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Study on the vulnerability and resilience of Caribbean Small Island Developing States (SIDS)

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ABSTRACT

Caribbean Small Island Developing States are considered to be particularly vulnerable to external shocks that stem from changes in climate and the increase in frequency and magnitude of natural disasters. Quantification of the extent of vulnerability of these islands may be measured by the use of several indices including the Economic Vulnerability Index (EcVI), the Disaster Deficit Index (DDI), the Environmental Vulnerability Index (EVI) and the Social Vulnerability Index (SVI). The capacity to build resilience may be measured by the Economic Resilience Index (ERI). Of importance in the measurement of vulnerability and resilience is the impact on women and children.

In order to reduce vulnerability and promote resilience, Caribbean SIDS are urged to develop adaptation strategies. Such strategies include the conduct of indepth studies on natural environmental impacts specifically in terms of biophysical and socio economic impacts. It is also necessary to review best practices in terms of preparedness, resilience building and climate change adaptation in other countries such as Cuba.

Addressing vulnerability and building resilience requires appropriate information and data and priority should be given to addressing data gaps. It would also be expedient to classify vulnerability and resilience as regional public goods wherein one country's benefit does not compromise another country's ability to benefit. Finally, it is important to acknowledge that vulnerability is, in part, is a function of gender so that indicators need to be disaggregated to reflect the country-specific gendered socioeconomic situation.

I. INTRODUCTION

The term vulnerability may be traced to the social sciences when the concept was used as a response to the “purely hazard-oriented perception of disaster risk in the 1970s” (Birkmann, 2006). This concept has evolved over time and has been the subject of intense research that focused on its multidimensional nature rendering its definition a challenging exercise. Birkmann (2006) noted that vulnerability is “... a paradox: we aim to measure vulnerability, yet we cannot define it precisely”.

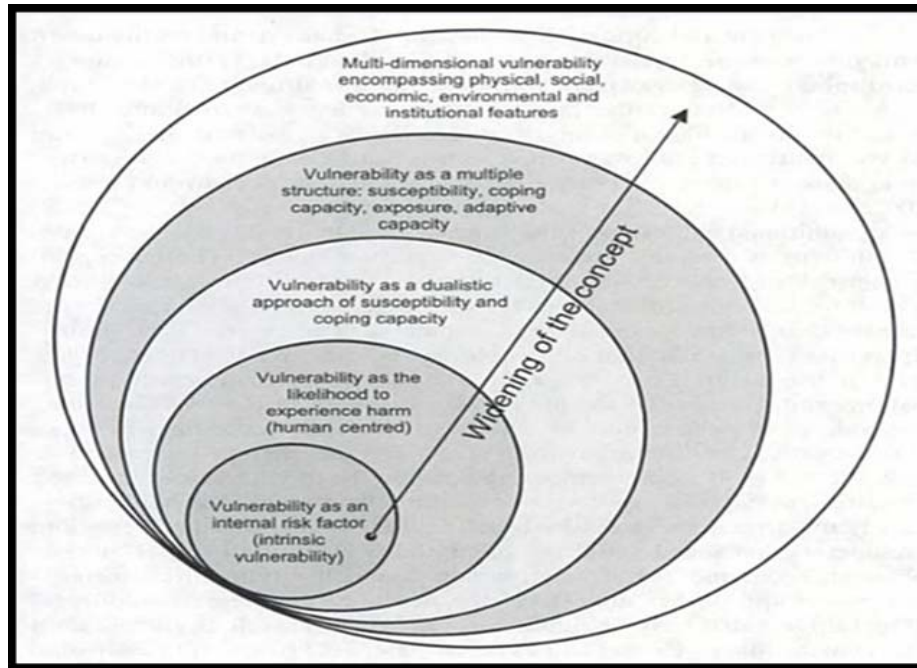
There are several definitions of vulnerability. These range from "fragility and lack of resilience in the face of outside forces" (Briguglio, 1995); “a state of defencelessness, insecurity and exposure to risk, shocks and stress” (Wratten, 1994); “vulnerability relates to risk”, (Gordon and Spicker, (1999) and “the well being of individuals, households or communities in the face of a changing environment” (Moser, 1996). For the purpose of this report, the definition as articulated by the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) will be used. It is defined within the context of climate change as “...the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC, 2004). The AR4 further notes that vulnerability is “...a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.”

Vulnerability encompasses:

- Economic vulnerability. This is a function not only of a system’s susceptibility to decay or degradation but also its ability to protect itself or recover having been exposed to stresses and shocks from outside forces
- Environmental vulnerability. This explains the sudden stresses and shocks from outside forces that produce instantaneous change that renders systems susceptible to damage
- Social vulnerability. This addresses “the susceptibility of humans and the conditions necessary for their survival and adaptation’ (WBGU (German Advisory Council on Climate Change) 2005)
- Biophysical vulnerability. This describes “the extent to which a system is susceptible to adverse effects of climate change and the extent to which it is able to adapt to such impacts’ (WBGU (German Advisory Council on Climate Change) 2005)

Figure 1 illustrates the progression of the concept of vulnerability starting from an intrinsic focus on internal risk (which is universally accepted) and broadening finally to a multi- dimensional approach which includes the physical, economic, social, environmental and institutional characteristics of the grouping being assessed.

FIGURE 8: KEY SPHERES OF THE CONCEPT OF VULNERABILITY



Source: Birkmann 2005

In applying this concept in assessing vulnerability, Bogardi, 2006 indicates that the following basic questions need to be considered:

- Can vulnerability be measured and quantified?
- Can vulnerability be aggregated to characterize societies' overall susceptibility to several distinct hazards?
- Can vulnerability and coping capacity be conceived and assessed separately?
- At what aggregation level can vulnerability be measured?
- Could vulnerability assessment results be scaled up or down?
- How can vulnerability be assessed in advance of a devastating event?
- What lessons can be learned from retrospective assessment of vulnerability?

Early attempts at measuring vulnerability focused on the economic dimension (Briguglio 1995; 1997 and 1998, Crowards and Coulter 1999 and Guillaumon 1999); the environmental dimension (Ribot et al 1996 and Kaly et al 1999); and the biophysical dimension (Pelling and Uitto 2001 and Crowards 2000). Measurement of vulnerability would greatly enhance understanding and application of the concept as well as strategies for building resilience.

The concept of resilience focuses on a system's ability to absorb or recover from exogenous or endogenous shock of an economic, social or environmental nature. According to Manyena (2006) resilience is perceived to be "... more of an expression, complimenting use of other disaster terms, such as vulnerability or risk". Building resilience may result in desired outcomes or may occur as a process

leading to desired outcomes (Kaplan, 1999)". Weinberg (1985) posits that disaster resilience may be viewed as a "deliberate process that comprises a series of events, actions or changes to augment the capacity of the affected community when confronted with singular, multiple or unique shocks and stresses, places emphasis on the human role in disasters.

The capacity of a system to be resilient may be determined by measuring its vulnerability to shocks. This may be achieved through the use of indicators¹ to develop an index² that would determine the health of the system.

The main purpose of this report is to provide a contextual framework within which a discussion of vulnerability and resilience indicators for Caribbean SIDS may be located.

Chapter 1 introduces the concept of vulnerability and risk within the context of disaster management. Methodological issues in developing indicators and deriving indices to measure vulnerability and resilience as well as the elaboration of environmental, economic and social vulnerability indices applicable to the Caribbean subregion are presented in Chapter II. Chapter III focuses on the vulnerability of the Caribbean subregion to climate change and extreme events. Chapter IV presents the application of these indices to adaptation in the Caribbean. Chapter V presents conclusions and recommendations.

¹ An indicator may be quantitative or qualitative.

² An index is a mathematical measure (quantitative) of vulnerability and resilience

II. INDICATORS AND INDICES OF VULNERABILITY AND RESILIENCE

A. Methodological issues in deriving indicators and indices

1. The vulnerability-resilience nexus

It is suggested in the literature that factors that determine vulnerability may also contribute to the building of resilience. In this regard, the poor are deemed vulnerable to disasters but their state of poverty (as opposed to indigence) may also build a measure of resilience to certain shocks. This vulnerability-resilience nexus may be regarded either as factors of each other or each component may be treated as separate entities.

Support for separation of vulnerability and resilience is stated by Paton (2001) in that “we can possess characteristics that can make us vulnerable and others that can influence our capacity to adapt at the same time”. Conversely, Manyena (2006) states that “...vulnerability could be viewed as a reflection of the intrinsic physical, economic, social and political predisposition or susceptibility of a community to be affected by, or suffer adverse effects when struck by a dangerous physical phenomenon of natural or anthropogenic origin. It also signifies a low level (rather than a lack) of disaster resilience, limiting capacity to recover; each system has some degree of resilience. Disaster resilience could be viewed as the intrinsic capacity of a system, community or society predisposed to a shock or stress to adapt and survive by changing its nonessential attributes and rebuilding itself.” O’Keefe (1976) argues that while vulnerability is not necessarily the opposite of resilience, it does not mean that the term vulnerability may be used interchangeably with resilience.

2. Indicators and indices

In recent times the occurrence of natural and manmade hazard events worldwide has heightened the need for disaster preparedness to involve multiple stakeholders, sometimes spanning several geographic regions. Preparations to address such disasters could be enhanced through the employment of tools that serve to measure the extent of vulnerability and therefore the ability of systems to build resilience. These usually take the form of indices and indicators. While some indices may rely on few indicators, they are still beneficial in that more than one variable is incorporated as compared to a single indicator. Also, as the number of indicators considered increases, the level of bias can be reduced and the message of the index becomes much clearer and accurate (Center for Hazards Research and Policy Development 2006).

The construction of an index involves the selection of relevant indicators which are aggregated. Use of several indicators that are measured in different units such as dollars or degrees of magnitude require standardization or scaling or any alternative methodology that removes the units attached to the variables thereby creating “unit less” variables. Weighting is also applied in situations where some indicators are of greater significance than others. Index construction and usage also gives rise to several other issues which include validation, data availability and bias, data decay, complexity and measurement, and compilation and analysis (Center for Hazards Research and Policy Development 2006).

The creation of indices brings specific challenges in terms of subjectivity, bias, weighting, mathematical combinations, selection of indicators and the sourcing of data. Methodological issues that exist in the construction and application of indices (especially vulnerability indices) include the dependence on data sets that exist rather than data that are truly representative. The environmental vulnerability index, for example, examines what data are available, after which indicators are selected

based on availability. Data decay poses another methodological challenge such that in many cases the subject matter such as vulnerability is dynamic in nature. The usefulness of Indices will therefore be subject to the accuracy of datasets over time. The multifaceted nature of the concept of vulnerability adds to the challenge of indicator selection. Indicators or variables that reflect vulnerability include access to resources, political and power while others have focused on quantifying human vulnerability which is ultimately difficult to measure.

It has also been suggested that the complexity of the concept of vulnerability and the variety of possible data sources that are necessary to quantify it add to the challenge of measurement, especially where, for example, there are a multitude of interactions that are all related to both vulnerability and risk. Further challenges in terms of compilation and analysis in combining occur.

3. Resilience indices and indicators

In the context of disaster resilience, composite indicators become important as a means of measuring the inherent conditions that lead to building resilience. Nardo et al. (2008) suggest that composite indicators are used to designate a manipulation of individual variables to produce an aggregate measure of disaster resilience. Nardo et al. (2008) also state that composite indicators become mathematical so that the variables that represent different dimensions of a concept can be fully captured.

To capture the effects of shock absorption or shock counteraction policies across countries, Briguglio et al., (2009) proposed four components (and their related indicators) of a resilience index (table 1).

TABLE 6: THE CONSTRUCTION OF THE RESILIENCE INDEX

Components of Economic Resilience Index	Determinants of Components	Importance of Components
Macroeconomic Stability	Fiscal Deficit(fiscal deficit to GDP ratio)	It is the result of fiscal policy which could engage in shock- counteraction
	Inflation and unemployment (Economic Discomfort/Misery Index)	It is highly influenced by monetary and supply side policies which could affect a state's degree of shock absorption
	External Debt (external debt to GDP ratio)	It influences the ability to obtain finance/ resources to facilitate shock counteraction
Microeconomic Market Efficiency	Economic Freedom of the World Index (Gwartney, J. and Lawson, R. 2005)	It measures the degree of market freedom and competition for efficiency which has a tendency to affect the state's shock counteraction
	Bureaucratic control of business activities	It identifies the extent of bureaucratic procedures influence on market competition and operations which have an inclination to influence shock absorption
Good Governance	Legal structure and security of property rights component of the <i>Economic Freedom of the World Index</i>	Index components of judicial independence, impartiality of courts, protection of intellectual property rights, military interference in the rule of law and integrity of the political and legal system have significant influence on the state's shock counteraction and absorption
Social Development	Education (UNDP HDI)	It measures adult literacy rates and school enrolment ratios which influences shock absorption
	Health (UNDP HDI)	It measures life expectancy at birth, quality and quantity of medical facilities, housing and accident proneness which has a tendency to affect shock absorption

Source: Compiled by Author

Calculation of the resilience index revealed that economic vulnerability and economic resilience have an inverse and positive relationship respectively, with economic growth. Resilience indices can therefore be effectively used to communicate to relevant stakeholders the importance of resilience building and thereby act as an effective focal point in policymaking by using an integrated approach to improve the four components featured in table 1. It is however important to note that the effectiveness of the index is dependent on the ‘appropriate coverage, simplicity, ease of comprehension affordability, suitability for international comparisons and transparency’ of its components (Briguglio 2003).

Rose (2004) also contributed to the discourse on resilience indices and noted that the concept of economic resilience is important because of the potential asset and business operational losses which could be incurred by economies in times of disasters. The study therefore suggested that measurements of economic resilience should incorporate the microeconomic, mesoeconomic and macroeconomic facets of society since they are all affected in times of disasters (see table 2 below for an elaboration of these three economic dimensions).

TABLE 7: LEVELS OF RESILIENCE AND TARGETED AREAS OF INTEREST

Resilience Target Level	Target areas of interest
Microeconomic	Individual behaviour of firms, households, or organizations
Mesoeconomic	Economic sector, individual market, or cooperative group
Macroeconomic	All individual units and markets combined though the whole is not simply the sum of its parts, due to interactive effects of an economy

Source: Rose 2004

B. A summary of existing vulnerability indices³

1. The environmental vulnerability index (EVI)

The EVI was developed by the Secretariat of the Pacific Applied Geoscience Commission (SOPAC), the United Nations Environment Programme (UNEP) and its other partners to ‘provide a rapid and standardized method for characterizing vulnerability...and identifying issues that may need to be addressed within each of the three pillars of sustainability⁴’ (UNEP and SOPAC 2005). The EVI is multi-dimensional in scope.

The primary purpose of the EVI is to assess the current change of the environment by providing information on short-term trends to indicate vulnerability of the environment over the next few years’ (UNEP and SOPAC 2005). The EVI not only determines vulnerability by the inherent characteristics of a country, but also the effects of natural hazards and human pressures on the quality of the environment and its susceptibility to disasters. This index is therefore important for adaptive management as it takes into consideration the potential effects of past disasters on the environment’s current risks. Some of the advantages and disadvantages of the EVI are summarized in table 3:

³ See Appendix 1 to this Report for a detailed summary of a number of vulnerability and resilience indicators and indices.

⁴ Environment, economy and society

TABLE 8: SUMMARY OF ADVANTAGES AND DISADVANTAGES OF THE EVI

Advantages of the EVI	Disadvantages of the EVI
<p>It is an effective indicator of vulnerability</p> <p>It identifies the extent to which an environment is prone to damage and degradation</p> <p>It utilizes relevant economic and social indices as they do impact the environment</p> <p>It allows for inter- country comparison of vulnerability indices</p> <p>It facilitates independent country vulnerability assessment using the 1-7 EVI scale to pinpoint strategic areas for improvement.</p> <p>It allows for comparison through time and space</p> <p>It can be used as a tool for adaptive management</p> <p>It can be used to raise awareness on the importance of environmental vulnerability and on strategies to control it.</p>	<p>The EVI is data intensive requiring as much as 80% data on the indicators for calculation</p>

Source: Compiled by Author

The classification in figure 2 uses the EVI's information-dense report card to analyze a country's degree of environmental vulnerability. Known as the classification table, it evaluates the overall EVI score that is derived from the 50 indicators (covering weather and climate, geology, geography, resources and services and human populations) which are assessed on a scale of 1-7. The interpretation of the EVI score is as follows:

- a country that obtains a score which is less than 215 is deemed to be environmentally resilient;
- a score between 215 and 264 categorizes the country's environment as being 'at risk'; and
- a score between 265 and 314, suggests a country's environment is highly vulnerable. The most undesirable score is that of 365 (or more) since this is interpreted as the country's environment is extremely vulnerable.

Figure 9: CLASSIFICATION OF EVI RESULTS

Extremely Vulnerable	365+
Highly Vulnerable	315+
Vulnerable	265+
At risk	215+
Resilient	<215

Source: Kaly and Pratt (2000)

2. The economic vulnerability indicator (EcVI)

The economic vulnerability index (EcVI) was first introduced by Briguglio in 1992. The EcVI seemed to suggest that SIDS, owing to their inherent characteristics⁵, tend to be more economically vulnerable than other groups of countries.

Briguglio et al. (2003), defined economic vulnerability as ‘the exposure of an economy to exogenous shocks arising out of its inherent characteristics, typically associated with smallness, while economic resilience is the policy-induced ability of an economy to withstand or recover from the effects of adverse shocks’ (Briguglio, L. et al. 2009). Table 4 summarises some of the key elements that contribute to a country’s economic vulnerability.

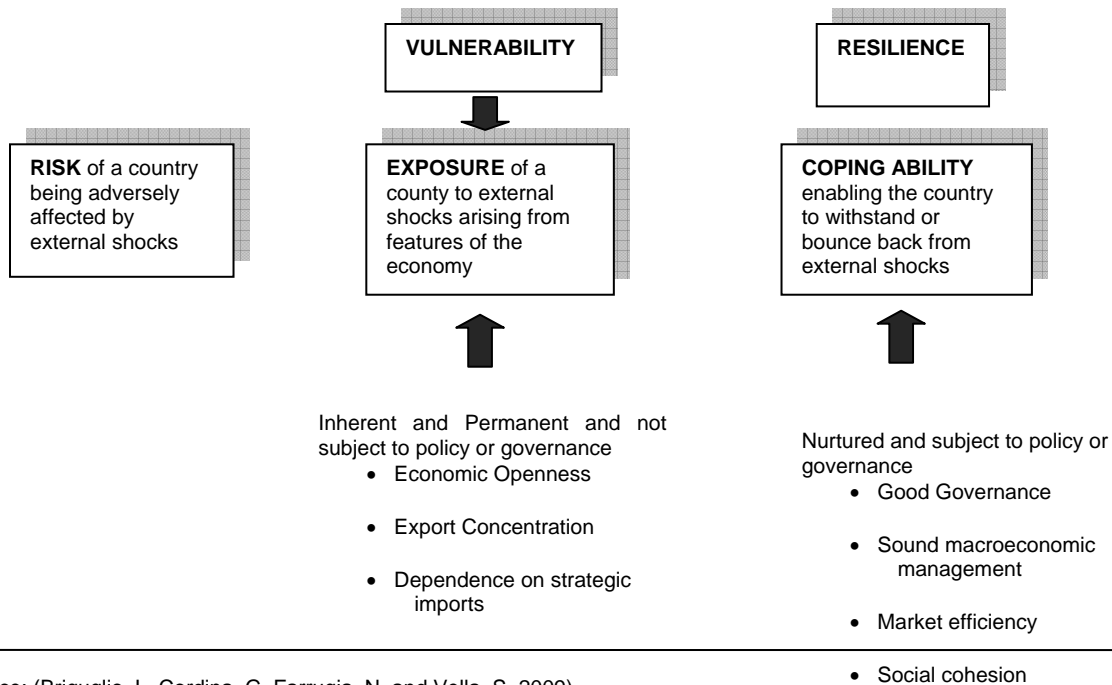
TABLE 9: CHARACTERISTICS THAT CONTRIBUTE TO ECONOMIC VULNERABILITY

Economic openness	Economic openness captures the degree to which a state is susceptible to economic conditions in the rest of the world. Measured by the ratio of exports or imports, or an average of both, as a percentage of GDP.
Dependence on a narrow range of exports	Measured by the export concentration index devised by UNCTAD, this only covers merchandise.
Peripherality	This concept is associated with insularity and remoteness, leading to high transport costs and marginalization from the main commercial centres.
Dependence on strategic imports	Looks at the extent to which a country’s viability depends on imports.

Source: Compiled by author from (L. Briguglio, 2003)

These two indicators, economic vulnerability and economic resilience, may be used to determine the degree of risk exposure to an economy from exogenous shocks as illustrated in Figure 3:

⁵ Some of these characteristics that contribute to the economic vulnerability of SIDS include their limited ability to exploit economies of scale; their lack of natural resource endowments; their inability to influence external prices and their lack of environmental and social resilience

FIGURE 10: DETERMINATION OF THE DEGREE OF RISK EXPOSURE

Source: (Briguglio, L. Cordina, G. Farrugia, N. and Vella, S. 2009)

Briguglio et al. (2009) suggest that there are four possible types of countries that may be identified based on the combinations of factors that are present within countries (table 5). In summary one may find countries that are either inherently vulnerable or inherently resilient or those that craft and implement policy to withstand or (inadvertently) exacerbate vulnerability.

TABLE 10: SCENARIOS FOR DETERMINING VULNERABILITY AND RESILIENCE

	Countries that adopt policies to withstand vulnerability.	Countries that adopt policies that exacerbate vulnerability.
Inherently vulnerable countries	The 'self made' scenario	Worst case scenario
Inherently resilient countries	Best case scenario	The 'Prodigal son' scenario

Source: Briguglio and Galea (2003)

3. Social vulnerability Index

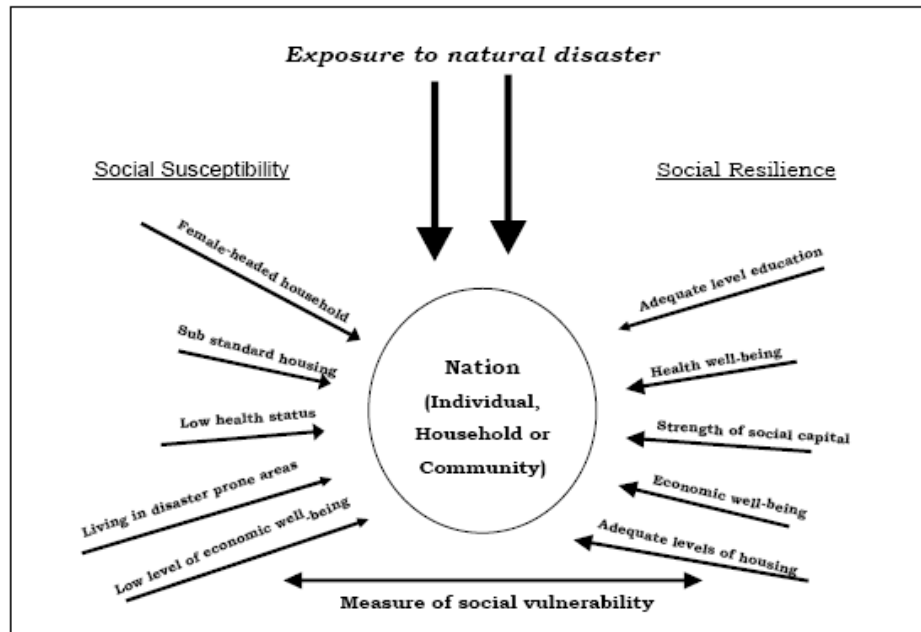
St. Bernard (2004) developed an index of social vulnerability for the Caribbean countries. St. Bernard (2004) suggested that:

"...social vulnerability is the inability of human units (individuals, households or families to cope with and recover from stresses and shocks, their inability to adopt to and exploit changes in physical, social and economic environments and their inability to maintain and enhance future generations."

Implicit in St. Bernard's definition is the importance of determining social vulnerability to complement environmental and economic vulnerability indices. St. Bernard (2004) further notes that "social vulnerability also may be seen as the extent to which the social system is able to respond, favourably or unfavourably, to the exposure to a sudden shock or event either of an economic, environmental, or social nature or a combination of those forces, and the society's capacity or incapacity to cope with, adopt or adapt to the impact".

Figure 4 adapted from Kambon (2002) seeks to capture the varied elements that may constitute social vulnerability. It shows that social vulnerability is a complex index composed of factors such as economic "well-being", environmental factors such as the extent to which the geographic area in which one lives is hazard prone, the quality of the housing in which one lives and the gender of the individual. The literature suggests for example that the majority of the poor persons globally are women, which suggests that one might expect, *a priori*, that women are likely to be more socially vulnerable than men.

FIGURE 11 : FRAMEWORK FOR THE SOCIAL DIMENSION OF VULNERABILITY TO A NATURAL DISASTER



Source: adapted from Kambon (2002)

The results of the Pilot Social Vulnerability Index in the Caribbean when compared to other indices in the Caribbean are captured in the table 6.

TABLE 6: RESULTS OF PILOT TEST OF THE SOCIAL VULNERABILITY INDEX COMPARISON TO OTHER MEASURES OF SOCIAL DEVELOPMENT BY SELECTED COUNTRIES

VI RANK	SOCIAL VULNERABILITY INDEX	HUMAN DEVELOPMENT INDEX 1998	POVERTY RATE – HEAD COUNT INDEX	ADJUSTED HUMAN DEVELOPMENT INDEX 1999 ¹⁶⁵
	St. Kitts and Nevis <i>0.421</i>	St. Kitts and Nevis <i>0.798</i>	Saint Lucia (1995) <i>25%</i>	St. Kitts and Nevis <i>0.457</i>
	St. Vincent and the Grenadines <i>0.456</i>	Grenada <i>0.785</i>	St. Kitts and Nevis (1999/2000) <i>31%</i>	St. Vincent and the Grenadines <i>0.437</i>
	Belize <i>0.473</i>	Belize <i>0.777</i>	Grenada (1998) <i>32%</i>	Belize <i>...</i>
	Saint Lucia <i>0.490</i>	St. Vincent and the Grenadines <i>0.738</i>	Belize (1996) <i>33%</i>	Grenada <i>0.396</i>
	Grenada <i>0.496</i>	Saint Lucia <i>0.728</i>	St. Vincent and the Grenadines (1995) <i>38%</i>	Saint Lucia <i>0.343</i>

The results of the Pilot Social Vulnerability Index suggests that additional data would need to be sourced if one were to adequately derive measures of social vulnerability for different countries for national policy planning or for regional development objectives.

The pilot project attempted to measure vulnerability of social institutions in five countries, including the following; Belize, Grenada, Saint Kitts and Nevis, Saint Lucia and Saint Vincent and the Grenadines. The results of which illustrated the following:

- Social Institution Vulnerability was seen to be least in Saint Kitts and Nevis
- Social Institution Vulnerability was seen to be high in Grenada and Saint Lucia. Education vulnerability seems to be high in Saint Vincent and the Grenadines and high in Saint Kitts and Nevis
- Vulnerability in terms of healthcare seems to be least in Belize and highest in Saint Kitts and Nevis and Saint Lucia
- The greatest threat to social order and security is seen in Saint Lucia and to a lesser extent Belize and lowest in Grenada.
- In terms of resource allocation the problem is greatest in Grenada.

It, however, was difficult to determine the relative impact of the different social sectors on the vulnerability status within each of the five countries.

At the national level, the importance of measuring social vulnerability status is manifest in efforts to gauge countries' needs for financial aid from funding and donor agencies. It is asserted that there may be countries where high levels of economic growth and high prospects for human development are concomitant with low levels of poverty but where severe threats impact negatively upon their state of vulnerability. Evidence of such vulnerability is critical in determining the viability of the sustainable development process.

According to Barber (1987), social sustainability is “the ability to maintain desired social values, traditions, institutions, cultures or other social characteristics.”

The index developed to measure social vulnerability has five sub-indices which include education, health, security, social order and governance, resources allocation, and communications architecture. It was noted that the model needed to be tested empirically to ascertain the extent to which the selected indicators adequately reflect social vulnerability.

III. VULNERABILITY INDICATORS IN THE CARIBBEAN CONTEXT

ECLAC 2005 asserts the vulnerability of the Caribbean subregion to a range of natural events which include earthquakes, volcanic activity, tsunamis, hurricanes and tropical storms, excessive rainfall, storm surges and coastal area the disaster preparedness index (Dpi) or the Disaster Resiliency Index (DRi) (Center for Hazards Research and Policy Development 2006), can be important in reflecting the region's vulnerability and by extension, resilience to such events.

In terms of measurement, the following are some of the underlying guiding principles for construction of the DRi (Center for Hazards Research and Policy Development 2006):

- Data should be obtained from objective sources that are easily accessible.
- Index measures should be standardized and normalized to permit cross-community comparisons.
- Accepted validation of measurements should be conducted.
- There should also be a level of consensus on measures and indicators.
- The measures require practitioner support and an institutional framework.

In preparation and construction of the proposed DRi, the following framework was utilized taking into consideration the variance in levels of preparedness and resilience of a community which needed to be modeled for vulnerability and resilience:

Vulnerability = hazard*probability*frequency*vulnerability measures (VM).

Disaster Resiliency Index (Dri)= Preparedness index(Pi)/vulnerability(V).

Where DRi>1, the community is considered more resilient

Where DRi<1, the community is considered less resilient.

From the above formulation, resilience may be interpreted as a country's preparedness in relation to its exposure to a unique set of hazards. The DRi is said to give a broad indication of resilience which according to the literature, is built on functional measures of preparedness and vulnerability measures which cover a variety of indicator types which include: hazards, community assets, social capital, infrastructure/ system quality, planning, social services, and population demographics

Table 7 provides the indicators for some Caribbean countries with respect to the Environmental Performance Index (EPI). Among those countries for which data were available⁶ the Dominican Republic, Suriname and Belize are among the best performers, with the addition of Guyana in terms of Environmental sustainability. These indices reflect a relatively sound degree of environmental resilience in the region.

Other vulnerability indicators such as the SVI and the EVI highlight greater vulnerabilities in Saint Kitts and Nevis and Saint Lucia. The indicators for Barbados, Jamaica and Trinidad and Tobago suggested these countries had the greatest environmental vulnerabilities.

A look at the PVI for the Dominican Republic, Jamaica and Trinidad and Tobago reflects high vulnerability for these countries while the figures obtained for the DDI suggest that the availability of economic resources will exceed economic resilience in the case of a Maximum Considered Event (MCE) for Barbados and the Dominican Republic. Not surprisingly economic vulnerability is particularly high in Jamaica.

⁶ A description of each of these indicators and their associated variables is available in Appendix 1

Table 7 also points to one of the main challenges envisaged in conducting indices in the Caribbean – data paucity. While it has been possible to derive indices for some Caribbean territories, a comprehensive reflection of the state of vulnerability and resilience in the region is lacking. In many instances, this inability to “zero in” focus on the vulnerabilities is due to the paucity of data and for indicators that are required for the calculation of the respective indices.

TABLE 7: VULNERABILITY AND RESILIENCE INDICATORS FOR SELECTED CARIBBEAN/ECLAC COUNTRIES

	EPI, 2010	ESI, 2005	SVI, 2007	EVI	PVI, 2007	DDI, 2008	RMI, 2008	EcVI, 2003
Anguilla	n.d.	n.d.	n.d.	312	n.d.	n.d.	n.d.	n.d.
Antigua & Barbuda	69.8	n.d.	n.d.	307	n.d.	n.d.	n.d.	n.d.
The Bahamas	n.d.	n.d.	n.d.	248	n.d.	n.d.	n.d.	n.d.
Barbados	n.d.	n.d.	n.d.	403	39	3.15	45	0.549
Belize	69.7		0.473	258	n.d.	n.d.	n.d.	n.d.
Cayman Islands	n.d.	n.d.	n.d.	343	n.d.	n.d.	n.d.	n.d.
Dominica	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Dominican Republic	68.4	43.7	n.d.	324	46	2.42	33	
Grenada	n.d.	n.d.	0.496	316	n.d.	n.d.	n.d.	n.d.
Guyana	59.2	62.9	n.d.	207	n.d.	n.d.	n.d.	n.d.
Haiti	39.5	34.8	n.d.	343	n.d.	n.d.	n.d.	n.d.
Jamaica	58	44.7	n.d.	381	51	0.73	43	0.706
Netherlands Antilles	n.d.	n.d.	n.d.	323	n.d.	n.d.	n.d.	n.d.
St. Kitts and Nevis	n.d.	n.d.	0.421	359	n.d.	n.d.	n.d.	n.d.
Saint Lucia	n.d.	n.d.	0.49	393	n.d.	n.d.	n.d.	n.d.
St. Vincent and The Grenadines	n.d.	n.d.	0.456	337	n.d.	n.d.	n.d.	n.d.
Suriname	68.2	n.d.	n.d.	211	n.d.	n.d.	n.d.	n.d.
Turks and Caicos	n.d.	n.d.	n.d.	292	n.d.	n.d.	n.d.	n.d.
Trinidad and Tobago	54.2	36.3		381	43	0.1	23	0.408

Key to values:

Values of the index are placed on a scale from 0 to 100. 100 represent the target while 0 represents the worst observed value.

Similar range to EPI.

Range between 0 and 1 with values closer to 1 indicating greater social vulnerability

Extremely Vulnerable (365+); Highly Vulnerable (315-365); Vulnerable (265-315); At Risk (215-265) and Resilient (,215)

Range bet 0 and 100, a value of 80 very high vulnerability; 40 to 80 high, 20 to 40 medium and <20 low

> 1 indicates that Economic resources will exceed Economic resilience

An index below 50 is considered unsatisfactory, 50-75 satisfactory; 75> outstanding

Values range between 0 and 1. Higher values indicate higher levels of Economic Vulnerability while lower values indicate lower levels of Economic Vulnerability

Sources:

Environmental Performance Index 2010: Country Scores. [Http://epi.yale.edu/Countries](http://epi.yale.edu/Countries)

Environmental Sustainability Index , Summary for Policymakers.http://sedac.ciesin.columbia.edu/es/esi/ESI2005_policysummary.pdf

St. Bernard (2007)

http://vulnerabilityindex.net/EVI_Country_Profiles.htm

IDB, 2010: Indicators of Risk and Risk Management: Program for Latin America and the Caribbean- Reports for Barbados, Jamaica and Trinidad and Tobago

Briguglio and Galea (2003)

Source: Compiled by Author from various sources cited above

In addition to the above, Briguglio (1995) has also identified that vulnerability indices may also be prone to some weaknesses which include:

- The subjectivity in the choice of variables - this is difficult to resolve but can be minimised if the objective of the index is clearly spelled out;
- Data problems – relate to lack or shortage of data; non-homogenous definitions across countries;
- The weighting and averaging procedure - the single value which is produced by a composite index may conceal divergences between the individual components or sub-indices, possibly hiding useful information: averaging would conceal, for example, situations where the effect of one variable cancels out the effect of another;
- The problem of aggregation addresses the level at which indices should be aggregated: national or regional; and
- Political aspects of pitching one country against another.
- For the selected indicators: Environmental Vulnerability Index (EVI), Prevalent Vulnerability Index (PVI), Economic Vulnerability Index (EcVI), Disaster Deficit Index (DDI), Economic Resiliency Index (ERI), Hurricane Disaster Risk Index (HDRI) and the Environmental Sustainability Index (ESI), the following analysis for Caribbean SIDS shows that in many instances data deficiency proves to be a critical factor in measuring and revealing a complete framework of vulnerability.

A. Environmental vulnerability index for the Caribbean

The EVI is perhaps the index that is most often used in the Caribbean subregion as evidenced by its application to almost all countries (table 8). The percentage of data that were available to facilitate the derivation of the EVI are also shown in table 8.

TABLE 8: DATA AVAILABILITY FOR THE DERIVATION OF THE EVI

Country	EVI	DATA%	STATUS
Anguilla	312	52	Vulnerable
Antigua and Barbuda	307	56	Vulnerable
Bahamas	248	62	At Risk
Barbados	403	70	Extremely Vulnerable
Belize	258	90	At Risk
Cayman Islands	343	60	Highly Vulnerable
Dominica	n.d.	n.d.	
Dominican Republic	324	90	Highly Vulnerable
Grenada	316	62	Highly Vulnerable
Guyana	207	90	Resilient
Haiti	343	92	Highly Vulnerable
Jamaica	381	94	Extremely Vulnerable
Netherlands Antilles	323	60	Highly Vulnerable
St. Kitts and Nevis	359	54	Highly Vulnerable
Saint Lucia	393	59	Extremely Vulnerable
St. Vincent and the Grenadines	337	54	Highly Vulnerable
Suriname	211	88	Resilient
Turks and Caicos	292	52	Vulnerable
Trinidad and Tobago	381	94	Extremely Vulnerable

Source: (EVI Country Profiles n.d.), http://vulnerabilityindex.net/EVI_Country_Profiles.htm

B. Prevalent vulnerability index for the Caribbean

ECLAC 2010, has suggested for the selected countries of Caribbean subregion an adjusted Prevalent Vulnerability Index (PVI). The adjusted index was proposed so as to allow for data gaps in calculation of the PVI.

TABLE 9: ADJUSTED PREVALENT VULNERABILITY INDEX

Country	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007
Bahamas	11.97	17.92	18.15	17.46	17.54	15.76	13.65	8.05	3.38	3.43
Belize	12.74	12.15	14.49	14.18	14.3	13.68	13.43	14.76	13.44	13.54
Dominica	21.33	19.54	19.61	18.96	18.38	18.2	18.81	19.02	18.74	7.7
Dominican Republic	21.93	20.96	27.18	23.81	23.94	28.92	27.33	25.49	23.46	26.48
Grenada	31.3	32	35.68	34.52	34.12	35.09	35.99	36.07	34.6	23.33
Guyana	15.41	22.98	20.97	21.23	20.8	19.78	20.56	21.83	2.05	1.6
Haiti	23.94	29.45	30.25	32.98	32.72	36.05	33.28	33.09	33.45	29.13
Jamaica	27.35	30.47	29.21	29.18	29.42	29.78	30.35	30.57	29.89	18.97
Saint Lucia	30.04	33.36	32.43	32.61	31.13	32.67	33.04	33.24	33.69	21.21
Suriname	9.63	18.55	9.92	11.04	7.69	8.61	8.38	9.29	2.03	0.94

Key: PVI ranges from 0 (lowest vulnerable) to 100 (highest vulnerability).

Source: ECLAC (2010)

Similar to the original PVI the range of the adjusted PVI is between 0 to 100. The adjusted PVI (table 9) utilises economic exposure/susceptibility and economic fragility/ resilience as two indicators. Even with adjustments made there were still insufficient data to arrive at PVI values for countries such as Anguilla, the Cayman Islands, Curaçao and the Turks and Caicos islands. The data paucity has therefore contributed to significant divergence between the PVI and adjusted PVI, as is evident in the values in table 10.

TABLE 10: COMPARISON OF THE PVI AND ADJUSTED PVI

Country	Prevalent Vulnerability Index (IDB)	Adjusted Prevalent Vulnerability Index (ECLAC)
Jamaica	51	18.97
Dominican Republic	46	26.48

Source: Compiled by Author from IDB: Indicators of Risk and Risk Management: Program for Latin America and the Caribbean- Reports for Barbados, Jamaica and Trinidad and Tobago (2010) and ECLAC (2010)

C. Disaster Deficit Index for the Caribbean

The DDI, data which are provided in table 11, has been used in the Caribbean as a measure of resilience for Barbados, Jamaica and Trinidad and Tobago. The data requirement for the calculation of this index includes the volume and cost of exposed elements to disasters (MCE Loss) and the stock of available funds for recovery (economic resilience) from disasters. The required information was sourced from the Ministry of Planning, Housing and the Environment, The University of the West Indies (Seismic Research Centre) and the individual Central Banks of Caribbean nations.

TABLE 11: DDI FOR BARBADOS, JAMAICA AND TRINIDAD AND TOBAGO

Country	DDI (return periods)	DDI 1995	DDI 2000	DDI 2005	DDI 2008
Barbados	<i>DDI₅₀</i>	-	1.00	1.30	1.49
	<i>DDI₁₀₀</i>	-	2.30	2.84	3.15
	<i>DDI₅₀₀</i>	-	5.22	5.58	5.75
Jamaica	<i>DDI₅₀</i>	0.17	0.30	0.56	0.28
	<i>DDI₁₀₀</i>	0.47	0.74	1.35	0.73
	<i>DDI₅₀₀</i>	1.58	2.11	3.57	2.40
Trinidad and Tobago	<i>DDI₅₀</i>	0.03	0.06	0.02	0.04
	<i>DDI₁₀₀</i>	0.07	0.17	0.06	0.10
	<i>DDI₅₀₀</i>	0.59	0.26	0.44	0.80

Source: IDB 2010: Indicators of Risk and Risk Management: Program for Latin America and the Caribbean- Reports for Barbados, Jamaica and Trinidad and Tobago

The case for possible retrofitting to the Caribbean context lies in the calculation of the MCE Loss as the IDB proposes the use of ‘general information about built areas and/ or on the population to make estimations of these inventories of exposed elements’. These proxy estimates would be derived from ‘the cost of square meter of some construction classes, built area (in city related to the number of inhabitants) and distribution of built areas in basic groups for ... public and private components which would be fiscal liabilities of the government in case of a disaster’ (IDB 2010).

D. Economic vulnerability index in the Caribbean

The Economic Vulnerability Index (EcVI) measures the extent of vulnerability of a country, which is seen as a measure of exposure to external forces outside a country’s control. It is calculated using the following sub-indices listed below:

- Openness Index = (average of imports and exports)
- Export Concentration Index = (United Nations Conference on Trade and Development (UNCTAD) calculations)
- Dependence on Strategic imports = (average imports of commercial energy as a percentage of domestic energy production)
- Peripherality = (the ratio of Freight on Board (FOB)/Cost Insurance Freight (CIF) factors and the Ratio of transport and freight costs to international trade in merchandise)

The EcVI, data for which are detailed in table 12, has been used in the Caribbean as a measure of vulnerability for Barbados, Jamaica and Trinidad and Tobago. The calculation of this index mainly requires trade related data for the computation of its sub- indices and such data may be sourced from the respective country Central Banks and the World Bank Development Indicators (WDI).

TABLE 12: ECVI FOR BARBADOS, JAMAICA AND TRINIDAD AND TOBAGO

Country	EcVI (2003)	Rank (th)
Barbados	0.549	12
Jamaica	0.706	3
Trinidad and Tobago	0.408	25

Source: (Briguglio 2003)

The ease of data access for the calculation of the EcVIs poses no real need for possible data retrofitting to the Caribbean context.

E. Economic Resiliency Index for the Caribbean

The ERI index aims to estimate the resilience of nation states to or ‘shocks’ of Natural disasters, and climate change (table 13). The derivation of the index relies on the use of indicators that reflect the “state” of a country vis-a-vis the country’s socio-economic, educational, health, governance, infrastructure, communications and environmental state. The indicators used are reflective of the areas in which the “shock absorbing” and “shock counteracting” resilience in an economy should be located. While the aforementioned indicators are not an exhaustive list of factors that contribute to resilience, they are thought to be the best available list of indicators.

TABLE13: CARIBBEAN SCORES- THE ECONOMIC RESILIENCY INDEX

Country	Score (out of 1)
Trinidad and Tobago	0.521
Belize	0.269
Jamaica	0.446
Dominican Republic	0.427
Barbados	0.397

Source: Briguglio and Galea (2003).

Of the 12 indicators used (see appendix of data requirements) 11 are readily available through online databases allowing this index to be constructed using simple desk research making this index a good base for retrofitting and modification for the Caribbean context. The only indicator for which data were not readily available for the majority of Caribbean countries is the Infrastructure and Communications Indicator. More specifically, information on updating and enforcement of safety standards and construction codes as well as infrastructure and housing insurance as a percent of GDP, is needed to inform this indicator. Further research would be required in order to extract the necessary information for this indicator, however a likely proxy could be found.

F. Hurricane disaster risk index for the Caribbean

Hurricanes remain one of the most recurrent and damaging natural hazards in the Caribbean region and with climate change the frequency and intensity of these events is expected to increase. Understanding the risk associated with hurricanes and hydrometeorological events is thus essential especially when the historical impact of hurricanes on quality of life infrastructure in the region is considered.

This index measures hazard, exposure, vulnerability and emergency response and recovery from hydro meteorological events. The index is developed in three stages involving firstly, the identification of factors- meteorological, engineering, economic and social that contribute to economic and life loss;

secondly, selection of measurable scalar indicators; and thirdly, use of a mathematical index to combine indicators into two composite index values.

This index is used primarily for the southern United States of America but could easily be adapted for use in the Caribbean subregion. The following is the status of data availability in the Caribbean countries to permit the calculation of the Hurricane Disaster Risk Index :

- Hazard Data availability (five Indicators) – Of the five indicators three are readily available, one is not readily available but not difficult to extract and one related to storm surge, would require significant further research to extract.
- Exposure Data availability (six Indicators) – The exposure indicators were broken down into Population, Building, Economic and Lifeline indicators. Of these six indicators three were readily available.
- Vulnerability Data availability (six Indicators) These indicators were broken down into Population, Building and economic vulnerability. The population indicators (three out of six) were readily available but for the final three indicators data was largely unavailable.
- Emergency Response and recovery (nine Indicators) Broken down into connectivity, Evacuation and Shelter, Mobility and Response resources. This grouping included six easily to readily attainable indicators for the region. The more difficult data requirements to fill included; evacuation clearance time, percentage of population expected to evacuate and percentage county land area detached from mainland.

Out of 26 indicators required to calculate this index, 15 could be acquired through the use of desktop research to calculate the index. The 11 that would require more intensive research include:

- Hazard – Rainfall: XH5 average forward speed of hurricanes [knots]
- Hazard – Storm Surge: XH4 % area below 50-year stillwater elevation
- Exposure – Economic: XE6 number of business units
- Exposure – Lifeline: XE7 value of power lines [dollars]
- Building: XE4 Median home value [dollars]
- Vulnerability – Building: XV4 Avg BCEGS grade
- Vulnerability – Building: XV5 % of homes that are mobile homes
- Vulnerability – Economic: XV6 % of business with less than 20 employees
- ERRC – Connectivity: XR1 % county land area detached from mainland
- ERRC – Evacuation & Shelter: XR3 evacuation clearance time [hours]
- ERRC – Evacuation & Shelter: XR4 % of population expected to evacuate

G. Environmental sustainability index (ESI) for the Caribbean

The ESI provides an assessment of the ability of nations to protect the environment over long timescales (decades). This index is meant to be used as an environmental decision making tool, for monitoring of national environmental performance and facilitating comparative policy analysis.

Last published in 2005, the ESI uses 76 data sets which track natural resource endowments, past and present pollution levels, environmental management portfolios and a society's capacity to improve its environmental performance. These datasets are then converted into 21 indicators of environmental sustainability allowing comparison across five broad categories: Environmental systems, reducing environmental stress, reducing human vulnerability to environmental stress, societal and institutional capacity to respond to environmental challenges. A high ESI score implies better environmental stewardship, see table 14 for scores of available Caribbean nations:

TABLE14: COMPARISON OF ESI SCORES FOR SELECTED CARIBBEAN TERRITORIES

Country	ESI Rank	Non OECD Rank	ESI score
Guyana	8	2	62.2
Jamaica	109	82	44.7
Trinidad and Tobago	139	110	36.6

Source: 2005 Environmental Sustainability Index, Summary for Policymakers

The revised ESI assesses how countries use its own environmental resources as well as assesses how a country uses its global environmental resources.

In summary, therefore, while there are many indices that may be useful to inform policy decisions on vulnerability reduction and resilience building in the Caribbean, the problem of data paucity has to be addressed before meaningful attention could be paid to effective disaster risk management which includes vulnerability reduction and resilience building from natural disasters and in adapting to the impacts of climate change.

IV. ADAPTATION TO CLIMATE CHANGE AND HYDRO-METROLOGICAL EVENTS IN THE CARIBBEAN

A. The threat of climate change in the Caribbean

The Caribbean has been experiencing weather patterns which some may attribute to climate change. Examples of these are the unusual rainfall in Guyana and Suriname and ensuing catastrophic flooding of 2005. Also, the drought of 2009 and 2010 and the increasing severity and in some cases frequency of windstorms are but a few of these hydro-meteorological events of concern⁷.

These changes in hydro-metrological events are sufficiently alarming in themselves as are the likely changes in water availability, agriculture, biodiversity and human health that may result from them. These changes represent the potential for serious natural hazards that may well threaten life, health, shelter and environment.

Caribbean SIDS are extremely vulnerable to external shocks. In economic terms, high degrees of economic specialization, natural resource based economies, limited economic resources, limited economic impact on global markets (inability to influence prices and global demand for their goods) and high transportation costs place fragile economies at the will of a multitude of forces that are beyond their control. Scarce land resources, high population densities (especially along coastal areas), small vulnerable watersheds, high levels of species endemism, location within a very active hurricane belt, proximity to active tectonic plates and relatively scarce water resources all contribute to environmental vulnerabilities of the Caribbean subregion.

To address vulnerability to these environmental shocks, countries may consider mitigation or adaptation measures within the limits of their available resources. Adaptation is defined in the IPCC's Third Assessment Report 2001⁸ as "an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities". Given the small contribution of the Caribbean subregion to greenhouse gas emissions, the focus should more appropriately be given to measures aimed at adapting to the impacts of climate change and disasters by building resilience.

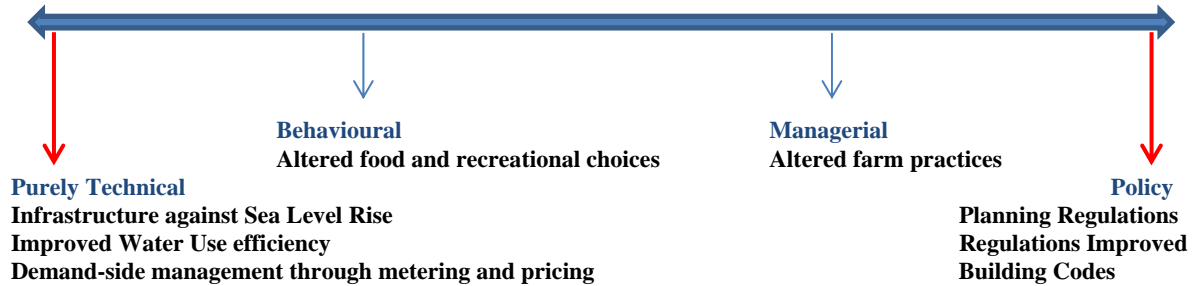
⁷ See Pantin and Attzs (2009).

⁸ http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml

B. Adaptation measures

Nurse (2007) suggests that adaptation responses may be categorised as shown in figure 5:

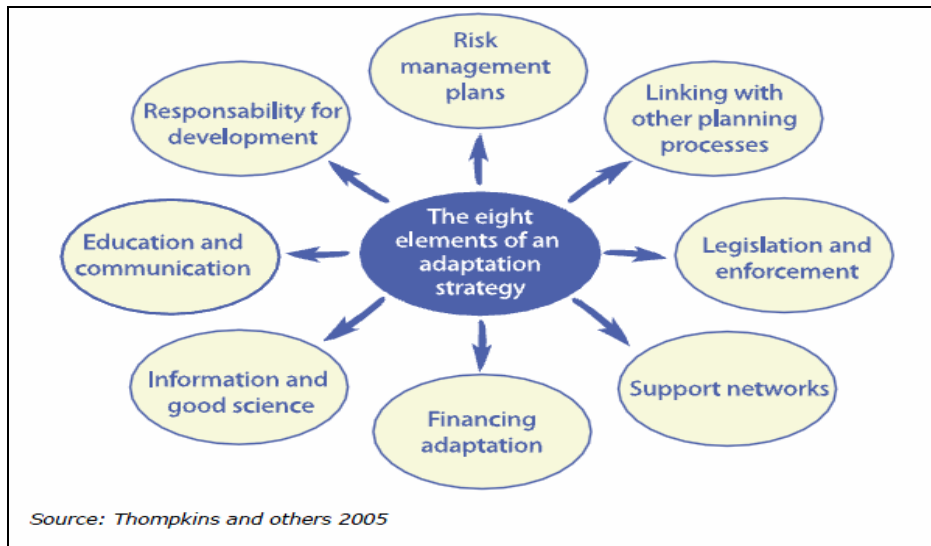
FIGURE 12: CATEGORIZATION OF ADAPTATION RESPONSES



Source: Nurse (2007)

Tompkins et al. (2005) suggest there are eight elements of an adaptation strategy as depicted in Figure 6:

FIGURE 13: ELEMENTS OF AN ADAPTATION STRATEGY



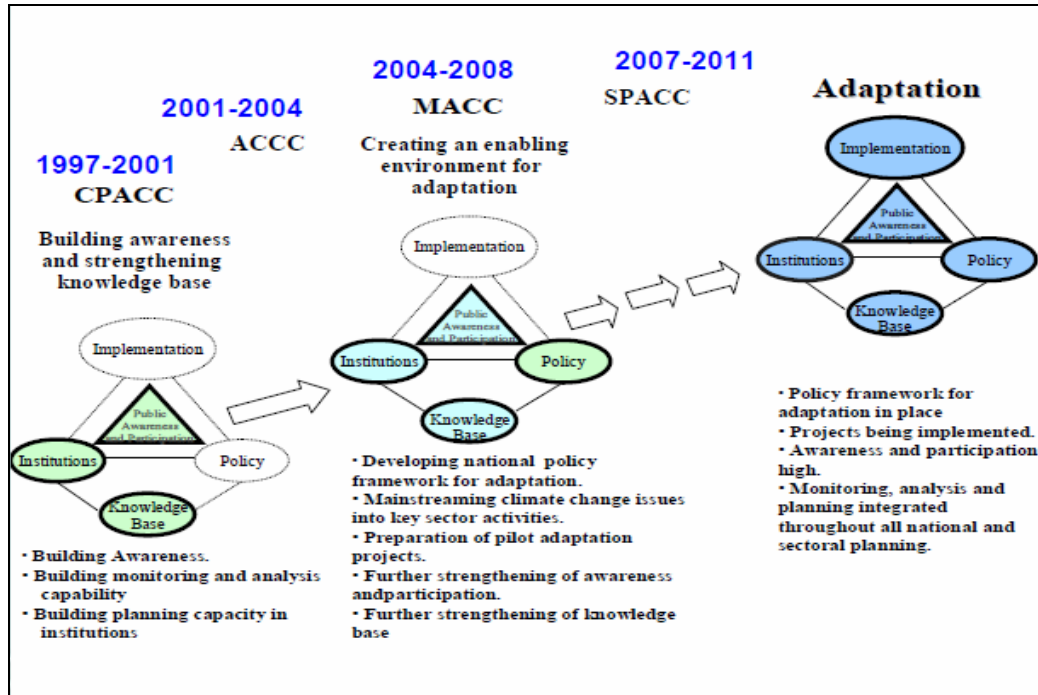
Source: Thompkins et al. 2005

The first and most important step in adaptation or building of resilience is enhancing the understanding of risk and the science behind the hazards that threaten the Caribbean region. In this regard, the Caribbean Community Climate Change Centre (CCCCC) was established in 2005 to coordinate activities in adapting to climate change and the inherent impacts that determine the frequency and magnitude of disasters. The main role of the CCCCC is to strengthen the technical and financial

capacity of CARICOM nations to respond to climate change through scientific research and capacity-building activities⁹.

Figure 7 details the programmes and activities in support of adaptation that are being implemented by CARICOM and the CCCCC.

FIGURE 14: ADAPTATION RELATED PROGRAMMES AND ACTIVITIES OF CARICOM AND CCCCC



Source: Carlos Fuller UNFCCC Technical Workshop on Costs and Benefits of Adaptation Options under the NWP¹⁰

Another adaptation/disaster risk management that is promoted throughout the Caribbean is the use of building codes. Improved building codes meant to build resilience to hydro-metrological events and hurricanes have been proposed in a number of Caribbean countries. Table 15 provides a summary of the status of implementation.

⁹ A number of other capacity building projects and organizations exist in the Caribbean, such as the Disaster Risk Reduction Center (DRRC) of the University of the West Indies. The DRRC has done significant research in the area of risk mapping producing a Caribbean Risk Atlas. Other research undertaken by the University of the West Indies Climate Studies Group, the Instituto de Meteorología de República de Cuba (INSMET), Caribbean Meteorological Organization (CMO), and the Caribbean Disaster Emergency Management Agency has contributed to the understanding of risk and vulnerability in the region.

¹⁰ SPACC- Special Program on Adaptation to Climate Change; CPACC- The Caribbean Planning for Adaptation to climate change project; ACCC- The Adaptation to Climate Change in the Caribbean; MACC- The Mainstreaming Adaptation to Climate Change project

TABLE 15: EXAMPLES OF CARIBBEAN ISLAND BUILDING CODES

Country	Building Code Status	Building Inspection Capacity
Anguilla	Building Code completed and being used administratively Building regulations mandating the use of the Code will be incorporated into the new Physical Planning Ordinance.	Being Developed One Inspector Employed by the Department of Physical Planning
Antigua and Barbuda	Completed Based on CECs model Building Code Legislated in 1996 as regulation under the Development Control Ordinance	Five Building Inspectors on Staff Training Programme to be developed.
Barbados	Draft Code developed in 1993	
Dominica	Code drafted, based on CECS models building code and submitted for legislative review. Dominica Physical Planning Act being set up to mandate the use of the Building Code	Development of Control Authority has five building inspectors
Jamaica	National Building Code drafted and distributed for comment in 1984 but not adopted Revised code in progress Building by- laws apply in each Parish and in Kingston- St. Andrew	Each Parish has building inspectors Staffing in some places will have to be augmented to ensure that building plans can be properly reviewed in accordance with the new Code.
Trinidad and Tobago	Building Code drafted and submitted for comments and enabling legislation submitted for legislative approval. For engineered buildings, British, American and Canadian codes are used as standards.	Special committee mandated to prepare building regulations for legislative review

Source: Thompkins et al. 2005

A number of land use planning adaptation strategies have also been proposed across the subregion. For example, coastal zoning in Jamaica is seen as a resilience building response to reducing vulnerability to the anticipated impacts of sea level rise. This zoning not only reduces the risk associated with coastal development but likely minimizes the vulnerability of non-zoned areas by supporting ecosystem services such as beach replenishment.

Physical adaptation or ‘purely technical’ adaptation is also occurring across the region, however due to the high costs associated with construction, especially coastal protection, this type of adaption is not as widespread as others. Examples of this type of adaptation include:

- The ongoing construction of sea defences such as groynes, protective dunes , stone or ‘rip-rap’ revetments on the palisades tombolo linking Port royal and Norman Manley International airport to the mainland of Jamaica in response to recent hurricane Ivan and to prepare for anticipated sea level rise and future hurricanes (GEF and GOJ funded);
- The extension and construction of dikes, levees, floodwalls, and seawalls across Guyana;
- Proposed Implementation of pilot adaptation measures in coastal areas (IBRD and GEF-funded) In Dominica, which involves detailed adaptation planning for coastal areas to reduce the impact of CC on biodiversity as well as reforestation and protection of wetland ecosystems, whose ecosystem services reduce the impact of hydro-metrological events and improve water supply;

- Low cost community based drainage improvement measures for the reduction of landside risk in the OECS disaster risk and reduction programme (UNDP funded 2006-2007)

A large number of disaster risk reduction programmes such as the Guyana Integrated Disaster Risk Management Plan (IDRM), the Second Saint Lucia Disaster Management Project (DMP II), Jamaica Comprehensive Disaster Management (CDM) cycle, and the Anguilla Comprehensive Disaster Management Strategy exist for the countries of the region. These programs largely focus on improving pre-event disaster preparedness, evaluation and mapping of risk, improving local and notional response capacity, education, and various methods of included hazard and risk assessment into the development approval process.

It is important to note that adaptation strategies are not strictly organized by governments and NGOs, individual adaptation options are also key for reducing vulnerability and risk. Common practices such as placing concrete blocks on zinc roofing in Jamaica are also key to adapting to hazards. However, it is important to conduct research of cost effective methods of reducing vulnerability coupled with education have the great potential for reducing the impacts of climate change.

V. SUMMARY CONCLUSIONS AND RECOMMENDATIONS

This report sought to present a summary of the multiple complex issues involved in determining and treating with the issues of vulnerability and resilience in Small Island Developing States of the Caribbean subregion. The challenges to Caribbean SIDS that arise from the impacts of climate change and natural disasters are particularly acute within the context of the inherent characteristics that typify these islands¹¹.

Determination of the extent of vulnerability of Caribbean SIDS to natural disasters and the impacts of climate change may be measured through the employment of vulnerability. However, the development of appropriate vulnerability indices for the Caribbean will be severely compromised unless the data paucity challenge is addressed in a holistic manner. As a corollary, policy implementation as it relates to comprehensive disaster risk management and adaptation to climate change will be thwarted thereby leaving the subregion exposed to the impact of natural hazard and climate related events.

There exists in the current literature some indices that may be readily replicated in the Caribbean context notwithstanding the gaps identified at (1) above. Some of these indices are The Economic Vulnerability Index (EcVI), the Disaster Deficit Index (DDI) and The ESI (Economic Resilience Index)

To complement the aforementioned three indices that may be used, the suggestion is for consideration to be given to the crafting of a Gender Vulnerability Index. Such an index will seek to marry traditional macroeconomic and social indicators, disaggregated by sex, but the result of which will give a clear sense of vulnerabilities among the sexes so that appropriate gendered policy responses may be identified.

The ability of Caribbean countries and societies to build resilience by adapting to the impacts of climate change or to reduce their vulnerability to different exogenous shocks will depend on a number of conditions. These vary from degree of exposure to the particular shock, to levels of poverty in the country or society, to the gender roles and functions in the society. A cross cutting issue in building resilience is that of gender equity. It is well documented that women in developing countries comprise a particularly vulnerable group in terms of the disproportionate extent to which they are affected by the negative impacts of exogenous shocks.

The overarching issue that arose was the conclusion that no single mechanism for building resilience to these impacts is applicable across the entire subregion. However, adaptation appears to be the best option for addressing these.

From these conclusions, five policy recommendations are identified as follows:

1. More detailed study is required on natural environmental impacts, specifically in terms of biophysical and socio economic impacts. There are a number of studies that record the impacts of different natural and manmade shocks on Caribbean SIDS. These reports are however usually done post-event with little concrete and published research that predicts the likely impact of such events on Caribbean SIDS. The first step in identifying vulnerabilities and in crafting appropriate resilient building responses should be the promotion of and engagement in research that clearly articulates and identifies biophysical and socio-economic impacts to a range of exogenous and endogenous shocks to which the

¹¹ Some of these inherent characteristics include the fact that island states have less diversified economies, are heavily dependent on one major economic activity, have relatively small populations and land masses and are economically dependent on externally propelled economic activities.

region is exposed. The impacts would then allow for the clear identification of vulnerable geographic areas, sectors or communities which would then be input into appropriate resilience building strategies.

2. Review of best practices to date in terms of preparedness, resilience building and climate change adaptation is encouraged. In the Caribbean region Cuba stands out as a flagship country that has not only successfully engaged in disaster risk reduction and climate change adaptation policy but also has a research agenda to inform its approach to crafting such policy. It may be useful to seek to replicate the research undertaken by Cuba but also identify policy implementation strategies that may have redounded to that country's benefit and which may be applicable to the wider Caribbean.

3. Addressing vulnerability and building resilience requires appropriate information and data – priority should be given to addressing data gaps. This policy recommendation may be viewed as a corollary to (1) above – to fully ascertain the vulnerabilities that may arise or that may be exacerbated by exogenous shocks one has to have appropriate social, economic and environmental data. The importance of current, up-to-date demographic data cannot be underscored enough. The assessment of a community, sector or region or economy as *vulnerable* and the crafting of *appropriate* resilience building policies or strategies depend on the availability of data.

4. Vulnerability and Resilience should be viewed as a Regional Public Good – one country's benefit should not compromise another country's ability to benefit. Caribbean SIDS face a common threat in natural hazards and most man-made hazards that affect one Caribbean economy have potential spill over impacts on the rest of the region. As noted earlier in this Report many Caribbean countries have scarce human and financial resources to permit each undertake tasks of vulnerability reduction and resilience building. Economies of scale can be realized through a regional effort to mainstream vulnerability reduction and resilience building into our development planning – the Caribbean may be comprised of several countries but the hazards to which we are exposed often affect more than one country directly and indirectly. The gist of the “Regional Public Good” approach to resilience building and vulnerability reduction that is being advocated is simple: if one country's resilience is built/or a country benefits as part of a regional approach to vulnerability, it does not preclude another Caribbean country from also benefitting from the collective approach to vulnerability reduction.

5. Acknowledgement that vulnerability is, in part, a function of gender so that indicators need to be disaggregated to reflect the country specific gendered socioeconomic realities It is well documented in the literature that not only do the poor suffer the most in times of disasters but the poor also tend to be female. With women constituting 70 per cent of the world's estimated 1.3 billion poor, there is need to have a gendered approach to vulnerability assessments as well as the solutions to address this vulnerability. This important dimension of the vulnerability and resilience indices has been recognised in the earlier work of ECLAC (2007), Kambon (2002). It is however vital as we move forward in developing an analytical framework to reduce resilience in the region and chart a course for sustainable development that gender specific data be collected so as to adequately reflect the social, economic and environmental realities of the region and therefore craft appropriate policy for development.

Annex

SUMMARY OF INDICATORS OF VULNERABILITY AND RESILIENCE

Index	Description	Data Requirements- Indicators/Variables	Source(s)
<p>The Disaster Deficit Index (DDI) and DDI'</p>	<p>The DDI Measures country risk from a macroeconomic and financial perspective according to possible catastrophic events. It requires the estimation of critical impacts during a given period of exposure (i.e a Maximum Considered Event- MCE), as well as the country's financial ability to cope with the situation.</p> <p>It reflects the degree of impact of events on countries in terms of economic losses incurred (contingent resources required to cover such losses caused by the MCE) and resource requirements to address such situations (measured as the economic resilience of the public sector).</p> <p>The DDI' serves as a complementary indicator to the DDI which reflects the annual average investment or saving that a country would have to make in order to approximately cover losses associated with major future disasters.</p>	<p>Forecasts for the DDI are based on historical and scientific evidence as well as the measuring of values of infrastructure and other goods and services that are likely to be affected by the event.</p> <p>It requires therefore estimates on: The expected intensity of a MCE; and Damage Functions for Exposed goods; which will inform the forecast of risk (i.e. potential damages x economic value).</p> <p>In addition, Economic resilience is measured by the resources available to the government (internal and external resources) which takes into account factors such as insurance and reinsurance payments; reserve funds for disasters; aid and donations; internal and external credit; new taxes; and the margin for budgetary reallocations- all of which can affect the availability of public resources to indicate economic resilience.</p>	<p>(Cardona 2005)</p>
<p>Local Disaster Index (LDI) and LDI'</p>	<p>The LDI examines propensity of social and environmental risks at a localized level to illustrate the disproportionate impact of "lower level events" such as flooding, avalanches, landslides, forest fires, droughts and small hurricanes, volcanic eruptions etc. on more vulnerable populations within the country which ultimately impacts on national development.</p> <p>It represents the spatial variation and dispersion of risks within the country from such events by considering information on events from individual "municipalities" to ultimately aggregate a LDI from indexes calculated for the individual effects of the event(s) such as deaths, persons affected etc.</p> <p>The LDI' takes into account the concentration of losses (direct physical damage) at the municipal level and is aggregated for all events in all countries. It shows the disparity of risk within a single country.</p>	<p>The LDI draws upon data from the DesInventar database (network of Social Studies in Disaster Prevention of Latin America) for:</p> <p>number of deaths; number of people affected; and losses in each municipality, and takes into account four wide groups of events: landslides and debris flows, seismo-tectonic, floods and storms and other events.</p>	<p>(Cardona 2005)</p>
<p>The Prevalent Vulnerability Index (PVI)</p>	<p>The PVI indicates the predominant vulnerability conditions in a country by measuring 3 items that are identified as areas that can reflect the indirect and tangible impacts of hazards. It is therefore, a composite indicator that draws upon: exposure and vulnerability PVI, Socio-economic fragility PVI and Lack of Social Resilience PVI.</p>	<p>The PVI is built on development indicators which are intended to reflect: exposure and susceptibility-</p> <p>Population Growth, avg. annual rate (%) Urban Growth, avg. annual rate (%) Population Density (people/5 Km²) Poverty-population below US\$ 1 per day PPP</p>	<p>(Cardona 2005)</p>

	<p>The indicators that belie the PVI are weighted, and are used to describe the 3 conditions mentioned above.</p>	<p>Capital Stock, million US\$ dollar/1000 km² Imports and exports of goods and services, % GDP Gross Domestic fixed investment, % of GDP Arable land and permanent crops, % land area.</p> <p>Socio-economic fragility: Human Poverty Index HPI-1 Dependents and proportion of working age population Social disparity, concentration of income measured using -Gini Index Unemployment, as % of total labour force Inflation, food prices, annual % Dependency of GDP growth of agriculture, annual % Debt servicing, % of GDP Human-induced Soil Degradation (GLASOD)</p> <p>And Lack of Resilience: Human Development Index, HDI [Inv] Gender-related Development Index, GDI [Inv] Social expenditure; on pensions, health and education, % of GDP [Inv] Governance Index (Kaufmann) [Inv] Insurance of Infrastructure and housing, % of GDP Television sets per 1000 people [Inv] Hospital beds per 1000 people [Inv] Environmental Sustainability Index, ESI [Inv]</p>	
<p>Environmental Vulnerability Index (EVI) – South Pacific Applied Geoscience Commission (SOPAC)</p>	<p>The EVI examines levels of risk and conditions now, predicting how the environment is likely to cope with future events. It reflects the extent to which the natural environment of a country is prone to damage and degradation. Three features of vulnerability are included in the EVI: environment, economic and social aspects of countries.</p> <p>The EVI is an average aggregated composite index of a risk exposure sub index (REI), an intrinsic resiliency sub index (IRI) and an environmental degradation sub index (IDI).</p> <p>The REI reflects the level of risks which act on the environment (i.e the intensity of risk events that may affect the environment as observed over the past 5 to 10 years); The IRI measures intrinsic vulnerability or resilience of the environment to risks, which refers to characteristics of countries that affect its ability to cope with hazards; and the EDI measures extrinsic vulnerability or</p>	<p>The indicators that inform each sub-index are as follows:</p> <p>Sub Index REI:</p> <ol style="list-style-type: none"> 1. Deviation in avg. sea temperatures during moderate or greater El Nino 2. Number of months over last 5 years during which rainfall is more than 20% above 30 yr average for that month (flood risk) 3. Number of months over last 5 years during which rainfall is more than 20% below 30yr average for that month (drought) 4. No. category 1-5 cyclones (<994 hPa central pressure) / decade / 10,000 sq km (last decade only) 5. Mean number of days per yr (last 5 yrs) in which the maximum temperature was >5oC above the mean monthly maximum (calculated over last 30 years) 6. Mean number of days per yr (last 5 years) in which the minimum temperature was 	<p>(Center for Hazards Research and Policy Development 2006)</p>

	<p>the resilience as a result of external forces acting on the environment.</p>	<p>>5°C below the mean monthly minimum (calculated over last 30 years)</p> <p>7. No. severe storms and tornadoes/10,000 sq. km / decade (last 10 years)</p> <p>8. Number of earthquakes over the last 50 yrs/ 10,000 sq km land areas with intensity of > 6.0 Richter</p> <p>9. No. tsunamis with runup 2m+ last 50 years /10,000 sq km coastal area</p> <p>10. No. volcanoes with potential for eruptions / 10,000 sq km land area</p> <p>11. % of land area burned by forest fires per yr (worst year of last 5 years)</p> <p>12. % of agricultural land under subsistence / organic agricultural</p> <p>13. Tons pesticides produced/imported/10,000 sqkm area (avg. last 5 yrs)</p> <p>14. Tons of N,P,K fertilizers produced or imported / 10,000 sq km of land area / year (average last 5 years)</p> <p>15. Rate of deforestation of primary forest (% of remaining forest lost per year) (average of last 5 years)</p> <p>16. % of ag. land which is mechanized, monoculture and or commercial</p> <p>17. # of commercial inshore fishing vessels / 10,000 sq km coast area /year (average of last 5 years)</p> <p>18. # of commercial offshore fishing vessels / area of EEZ / year (average of last 5 years)</p> <p>19. Destructive fishing methods used? (dynamite, etc)</p> <p>20. No. of patrols run (boat or plane) /10,000 sqkm of EEZ (avg last 5 yrs)</p> <p>21. Fisheries observer programs</p> <p>22. % of marine zone set aside as reserves</p> <p>23. Environmental Legislation</p> <p>24. % of development projects accomp. by Environmental Impact Assess.</p> <p>25. % of terrestrial zone set aside as reserves</p> <p>26. Ton coral extracted/year/10,000 sqkm coast zone (avg of last 5 years)</p> <p>27. Kilotons of sand/gravel extracted/year/10,000 sqkm coastal area (avg last 5 yrs)</p> <p>28. Kilotonnes of all mining material (ore + tailings) extracted / 10,000 sq km land area / year (avg of last 5 years)</p> <p>29. Total tonnage of imported toxic or hazardous wastes / 10,000 sq km land area / year (average last 10 years)</p> <p>30. Millions of liters of hydrocarbons used / 10,000 sq km land area / year (average over last 5 years)</p>	
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Disaster Risk Index (DRI)	The DRI measures the risk of death in disasters through 3 components: physical exposure, vulnerability, and risk. The	Risk 1. # of Killed	(Center for Hazards Research and Policy

	<p>methodology involves a Mortality-calibrated index (which enables the calculation of the average risk of death in large and medium scale disasters: earthquakes, tropical cyclones, floods and droughts); calculation of physical exposure (by identifying the areas exposed to each of the four hazard types; and the calculation of relative vulnerability by dividing the number of people actually killed by the number exposed.</p> <p>The index measures hurricanes, floods, earthquakes and drought impacts and can be applied for international comparisons of countries.</p>	<p>2. Killed / Population 3. Killed / Population Exposed</p> <p>Vulnerability</p> <ol style="list-style-type: none"> 1. Economic: GPD per inhabitant at purchasing power parity 2. Economic: Human Poverty Index (HPI) 3. Economic: Total debt service (% of the exports of goods and services) 4. Economic: Unemployment, total(% of labor force) 5. Economic Activity: Arable land (in thousands of hectares) 6. Economic Activity: % of arable land and permanent crops 7. Economic Activity: % of urban population 8. Economic Activity: % of agricultures dependency for GDP 9. Economic Activity: % of labor force in agricultural sector 10. Quality of Environment: Forests and woodland (in % of land area) 11. Quality of Environment: Human-induced soil degradation(GLASOD) 12. Demography: Population growth 13. Demography: Urban Growth 14. Demography: Population Density 15. Demography: Age dependency Ratio 16. Health and Sanitation: % of people with access to improved water supply 17. Health and Sanitation: # of physicians per 1,000 inhabitants 18. Health and Sanitation: Number of hospital beds 19. Health and Sanitation: Life expectancy at birth for both sexes 20. Health and Sanitation: Under five year olds mortality rate 21. Early warning capacity: # of radios per 1,000 inhabitants 22. Education: illiteracy rate 23. Development: Human Development Index (HDI) 	<p>Development 2006)</p>
<p>Hurricane Disaster Risk Index (Davidson and Lambert)</p>	<p>There are 2 variations to the HDRI- economic HDRI and Life HDRI. The index measures: Hazard, Exposure, Vulnerability and Emergency Response and recovery (ERRC). The index is developed in 3 stages involving the identification of factors- meteorological, engineering, economic and social that contribute to economic and life loss; selection of measurable scalar indicators; and use of a mathematical index to combine indicators into two composite index values.</p> <p>The index measures hurricanes' impacts</p>	<p>Hazard</p> <ol style="list-style-type: none"> 1. wind: mean return of hurricanes Cat 1-2 2. wind : mean return period of hurricanes Cat 3-4 3. wind: mean return period of hurricanes Cat 5 4. Storm Surge: % area below 50-year Stillwater elevation 5. Rainfall: average forward speed of hurricanes [knots] <p>Exposure</p> <ol style="list-style-type: none"> 6. Population: resident population 	<p>(Center for Hazards Research and Policy Development 2006)</p>

	<p>and has been applied to U.S. Counties.</p>	<p>7. Population: average daily # of tourist, June-Nov 8. Building: # of housing units 9. Building: Median home value [dollars] 10. Economic: income from agriculture [\$1000's] 11. Economic: number of business units 12. Lifeline: value of power lines [dollars] Vulnerability 13. Population: % of population aged 0-4 or 65+ 14. Population: % of population (aged16-64) w/mobility limitation 15. Population: public educator indicator 16. Building: Avg BCEGS grade 17. Building: % of homes that are mobile homes 18. Economic: XV6 % of business with less than 20 employees ERRC 19. Connectivity: % county land area detached from mainland 20. Evacuation & Shelter: # of shelters available 21. Evacuation & Shelter: evacuation clearance time [hours] 22. Evacuation & Shelter: % of population expected to evacuate 23. Mobility: Population density [people per square km] 24. Mobility: City layout (road in grid=0, otherwise=1) 25. Resources: # of hospital beds per 100,000 people 26. Resources: # of physicians per 100,000 people 27. Resources: Per capita state gross product [constant 1990 US\$]</p>	
<p>Social Flood Vulnerability Index –</p> <p>Vulnerability to flooding: Health and social dimensions (Tapsell, Penning-RowSELL, Turnstall, Wilson)</p>	<p>This vulnerability to flooding index is a composite additive index which is based on three social characteristics and four financial-deprivation indicators. It measures therefore: health problems; financial deprivation; elderly; and single parents. The SFVI is categorized into five bands with category 1 representing low vulnerability, 3-average vulnerability and 5- high vulnerability.</p> <p>The SFVI is limited to small geographical areas.</p>	<p>1. Unemployment: unemployed residents aged 16 and over as a percentage of all economically active residents aged over 16 2. overcrowding: households with more than one person per room as a % of all households 3. none-car ownership: households with no car as a % of all households 4. non-home ownership: households not owning their own home as a percentage of all households 5. the long term sick: residents suffering from limiting long-term illness as a percentage of all residents 6. single parents: lone parents as a proportion of all residents 7. the elderly: residents aged 75 and over</p>	<p>(Center for Hazards Research and Policy Development 2006)</p>

		as percentage of all residents.	
<p>Social Vulnerability Index (SoVI)</p> <p>Social Vulnerability to environmental hazards (Cutter, Boruff, Shirley)</p>	<p>The SoVI is a composite additive index which measures vulnerability based on: Personal Wealth, Age, Density of the build environment, Single Sector Economic Dependence, Housing Stock and Tenancy, Race, Ethnicity, Occupation, Infrastructure Dependence.</p> <p>It measures vulnerability to environmental hazards.</p>	<ol style="list-style-type: none"> 1. Median Age 2. Per capita income 3. Median dollar value of owner-occupied housing 4. Median rent 5. Number of physicians per 100,000 population 6. Vote cast for president (percent voting for leading party) 7. Birth rate per 1000 population 8. Net international Migration 9. Land in farms as percent of total land 10. % African American 11. % Native American 12. % Asian 13. % Hispanic 14. % of Population under the age of 5 15. % of Population over the age of 65 16. % of civilian labor force unemployed 17. Average number people per household 18. % of households earning more the \$75,000 per year 19. % living in poverty 20. % renter occupied housing units 21. % rural farm population 22. General local government debt to revenue ratio 23. % of homes that are mobile 24. % of population over the age of 25 with no high school diploma 25. Number of housing units per square mile 26. Number of housing permits per new residential construction per square mile 27. Number of manufacturing establishments per square mile 28. Earnings in all industries per square mile 29. Number of Commercial establishments per square mile 30. Value of all property and farm products sold per square mile 31. % of population participating in the labor force 32. % of females participating in the civilian labor force 33. % employed in primary extractive industries 34. % employed in transportation, communications and other public utilities 35. Percent employed in service occupations 	<p>(Center for Hazards Research and Policy Development 2006)</p>

		<p>36. Per capita residents in nursing homes</p> <p>37. Per capita number of community hospitals</p> <p>38. % population change</p> <p>39. % of Urban Population</p> <p>40. % females</p> <p>41. % female-headed households, no spouse present</p> <p>42. Per capita social security recipients</p>	
<p>The Environmental Sustainability Index (ESI) and Revised ESI</p>	<p>The ESI provides an assessment of the ability of nations to protect the environment. Data sets used to calculate the ESI can be categorized under 5 broad categories: Environmental systems, reducing environmental stress, reducing human vulnerability to environmental stress, societal and institutional capacity to respond to environmental challenges.</p> <p>The Revised ESI assesses how countries uses its own environmental resources as well as assesses how a country uses its global environmental resources</p>	<p>Environmental systems</p> <p>Reducing environmental stress</p> <p>Reducing human vulnerability to environmental stresses</p> <p>Capacity to respond to environmental changes</p> <p>Global Stewardship</p> <p>Revised ESI:</p> <p>National Level –</p> <p>Air quality, Water stress, terrestrial systems, biodiversity.</p> <p>urban SO2 concentration</p> <p>urban NO2 concentration</p> <p>urban TSP concentration</p> <p>fertiliser consumption per hectare arable land</p> <p>pesticide use per hectare of crop land</p> <p>industrial organic pollutants per available fresh water</p> <p>% of country's territory under severe water stress</p> <p>severity of human induced soil degradation</p> <p>% land area affected by human activities</p> <p>Percentage of mammals threatened</p> <p>percentage of breeding birds threatened</p> <p>% change in forest cover</p> <p>Global Level –</p> <p>Inputs to land</p> <p>radioactive waste</p> <p>Inputs to air-</p> <p>carbon dioxide emissions per capita</p> <p>Resources consumed-</p> <p>consumption pressure per capita</p> <p>ecological footprint per capita</p>	<p>(Eriksen 2006)</p>
<p>Natural Hazard Vulnerability Indicator (NHVI) (Wagner et. al.)</p>	<p>The Natural Hazard Vulnerability Indicator tries to incorporate in one measure vulnerability and the likely socioeconomic impact of disasters. It suggests a method linking vulnerability of a country to natural disasters. It is defined as the product of the disaster affected population and the disaster</p>	<p>Disaster affected population</p> <p>Total population</p> <p>Disaster related economic loss</p> <p>GNP in each country</p>	<p>(DRM World Institute for Disaster Risk Management n.d.)</p>

	related economic loss rate.		
The Economic Vulnerability Index (EcVI) (Lino Briguglio)	<p>The Economic Vulnerability Index (EcVI) was initially developed to explain the seeming contradiction that a country can be economically vulnerable alongside a relatively high GDP per capita, as was the case in Singapore. This index is designed to measure the extent of vulnerability of a country, which is seen as a measure of exposure to external forces outside a country's control. It is composed of the levels of openness, concentration, energy dependence and transport costs.</p> <p>The Economic Vulnerability Indices so far produced indicate clearly that small island developing states, as a group, tend to be more economically vulnerable than other countries.</p>	<p>The components of the Vulnerability Index in the context of SIDS are related to inherent conditions which render them exposed to external factors, and include economic openness, dependence on a narrow range of exports, peripherality, and dependence on strategic imports.</p> <p>Economic Openness</p> <p>Exports or imports, or average of both, as a percentage of GDP</p> <p>Dependence on a narrow range of exports</p> <p>Export concentration index by UNCTAD or concentration index with exports of services included</p> <p>Dependence on strategic imports</p> <p>Average imports of commercial energy as a percentage of domestic energy production</p> <p>Dependence on food imports – quantity of basic food items imported</p> <p>Peripherality</p> <p>Ratio of FOB/CIF factors (freight on board)/(cost, insurance and freight)</p> <p>Ratio of transport and freight costs to international trade in merchandise</p>	(L. C. Briguglio 2006)
The Economic Vulnerability Index Adjusted for Resilience (EVIAR) Briguglio and Galea (2003)	<p>The EcVI is modified to incorporating an economic resilience component. This measure is known as the Economic Vulnerability Index Adjusted for Resilience (EVIAR). This measure assists in explaining the “Singapore Paradox” that inherently vulnerable countries through concerted action and suitable policies can succeed in strengthening their economic resilience and overcoming their vulnerability. The index uses GDP per capita as a proxy for resilience, which is expected to assess the degree to which economically vulnerable countries are able to cope with that vulnerability. The index is calculated as a combination of the EcVI and GDP per capita.</p>		(L. a. Briguglio 2003)
Lack of Resilience Index (PVILR) (Cardona, 2007)	<p>Lack of Resilience Index (PVILR) was viewed as a vulnerability factor to natural disasters and was represented by means of the inverse relationship (Inv) of a number of variables that measure human development, human capital, economic redistribution, governance, financial protection, community awareness, the degree of preparedness to face crisis situations, and environmental protection.</p>	<p>Human Development Index, HDI [Inv]</p> <p>Gender-related Development Index, GDI [Inv]</p> <p>Social expenditures on pensions, health and education as a percent of GDP [Inv]</p> <p>Governance Index (Kaufmann) [Inv]</p> <p>Infrastructure and housing insurance as a percent of GDP [Inv]</p> <p>Television sets per 1000 people [Inv]</p> <p>Hospital beds per 1000 people [Inv]</p> <p>Environmental Sustainability Index, ESI [Inv]</p>	(Cardona. 2007)
The Committee	The CDP of the United Nations Economic	The vulnerability index developed by	(L. a. Briguglio)

<p>for Development Policy (CDP) Economic Vulnerability Index</p>	<p>and Social Council (ECOSOC) developed a vulnerability index to identify Least Developed Countries (LDCs) (Commonwealth Secretariat and World Bank, 2000). The components of the index include the share of manufacturing and modern services in GDP, merchandise export concentration, instability of agricultural production, instability of exports of goods and services and population size (weighted aggregate of all these components). This index assigns importance to instability, which implies that countries with relatively higher unstable export growth or agriculture production are assigned higher vulnerability scores.</p> <p>The CDP Vulnerability Index assigns importance to instability, which implies that countries with relatively higher unstable export growth or agriculture production are to be assigned higher vulnerability scores</p>	<p>Committee for Development Policy (CDP) of the UN ECOSOC which is used for the purpose of identifying the Least Developed Countries (LDC) is made up of the following components:</p> <p>Share of Manufacturing and Modern Services in GDP;</p> <p>Merchandise export Concentration;</p> <p>Instability of Agricultural Production;</p> <p>Instability of Exports of goods and services; and</p> <p>Population size.</p>	<p>2003)</p>
<p>Index of Resilience to Climate Change and Natural Disasters. (Briguglio and Galea, 2003)</p>	<p>Resilience relates to the ability to cope with a hazard and therefore refers to what a country or individual can do. Briguglio and Galea (2003) stated that a resilience index compliments a vulnerability index and can be used to assess the degree to which a country is moving ahead or otherwise is coping or withstanding its vulnerability.</p>	<p>Economic</p> <p>GDP per capita</p> <p>Social- education</p> <p>Human Development Index, HDI</p> <p>Gender-related Development Index, GDI</p> <p>Social expenditures on pensions, health and education as a percent of GDP</p> <p>Proportion of the population 20 years and over that has attained at least 3 O'level passes or possess a craft certificate</p> <p>Proportion of the population 20 years and over that has attained passes science or technology subjects</p> <p>Adult functional literacy rate - population 15 years and over</p> <p>Social- health</p> <p>Hospital beds per 1000 people</p> <p>Proportion of the working population with HIV/AIDS</p> <p>Governance</p> <p>Governance Index</p> <p>Infrastructure and communications</p> <p>Updating and enforcement of safety standards and construction codes</p> <p>Infrastructure and housing insurance as a percent of GDP</p> <p>Environment</p> <p>Environmental Sustainability Index, ESI</p>	<p>(L. a. Briguglio 2003)</p>
<p>Index of Social Vulnerability to climate change (for Africa) (Vincent, 2004)</p>	<p>The index was created to empirically assess relative levels of social vulnerability to climate change-induced variations in water availability. A theory-driven aggregate index of social vulnerability was formulated through the weighted average of five sub-indices: economic well being and stability, demographic structure, institutional stability and strength of public infrastructure, global interconnectivity and dependence on natural resources.</p>	<p>Economic well-being and stability</p> <p>Standard of living/poverty - the % of the population living below the specific poverty line</p> <p>Change in % urban population</p> <p>Demographic structure</p> <p>Dependent population - population under</p>	<p>(Vincent 2004)</p>

		<p>15 and over 65 as % of total</p> <p>Proportion of the working population (adults aged 15-49) with HIV/AIDS</p> <p>Institutional stability and strength of public infrastructure</p> <p>Health expenditure as a proportion of GDP</p> <p>Telephones - number of mainland telephone lines per thousand population in 2000</p> <p>Corruption</p> <p>Global inter-connectivity</p> <p>Trade balance</p> <p>Natural resource dependence</p> <p>Percentage rural population</p>	
<p>Social Vulnerability Index (for the Caribbean) Dr. Godfrey St. Bernard (2007)</p>	<p>The index of social vulnerability was developed for the Caribbean countries at the national level. It was a pilot study that examined five countries in the region – Belize, Grenada, St. Kitts and Nevis, St. Lucia and St. Vincent and the Grenadines. The index had five sub-indices which included education, health, security, social order and governance, resources allocation, and communications architecture</p>	<p>Education</p> <p>Proportion of the population 20 years and over with exposure to tertiary level education</p> <p>2. Proportion of the population 20 years and over that has successfully completed secondary education</p> <p>3. Adult literacy rate - population 15 years and over</p> <p>Health</p> <p>Life expectancy at birth</p> <p>Security, Social Order and Governance</p> <p>Indictable Crimes per 100,000 population</p> <p>Resources Allocation</p> <p>Proportion of all children (under 15 years) belonging to the two poorest quintiles</p> <p>Proportion of working age population (15-64) belonging to the two poorest quintiles with no more than primary school education</p> <p>Proportion of the population (15 years and over) belonging to the two poorest quintiles with no medical insurance coverage</p> <p>Proportion of population belonging to the two poorest quintiles and living in households where the head was not employed</p> <p>Communications Architecture</p> <p>Computer literacy rate - population 15 years and over</p>	(Bernard 2007)
<p>Environmental Performance Index (EPI)</p>	<p>The EPI (Revised as the Yale EPI in 2008) focuses on</p> <p>i) Reducing environmental stresses on human health (the environmental health objective) such as environmental burden of diseases, and the effects of water and air pollution on humans.</p> <p>ii) Promoting eco-system vitality and sound natural resource management (the ecosystem vitality objective) such as climate change, biodiversity and habitat, and the effects of air and water pollution on the</p>	<p>Environmental Burden of Disease</p> <p>Access to Sanitation</p> <p>Access to water</p> <p>Indoor Air Pollution</p> <p>Outdoor Air Pollution</p> <p>Sulfur dioxide emissions per populated area</p> <p>Nitrogen Oxide emissions per populated area</p> <p>Non Methane organic volatile compound</p>	<p>(Yale center for Environmental Law and Policy, Yale University and The Centre for Earth Science Information Network, Colombia University 2010)</p>

	<p>ecosystem.</p> <p>The EPI acknowledges that there is no “right way” with respect to the scope of an environmental index, however the twenty five (25) indicators chosen provides a comprehensive and focused assessment of global environmental challenges. Each indicator stems from principles of either environmental health or ecological science and is representative of the core elements of environmental policy challenges.</p>	<p>emissions per populated area</p> <p>Ecosystem Ozone</p> <p>Water Quality Index</p> <p>Water Stress Index</p> <p>Water Scarcity Index</p> <p>Biome Protection</p> <p>Marine Protection</p> <p>Critical Habitat Protection</p> <p>Annual Change in Forest Cover</p> <p>Growing Stock rate</p> <p>Marine Trophic Index slope</p> <p>Trawling and dredging intensity</p> <p>Agriculture water intensity</p> <p>Pesticide regulation</p> <p>Agriculture subsidies</p> <p>Greenhouse Gas emissions per capita (including land use emissions)</p> <p>Industry greenhouse gas emissions intensity</p> <p>CO2 emissions per electricity generation</p>	
<p>Predictive Indicator of Vulnerability (PIV)</p> <p>Adger et al.. (2004)</p>	<p>The PIV links social vulnerability with climate adaptation. It focuses on vulnerability to climate change and excludes geophysical events in its assessment. The PIV is outcome driven and aggregates climate-related mortality from 1971 to 2000. The PIV score is derived as the average of 11 indicators.</p>	<p>Literacy (15-24 years)</p> <p>Literacy >15 years</p> <p>Male to female literacy ratio</p> <p>Sanitation</p> <p>Calorie Intake</p> <p>Life expectancy</p> <p>Maternal Mortality</p> <p>Voice and accountability</p> <p>Civil liberties</p> <p>Political Rights</p>	<p>(Gall 2007)</p>

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