Informing Climate Investment Priorities for Coastal Populations

Adrien Comte,
Linwood Pendleton,
Emmanuelle Quillérou,
Denis Bailly

Since the 1990s, the Intergovernmental Panel on Climate Change (IPCC) has used global level analyses of vulnerability to inform investment and action against the effects of climate change. Beyond the IPCC, the practice has been used widely to understand the vulnerability of coastal areas to a variety of hazards, including climate change. These analyses, however, have been driven by objectives that change from one assessment to the next, with very different conceptualisations of vulnerability. Over time these analyses have become increasingly data intensive and complex, drawing from an ever-expanding number of indicators. Such variations in objectives, conceptualisations and data have led to different and often contradictory rankings of priority areas for climate change action. The increased complexity makes it more difficult to disentangle the root causes of these different rankings and the degree to which climate change influences vulnerability rankings, compared to other factors such as local environment factors and the adaptive capacity of populations to deal with environmental change. If these global indicator analyses were deconstructed, climate decision-makers could use them as scoping studies rather than expect them to provide comprehensive and robust priorities for investment. Such scoping studies, if they are to be truly useful to climate decision-makers, need to be simplified and harmonised to isolate climate change specific drivers. They can help target the locations for more in-depth local level analyses and should be supplemented by global level analyses of costs of climate action including technical, social and economic factors.

THE NEED FOR GLOBAL LEVEL ANALYSES TO IDENTIFY CLIMATE CHANGE IMPACTS ON COASTAL POPULATIONS AND THEIR LIVELIHOODS FOR INFORMED ACTION

More frequent extreme weather events such as 2005 hurricane Katrina in the USA and 2013 typhoon Haiyan (Yolanda) in the Philippines provide a preview of the kind of disasters that may accompany climate change and the need to identify areas at particular risk to mitigate their impact. Other long-term changes, such as sea-level rise, ocean acidification, and changes in sea surface temperature are expected to put millions of people and billions of dollars' worth of infrastructure at risk (Hoegh-Guldberg *et al.*, 2014; Ocean and Climate, 2015). Article 4.4 of the United Nations Framework Convention on Climate Change (UNFCCC) states that developed countries shall "(...) assist the developing country parties that are particularly **vulnerable** to the adverse effects of climate change in meeting costs of adaptation to those adverse effects" (emphasis added) (United Nations, 1992). In addition, international development targets such as the Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) have created a demand for scientific assessments at the global level that can help inform climate and development investment and action.

Global level indicator-based vulnerability analyses have become very popular as a tool to identify "developing country parties that are particularly vulnerable to the adverse effects of climate change" who will receive help from less vulnerable countries, in the form of financial transfers to "(meet the) costs of adaptation to those adverse effects" (United Nations, 1992). The Intergovernmental Panel on Climate Change (IPCC) was an early adopter of global level indicator-based vulnerability analyses in order to identify more vulnerable places in particular need of assistance to combat climate change.

In practice, though, indicator-based vulnerability analyses have faced challenges when applied at a global level. Hinkel (2011) argues that vulnerability analysis was originally designed and is best suited for application at the local level and not the global level. Indicator-based vulnerability analyses at the global level continue to be subject to much debate within the research community. There is no agreed upon approach to global indicator-based vulnerability analysis which has resulted in a variety of applications, even for those focused specifically on marine and coastal applications, and a drive for such analyses to become more data intensive and "comprehensive" over time. While all global vulnerability analyses contain useful data, the assumptions and final scores used for prioritising countries produced by such analyses are difficult to use to understand climate vulnerability and thus opportunities for climate-related investment.

The challenges that confront the global level application of vulnerability analyses for use in targeting climate-related investment include:

- a lack of harmonised conceptualisation of vulnerability and associated concepts, in particular impact and adaptive capacity,
- added to an ever expanding number of variables used for such analyses, many of which are not available reliably at the global level, resulting in increased complexity of analysis and combination of very different metrics together which make it difficult to isolate climate impacts on populations from other factors,
- a lack of consideration of the costs of action in addition to climate vulnerability and impacts.

If they are to be useful to decision-makers who are focused on issues of climate change, current global level analyses should not be designed and applied as comprehensive studies but rather as scoping studies that focus clearly on the basic pathways that link climate change to impacts on people, without extending the analysis to determine overall vulnerability which is context specific. These global level "impact analyses" then could be supplemented by more refined local level analyses and analyses of costs of action to provide information useful to climate action and investment from the global down to the local level (an example at the local level is the cost effectiveness analysis by Ramirez *et al.*, forthcoming).

CONTRASTED CONCEPTUALISATIONS OF VULNERABILITY AND ASSOCIATED CONCEPTS

Vulnerability is a concept that is intuitively understandable and simple, allowing for integration of physical, ecological, and human impacts of climate change. The concept emerged in relation to disaster management at the local level (e.g. Weichselgartner, 2001) and has evolved over time to be used by interdisciplinary research on a number of topics including climate change (Turner *et al.*, 2003). However, the vulnerability concept lacks harmonised definition and measurement for consistent practical applications (Adger, 2006), which means it is difficult to choose among competing approaches or to understand their differences.

The lack of a harmonised definition for vulnerability can be best illustrated through the evolution of the framework used by the IPCC for vulnerability analyses at the global level between 2001 and 2014 (Figure 1a,b). In the Third Assessment Report, vulnerability was defined as "a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity" (Schneider and Sarukhan, 2001, p.90, Figure 1a). In the Fifth Assessment Report, the definition of vulnerability changes to "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (Oppenheimer *et al.*, 2014, p.1046, Figure 1b). The concept is also applied from a variety of perspectives in the IPCC reports (vulnerability of ecosystems, populations, the economy) potentially adding to possible confusion over the message conveyed.

Even though conceptualisations differ for the definition of vulnerability, the core of the vulnerability framework remains relatively unchanged and can be boiled down to its components of hazard, exposure, sensitivity, adaptive capacity and vulnerability (Figure 2, see Schneider and Sarukhan, 2001 and Ionescu *et al.*, 2009 for more information). Key differences between the frameworks lie in the way the relationship between vulnerability and the other factors is formalised, and the feedbacks and actions that influence and are influenced by vulnerability - namely adaptation, mitigation,

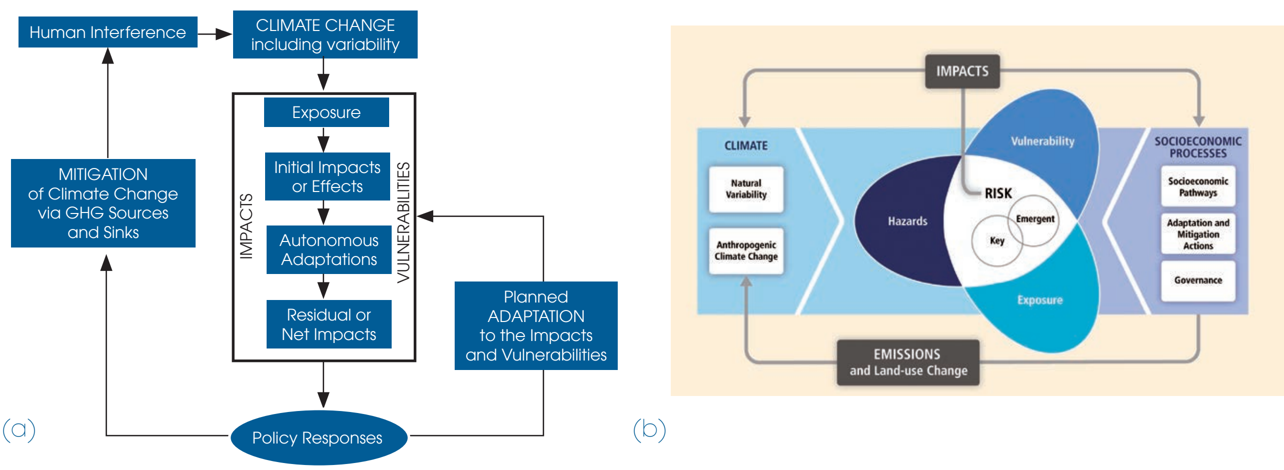

Fig.1 — 2001 and 2014 conceptual frameworks used by the IPCC for vulnerability analyses. Sources: (a) Places of adaptation in the climate change issue (Schneider and Sarukhan, 2001, p.90) (b) Schematic of the interaction among the physical climate system, exposure, and vulnerability producing risk (Oppenheimer et al., 2014, p.1046).

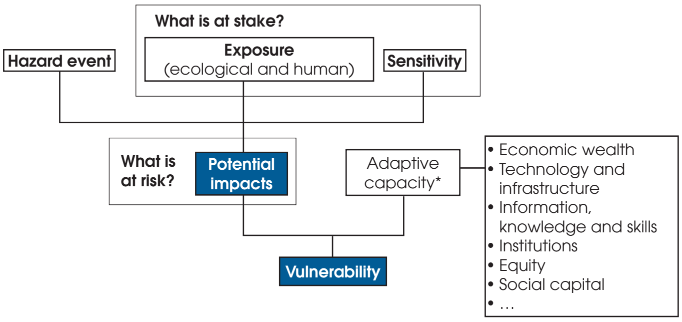

Fig.2 — Contributing factors to potential impacts and vulnerability (adapted from Schneider and Sarukhan, 2001 and Ionescu et al., 2009). Non bold: (Descriptive) factors contributing to vulnerability; bold: predictive and speculative outcomes; * Adaptive capacity tends to be the most context specific.

and governance. This flexibility in the framework makes the vulnerability concept well suited to analysis at the local level, where more context-specific information is available (Hinkel, 2011). It makes however the concept more difficult to use at the global level in a consistent way, which would require more of a 'blueprint' approach to be a comparative guide to investment across different types of risks and social contexts.

A number of global indicator analyses, applied to marine resources, have been conducted by academics (e.g. Allison *et al.*, 2009; Barange *et al.*, 2014; Cooley *et al.*, 2012, Hughes *et al.*, 2012; Halpern *et al.*, 2012) and NGOs (Burke *et al.*, 2011; Beck, 2014; Harrould-Kolieb *et al.*, 2009, Huelsenbeck 2012) to assess ocean health and the specific risks faced by coral reefs and the people that depend upon them. Each has appropriated and redefined the core concepts of the approach differently. Even when definitions are common, the indicators and corresponding datasets used to measure hazard, exposure, sensitivity, adaptive capacity as well as the formulae used to calculate vulnerability itself vary across these studies, mostly in relation to available data and specific focus of these studies.

Lack of agreed definition and measure of vulnerability, ambiguous use of the concept for multiple perspectives (what/who is vulnerable to what changes), have partly impaired the establishment of global analyses that help set up clear priorities for climate investment and action.

WHAT DO GLOBAL VULNERABILITY ANALYSES ACTUALLY REVEAL: UNDERSTANDING CONFLICTING VULNERABILITY RANKINGS FROM CLIMATE CHANGE IMPACTS ON COASTAL HUMAN POPULATIONS

Conceptual differences and different indicators used in global analyses of coastal and marine risks have led to very different rankings of priorities for countries at risk. Table 1 shows a large number of different countries that appear in the top 10 in terms of vulnerability or poor ocean health. Of these, 35 appear in the top 10 of only one of the reports.

In an effort to be more comprehensive and to reflect the different abilities of coastal populations to deal with climate change, recent indicator-based global level analyses include coping and adaptive capacities. All but one of these studies includes measures of capacity (Harrould-Kolieb *et al.*, 2009). There are two immediate consequences of the use of capacity measures in these analyses. First, developed countries that face large potential impacts from climate change never rank high – even though the value of needed climate-change related investment may be extremely large. Second, it becomes difficult to know, using final scores alone, whether a high indicator score is due to vulnerability caused by climate change or inherent vulnerabilities caused by demographic, political, and social factors. Some empirical work suggests that global adaptive capacity indicators can be identified (Brooks *et al.*, 2005) but they so far reflect generic issues such as education and poverty that may be very important for development and well-being but not necessarily for dealing with sectoral impacts of climate change (Hughes *et al.*, 2012).

A TWO-TIERED APPROACH FOR GLOBAL ANALYSIS TO INFORM CLIMATE INVESTMENT AND ACTION

To avoid the challenges described above and to move towards a more transparent approach to global indicator analyses that can be used to identify climate action, we need a simplification and harmonisation of analyses to understand the impacts of climate change, and global environmental change, at the global level for coastal human populations.

Specifically, we suggest a two-tiered approach for classifying existing studies to better identify common elements, and guide further global analysis (Figure 3):

1. GLOBAL LEVEL IMPACT ANALYSES (first tier): At the global level, we should focus on **simplified and more standardised** scoping analyses for which good global data are available. These simpler approaches should link climate change directly to impact, be limited to impacts, and not include measures of adaptive capacity so as to clearly separate development issues from threats driven by climate change. A focus on global-level impact analyses can help identify countries where:

a. climate action may be warranted (mitigation, adaptation or other),
b. additional, finer scaled vulnerability analysis may provide crucial information to set up appropriate policy action, and
c. monitoring and science may yield socially relevant results.

The scores used to rank countries could be presented by impact or as a summary measure of how high-ranked countries scored across the impacts considered. Global-level scoping analyses based on impacts are meant to guide more refined and more data-intensive local level analyses, but do not aim to replace such local level analyses. Ideally, such analyses are accompanied by a global scale analysis of technical, economic and social costs of action for comparison to potential benefits from impact mitigation and adaptation.

2. LOCAL LEVEL ANALYSES (second tier): The global scoping analyses will identify places where more thorough, and more **comprehensive local level analyses** can be used to identify concrete investment actions and the degree to which these places are vulnerable to climate change. At the local level, more refined, data-intensive analysis can be used to better understand local impacts of global and local changes and be-

Rank	Reef at risk revisited (Burke *et al.*, 2011)	Coasts at risk (Beck, 2014)	Allison *et al.*, 2009	Ocean Health Index (Halpern *et al.*, 2014)	Oceana (Harrould-Kolieb *et al.*, 2009)	Oceana (Huelsenbeck, 2012)
1	Comoros	**Antigua-and-Barbuda**	**Angola**	**Saint- Vincent-and- Grenadines**	**Japan**	Comoros
2	Fiji	Tonga	RD Congo	Haïti	**France**	**Togo**
3	**Grenada**	**Saint-Kitts-and-Nevis**	**Russian Federation**	**Ivory Coast**	**United Kingdom**	**Cook Islands**
4	Haïti	Vanuatu	**Mauritania**	Sierra Leone	**Netherlands**	Kiribati
5	Indonesia	Fiji	**Senegal**	**Nicaragua**	**Australia**	**Erythrea**
6	Kiribati	**Brunei Darussalam**	**Mali**	**Libya**	**New Zealand**	Mozambique
7	Philippines	**Bangladesh**	Sierra Leone	RD Congo	Philippines	**Madagascar**
8	**Tanzania**	Philippines	Mozambique	**East Timor**	**United States**	**Pakistan**
9	Vanuatu	**Seychelles**	**Niger**	**Dominica**	**Malaysia**	Sierra Leone
10		Kiribati	**Peru**	**Liberia**	Indonesia	**Thailand**

Table 1 — Examples of rankings for coastal communities at risk from climate change. In bold, countries found in the top 10 of only one of the reports.

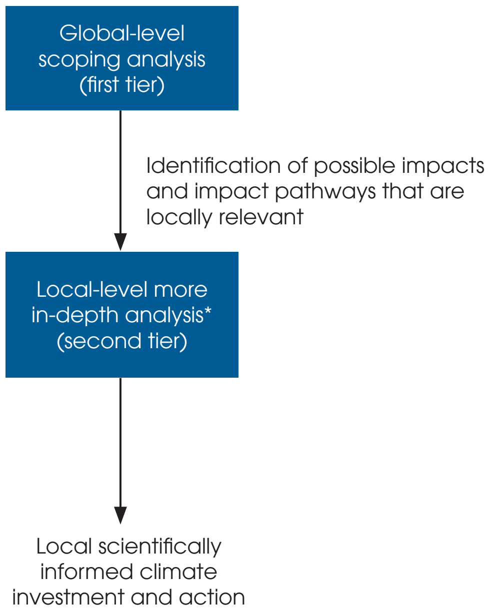

Fig.3 — Stratégie à deux niveaux pour l'analyse scientifique et l'action informée (*comprend l'étude et le suivi de la vulnérabilité).

haviours. Such analyses would include, but not be limited to, vulnerability analyses, and would help identify key environmental and ecological factors affecting human dependencies which are most impacted by climate change. There already exists a number of relevant local level analyses which have been successfully applied in developed and developing countries that could be better used to understand climate impacts and actions (e.g. Cinner *et al.*, 2012; Ekstrom *et al.*, 2015; Yusuf and Francisco, 2010; Arias *et al.*, forthcoming; Sajise *et al.*, forthcoming).

This two-tiered approach is a pragmatic way to make the most of available data, approaches and scientific methods to undertake meaningful analyses that can guide climate action and help prioritise efforts where most urgently needed. It also helps provide a global-level, transparent framework while keeping local flexibility for climate investment and action from the global down to the local level. Like vulnerability analysis, the approach combines natural and social sciences to understand the potential impacts on people of climate change, but it does so at levels that better match the social science concepts to the scale at which relevant data are available. The first tier allows for meaningful policy recommendations at the global level, while the second tier provides the needed flexibility in relation to changing spatial and human contexts.

Such a two-tiered approach still requires continued improvements in the quality and quantity of natural and social science data. While natural science data regarding climate, oceanography, corals and fisheries continues to improve, human data lag behind, especially data about local fisheries, tourism and the built environment.

CONCLUSION

The first tier of the two-tiered approach could be useful to identify all countries that are likely to experience large direct or indirect impacts from climate change. If applied to a pool of recipient countries alone (*i.e.* developing countries under Article 4.4 of the UNFCCC receiving international transfers), such a tier could be used to identify places where foreign assistance to meeting the costs of adaptation under the UNFCCC may be most useful. The second tier could be used by developed and developing countries alike to inform more fine-tuned context-appropriate investment within countries, and not just international transfers. This second tier can consider different types of action, including climate change action but not exclusively, and different investment options into mitigation, adaptation and science.

In addition to the two tiers proposed here, we also urge a parallel but separate global scale analysis of costs of action including technical, social and economic factors is conducted. The combination of the two-tiered approach and global scale analysis of costs of action should provide necessary information for informed climate investment and action.

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