DEFINING AND ASSESSING THE RISK OF A SMALL ISLAND STATE BEING HARMED BY SEA-LEVEL RISE

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Abstract:

The purpose of this paper is to assess the risk of country being harmed by sea-level rise, distinguishing between (a) natural factors, which are associated with inherent vulnerability and (b) policy-induced or community based measures, which are associated with adaptation. The focus will be on Small Island Developing States (SIDS) are members of the Alliance for Small Island States (AOSIS). It is argued that the distinction is useful as a methodological approach and for policy making. The approach utilised in this paper involves the construction of two indices for vulnerability and adaptation potential respectively and these are juxtaposed to assess the risk of a SIDS to be harmed by sea-level rise. The major findings of this paper are that the SIDS that are the most vulnerable to sea-level rise are those with very limited adaptation potential. The originality of the paper is that it highlights the distinction between natural and man-made risks in arriving at a total assessment of risk – a distinction of utmost importance for policy making. An important, although obvious, conclusion is that adaptation does not reduce the inherent vulnerability of the countries concerned, but it serves to enable humans to withstand, bounce back from or absorb the effects of vulnerability to climate change.

Keywords:
Sea-level, Risk assessment, Small Island Developing States, Coastal regions

1 Introduction

The purpose of this paper is to assess the risk of a country being harmed by sea-level rise, distinguishing between (a) natural factors, which are associated with inherent vulnerability and (b) policy-induced or community based measures, which are associated with adaptation. The focus will be on 39 Small Island Developing States (SIDS) which are members of the Alliance for Small Island States (AOSIS).[1]

[1] The list of SIDS members of AOSIS is available at: http://aosis.org/about/members/ It should be noted that some members of AOSIS are not really islands (e.g. Guyana, Suriname and Guinea Bissau). Some others are part of an island (e.g. Haiti, Dominican Republic and Papua New Guinea). In addition, some of the member states are not actually small e.g. Cuba, Haiti, Dominican Republic, Papua New Guinea and Singapore). Nevertheless, as we shall show below, the countries that we identified as the most vulnerable are really small island developing states.

This methodological approach sharpens the definition of vulnerability, by confining it to inherent and natural conditions. Man-made or policy-induced factors are, according to this approach, associated with adaptation or maladaptation. [2] The approach utilises indices of vulnerability and adaptation, and juxtaposes them to arrive at an assessment of risk.

Many definitions of vulnerability and adaptation exist, most of which do not clearly distinguish between inherent and self-inflicted changes, as is the case with the following IPCC (2014) definition:

> "The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." (Agard and Schipper, 2014)

In this definition, there is no distinction between inherent (or natural) features and man-made adaptation … as a matter of fact this definition includes policy induced factors such as lack of coping ability by the government or society at large. In other words, this definition also includes adaptation.

In the paper we focus on one important consequence of climate change, namely sea-level rise.[3] According to Nurse et al (2014)[4] sea-level rise (SLR) poses one of the most widely recognized climate change threats to low-lying coastal areas on small islands. The authors assigned high confidence to such an assertion with robust evidence and a high degree of agreement in the literature.

This threat arises mostly because a large proportion economic activity in SIDS occur on the coastal area. Recognition of this concern was expressed in various studies, including Cazenave and Llovel (2010); Nicholls and Cazenave (2010) and Church and White (2011). It is widely recognised that sea-level rise may not only cause inundation of low lying coastal areas, but also shoreline erosion, and destruction of important ecosystems such as wetlands and mangroves.

According to Church et al (2013)[5] over much of the 20th century, global mean sea level rose at a rate between 1.3 and 1.7 mm annually (WGI AR5 Table 13.1), and an acceleration is detected in longer records since 1870 (WGI AR5 Section 13.2.2.1), albeit with large regional differences, with some regions in the Indian Ocean and tropical Pacific have been significantly higher than the global average (Dunne et al., 2012; Becker et al (2012).).

The rest of this paper is organised as follows. Section 2 presents a literature review on a number of themes relating to this paper. Section 3 discussed the methodology, based on a distinction between (a) inherent vulnerability features of a country and (b) policy-induced or

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[2] On the question of maladaptation see Juhola et al.,. (2016).

[3] It should be stated at the outset that this method used in this study is not intended to measure vulnerability to climate change in all its aspects, given that besides sea-level rise, climate change is likely to have additional impacts on small island states including health, biodiversity and water resources (see Nurse et al, 2014).

[4] Contribution to Working Group II (Chapter 29) of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

[5] Contribution to Working Group I (Chapter 13) of the IPCC Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)

community based adaptation measures, and presents four scenarios relating to these factors. Section 4 contains an attempt to measure the risk of a small island developing state being harmed by sea-level rise on the basis of the distinction discussed in the previous section. Section 5 concludes the paper with a number of implications derived from the previous section.

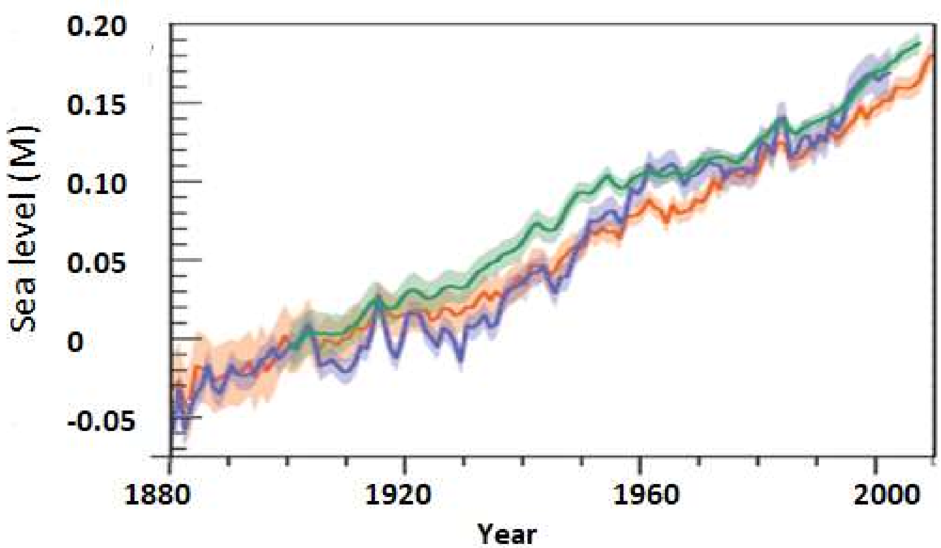
2 Literature Review

2.1 Sea-level rise and its measurement

Church et al. (2013) contend that it is virtually certain that globally the sea level is rising and that sea-level rise rates are accelerating. The authors explain that instrumental record of sea level change consist mainly of tide gauge measurements over the past two to three centuries and, since the early 1990s, of satellite-based radar altimeter measurements.

The tide-gauge instruments are devices for measuring the change in sea level relative to a given level, generally using electronic sensors which are transmitted to a computer.[6] The is a relatively long historical record derived from data in a large number of stations worldwide (see Douglas 2001, Ray and Douglas, 2011) for a record of measurements of sea level derived from tide-gauge readings.

Figure 1
Yearly average global mean sea level (GMSL)



Source: Church et al (2013).

The satellite altimetry mode of measuring sea level started in 1992,[7] with various satellite projects launched since that time. A satellite altimeter is a radar that precisely measures the range from the radar antenna to the ocean surface. This method measures sea level on a global basis with a high degree of precision (see Ablain et al. 2015 and Fu and Cazenave, 2000).

[6] See http://tide.gsi.go.jp/ENGLISH/history.html for a description of different types of tide-gauges.
[7] The Altimeter technology started to be developed during the 1960s, with the flights of artifical satellites (see Fu and Caseneve, 2000).

According to Church et al (2013) both these technical approaches indicate that sea-level rise has occurred and it is very likely that sea-level rise will continue rising during the 21st century, possibly exceeding the rate observed between 1971 and 2010 due two main factors, namely ocean warming and loss of mass from glaciers and ice sheets.

The dominant contributors to the 20th century sea-level rise are (a) thermal expansion, with about half of the past century's rise in sea level being attributable to warmer oceans occupying more space, and (b) glacier melting , with large ice formations, like glaciers and the polar ice caps, melting. 20th century global mean sea-level rise. Observations since 1971 indicate that thermal expansion and glaciers explain 75% of the observed rise (Church et al. 2013).

The sea-level rise prediction put forward in Church et al. (2013) range from 28 to 98 centimeters in mean sea-level rise by 2100, relative to 1986–2005, although there are bands of alternative ranges produced by different emissions scenarios, and because there are still uncertainties about when and how quickly ice sheets will melt. However, Church et al (2013) leave no doubt that sea-level rise will continue to occur and conclude their paper, based on extensive appraisal of peer-reviewed studies, by stating that "sea level will continue to rise for centuries, even if GHG concentrations are stabilized, with the amount of rise dependent on future GHG emissions. For higher emission scenarios and warmer temperatures, surface melting of the Greenland ice sheet is projected to exceed accumulation, leading to its long-term decay and a sea-level rise of metres."

2.2 Small island states and sea-level rise

The literature on small island states has mushroomed during the recent three decades, mostly due to the importance that small states are being assigned in the international arena. About 20% of UN members are small island states, organised in a lobby group called the Alliance for Small Islands States (AOSIS). Three global conferences on the sustainable development of small island developing states[8] have been organised under the auspices of the United Nations, and these have drawn attention to the special conditions of such states, including their high degree of vulnerability to climate change. (Kelman and West, 2009, Gillepsie, 2003).

In the three outcome documents of these three global conferences[9] climate change was assigned centre stage, and topped the list of major concerns relating to sustainable development of SIDS. It is well-known that climate change will have a number of impacts, but for SIDS, sea-level rise is, understandably a major source of vulnerability within the climate change discourse. The outcome document of the 2014 Samoa International meeting on SIDS, states "We recognize that sea-level rise and other adverse impacts of climate change continue to pose a significant risk to small island developing States and their efforts to achieve sustainable development and, for many, represent the gravest of threats to their survival and viability, including, for some, through the loss of territory."

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[8] Held in Barbados in 1994, Mauritius in 2005 and Samoa in 2014.

[9] The three outcome documents are (1) the Barbados Programme of Action (BPoA) is available at http://www.un.org/esa/dsd/dsd_aofw_sids/sids_pdfs/BPOA.pdf, (2) the Mauritius Strategy of Implementation (MSI)
available at: http://unohrlls.org/UserFiles/File/SIDS%20documents/mauritius.pdf and (3) the Samoa Pathway Outcome document, available at: http://www.sids2014.org/index.php?menu=1537 .

Because climate change, and in particular SLR, poses an important threat for SIDS, these states have, since the creation of AOSIS, collectively been at the forefront of climate change negotiations in the international arena. In fact, under the auspices of AOSIS, small island states have built a cohesive coalition, sparkling further attention from scholars on how AOSIS has fared in the climate change regime (Betzold et al. 2012, de Águeda Corneloup and Mol, 2014; Hoad, 2015).

It is worth noting that vulnerability to climate change poses an ethical problem also, to the disadvantage of SIDS. This is clearly articulated in the Barbados Programme of Action (BPOA), which states that while SIDS are among those that contribute least to global climate change and SLR, they are among those that would suffer most from the adverse effects of such phenomena, and could in some cases become uninhabitable.[10]

The IPCC also acknowledged the relatively high degree of climate change vulnerability facing small island states, and dedicated focussed reports to such territories. In the first assessment report there was no special paper on small islands, although there was considerable reference to small islands even in that overall report. The IPCC Second Assessment Report, published in 1995 confirmed the vulnerable condition of small islands, and included in a specific paper titled "Coastal Zones and Small Islands" (Bijlsma et al., 1996). The Third (Nurse et al., 2001), Fourth (Mimura et al., 2007)) and Fifth (Nurse et al. 2014) Assessment Reports each contained a dedicated paper on small islands. In all these reports, SLR was considered as a major cause of concern for small island states and highly attributable to climate change.

In the IPPC fifth assessment report, Nurse at al. (2014), identify the main regions where small island states are located and reproduce predictions if the likely magnitude of sea-level rise for the last two decades of the 21st Century compared to 1986-2005. The results are shown in Table 1, which data was adapted from Church et al (2013) Figure 13-20.

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Table 1: Small island region RCP4.5 annual projected change for 2081–2100 compared to 1986–2005

Region	Range (meters)
Caribbean	0.5 – 0.6
Mediterranean	0.4 – 0.5
Northern tropical Pacific	0.5 – 0.6
Southern Pacific	0.5 – 0.6
North Indian Ocean	0.4 – 0.5
West Indian Ocean	0.5 – 0.6

Source: Nurse et al (2014)

Although, as Nurse et al (2014) and Nicholls (2003) argue, small islands of the Caribbean, Indian Ocean and Pacific Ocean tend to be highly vulnerable to sea-level rise, not all small islands are equally vulnerable in this regard, firstly due to the typology of the island and secondly due to regional differences in sea-level rise. In addition to typological factors, there are differences within the islands themselves. Some islands, such as the Tuvalu, Maldives and

[10] http://www.un.org/esa/dsd/dsd_aofw_sids/sids_pdfs/BPOA.pdf

Kiribati are almost uniformly low lying whereas other islands have steep outer slopes but may also have some parts which are low lying, and densely populated.

There is therefore a combination of various processes that produce a complex pattern of total sea level change, leading to a global average, and various regional processes can result in large departures from the global average. For example, some parts of the Indian Ocean and tropical Pacific, rates have been significantly higher than the global average (Dune et al, 2012; Becker et al, 2012). In some cases, regional variations are associated with extreme sea-level rise. which as Wong et al., (2014) explain these arise from combinations of factors including astronomical tides, storm surges, and wind waves.

2.3 Commonly used approaches to assess coastal vulnerability

One of the most common approaches used to assess coastal vulnerability to sea-level rise is the so called Coastal Vulnerability Index (CVI), which was originally developed by Gornitz et al. (1994) and further refined by Thieler and Hammar-Klose (1999). The CVI is a takes into account a number of variables, and the risk of the coast being harmed by sea-level rise is assessed according to the score of such an index.

Cooper and McLaughlin (1998) present various motivations for constructing a CVI. These include (a) to facilitate shoreline management under existing conditions, (b) to categorize potential shoreline responses to future sea-level rise, and (c) for data storage and management. The authors also argue that predictive models of where and how inundation and erosion are likely to take place and how much land is going to be lost are of great service in providing management strategies especially if they can be incorporated into an easily understood coastal classification.

Variables that often feature in the CVI are geological ones, such geomorphology and coastal slope and physical variables, such is sea-level rise, shoreline erosion or accretion rate, mean tide range and mean wave height. The variables are often grouped into two or three categories, namely geological variables and physical variables. Generally speaking each variable is measured along a five-point mapping scale where the lowest degree of risk of harm from inundation is assigned a value of 1 and the highest degree of risk of harm a value of 5. Studies based in this methodology included Hammar-Klose et al. (2003), Pendleton et al. (2005), Doukakis (2005), Rao et al. (2008), Kumar et al. (2010), and Özyurt & Ergin (2010).

Some studies, including Balicia et al (2012), and Wu et al. (2002), Yan et al (2016) include socio-economic variables in the CVI, in addition to the natural ones. Wu et al, in discussing coastal social vulnerability refer to a number of socio-economic variables including gender, age, disability, family structure and social net-works, housing and built environment, income and material resources and race and ethnicity. Balica et al (2012) associated the social vulnerability with the effects of flooding with the day-to-day lives of the population that belongs to the system, so the presence of human beings and related to it feature in such an index including deficiencies in mobility of human beings associated with gender, age or disabilities, destruction of houses, disruption in communications, in the agricultural process, or even fatalities, as well as economic activities, which can be negatively affected by coastal flooding, including tourism, fisheries, navigation, industries, agriculture, availability of potable water, etc. Balica et al also add an administrative and institutional subsystem that includes administration, legislation and regulation, where the decision, planning and management processes take place.

A number of studies, have a global scope (Vafeidis et al., 2008; Neuamn et al., 2015) or cover a group of countries, territories, or cities (Bellard et al 2013; Nicholls et al. 2008, Balica et al, 2012).

Some at pitched at the national level (Devoy, 2008, Doukakis, 2005), with most studies focussing on a selected coastal area or delta (Diez et al., 2007; Hereher, 2015;, Özyurt and Ergin, 2010; Shaw et al, 1998; Thieler and Williams. 2003;, Rao et al., 2008; Refaat and Eldeberky, 2016; and Yin et al., 2012).

Various databases have been used for constructing the CVI or similar indices. Vafeidis et al. (2008) describe a number of such databases including the *Sea Around Us Project* (SAUP) database, CoastBase - European virtual coastal and marine data warehouse, the EUROSION database and the Land-Ocean Interactions in the Coastal Zone (LOICZ) typology. The main conclusion of the Vafeidis et al. (2008) is that these databases had limited potential in coastal modelling and analyses, including impact and vulnerability analysis, and for this purpose the authors produced the so-called DIVA database as part of the DINAS-COAST project. This database was designed specifically for impact and vulnerability analysis under sea-level rise. (on this matter, see also Klien and Hinkel (2009). This database was used in various studies including El-Raey et al (2015) and Neuman et al. (2015). DIVA has the advantage of being flexible and including a vast range of data. However, Muis et al. (2015) argue that DIVA poorly suited to measuring vulnerability in local or regional contexts.

Formosa et al (2017), a study which on which the present study relies for its data, directly used satellite data to estimate land elevation, on the basis of which a vulnerability assessment was made. The authors estimated land elevation in 39 SIDS as well the number of persons living in coastal areas, with data derived from various spatial datasets. The process entailed the extraction of boundaries data relating to an island's coastal boundary from the SEDAC (2000), the GSHHG (NOAA NCEI, 2016) and the Open Street Map (2017) datasets. From these the authors generated data for three coastal buffer zones of 1km, 5km and 7km from the coast respectively. Elevation datasets were derived from a series of height maps covering the 0.5m, 1m and 2m elevations as sourced from the Shuttle Radar Topography Mission (SRTM) (CGIAR, 2008) dataset. Borders and Rivers data were extracted from the CIA World DataBank (Pape, 2004). The urban zones were extracted from the ESA GlobCover Land Cover Map (ESA, 2009). All this data was sourced in November 2016.

The processing of the data in Formosa et al (2017) entailed the conversion of the SRTM raster data layers to vector format to enable us to derive overlay analysis which generated the results. The SRTM (2008) datasets at 90m resolution were used as against the ETOPO1 dataset (Amante and Eakins, 2009) that rendered a 1.852 km resolution. This refinement of the SRTM dataset permitted the extraction of data at the diverse base buffers employed in this study. A series of spatial queries based on point-in-polygon and polygon-in-polygon were employed to enable the quantification of the base data.

The authors admitted that the higher resolution used in this study might still not be precise enough to ascertain that all areas are at or above a given elevation (say two meters height) across the entire 90m pixel, as the centroid of each pixel gives one point which represents the elevation in the pixel.

The authors also noted that the analysis does not consider slope as one of its variables, resulting in a situation where centroids that were located in low-lying areas that fall behind high degree slopes, cliff edges and other natural escarpments may have been included in this study. Additionally, the slope analysis could help link different isolated low-lying areas through connectivity and adjacency spatial analysis where slope could enable the areas to be linked resulting in larger inundated zones. The slope variable is to be added on in future studies to ensure a more complete picture. The authors further argue that these shortcomings were mostly the result of data limitations. It goes without saying that these limitations call for further study on the theme of this paper.

The population data was derived from a database (CIESIN, 2016) covering a point-based representation of a populated area, in 2015, such that the point represents the whole area, which implies that only a centroid is identified in the point-in-polygon data query, representing an urban area. This means that the city or entire urban area is represented by a centroid and not by individual polygons or points pertaining to the different minor towns/villages/hamlets falling within the urban zone. This results in a situation where a centroid that does not intersect the polygons is not included in this study. The resultant figures are therefore likely to be conservative numbers that reflect only those towns which are identified by the spatial query.

2.4 The vulnerability and resilience framework

The vulnerability and resilience (V&R) framework is essentially an attempt to juxtapose the extent of inherent feature that lead to exposure to harmful effects of an external force, and the extent to which appropriate policy measures and community action could enable the withstanding or the bouncing back from such harmful effects. This methodological approach can be used to assess the risk of the territory of being harmed by climate change as in Briguglio (2010).[11] This framework will be discussed further below.

Vulnerability

The meaning of the word "vulnerability" originates from its Latin root *vulnerare* "to wound". This associates "vulnerability" with exposure to damage and with susceptibility of being harmed by external forces as a result of exposure to such forces. The concept of vulnerability has been given considerable importance in global conferences on SIDS mentioned above. The stimulus for developing such an index came mostly from the SIDS themselves, notably through the Alliance of Small Island States (AOSIS) in the run up to and during the 1994 Barbados Global Conference.

In the literature one finds various definitions of vulnerability to climate change. In the quotation shown in the introduction to the present paper, referring to a recent IPCC definition, (Agard and Schipper, 2014) vulnerability is attributed to inherent features of a territory as well as adaption. A more general definition is that Vulnerability is the manner and degree to which a system is susceptible to adverse effects of climate change (Adger, 2005; Smit et al., 2000)

[11] The V&R framework was first proposed by Briguglio (2000;) and further refined in Briguglio (2004) for the economic system and was applied quantitative by Briguglio et al (2006; 2009). The same author applied this framework to the risk of being harmed by a disaster (Briguglio,2003) and the risk of being harmed by Climate change (Briguglio, 2010).

where again here there is no distinction between natural and man-made effects.

Resilience and Adaptation

Resilience may be considered as the obverse of vulnerability and it is generally defined in terms of the ability to recover quickly from the effect of an adverse incident. This definition originates from the Latin *resilire* 'to rise again'. The term "resilience" been used to refer to policy-induced factors, such as, for example, good economic governance, which enable countries to withstand or bounce back from the negative effects of economic vulnerability (Briguglio et al., 2006; 2009). This concept was analysed in depth in Ionescu (2016).

With regard to adaptation, there are various definitions of this term (Adger et al., 2005; Smit et al., 2000, Burton et al., 2006; Nicholls et al., 2007, Wise et al., 2014; Noble et al., 2014). The formal 2014 IPCC definition of is;

> "The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." (Agard and Schipper, 2014).

Noble et al. (2014) list a number of adaptation options, as shown in Table 2, which the same authors grouped under the headings of structural, social and institutional, and which could by pursued simultaneously as part of adaptation plans. From this table, it can be seen that the options are various, and it is therefore not an easy task to measure these policy-induced and community based adaptation measures.

Table 2: Categories and examples of adaptation options

Category		**Examples of Options**
Structural / physical	**Engineered and built environment**	Sea walls and coastal protection structures; flood levees and culverts; water storage and pump storage; sewage works; improved drainage; beach nourishment; flood and cyclone shelters; building codes; storm and waste water management; transport and road infrastructure adaptation; floating houses; adjusting power plants and electricity grids .
	Technological	adjusting power plants and electricity grids New crop and animal varieties genetic techniques; traditional technologies and methods; efficient irrigation; water saving technologies including rainwater harvesting; conservation agriculture; food storage and preservation facilities; hazard mapping and monitoring; technology; early warning systems; building insulation; mechanical and passive cooling; renewable energy technologies; second-generation biofuels.
	Eco-system based	Ecological restoration including wetland and floodplain conservation and restoration; increasing biological diversity; afforestation and reforestation; conservation and replanting mangrove forest; bushfire reduction and prescribed fire; green infrastructure (e.g., shade trees, green roofs); controlling overfishing and fisheries co-management; assisted migration or managed translocation; ecological corridors; ex situ conservation and seed banks; community-based natural resource management; adaptive land use management.
	Services	Social safety nets and social protection; food banks and distribution of food surplus; municipal services including water and sanitation; vaccination programs; essential public health services including reproductive health services and enhanced emergency medical services; international trade
Social	**Educational**	Awareness raising and integrating into education; gender equity in education; extension services (9.4.4); sharing local and traditional knowledge (12.3.4 and 28.4.1) including integrating into adaptation planning (29.6.2.1); participatory action research and social learning; community surveys; knowledge-sharing and learning platforms; international conferences and research networks; communication through media.
	Informational	Hazard and vulnerability mapping; early warning and response systems including health early warning systems; systematic monitoring and remote sensing; climate services including improved forecasts; downscaling climate scenarios; longitudinal data sets; integrating indigenous climate observations; community-based adaptation plans including community-driven slum upgrading and participatory scenario development.
	Behavioural	Accommodation; household preparation and evacuation planning; retreat and migration which has its own implications for human health and human security; soil and water conservation; livelihood diversification; changing livestock and aquaculture practices; crop-switching; changing cropping practices, patterns, and planting dates; silvicultural options; reliance on social networks;

Institutional	**Economic**	Economic Financial incentives including taxes and subsidies; insurance including index-based weather insurance schemes; catastrophe bonds; revolving funds; payments for ecosystem services; water tariffs; savings groups; microfinance; disaster contingency funds; cash transfers.
	Laws and regulations	Laws and regulations Land zoning laws; building standards; easements; water regulations and agreements; laws to support disaster risk reduction; laws to encourage insurance purchasing; defining property rights and land tenure security; protected areas; marine protected areas; fishing quotas; patent pools and technology transfer.
	Government policies/programmes	National and regional adaptation plans including mainstreaming climate change; sub-national and local adaptation plans; urban upgrading programs; municipal water management programs; disaster planning and preparedness; city-level plans; district-level plans; sector plans which may include integrated water resource management; landscape and watershed management; integrated coastal zone management; adaptive management; ecosystem-based management; sustainable forest management; fisheries management; community-based adaptation.

Source: Noble et al (2014).

Juxtaposing vulnerability and resilience

According to Briguglio (2004) the risk of harm has two elements, the first is inherent exposure to the harmful effects caused by an external agent (vulnerability). This first feature is therefore associated with the nature of the effected subject. The second feature is nurtured and associated with policy measures or community action aimed at coping, withstanding or recovering from the same effects. This second element is therefore nurtured. The risk of being adversely affected by external harmful effects is therefore the combination of these two elements – with the risk being positively related to vulnerability and negatively related to resilience.

Briguglio (2010) proposed four country scenarios, based on the relationship between inherent vulnerability and nurtured adaptation, shown in Table 3

Table 3: The Four Country Scenarios.

Adaptation / **Vulnerability**		**Adaptation measures**	
		Countries characterised by maladaptation or where adaptation measures are absent or limited.	Countries characterised by good adaptation measures as a result of policy or community action.
Inherent vulnerability	Countries that are highly vulnerable to the harmful effects of climate change.	1. The “highest-risk” or “worst-case” scenario	2. The “managed-risk” or “self-made” scenario
	Countries that are not highly vulnerable to the harmful effects of climate change.	3. The mismanaged-risk” or prodigal-son” scenario	4. The “highest-risk” or “best-case” scenario

The “lowest-risk” or “best-case” scenario applies to countries 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.

The “highest-risk” or “worst-case” scenario applies to countries 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 low-income and low-lying SIDS, exposed to sea-level rise, will have a very high risk of being harmed by climate change, in line with the arguments presented with regard to Figure 1.

Countries 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. Community based action, conducing to adaptation also enables a country to manage the risk. This group of countries can also be labelled "self-made" in the sense that they would have taken steps to make up for their disadvantage. These countries remain inherently vulnerable, but their adaptation measures reduce the risk associated with exposure to climate change effects.

Countries 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 limited exposure to climate change. At times, they adopt practices which exacerbate their vulnerability. This scenario can also be labelled "prodigal-son", the analogy being that though these countries belong to the low vulnerability family of countries, they, like the prodigal son, mismanaged their assets.

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 or likely. However, given that adaptation is policy or community driven, movement from the left quadrants to the right quadrants is possible.

3 Methodology

In this paper we shall attempt to quantitatively assess the risk of 36 SIDS[12] of being harmed by sea-level rise. The methodological approach is built of the V&R framework discussed in the literature review section, with the basic change being that instead of the term "resilience" we shall use the term "adaptation", given that the latter term is commonly used in the literature on climate change.

3.1 Inherent and policy-induced realities

The basic argument proposed in this paper is that risk of being harmed by sea-level rise depends positively on natural vulnerability and negatively on adaptation potential. In other words, the concept of vulnerability is confined to inherent conditions which exposes a country to the harmful effects of climate change in this case sea-level rise. The concept of adaptation potential, on the other hand, as used in this paper, relates to the ability of a country to withstand, absorb or bounce back from the harmful effects of sea-level rise, as a result of government policy or community action.

3.2 Advantages of the methodology

Defining risk in terms of inherent vulnerability and anthropogenic adaptation or maladaptation has a number of methodological advantages, including:

- If the definition of vulnerability is restricted to refer to inherent features, it follows that the country or a country having these features has practically no control over their incidence. In other words, highly vulnerable countries/countries cannot be accused of inflicting

[12] There are 39 small island states members of AOSIS. We have eliminated Cook Islands and Niue due to lack of data relating to the variables that we have used to measure adaptation potential and Singapore because it was a major outlier in terms of income per capita.

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. 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.

- If the definition of adaptation is constrained to refer to what humans 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 and the result of community action. Adaptation can also be inherent, but in the context of this methodological approach inherent adaptation would be included with lack of low level of vulnerability.
- The juxtaposition of the two factors would then refer to the "risk of a country being harmed by climate change", due to inherent vulnerability features, counterbalanced to different extents, by nurtured adaptation.

3.3 Diagrammatic approach

The arguments developed above are shown graphically in Figure 1.

Figure 1: Conceptual framework for assessing the risk of being affected by climate change

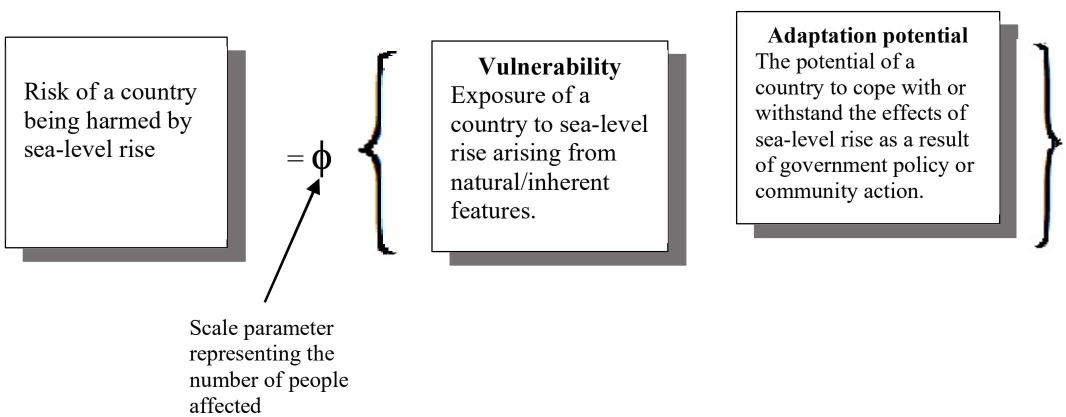

Figure 1 shows that risk of being harmed by climate change has two elements, the first being associated with the inherent conditions of the country that is exposed and the second associated with conditions developed by humans to absorb, cope with or bounce back from external shocks. The risk of being adversely affected by climate change is therefore the combination of the two elements. The negative sign in front of the adaptation element 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.

3.4 Measuring vulnerability to sea-level rise

The approach adopted in this paper to measure sea-level rise vulnerability is based on Formosa et al. (2017), who derived the data pertaining to the coastal area in terms of elevation and population living in these areas from various spatial datasets.

Using this data Formosa et al., 2017) were able to estimate the area within a 1 km coastal buffer with an elevation on 1 meter or lower, and the number of persons living in that area.[13] In this paper, the sea-level rise vulnerability index will be based on this data.

It should be noted that the results of Formosa et al. shown in Appendix 2 of this paper refer to population centres that overlap the coastal buffers and the elevation polygons, on a point-based spatial entity available. Thus the data represents only those towns that have intersected the coastal buffer and where the elevation under study falls within the relevant coastal buffer. The value of 0 population in this table means that there no substantial inhabited space within the 1 km coastal buffer with a 1 meter elevation. Therefore, the results may underestimate the population size where the population is sparsely distributed.

To construct our vulnerability index we rescaled the areas of the 36 SIDS so as to take a value of 0 to 1 using the Max/Min formula,[14] and we did the same with the data on population residing in that area. We then took an average of the two rescaled indices.

3.5 Measuring Adaptation

As has been shown in the literature review, adaptation has many facets and it is impossible to measure it directly across countries. In this paper, we utilise the term “adaptation potential” assuming that, for a given country, this depends on its economic and political situation, based on the argument that countries with higher levels of economic development and of good political governance are better able to cope with, withstand and recover from the harmful effects of sea-level rise. [15]

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[13] Formosa et al. (2017) also derived estimates of elevation of 0.5m, 1m and 2m elevation within a 1 km, 5km and 7km coastal buffers of the 39 SIDS. They find that about 5.8% of the inhabited areas of the 39 SIDS lie within the 1 km buffer, of which 4.4% has an elevation of 1 meter or lower. The full set of data for the 39 SIDS is presented in Appendix 1. The same authors also present data on the population living in different areas that would be inundated, assuming different elevations, 0.5m, 1m and 2m. They find that about 3,460,490 persons (amounting to 5.5% of the population of the 39 SIDS) live within a 1km coastal buffer, of which 77,711 (2.2%) lived in areas which are likely to be inundated by a 1m sea-level rise. The full set of data for the 39 SIDS is shown in Appendix 2. In the present study we have taken a 1km coastal buffer with 1m elevation, as we consider this is more directly related to the harm of sea-level rise, referring to the area that is likely to be inundated by a 1m sea-level rise within a 1 km buffer.

[14] The country scores were rescaled to take a value of between 0 and 1 using the following formula:

$$X_r = \frac{X_i - X_{\min}}{X_{\max} - X_{\min}}$$

Xr =the rescaled score.
Xi =the actual score.
Xmin and Xmax =the minimum and the maximum of all scores of a given variable.

[15] It would have been useful to include a social cohesion indicator the adaptation potential indicator as this could be to successful community based adaptation and could also indicator the extent to which relations within a society are properly developed, enabling an effective functioning of the regulatory apparatus without the hindrance of civil unrest. However data for this purpose was not available. We also considered including a social development indicator using the health and education components of the Human Development Index, but data for Tuvalu and Marshall Islands, two very vulnerable SIDS, was not available, so we decided not to use these indicators. However, the Political Stability and Absence of Violence Indictor, which we used for constructing the Adaptation Potential Index may, to an extent, capture social cohesion and social development.

Economic development is likely to be highly associated with adaptation potential. In this regard Nicholls et al. (2007, 2008) argue that territories in rich countries have much better protection levels than cities in the developing world. This is due to the ability by richer countries to afford the cost of protection infrastructures. In addition, as Nicholls et al (2008) argue, in richer countries there is a tendency for a higher degree of risk aversion due in part to the higher value of assets involved.

Good governance is likely to lead to an atmosphere of predictable laws and credible policies, and this is likely to improve the chances of appropriate adaptation measures in the face of sea-level rise. Absence of good governance on the contrary could lead to economic and social chaos and civil unrest, thereby exacerbating the harmful effects of sea-level rise.

It should be noted that we have selected two components of the WGI, namely (a) government effectiveness and (b) political stability and absence of violence and terrorism, as we consider these to be most relevant to adaptation potential. Government effectiveness relates the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Political Stability and Absence of Violence/Terrorism relates to the likelihood of political instability and/or politically-motivated violence, including terrorism.

Basing on these arguments, we have taken two indicators to measure adaptation potential namely (1) an index of the stage of development measured by gross domestic product (GDP) per capita in purchasing power parity (2) an index political governance measured by two mentioned components of the Worldwide Governance Indicator. All data pertained to an average of between 2000 and 2015. To construct our adaptation potential index we again rescaled the data so as to take a value of 0 to 1 using the Max/Min formula described above. We then took an average of the two rescaled indices.

4 Results

4.1 Areas of SIDS and their coasts

The results of rescaling the area within a 1kilometre coastal buffer with an elevation of 1 meter are shown in Appendix 3. It can be seen that the most vulnerable SIDS in this regard are: Guyana, Bahamas, Timor Leste, Kiribati, Tuvalu, Seychelles, Solomon Islands, Fiji, Micronesia (Fed. States), Maldives and Vanuatu in that order.

4.2 Measuring adaptation

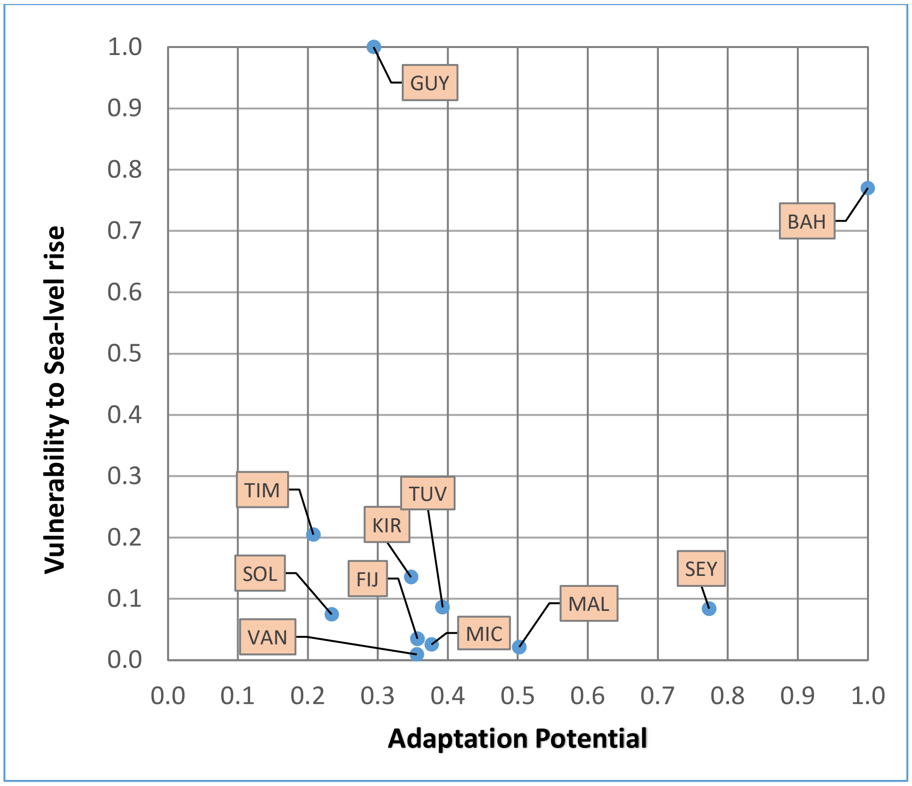
As explained above, we proxied adaptation potential by two indices, namely good governance (assigning 25% weight to each of PS and GE) and income per capita in purchasing power parity (to which we assigned a 50% weight).

The results are shown in Appendix 4. The countries with the highest adaptation potential, using the indicators just mentioned, turned out to be the following: Bahamas, Trinidad and Tobago, Barbados, Antigua and Barbuda, St. Kitts and Nevis, Seychelles, Mauritius.

4.3 Juxtaposing vulnerability and adaptation

As argued above, the risk of being harmed by climate change is a function of two elements, namely inherent vulnerability and nurtured adaptation. By juxtaposing the two indices described above, namely (a) an index that captures inherent vulnerability features derived from Formosa et al (2017) and (b) an index that captures policy induced or community based adaptation, one can therefore assess the extent of risk of a country being harmed by climate change. We chose the 11 most vulnerable SIDS in terms of the proportion of the population residing within 1 km coastal buffer in areas with an elevation of 1m or lower [16] and we juxtaposed their adaptation potential index, with the results being shown in Figure 2.

Figure 2. Juxtaposing vulnerability and adaptation



The scatter points represent the 11 SIDS which in Appendix 1, are named and classified according to the population data described above. It can be seen that most of these 11 SIDS are in the "highest-risk" category, as they are highly vulnerable to see level rise, with limited adaptation potential, with Guyana topping the list. Seychelles and The Bahamas while also being highly vulnerable to sea-level rise, have relatively higher adaptation potential.

4.4 Some caveats

These results should be interpreted with some caution, due to the measurement weaknesses indicated above, including that the vulnerability index, relates to sea-level rise only and its

[16] It is important to note that most of the 39 SIDS members of AOSIS are highly vulnerable to sea-level rise in view of the fact that they have a relatively large coastal area in relation to the land mass. We decided to refer only to those SIDS with a relatively large population living within 1 kilometre coastal buffer that has an elevation of 1 meter or lower.

measurement is subject to various assumptions listed in the methodology section. In particular, the population estimates are likely to be understated due to the possibility that there may be persons living in the areas out of the city centroid that are not captured in the data, as explained above.

- the adaptation potential index is a very basic and refers to economic development and governance only. This index, for example, does not take into account difficulties related to the topology of the islands and its location in taking adaptation measures..

In our study we did not take into account the loss of value as a result of degradation of coastal habitats, shoreline erosion, loss of tourism and recreational facilities. loss of cultural assets and negative impacts on coastal agriculture and fishing. If a value is added to such losses, the ranking of vulnerable SIDS would probably differ.

This study cannot be considered as having explored the social aspects fully given that such an exercise would require information about the social conditions of the persons affected by sea-level rise, including their ability to adapt to inundation.

In addition, we did not take into account the effect of storm surges and high waves, which could exacerbate the harmful effects of sea-level rise and which occasionally hit the coastal areas of SIDS. This not only affects residents and habitats on the coastal area but may also have economic repercussions due to due to a reduction in the size of beaches and in some instances water intrusion in economic structures such as those associated with tourism and fisheries.

Sea-level rise can also have repercussions in areas which are not proximate to the coast, such as for example that saline water could reach upstream estuaries and rivers, negatively affecting habitat and possibly threatening drinking-water availability.

5 Conclusion

5.1 The main findings

In this paper we have utilised data available in Formosa et al (2017) relating to the area of 1 kilometre coastal buffers characterised by an elevation of 1 meter or less, and the population residing in these areas. The focus was on the inhabited islands of 36 SIDS.

Basing on these findings, we attempted to show which SIDS are likely to be at the highest risk of being harmed by sea-level rise. The results suggest, keeping in mind the caveats listed above, that in 11 SIDS are the most vulnerable of being harmed by sea-level rise, most of which have very limited adaptation potential.

In these SIDS, about 3.5 million persons (5.5% of the SIDS' population) live within a 1km coastal buffer, of whom 77,711 reside in areas below a 1m elevation, concluding that these will be directly highly affected with a sea-level rise of 1 meter, basing on 2015 population data. This amounts to 2.2% of the population living within this coastal buffer.

It should be emphasised that these eleven SIDS, namely Guyana, Bahamas, Timor Leste, Kiribati, Tuvalu, Seychelles, Solomon Islands, Fiji, Micronesia (Fed. States), Maldives and Vanuatu, are the most vulnerable to sea-level rise using the strict yardstick described above.

However, as argued in various parts of this paper, all SIDS are highly vulnerable to sea-level rise, if for nothing else, in view of their large coastal area in relation to their land mass.

It could be argued that there was no need to write a paper on this finding, as it was well known that these 11 SIDS are highly vulnerable to sea-level rise. While this is true, this paper adds further proof to this assertion. In addition, the juxtaposition to sea-level rise vulnerability to adaptation potential is may provide a useful methodological approach to the analysis of the risk of a country being harmed by climate change.

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 or community action.

The methodology emphasizes the benefits of policies that promote adaptation, which is an important component of risk management in the context of climate change. Adaptation does not reduce the natural vulnerability of the countries concerned, but they do serve to enable humans to cope with, withstand, bounce back from or absorb the effects of climate change. The main lesson that can be drawn from this paper is that being highly vulnerable to climate change due to natural factors need not translate into being highly at risk of being harmed by climate change, if appropriate adaptation safeguards are put in place. Conversely, countries that are not inherently highly vulnerable to climate change may be highly affected if man-made activity exacerbates the inherent vulnerability – a possibility labelled as "negative adaptation" or "maladaptation" in this paper.

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Appendix 1: Areas within a 1 kilometre coastal buffer with an elevation of 1 meter or lower in inhabited islands

Country	1	2	3	4	5	6
	Total Inhabited area (km²)	1km buffer		1m elevation & 1km buffer		
		Area (km²)	Col 2/Col 1 (%)	Area (km²)	Col 4/Col 1 (%)	Col 4/Col 2 (%)
Antigua and Barbuda	447.5	165.7	37.0%	9.1	2.0%	5.5%
Bahamas	8205.7	2603.1	31.7%	340.5	4.1%	13.1%
Barbados	434.6	90.7	20.9%	0.2	0.0%	0.2%
Belize	21521.2	1066.7	5.0%	178.9	0.8%	16.8%
Cape Verde	4032.5	843.7	20.9%	30.5	0.8%	3.6%
Comoros	1653.5	364	22.0%	0.4	0.0%	0.1%
Cook Islands	206.1	114.4	55.5%	0.8	0.4%	0.7%
Cuba	108535.5	5236.1	4.8%	666.6	0.6%	12.7%
Dominica	754	134.9	17.9%	0.4	0.1%	0.3%
Dominican Republic	48316	1310.4	2.7%	82.4	0.2%	6.3%
East Timor	14959	955.2	6.4%	21.9	0.1%	2.3%
Fiji	18548.8	2667.6	14.4%	74.8	0.4%	2.8%
Grenada	314.6	89.4	28.4%	0.2	0.1%	0.2%
Guinea-Bissau	32740.6	2190.8	6.7%	57	0.2%	2.6%
Guyana	210029.3	5340.5	2.5%	301.7	0.1%	5.6%
Haiti	26857.9	1617.7	6.0%	35.5	0.1%	2.2%
Jamaica	10999.8	692.6	6.3%	59.5	0.5%	8.6%
Kiribati	878.1	503.3	57.3%	40.1	4.6%	8.0%
Maldives	145.9	145.9	100.0%	5.8	4.0%	4.0%
Marshall Islands	53.4	53.4	100.0%	3.1	5.8%	5.8%
Mauritius	1976.3	287.3	14.5%	0.8	0.0%	0.3%
Micronesia (Fed. States)	663.3	366.1	55.2%	6.7	1.0%	1.8%
Nauru	21.7	14.3	65.9%	0.1	0.5%	0.7%
Niue	262.1	62.8	24.0%	0.1	0.0%	0.2%
Palau	416.2	184.5	44.3%	2.5	0.6%	1.4%
Papua New Guinea	449252.4	11077	2.5%	167.3	0.0%	1.5%
St Kitts and Nevis	263	100.6	38.3%	1	0.4%	1.0%
St Lucia	604.8	134.4	22.2%	0.3	0.0%	0.2%
St Vincent/Grenadines	396.2	122.3	30.9%	0.4	0.1%	0.3%
Samoa	2840.2	393.8	13.9%	0.6	0.0%	0.2%
Sao Tome and Principe	992.5	200.6	20.2%	0.2	0.0%	0.1%
Seychelles	194.8	119.4	61.3%	5.8	3.0%	4.9%
Singapore	640.7	152.5	23.8%	2.2	0.3%	1.4%
Solomon Islands	27998.6	5374.1	19.2%	184.5	0.7%	3.4%
Suriname	143300.5	5098.1	3.6%	192.3	0.1%	3.8%
Tonga	365.7	191.1	52.3%	0.6	0.2%	0.3%
Trinidad and Tobago	5151.2	551.7	10.7%	3.8	0.1%	0.7%
Tuvalu	17.5	17.5	100.0%	0.7	4.0%	4.0%
Vanuatu	12186.6	2450.4	20.1%	19.8	0.2%	0.8%
Total	**1157178.3**	**53084.6**	**4.6%**	**2499.1**	**0.2%**	**4.7%**

Appendix 2: Population living in areas within a 1 kilometre coastal buffer with an elevation of 1 meter or lower in inhabited islands

Country	1	2	3	6	7	8
	Total Population	Within a 1 km Buffer		Population in 1m elevation & 1 km buffer		
		Number	Col 2/Col 1	Number	Col 7/Col 1	Col 7/Col 2
Guyana	767085	37381	4.9%	21352	2.8%	57.1%
Bahamas	388021	45804	11.8%	20146	5.2%	44.0%
East Timor	1184764	49168	4.2%	5748	0.5%	11.7%
Kiribati	112704	112592	99.9%	8703	7.7%	7.7%
Tuvalu	9920	9920	100.0%	489	4.9%	4.9%
Seychelles	96469	68068	70.6%	3272	3.4%	4.8%
Solomon Islands	581583	204812	35.2%	8719	1.5%	4.3%
Fiji	885804	164822	18.6%	3272	0.4%	2.0%
Micronesia Fed. States	92206	75718	82.1%	1112	1.2%	1.5%
Maldives	358813	358813	100.0%	4374	1.2%	1.2%
Vanuatu	264653	97521	36.8%	524	0.2%	0.5%
Antigua and Barbuda	91818	33994	37.0%	0	0.0%	0.0%
Barbados	284215	0	0.0%	0	0.0%	0.0%
Belize	359287	0	0.0%	0	0.0%	0.0%
Cape Verde	520505	0	0.0%	0	0.0%	0.0%
Comoros	788474	0	0.0%	0	0.0%	0.0%
Cook Islands	20276	6444	31.8%	0	0.0%	0.0%
Cuba	11389565	580028	5.1%	0	0.0%	0.0%
Dominica	72679	0	0.0%	0	0.0%	0.0%
Dominican Republic	10378642	118934	1.1%	0	0.0%	0.0%
Grenada	101575	0	0.0%	0	0.0%	0.0%
Guinea-Bissau	1844325	13300	0.7%	0	0.0%	0.0%
Haiti	10711060	358380	3.3%	0	0.0%	0.0%
Jamaica	2793334	88230	3.2%	0	0.0%	0.0%
Marshall Islands	52993	52993	100.0%	0	0.0%	0.0%
Mauritius	1272941	161004	12.6%	0	0.0%	0.0%
Nauru	10222	9139	89.4%	0	0.0%	0.0%
Niue	1610	155	9.6%	0	0.0%	0.0%
Palau	21291	13769	64.7%	0	0.0%	0.0%
Papua New Guinea	7620053	105381	1.4%	0	0.0%	0.0%
St Kitts and Nevis	55573	13958	25.1%	0	0.0%	0.0%
St Lucia	184999	24264	13.1%	0	0.0%	0.0%
St Vincent/Grenadines	114712	28399	24.8%	0	0.0%	0.0%
Samoa	193229	8149	4.2%	0	0.0%	0.0%
Sao Tome and Principe	190345	74548	39.2%	0	0.0%	0.0%
Singapore	5598164	412389	7.4%	0	0.0%	0.0%
Suriname	542973	12926	2.4%	0	0.0%	0.0%
Tonga	106170	101225	95.3%	0	0.0%	0.0%
Trinidad and Tobago	1360087	18262	1.3%	0	0.0%	0.0%
Total	**61,423,139**	**3,460,490**	**5.6%**	**77,711**	**0.1%**	**2.2%**

Appendix 3: Rescaled data on population within a 1km coastal buffer with an elevation of 1m or lower.

Country	Population	Rescaled Population
Antigua and Barbuda	0.0%	0.000
Bahamas	44.0%	0.770
Barbados	0.0%	0.000
Belize	0.0%	0.000
Cape Verde	0.0%	0.000
Comoros	0.0%	0.000
Cuba	0.0%	0.000
Dominica	0.0%	0.000
Dominican Republic	0.0%	0.000
Fiji	2.0%	0.035
Grenada	0.0%	0.000
Guinea-Bissau	0.0%	0.000
Guyana	57.1%	1.000
Haiti	0.0%	0.000
Jamaica	0.0%	0.000
Kiribati	7.7%	0.135
Maldives	1.2%	0.021
Marshall Islands	0.0%	0.000
Mauritius	0.0%	0.000
Micronesia (Fed. States)	1.5%	0.026
Nauru	0.0%	0.000
Palau	0.0%	0.000
Papua New Guinea	0.0%	0.000
Samoa	0.0%	0.000
Sao Tome and Principe	0.0%	0.000
Seychelles	4.8%	0.084
Solomon Islands	4.3%	0.075
St Kitts and Nevis	0.0%	0.000
St Lucia	0.0%	0.000
St Vincent/Grenadines	0.0%	0.000
Suriname	0.0%	0.000
Timor Leste	11.7%	0.205
Tonga	0.0%	0.000
Trinidad and Tobago	0.0%	0.000
Tuvalu	4.9%	0.086
Vanuatu	0.5%	0.009

Appendix 4: Construction of the Adaptation Potential Index

	Political Stability No Violence		Government Effectiveness		GNI per Capita in PPP$		Adaptation Potential Index	
Country	AVG 2010-16	Rescaled	AVG 2010-16	Rescaled	AVG 2010-16	GNI Rescaled	Average	RS Average
Antigua and Barbuda	0.971	0.824	0.340	0.694	22543	0.690	0.725	0.795
Bahamas, The	1.026	0.850	0.868	0.864	30916	0.965	0.911	1.000
Barbados	1.162	0.915	1.288	1.000	17041	0.510	0.734	0.805
Belize	0.104	0.412	-0.497	0.423	8040	0.214	0.316	0.345
Cape Verde	0.750	0.719	0.096	0.615	6215	0.154	0.411	0.449
Comoros	-0.323	0.209	-1.626	0.058	1516	0.000	0.067	0.071
Cuba	0.445	0.574	-0.248	0.504	10684	0.301	0.420	0.460
Dominica	1.058	0.866	0.409	0.716	10584	0.298	0.544	0.596
Dominican Republic	0.155	0.436	-0.465	0.433	12912	0.374	0.405	0.443
Fiji	0.226	0.470	-0.576	0.397	8189	0.219	0.326	0.357
Grenada	0.625	0.660	0.059	0.603	11894	0.341	0.486	0.532
Guinea-Bissau	-0.720	0.020	-1.365	0.143	1574	0.002	0.042	0.044
Guyana	-0.307	0.216	-0.184	0.524	6648	0.169	0.269	0.294
Haiti	-0.763	0.000	-1.806	0.000	1639	0.004	0.002	0.000
Jamaica	0.025	0.374	0.184	0.643	8448	0.228	0.368	0.403
Kiribati	1.116	0.893	-0.670	0.367	1697	0.006	0.318	0.348
Maldives	0.123	0.421	-0.302	0.486	15629	0.463	0.458	0.502
Marshall Islands	1.019	0.847	-1.496	0.100	3104	0.052	0.263	0.287
Mauritius	0.888	0.785	0.951	0.891	17411	0.522	0.680	0.745
Micronesia, Fed. Sts.	1.091	0.881	-0.574	0.398	3028	0.050	0.345	0.377
Nauru	0.899	0.790	-0.581	0.396	8058	0.215	0.404	0.442
Palau	1.062	0.867	-0.582	0.396	13496	0.393	0.512	0.561
Papua New Guinea	-0.562	0.096	-0.683	0.363	3065	0.051	0.140	0.152
Samoa	1.034	0.854	0.208	0.651	4968	0.113	0.433	0.474
São Tomé and Principe	0.115	0.417	-0.735	0.346	2767	0.041	0.211	0.230
Seychelles	0.733	0.711	0.343	0.694	23067	0.708	0.705	0.773
Solomon Islands	0.397	0.551	-0.934	0.282	1914	0.013	0.215	0.234
St Kitts and Nevis	0.815	0.750	0.484	0.740	22628	0.693	0.719	0.789
St Lucia	0.845	0.764	0.421	0.720	12867	0.373	0.557	0.611
St Vincent/Grenadines	0.894	0.787	0.511	0.749	10325	0.289	0.529	0.579
Suriname	0.171	0.444	-0.159	0.532	15102	0.446	0.467	0.511
Timor-Leste	-0.304	0.218	-1.149	0.212	6610	0.167	0.191	0.208
Tonga	0.872	0.777	-0.312	0.483	4771	0.107	0.368	0.403
Trinidad and Tobago	0.158	0.438	0.299	0.680	31976	1.000	0.779	0.855
Tuvalu	1.341	1.000	-0.779	0.332	3095	0.052	0.359	0.393
Vanuatu	0.911	0.796	-0.449	0.438	2540	0.034	0.325	0.356