



Centre d'Etude et de Recherche en Economie,
Gestion, Modélisation et Informatique Appliquée

Document de travail 2010-07

Septembre 2010

“How to measure vulnerability and resilience? Lessons learnt from the pioneer studies on small islands developing states”

Valérie ANGEON & Samuel BATES

How to measure vulnerability and resilience? Lessons learnt from the pioneer studies on small islands developing states (SIDS)

Valérie Angeon and Samuel Bates

31 mars 2010

Valérie Angeon

Assistant Professor

University of French West Indies

Ceregmia

valerie.angeon@martinique.univ-ag.fr

Samuel Bates

Assistant Professor

University Paris-Dauphine

LEDa-SDFi

samuel.bates@dauphine.fr

Abstract

Small islands developing states constitute a fruitful topic to work on concerning the question of vulnerability and resilience. As debated in the economic literature, these territories present structural characteristics - smallness, remoteness and insularity - that are considered as strong handicaps, which impede their development. Several empirical tests have been implemented to measure the vulnerability of SIDS. The results reveal the importance of the phenomenon but are resolutely based on different computation methods and do not systematically cope with sustainable considerations. Therefore, there are as many methodologies as empirical studies, a fact that can seriously be prejudicial not only to the robustness of the results, but also to the validity of the used methodologies which appear contingent to the specific studied cases. This paper tries to develop a generic computation method to assess vulnerability and resilience. It is based on the graph theory and the Nepomiastchy-Ravelli algorithm in order to identify a minimum set of variables respecting five dimensions that should necessarily be taken into account: economic, social, environment, governance, insularity. A complete and new composite index of vulnerability and resilience is suggested in accordance with the following generic principles: accuracy, simplicity, ease of interpretation, computation robustness, comparability, universality and flexibility.

Key words: Small islands developing states (SIDS), vulnerability, resilience, sustainable development, composite index, graph theory, Nepomiastchy-Ravelli algorithm

Résumé

Comment mesurer la vulnérabilité et la résilience ? Leçons tirées de cas d'étude pionniers sur les petits Etats insulaires en développement

Les petites économies insulaires constituent un terrain d'étude privilégié pour appréhender les questions de vulnérabilité et de résilience. Comme cela est débattu dans la littérature économique, ces territoires présentent des caractéristiques structurelles – petite dimension, éloignement, insularité – qui ont longtemps été considérées comme des handicaps entravant leur développement.

Plusieurs travaux empiriques cherchent à mesurer et évaluer le degré de vulnérabilité des petites économies insulaires en développement (PEID). Aussi divers soient-ils, les résultats attestent de la fragilité de ces entités. Ils reposent néanmoins sur des méthodes de calculs différentes qui ne prennent en outre pas en compte des considérations en termes de développement durable. On dénombre ainsi autant de méthodologies de calcul de vulnérabilité que d'études empiriques, un fait qui s'avère préjudiciable non seulement à la robustesse des résultats qu'à la validité des méthodes utilisées. Ce texte présente les linéaments d'une méthode générique de mesure de la vulnérabilité et de la résilience. La méthode proposée s'appuie sur les apports de la théorie des graphes et de l'algorithme de Nepomiastchy-Ravelli afin d'identifier l'ensemble minimum de variables à considérer pour toute mesure de vulnérabilité et de résilience. Cinq dimensions essentielles sont observées : économique, sociale, environnementale, gouvernance et insularité. Dès lors, un indice composite de vulnérabilité et de résilience est proposé qui respecte les principes génériques suivants : précision (de la quantification des concepts), simplicité, validité méthodologique (dans la synthèse des composantes de l'indicateur), facilité d'interprétation, robustesse du calcul (à des variations non significatives des composantes ou à des erreurs marginales de mesure), comparabilité, universalité d'application et flexibilité dans la construction de l'indicateur.

Mots-clés : Petits Etats insulaires en développement (PEID), vulnérabilité, résilience, développement durable, indice composite, théorie des graphes, algorithme de Nepomiastchy-Ravelli

In the economic literature, small islands developing states constitute a fruitful topic to especially work on vulnerability and resilience issues. Numerous works can be checked out on these special areas where smallness, remoteness and insularity appear as factors of fragility. Though these contributions are different, they present the same weaknesses. They mainly consider economic variables and do not refer to a unique and generic methodology to assess vulnerability and resilience degrees in specific case studies.

Our contribution intends to fill in this gap from an original method which is suggested to measure vulnerability and resilience. Firstly, we update the debates on vulnerability and resilience by considering different criteria of sustainable development (economic, social, environment, governance¹) in order to assess both phenomena. Secondly, we build two synthetic indicators based on a generic methodology (the graph theory and the Nepomiaschty-Ravelli algorithm) that conforms to the following principles: accuracy, simplicity, ease of interpretation, computation robustness, comparability, universality and flexibility.

Our contribution is therefore twofold: (i) the variables chosen according to a frame of reference dealing with sustainable development (ii) the computation procedure *per se*. The following section will expose and discuss our methodological arguments. First of all, the added value of a focused sustainable development perspective is put forward in order to cope with vulnerability and resilience. Then the innovating computation method is explained.

1. Why should it be reasoning in terms of sustainable development to cope with vulnerability and resilience?

In twenty years, sustainable development has gained more and more importance in social sciences. However, the concept still needs to be more convincingly adopted by worldwide decision makers. As being recently evoked in the Copenhagen conference (2009), the implementation of sustainable development strategies is crucial for small islands which face strong vulnerability. This fact has been brought to light since the Earth Summit (Rio, 1992)², and the Barbados conference (1994) which was followed 10 years later by the Mauritius one (2005)³.

For instance, the question of climate change and its dramatic consequences will be undoubtedly multiple and of first importance in every fields: environmental (i.e. natural disasters frequency and intensity, sea-level rises, scarcity or even depletion of natural resources, loss of biodiversity), social (i.e. increase in humanitarian, sanitarian or food crises), economics (i.e. financing of irreversible damages, growing poverty of less developed States mostly impacted by natural disasters). This global challenge necessitates a collective and urgent action, which deeply implies governance principles.

Small islands developing states are unanimously recognized as vulnerable areas (Briguglio, 1993, 1995, 2001, 2004; Briguglio et Galea, 2004; Adrianto et Matsuda, 2004; United Nations 2005; van der Velde *et al.*, 2006; Dehoorne and Saffache, 2008). Each pillar of sustainable development should be then considered in a systemic and holistic approach. This invites us to move from our traditional thinking habit. Nevertheless, in the literature on vulnerability and resilience, one of the three classical pillars is usually emphasized – mostly economic (Briguglio, 1993, 1995; World Bank, 2000; Briguglio, 2004) and sometimes environmental as the SOPAC (2005) instigated it. Some significant works try to integrate both variables (Adrianto and Matsuda, 2004; Bayon, 2007) but no specific contribution according to a frame of reference dealing with sustainable development is noticed.

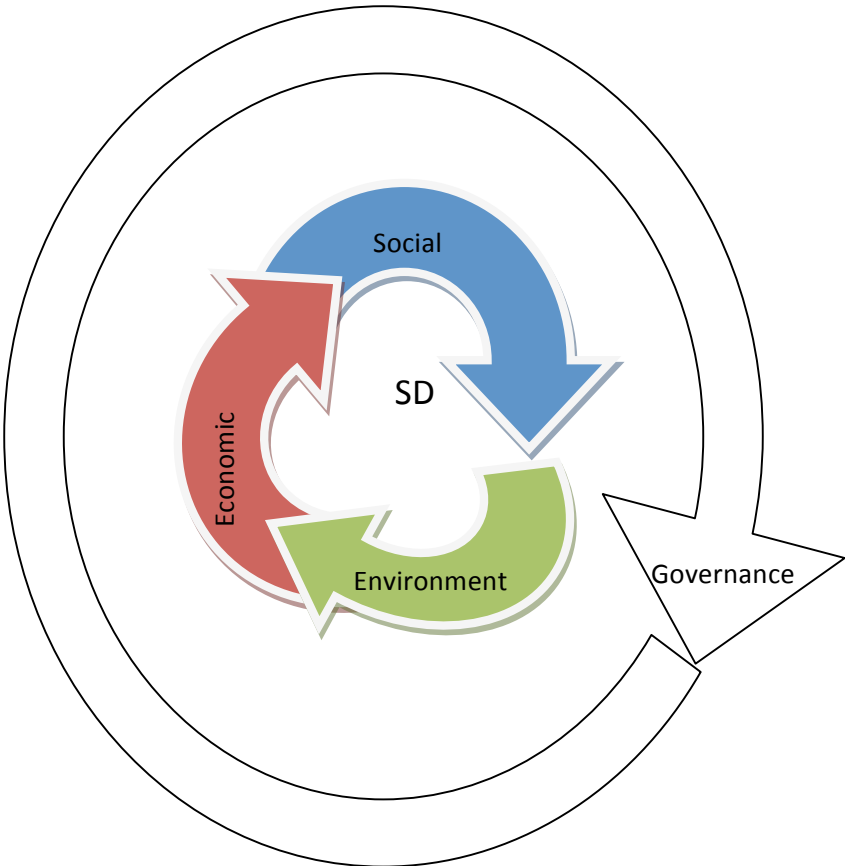
¹ Governance means institutions quality, e.g. the “rules of the games” shaping people behaviour.

² We should keep in mind that SIDS have been presented as specific case studies for environment and development since the Earth Summit.

³ These two post Earth Summit conferences shed light on the awareness degree on sustainable development issues by creating new institutions and practices in favour of sustainable development.

To fill in this gap, a general approach which integrates several dimensions of sustainable development is suggested. We then take into account the three classic pillars of sustainable development (economic, social, environment) plus some determinants of governance since the so-called leitmotiv “it is time to act” remains relevant to achieve sustainable development targets. Our methodology is then being based on four set of variables to assess vulnerability and resilience (See figure 1 below).

Figure 1 Significant types of variables to build vulnerability and resilience indicators



The proposed method identifies a minimum set of variables respecting the four aforementioned dimensions. Then economic, social, environmental as well as governance variables are distinguished. In a more complex and elaborated scheme, we also integrate a fifth variable in order to specify whether insularity is a determining factor of vulnerability.

2. An original and generic calculus method for vulnerability and resilience

Vulnerability and resilience mix a high number of quantitative as well as qualitative proxy variables. To determine whether a territory is more vulnerable than resilient or conversely, it is derogatory to

synthesize not only the different dimensions (economic, social, environmental, political), but also the associated variables. This leads to several synthetic sub-indices.

Nevertheless, as Farrugia (2007) emphasizes, if composite indices allow understanding highly complex phenomena, they suffer from a recurrent flaw: their potential subjectivity. Indeed, Saisana and Tarantola (2002), Lievesley (2005), Farrugia (2007) and the European Commission Joint Research (2008), provide a wide critical analysis on the computation and on the usefulness of composite indices. From this literature, a few but key principles to create an alternative composite index should be focused on. They aim at setting a generic index of reference on the statistical and theoretical viewpoints.

2.1. Principles of the new composite index

Eight main principles should be thoroughly observed to give evidence on the robustness of the developed method.

Principle 1: Accuracy

The composite index and its components should effectively measure the quantitative and qualitative phenomenon they intend to assess.

Principle 2: Simplicity

The composite index should be simple due to its parsimonious building, its computation modus operandi and its efficiency. This principle is a key one provided that other principles lead to avoid statistical invalidity.

Here, parsimony means that the adequate number of variables able to capture the various dimensions of vulnerability and resilience should be as little as possible. Indeed, too many variables could involve a too more complex computation with a risk of blurred information from the composite index.

Principle 3: Methodological soundness

The aim is to insure some logical linkage among the several sub-indices included in the final composite index, considering there is no total independence between vulnerability and resilience.

Principle 4: Ease of interpretation

The composite index should be easily reading at two levels: statistical and graphical. Both interpretations should answer the key question: Does the studied economy is more resilient than vulnerable?

Principle 5: Computation Robustness

As Briguglio (1995) or Atkinson et al. (1997) remind us, a good synthetic index should be invariant to differences in unity among variables and invariant to differences in scale among countries.

Principle 6: Comparability

The composite index should be computed from variables that are homogeneously measured through time and throughout the world. It is necessary to obtain a non-distorted ranking of several countries in terms of net vulnerability or resilience.

Principle 7: Universality

The composite index should be transposable to very different contexts. This implies the use of data which availability is not too specific to particular countries or contexts.

Principle 8: Flexibility

Empirical knowledge on vulnerability and resilience follows an ongoing updating process insofar as measurement issues of both concepts for SIDS are still perfectible. As a consequence, any new composite index that could respect the 7 previous principles should be easily improved according to statistical updates.

2.2. Technical implications of the 8 principles

First of all, parsimony imposes the research of a minimum number of variables consistent enough to provide the effective net degree of vulnerability or resilience. This contributes to efficiency since it should impose no redundancy among the components inside the synthetic index. That is the reason why any variable referring to the economic dimension should not be included in another variable associated with social, environmental or governance aspect. Of course, the dependence among the different dimensions explains why resilience and vulnerability are characterized by feedback relations. Consequently, the idea consists in identifying the key relations among a minimum set of variables. As an impulse to the global network of interdependences, these relations explain the result in terms of vulnerability and resilience. This short list of variables should base the composite index computation and its sub-indices one. This group of variables is labeled the “minimum solving set” that determines the vulnerability and resilience degrees.

Forgetting one variable inside the minimum solving set leads to quantitatively misestimate of both notions of interest. Simultaneously, as the core relations among variables associated with vulnerability and resilience is focused on, there is less probability to add inefficient redundancy in the computation process. Therefore, the composite index computation will avoid any adjusting from high correlation as it is generally made in the existing literature. Indeed, such corrections may be reviewed. The usual statistical adjustments are inefficient due to additional computations that are not always consistent owing to potential limited sample length. They introduce additional errors beyond the uncertainty associated with statistical data and they are polluted by subjectivity issues.

Determining the minimum solving set of variables from an objective procedure allows avoiding any weighting issues. Each variable inside this set is equally important to give an empirical interpretation of vulnerability and resilience. This is a key advantage of the computation procedure since giving different weights for several variables could be also subjective or cost additional econometric computations with unavoidable errors. Briguglio (1995) acknowledges that there is no indisputable evidence on the higher validity of weighting versus non-weighting computations for a composite index.

Once the minimum solving set of variables is identified, it is important to stay close to traditional aggregation and standardisation techniques in order to build the composite index. Statistically, this aggregation should lead to a composite index whose sign or values should be compared to a reference. The aim is to rapidly identify whether vulnerability sources trespass on resilience sources. Reasoning on sub-indices of vulnerability and resilience, it is possible to locate the current SIDS state similarly to Briguglio et al. (2008). They distinguish four situations that can be graphically depicted:

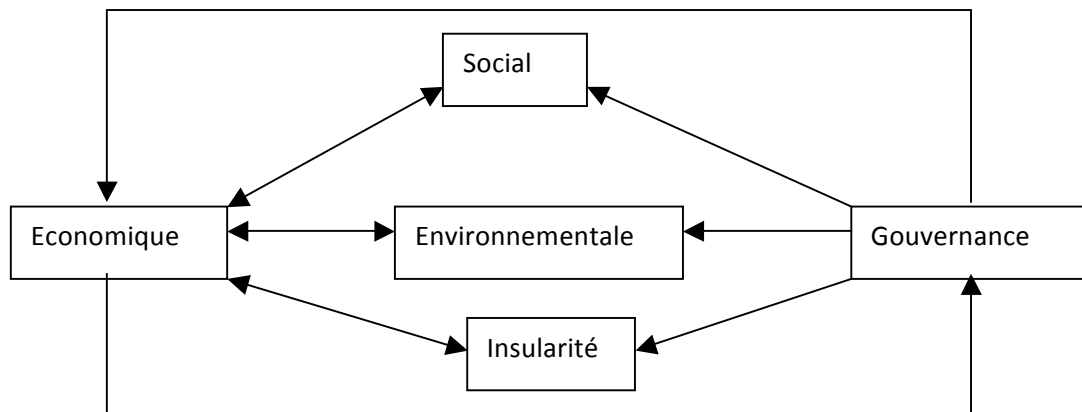
- Very favourable category: high resilience and low vulnerability;
- Very unfavourable category: the reversed to the previous situation;
- Prodigal son category: low-low resilience and vulnerability;
- Self-made countries category: high-high resilience and vulnerability.

However, contrary to Briguglio and Galea (2004) who arbitrary determine the limit values of the composite index among the different categories, our method defines a more objective boundaries from a mathematical simulation aside the composite index.

2.3 Insight on results in the building process of the composite index

From a critical review of variables that are currently used in our topic, from the different previous principles and their implications, among the most common used variables our new method will select a minimum solving set of 30 variables that respect the following relations.

Figure 2 Synthetic graphic



This graph gives evidence on the structure of vulnerability and resilience phenomena for SIDS. It is clearly shown that insularity is an additional important determining factor for SIDS whereas in other non-islander states it could be missing.

References

Adrianto L., Matsuda Y., 2004. Study on assessing economic vulnerability of small island regions, *Environment, Development and Sustainability*, n°6, p. 317-336.

Atkinson G. et al., 1997. *Measuring Sustainable Development: Macroeconomics and the Environment*, Edward-Elgar Publisher, Cheltenham UK.

Bouayad-Agha, Hernandez. 1993. *Etude des besoins de développement propres aux petits Etats membres et de la façon dont le système des Nations Unies pour le développement répond à ces besoins*, Rapport, Genève, 1993.

Briguglio L. et al. 2008. "Economic Vulnerability and Resilience: Concepts and Measurements Series", WIDER Research Paper, vol. 2008/55.

Briguglio L., 2004. « Economic Vulnerability and Resilience: Concepts and Measurements », International Workshop on "Vulnerability and Resilience of Small States", Commonwealth Secretariat and University of Malta, University Gozo Centre, Malta, 1er-3 mars.

Briguglio L. 2001. The Vulnerability Index , *Workshop on Trade, Sustainable development and Small Islands Developing States*, Montego Bay – Jamaica, 12-15 December 2001.

Briguglio L. 1993. The economic of small islands developing states study commissioned by CARICOM for the regional technical meeting of the global conference on the sustainable development of small island developing states (Port of Spain, Trinidad and Tobago), July 1993.

Briguglio L. 1995. Small islands developing states and their economic vulnerabilities, *World Development*, 23(9), p. 1615-1632.

Briguglio L., Galea W., 2004, «Updating and Augmenting the Vulnerability Index», Mimeo.

Dehoorne O., Saffache P. (dir.) 2008. *Mondes insulaires tropicaux. Géopolitique, économie et développement durable*, Paris, Ellipses (collection : Carrefours, Les Dossiers), 251 p.

European Commission, Joint Research Centre, 2008. *Handbook on Constructing Composite Indicators: Methodology and User Guide*, OECD Publishing.

Farrugia N., 2007. "Conceptual issues in constructing composite indices", Occasional Paper, Institute of Islands and Small States, 2007/1: Malta.

Lievesley D., 2005. The politics of performance indicators, *Workshop on European Indices and Scoreboards*, Brussels.

Saisana M., Tarantola S., 2002. *State-of-art report on current methodologies and practices for composite indicator development*, European Commission Joint Research Centre, EUR 20408 EN.

SOPAC, 2005. Building Resilience in SIDS. The Environmental Vulnerability Index, Report, 16p.

World Bank, 2000. Small States: Meeting Challenges in the Global Economy, Report of the Commonwealth Secretariat/World Bank Joint Task Force on Small States, Washington DC and London, April 2000.