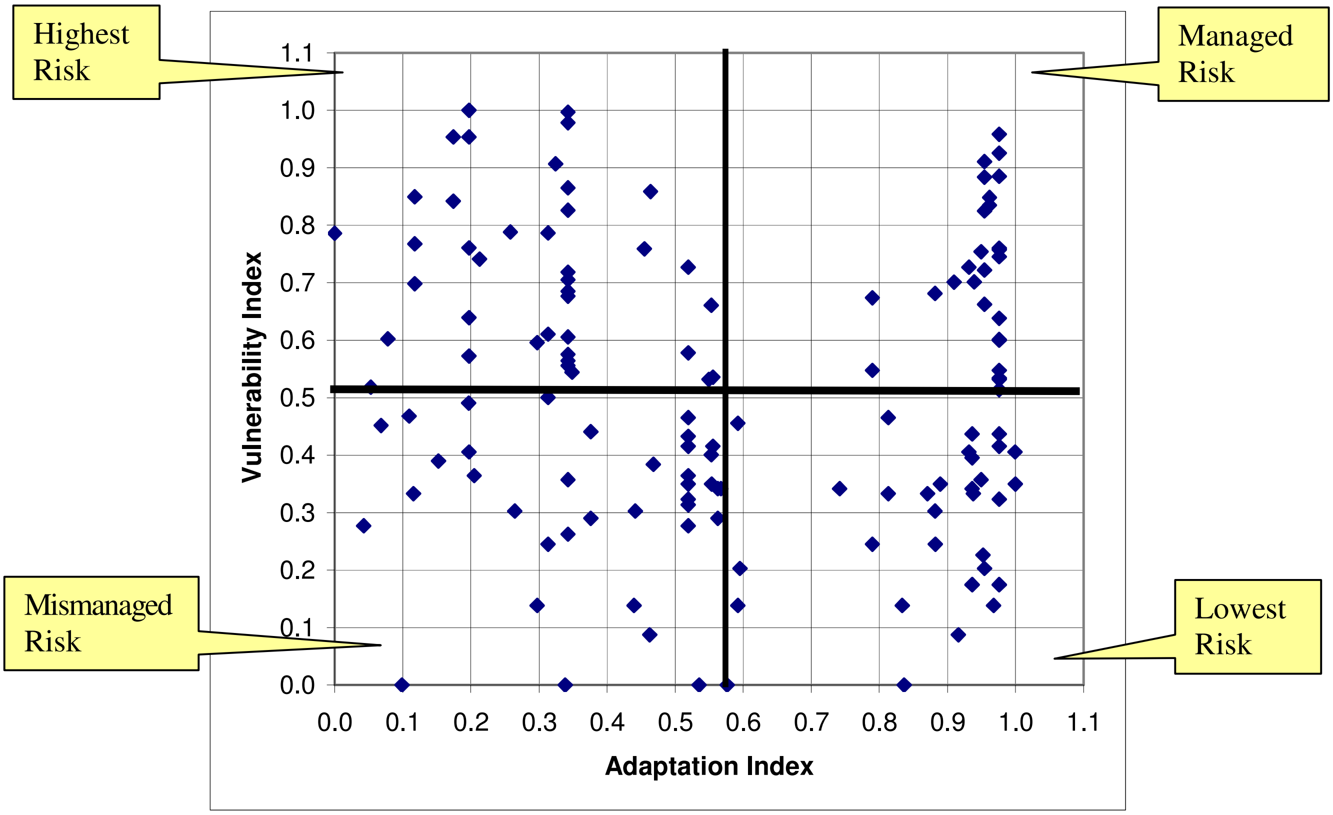


Figure 2. Four Possible Scenarios

Adaptation Policies → / Inherent Vulnerability ↓	Territories where adaptation measures are absent/limited or where climate change effects are exacerbated	Territories that implement appropriate adaptation policies
Territories with high inherent vulnerability to climate change effects	The "highest risk" or "worst case" scenario	The "managed risk: or "self-made" scenario
Territories with low inherent vulnerability to climate change effects	The "mismanaged-risk" or "prodigal-son" scenario	The "lowest risk" or "best-case" scenario

Table 3: Juxtaposing Vulnerability and Adaptation



Sources: The Vulnerability Scores are derived from the C scenario proposed by Nicholls et at (2008), which relate to the situation in 2005, rescaled as indicated in the text of this study. The GDP per capita scores are the averages of 3 years (2003-2005) sourced from *UNCTAD Handbook of Statistics* (2007).

Appendix 1: The Four Scenarios

Low Vulnerability – High Adaptation			
Lowest-Risk (Best-Case) Scenario			
Australia	Sydney	0.936	0.175
Australia	Adelaide	0.936	0.175
Australia	Melbourne	0.936	0.341
Australia	Brisbane	0.936	0.395
Australia	Perth	0.936	0.437
Canada	Montréal	0.932	0.406
Denmark	Copenhagen,088	0.999	0.406
Finland	Helsinki	0.952	0.226
France	Marseille Aix en Provence	0.938	0.333
Greece	Athens	0.834	0.138
Ireland	Dublin	1.000	0.350
Israel	Tel Aviv Jaffa	0.836	0.000
Italy	Naples	0.916	0.087
Japan	Sapporo	0.954	0.203
Korea, Republic of	Ulsan	0.790	0.245
Kuwait	Kuwait City)	0.871	0.333
Lebanon	Beirut	0.595	0.203
Libyan Arab Jamahiriya	Tripoli	0.592	0.138
Libyan Arab Jamahiriya	Banghazi	0.592	0.455
New Zealand	Auckland	0.882	0.245
Portugal	Porto	0.813	0.333
Portugal	Lisbon	0.813	0.465
Saudi Arabia	Jiddah	0.742	0.341
Singapore	Singapore	0.890	0.350
Spain	Barcelona	0.882	0.302
Sweden	Stockholm	0.968	0.138
United Kingdom	Glasgow	0.950	0.357
United States	San Jose	0.976	0.175
United States	San Diego	0.976	0.175
United States	Portland	0.976	0.323
United States	Seattle	0.976	0.415
United States	Washington DC,	0.976	0.437
High Vulnerability – High Adaptation			
Managed-Risk (Self-Made) Scenario			
Canada	Vancouver	0.932	0.727
China, Hong Kong SAR	Hong Kong	0.882	0.682
Germany	Hamburg	0.940	0.701
Japan	Hiroshima	0.954	0.663
Japan	Fukuoka Kitakyushu	0.954	0.722
Japan	Nagoya	0.954	0.825

Japan	Tokyo	0.954	0.884
Japan	Osaka Kobe	0.954	0.911
Korea, Republic of	Pusan	0.790	0.548
Korea, Republic of	Inchon	0.790	0.674
Netherlands	Rotterdam	0.962	0.835
Netherlands	Amsterdam	0.962	0.849
Puerto Rico	San Juan	0.976	0.532
United Arab Emirates	Dubai	0.910	0.701
United Kingdom	London	0.950	0.754
United States	Houston	0.976	0.514
United States	Providence	0.976	0.534
United States	Los Angeles	0.976	0.548
United States	Baltimore	0.976	0.600
United States	San Francisco	0.976	0.601
United States	Philadelphia	0.976	0.638
United States	Boston	0.976	0.745
United States	Virginia Beach	0.976	0.757
United States	Tampa	0.976	0.760
United States	New Orleans	0.976	0.886
United States	New York	0.976	0.925
United States	Miami	0.976	0.958
Low Vulnerability – Low Adaptation			
Mismanaged-Risk (Prodigal-Son) Scenario			
Algeria	El Djazaïr	0.468	0.384
Angola	Luanda	0.339	0.000
Brazil	Salvador	0.519	0.277
Brazil	Fortaleza	0.519	0.313
Brazil	Maceió	0.519	0.323
Brazil	Natal	0.519	0.350
Brazil	Baixada Sanista	0.519	0.364
Brazil	Recife	0.519	0.415
Brazil	Porto Alegre	0.519	0.433
Brazil	Belém	0.519	0.465
Cameroon	Douala	0.264	0.302
China	Yantai	0.342	0.262
China	Hangzhou	0.342	0.357
Colombia	Barranquilla	0.440	0.138
Cuba	La Habana	0.536	0.000
Dominican Republic	Santo Domingo	0.442	0.302
Ghana	Accra	0.116	0.333
Guinea	Conakry	0.109	0.468
Haiti	Port au Prince	0.099	0.000
India	Visakhapatnam	0.197	0.406

Indonesia	Ujung Pandang	0.314	0.245
Indonesia	Surabaya	0.314	0.500
Korea, Dem. People's Republic of	N'ampo	0.152	0.390
Malaysia	Kuala Lumpur	0.576	0.000
Morocco	Rabat	0.376	0.290
Morocco	Casablanca	0.376	0.441
Pakistan	Karachi	0.197	0.491
Panama	Panama City	0.567	0.341
Peru	Lima	0.463	0.087
Philippines	Davao	0.297	0.138
Senegal	Dakar	0.205	0.364
Somalia	Mogadishu	0.042	0.277
South Africa	Cape Town	0.563	0.290
South Africa	Durban	0.563	0.341
Turkey	Izmir	0.556	0.415
United Republic of Tanzania	Dar es Salaam	0.068	0.452
Uruguay	Montevideo	0.553	0.350
Venezuela	Maracaibo	0.553	0.401
High Vulnerability – Low Adaptation			
Highest-Risk (Worst-Case) Scenario			
Argentina	Buenos Aires	0.550	0.532
Bangladesh	Chittagong	0.117	0.699
Bangladesh	Khulna	0.117	0.768
Bangladesh	Dhaka	0.117	0.849
Brazil	Rio DJ	0.519	0.578
Brazil	Grande Vitoria	0.519	0.727
China	Wenzhou	0.342	0.556
China	Qingdao	0.342	0.564
China	Dalian	0.342	0.575
China	Taipei	0.342	0.606
China	Fujian	0.342	0.676
China	Zhanjiang	0.342	0.686
China	Xiamen	0.342	0.705
China	Ningbo	0.342	0.719
China	Shenzen	0.342	0.826
China	Tianjin	0.342	0.865
China	Shanghai	0.342	0.979
China	Guangdong	0.342	0.997
Côte d'Ivoire	Abidjan	0.258	0.788
Ecuador	Guayaquil	0.455	0.759
Egypt	Alexandria	0.325	0.907
India	Cochin	0.197	0.573
India	Chennai	0.197	0.639

India	Surat	0.197	0.761
India	Calcutta	0.197	0.954
India	Mumbai	0.197	1.000
Indonesia	Palembang	0.314	0.611
Indonesia	Jakarta	0.314	0.787
Mozambique	Maputo	0.053	0.518
Myanmar	Rangoon	0.000	0.786
Nigeria	Lagos	0.213	0.741
Philippines	Manila	0.297	0.596
Russian Federation	St. Petersbourg	0.553	0.661
Thailand	Bangkok	0.464	0.858
Togo	Lomé	0.078	0.602
Turkey	Istanbul	0.556	0.536
Ukraine	Odessa	0.349	0.544
Viet Nam	Hai Hong	0.175	0.842
Viet Nam	Ho Chi Minh City	0.175	0.954

Sources: The Vulnerability Scores are derived from the C scenario proposed by Nicholls et at (2008),, rescaled as indicated in the text of this study. The GDP per capita scores are the averages of 3 years (2003-2005) sourced from *UNCTAD Handbook of Statistics* (2007).