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Towards a Quantifiable Measure of Resilience

Christophe Béné
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Towards a Quantifiable Measure of Resilience

Christophe Béné

Summary

The objective of this paper is twofold. First it illustrates and discusses some of the challenges related to the measurement of resilience by reviewing some of the most recently published and grey literature on resilience in relation to food security. Second it proposes a new framework that addresses some of the concerns and limitations of resilience measurement identified in that literature. The main postulate of this framework is that the 'costs of resilience' (that is, the different ex-ante and ex-post investments, losses, sacrifices, and costs that people have to undertake at individual and collective levels to 'go through' a shock or an adverse event) provide an appropriate and independent metric to measure resilience across scales and dimensions. The paper shows how the independent nature of this metrics offers an explanatory power that can be used to infer, in a testable and rigorous manner potential, causalities between the metric and household and/or community characteristics. Empirical and theoretical examples are used throughout the paper to illustrate the arguments.

Keywords: Resilience measurement; Food security; Poverty; Vulnerability; Shocks.

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Abbreviations

CES-D	Center for Epidemiological Studies - Depression Scale
CS4C	Coping Strategies for Cash
CS4FS	Coping Strategies for Food Security
CSI	Coping Strategy Indicators
EC	European Commission
EMDAT	Emergency Events Database
DFID	Department for International Development
FAO	Food and Agriculture Organisation of the United Nations
IPCC	Intergovernmental Panel on Climate Change
LDI	Livelihood Diversification Index
NGOs	Non-governmental organisations
PTSD	Post Traumatic Stress Disorder
RWA	Relational Wellbeing Assessment
RI	Resilience Index
UK-ESRC	United Kingdom – The Economic and Social Research Council
USAID	United States Agency for International Development
WeD	Wellbeing in Developing Countries
WFP	United Nations World Food Programme

Introduction – Why shall we bother about resilience?

Resilience now dominates much of the mainstream aid discourse, where it is being used to frame discussions around climate change, social protection, sustainable development, macro-economic development and humanitarian response to emergencies. This increasing interest offers an opportunity for (re)designing and implementing more effective forms of intervention. Specifically, a variety of actors (International development agencies, non-governmental organisations (NGOs), and scholars) are now proposing resilience as a framework for fostering deeper integration between humanitarian and longer-term development interventions (Osbahr 2007; DFID 2011; USAID 2012; Levine *et al*. 2012).

The use of resilience as a policy narrative that might help break the silos between humanitarian and longer-term development interventions is welcome. The relevance of the concept need not be limited however to this integrative function. Resilience can play a more 'analytical' role in relation to understanding vulnerability reduction and promoting human development. The world is facing an increasingly uncertain future where economic volatility at both global and local levels, but also more frequent and more severe climate and weather related adverse events, will affect the population and economy of developing countries. There is therefore an urgency for planners and decision-makers of these countries (and those supporting them) to be able to identify amongst the different options and alternatives that they can afford which ones are the most impact-effective in terms of helping households, communities and societies deal with these changes and shocks (Venton *et al*. 2012). For instance, should these planners choose (i) to prioritise interventions that aim at protecting the agricultural sector against climate change? or (ii) should they instead decide to focus on strengthening the country's infrastructures (ports, road and power networks) and make those infrastructures climate proofed? or (iii) should they instead decide to protect the country's export activities and the wider economy from price volatility? Finally if they decide to go, say, for the first option and support the agricultural sector, should they only consider supporting the top 25 per cent of the farmers (because those are the group that is thought to be more likely to respond effectively to interventions) or should they include the entire farming population?

In order to answer questions such as these, it is necessary to better comprehend how people (individually and collectively) respond to shocks. In other words, there is a need to better understand resilience at all societal levels (individual, households, communities, societies). One necessary step in this process is to better measure resilience. Without being able to measure and/or to monitor resilience, policy makers and societies more broadly will not be in position to identify and support interventions that have more effect on people's ability to respond and to accommodate adverse events. Putting this resilience measurement into practice is therefore a priority, but it is not an easy task and many challenges lie ahead.

The objective of this paper is twofold. First it will review the most recently published and grey literature on resilience in relation to food security to illustrate and discuss some of the challenges related to the measurement of resilience. Second it will propose a new framework that addresses some of the concerns and limits of resilience measurement as identified in the literature. The main postulate of this framework is that the 'cost of resilience' (that is, the different ex-ante and ex-post investments, losses, sacrifices, and costs that people have to incur at individual and collective levels to 'go through' a shock or an adverse event) provides an appropriate and *independent* – metric to measure resilience across scales and

dimensions. Furthermore the independent nature of these metric, which is the attribute that most of the current resilience indicators lack (see below), offers an explanatory power that can then be used to test in a rigorous manner potential causalities between the metric and household and/or community characteristics that are thought to be important for building resilience.

Throughout the paper, we will iterate between theory and empirical examples in order to build different elements of our argument. These examples are not presented as 'evidence' of the appropriateness of the approach but are instead a first attempt to ground elements of the framework – more illustrative or more convincing examples might exist in the literature. These concrete examples are important however, in particular, to suggest the 'feasibility' of the approach proposed.

1 Measuring resilience – what do we already know?

1.1 The circular argument and the need for independent metric

The majority of approaches, tools and methods that have been proposed in the literature to measure resilience reflect the diversity of disciplines and sectors that have appropriated the term. With some rare exceptions (e.g. Sanders, Sungwoo and WooSung 2008), most of these various attempts usually adopt an inductive approach whereby particular households and/or community characteristics (such as technological capacity, skills, education and gender indexes, economic status, quality of the environment and natural resources, equity and efficiency of management institutions, levels of income and/or assets, political structures and index of good governance, infrastructure, access to knowledge and information and the speed and breadth of innovation) are assumed to be building blocks of resilience, and as such, are used as proxies to measure the level of resilience – see Frankenberger and Nelson (2013a) for a detailed review of some of these different approaches in the context of food security.

This bottom-up and experience-based derivation of 'resilience' measures is valuable. But it is limited in its ability to help us identify and understand more precisely the processes and mechanisms that actually lead to strengthen resilience. Indeed in this inductive process, the choice of combination of specific characteristics that are used as proxies for resilience often tends to be (a) case-specific, (b) reflect the initial discipline or background of the person who design the methods, and (c) rely on available data, rather than being derived/constructed from a deductive and generalizable approach (Frankenberger and Nelson 2013a).

Unavoidably, this inductive process leads to circular analyses where resilience indexes are first built from an *a priori* identified combination of household or community indicators, and then used to evaluate the impact of resilience interventions on households, leading to circular (or non-independent) analyses (**Box 1**). This issue raises some concerns about the rigour and replicability of these resilience measures, since it limits both the comparability and refutability of the models proposed. This stresses the need to develop ***independent*** indicators of resilience (**Box 2**), that is, indicators that are not directly derived from the characteristics of the specific households or communities which are to be tested – see also the Proceedings of the Rome Expert Consultation (Frankenberger and Nelson 2013b).

Box 1 The circular argument of resilience measurement (theoretical example)

■ **The context**: As an NGO regional director in the Sahel region, John Smith (JS) leads a program that aims at 'strengthening the resilience' of communities to climate change. ■ **The methodological issue**: Resilience cannot be measured directly – JS therefore needs to 'construct' a Resilience Index (RI). For that he combines together several household and community variables, which he expects – based on his long field experience – are important for resilience. In particular amongst these JS includes a Livelihood Diversification Index (LDI), so that RI = *f*(LDI, other characteristics). ■ **The intervention**: JS's team designs and implements a series of activities with the explicit objective to help the targeted communities to diversify their households' livelihood strategies – as an attempt to strengthen their resilience. ■ **Testing the impact**: After three years, JS now needs to demonstrate the impact of his project on the resilience of the targeted communities. For this he compares the RI before the intervention (using the baseline data he had collected) and after the intervention. Since the level of livelihood diversification of the households has (hopefully) been improved through the project activities, the post-project LDI is likely to be greater than the pre-project (baseline) LDI, i.e. $LDI_{\_before} < LDI_{\_after}$, thus transmitting mechanistically this change to the RI. The project evaluation shows indeed that: $RI_{\_before} < RI_{\_after}$. ■ **First (wrong) conclusion**: Since the data shows that $RI_{\_before} < RI_{\_after}$ JS concludes that his initial hypothesis was correct: households' resilience can be strengthened by helping these households diversify their livelihoods. This conclusion however is incorrect: what the empirical data shows is in fact that the project has effectively improved the households' level of livelihood diversification – it does not prove that the intervention has actually improved resilience. ■ **Understanding resilience**: As a further attempt to better understand what factors can help strengthening resilience, JS's M&E team proposes to use the project data to run a series of causal analyses. In particular they regress the change in RI against a whole series of household and communities characteristics as an attempt to determine what factors do affect the level of household resilience. (Not surprisingly) they found some strong statistical correlations between the RI and some variables directly related to households' livelihood diversification, in particular the level of engagement of households in non-farming activities. ■ **Second (wrong) conclusion**: JS's team therefore concludes that livelihood diversification (and in particular non-farming activities) is a key-factor affecting resilience. However since RI = *f*(LDI), the regression was in fact almost certainly going to show some level of correlation between RI and these livelihood diversification variables. This does not prove however that livelihood diversification is a necessary attribute of resilience.

1.2 The need for a multi-scale, generic, and multi-dimensional metric

In addition to these fundamental issues of independent variables, current resilience measures also face some operational challenges. The review of the literature indicates for instance that the large majority of the approaches proposed often limit their analyses at one unique level of resilience – usually the household level (see e.g. Ciani and Romano 2013; Kurtz and Langworthy 2013). Fewer analyses propose some forms of measure at a higher, e.g. community or even system level (Cutter *et al*. 2008; Béné *et al*. 2011), and none provide an approach or a methodology that allows us to operate at several levels simultaneously. Yet all these analyses (and virtually every paper published on resilience) recognise the multi-scale nature of resilience (Berkes and Folke 1998; Carpenter *et al*. 2001; Folke 2006; Leach 2008; Béné et al. 2012).

The second major operational challenge is the fact that, by nature, resilience is time, space, livelihood and shock-specific: the famous 'resilience is of whom... to what'. Yet at the same time frameworks developed to measure resilience need to be generic enough to allow measures to be scaled out (from one community to the next) and to allow multiple

Box 2 A good example of an independent measure of resilience

■ **The context**: In this example Sanders *et al*. (2008) were interested in assessing the health resilience of a particular group of vulnerable households – African American families with incomes below 250 per cent of the federal poverty level (the resilience of whom to what) – where health resilience was defined as 'the capacity to maintain good health in the face of significant adversity' (p.1001) – note that this definition is relatively similar to what a lot of studies would use, in a different context, in relation to, e.g. food security. ■ **The objective**: Sanders et al.'s aim was to determine whether a certain social–epidemiological framework, made up of a combination of risk and protective factors common to a large number of chronic conditions, could explain capacity for health resilience for that particular group. To make the link with the previous discussion even more explicit, their objective was basically similar to the 'Understanding resilience' step in Box 1. ■ **The approach**: The social–epidemiological framework they used included multiple levels of potential influence, starting with community context (social support), the built environment (housing quality) and the family. At the individual level the framework includes individual mental health and health behaviour. They then used a particular marker, tooth retention, as their indicator of health resilience. ■ **The findings**: Using logistic regression models with a series of covariates (age and gender) along with income and education to adjust for residual effect, they were able to show that individuals with better-quality housing, accessible social support, strong church connections, sound mental health, and who were non-smokers were about three times more likely to display capacity for health resilience than other adults. ■ **Independence of the resilience indicator**: The point to retain from this example is that their marker for resilience (tooth retention) was independent of all the variables that they tested, thus allowing them to examine rigorously the respective and combined impacts of these variables on resilience capacity.

comparisons. In particular, in order to enhance the understanding and derive relevant lessons, analyses need to enable us to:

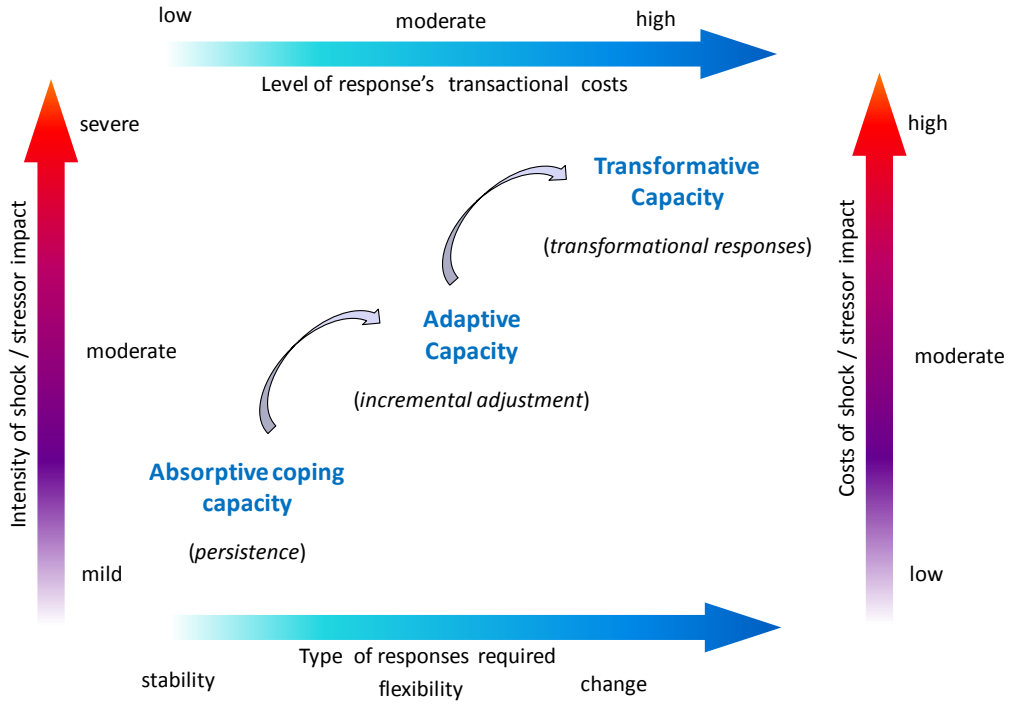
- compare between types of shocks: is a given community more resilient to one type of shock (e.g. decennial drought) than to another (e.g. recurrent flood)?
- compare between households' livelihoods strategies: which socio-economic group is the less resilient to a particular shock -for example in the case of drought, is it agro-pastoralists or farmers specialised in some cash-crops?
- compare between households' responses to shock: are households who have the ability to rely on remittance to rebuild their assets after a disaster quicker to 'bounce back' than households who rely on external/humanitarian assistance?
- compare between interventions that aim at strengthening resilience: is an intervention that adopts an asset-based approach more impact-effective (in terms of strengthening the resilience of the households) than an intervention that focuses on reinforcing the social cohesion of the same community?

Most of – if not all – the frameworks that are proposed in the literature are closely tailored to the community (or cluster of communities) where they are applied (in a genuine attempt to capture the specificity of that/those particular community/ies). However, as such they do not permit the types of comparisons listed above and therefore limit the lessons learned to a narrow domain.

Third important consideration; the same way that it is multi-scale, resilience is also multi-component. A good illustration of this is the two components (social and ecological) around which the Resilience Alliance and many academics have built up their understanding of resilience (e.g. Berkes and Folke 1998; Carpenter *et al*. 2001; Folke 2006; Resilience Alliance 2012). Some others refer to the economic component of resilience (e.g. Brigulio *et al*. 2005). Hence the framework proposed to measure resilience should be designed in a way

that allows for integrating this multi-component nature. As any multi-component concept, this raises a certain number of additional methodological challenges. It also stresses again the limit of a lot of current analyses which have been thought and designed to measure resilience of one particular component (e.g. income resilience to drought), and are not therefore well equipped to provide an adequate, comprehensive framework that integrate other resilience component such as ecological resilience for instance.

Figure 1. Conceptualisation of resilience in relation to its constitutive elements (Source: derived from Béné et al. 2012 and Béné, Headey and Haddad 2013).



Final consideration: the importance of keeping in mind that (a) resilience results from the synergy and trade-offs between three core attributes: the absorptive, the adaptive and the transformative capacities of households (or system) under consideration (Béné et al. 2012 and (b) that these three capacities are drawn on strategically to respond to different levels/intensity of stress/shock. The lower the intensity of the shock, the more likely the household (or community, or system) will be able to resist it effectively. When the absorptive capacity is exceeded, however, the individual will then exercise their adaptive resilience. Eventually, if the change required is so large that it overwhelms the adaptive capacity of the household, (or community or (eco)system), transformation will happen (either deliberate or forced). The intensity of shock/stress is not however the only factors that agents consider when responding. Every type of responses and their outcomes (persistence, incremental adjustment or radical transformation) have different transactional costs, and as we move from absorptive resilience, to adaptive resilience and to transformative resilience, the transaction costs and risks associated to these changes increase. The underlying idea is that 'the more you change the higher the transactional costs'. In other words, it costs more to transform a system than to maintain it as it is or to rebuild it as it was (Béné et al. 2012). These costs are obviously something that people -at individual or societal level- try to minimize. In other words, people don't simply try to reduce the detrimental direct effects of an advert event; they also usually try to minimize the costs it takes to respond and recover from that event. Resilience response results from that trade-off between these different dynamics: intensity of shock, costs of impact, and costs of response (**Fig. 1**).

1.3 What it takes to be resilient?

Building on these last points and on the work of the Intergovernmental Panel on Climate Change (IPCC)[1], an 'operational' definition of resilience would be: 'any capacity and skills, and action, strategy, investment and anticipation, which helps individual, households and communities to anticipate, absorb, accommodate, or recover from the impacts of a particular adverse event (shock, stress, or (un)expected changes)'.

The purpose of proposing this operational definition is not to add to the already very long list of definitions but to stress that resilience results from the sum of all the different *actions, strategies, investments, and anticipations*[2] that contribute to build that specific ability to deal with shocks, and that are undertaken ex-ante and ex-post, at different levels (individual, household, community, system, etc.). The key point here is to recognise that anticipating, absorbing, accommodating, and recovering from the effects of a hazardous event induces some *costs*. One concrete example, which most of the readers will be familiar with, is the case of a farmer who takes the decision to sell part of his productive assets (say one of his two oxen) in order to smooth his family's food consumption in the months following a drought event. The direct cost of this decision – which is taken as part of his immediate resilience strategy – is the losses that this farmer will face next season, when he will be unable to use his ox-powered plough to prepare his land. This cost can be measured in terms of loss in next season's crop.

Yet, faced with the same initial shock (drought), a more resilient farmer would not have had to sell his oxen – perhaps he would have used part of his savings instead. For that second, more resilient, farmer, the costs of passing through the drought, is therefore lower. This suggests that if a household has built up a high level of resilience – or lives in a more resilience-inducing environment – than a less resilient household, the former is expected to face lower costs[3] when the two are affected by the same advert event. In other words, a more resilient household (or community, or system) is one that makes less 'sacrifices' (i.e. that pay lower resilience costs*) to pass through a given shock, than a less resilient household (or community, or system).

2 Measuring the costs* of resilience as a way to quantify resilience

From the discussion above it follows that resilience can be measured in terms of the costs* that a household (or a community, or an ecosystem) has to 'pay' to pass through a particular shock. These costs* can be broadly grouped into three categories:

- the ex-ante investments made as preparedness process (anticipation costs)
- the costs of destruction following the impact of the shock
- the ex-post costs* of recovery, including the replacement costs of what has been destroyed but also the various costs* associated with change/adaptation, or transformation and the cash/food/assets transfers that are implemented through ex-post emergency/assistance interventions.

[1] The IPCC defines resilience as the 'ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner' (IPCC 2012: 3)".
[2] In Sen's perspective, these 'actions, strategies, investments, and anticipations' are part of what he would term "capability".
[3] The use of the term 'costs' is hugely problematic here, given its close association in the literature with economic/financial (cost-benefit) analyses. We use it therefore in default of a better term, but, as the rest of this paper will make clear, resilience is not simply about economics or financial costs, it is also about social, psychological, or ecological 'costs'. To make this important distinction more explicit, we juxtapose an asterisk '*' symbol to the term when we refer to it in a non-economic sense in the rest of this paper.

In simple terms:

resilience costs* = anticipation costs* + impact costs* + recovery costs*

Our postulate is that quantifying these resilience costs* gives an indication of the level of resilience of a system (or component of that system). The lower the resilience costs*, the more resilient the system is (to a given shock).

Recently Venton and her colleagues (2012) also proposed to measure the 'costs of resilience'. Their objective however was not to establish a way to quantify resilience, but to get a sense of how much it costs (to donors) to build resilience and whether resilience interventions are more cost-effective than conventional humanitarian interventions. Their ways to measure resilience was therefore focussing on the (financial) costs of implementing a broad range of interventions, each of them being expected to increase community's resilience. Whether or not these interventions did actually increase the targeted communities' resilience is not discussed in their analysis. But the important point is that they limited their estimation to externally-driven interventions funded by donors. The costs of resilience they were interested in were, in fact, the costs occurring to these donors. By focusing on external interventions they disregard the formal and informal, individual and/or collective mechanisms and strategies that are developed and implemented by the populations themselves, as if resilience was exclusively exogenously constructed. Our approach is different. We recognised that, although it can be strengthened through external interventions, resilience is also an inherent, intrinsic, ability, which results first and foremost from population's activities and strategies.

Our main argument is not however whether resilience is intrinsic or not (there is little doubt that this is intrinsic), our main argument is that a household (community/system) that has acquired or developed resilience will face lower cost/sacrifice/pain to pass through and recover from a particular shock than a household (community/system) that is not resilient. If this postulate is correct, what we have is a method to measure resilience in a quantifiable way. More importantly, this measure does not depend on *a priori* set of household and/or community attributes. Instead it is built independently and can therefore be used to test whether particular household or community characteristics (such as, e.g. education, social cohesion or good governance) are indeed critical in strengthening resilience (see section 3 below).

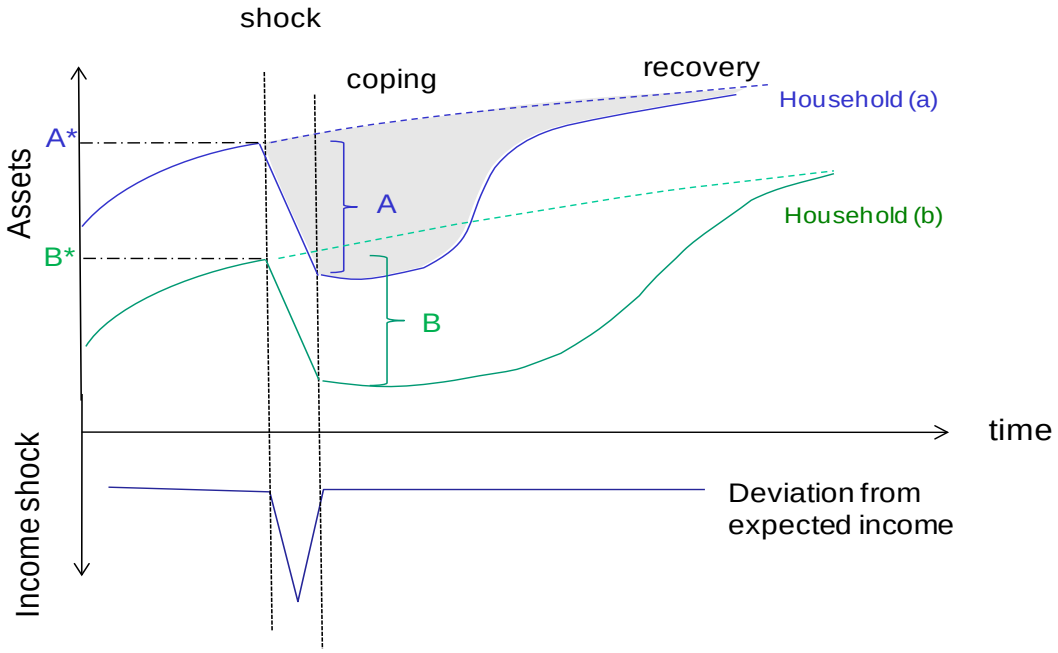
2.1 Building on the existing

Measuring resilience by estimating the costs* it takes to go through a shock is not new in itself. A few years ago, Michael Carter and his colleagues had adopted a similar approach. In their 2007 paper these authors explore the way households in Honduras and in Ethiopia responded to two distinct disasters: Hurricane Mitch in Honduras in 1998 and the 1998-2000 drought in Ethiopia. Carter and his colleagues were not interested in resilience *per se* (although they mention the term in passing in several places in the paper); they were interested in determining whether a disaster can be so detrimental that it 'pushes down' households below a critical asset level under which these households are not able to recover (what they call the 'poverty trap' threshold). In Carter's words:

> '...what are the longer-term effects of shocks on households and their livelihoods? Are households able to quickly re-establish their livelihoods and the assets needed to support them, or is recovery a slow, drawn-out process, especially for poorer households who may be less able to leverage the resources needed to rebuild? Indeed, is there a ''poverty trap'' from which households can rarely recover...' (Carter *et al*. 2007: 836)

In their analysis, Carter and his colleagues used panel data to estimate two critical pieces of information: (i) the loss in assets that was induced directly by the disaster, and (ii) the households' recovery rate, that is, how quickly households were able to rebuild their assets after the shock. **Fig. 2** represents this idea (in the case of the Hurricane Mitch). The size of the total direct costs at the household level (shaded grey area in Fig. 2) can be interpreted as resulting from two costs: (i) the costs of the impact (how deep is the drop in the assets following the impact of the hurricane – represented by the value A on the graphic), and (ii) the 'integral' costs of recovery, that is the area between the level of assets during the recovery and what it should have been if the households had not been hit – i.e. the counterfactual – represented by the dotted line[4]. Analysing these data for the Ethiopian and Honduran households, Carter and his colleagues found three results that are relevant for our discussion.

Figure 2 Impact of Hurricane Mitch on households' assets. In grey the (direct) costs of resilience for the household (a) (Source: adapted from Carter *et al*. 2007)



First, they found that the percentage of households that were affected by the hurricane increases with household wealth; this suggests that the better-off in the community are more likely to be affected than the poorer. This result is not necessarily intuitive, as it 'contradicts the notion that poorer households are more vulnerable [than better-off households] to shocks' (Carter *et al*. 2007: 842). However they also found that the losses faced by poorer households (green curve labelled (b) in Fig. 2) were proportionally larger than those for richer households (blue curve (a) in Fig. 2) in the same communities. In other words, the poor have very little to lose (which explains why the richer in these communities are likely to lose more – in absolute terms), but that 'very little' is actually a larger share of the poor's initial assets. On Fig. 2 this translates by the fact that $|A| > |B|$ but $A/A^* < B/B^*$. The third relevant finding of Carter's analysis is that the poorer are slower at rebuilding their asset-base than the richer, a feature which is captured on Fig. 2 by the fact that the slope of the recovery period for curve (b) is lower than for curve (a).

[4] Carter *et al*. (2007) did not exactly estimate the difference between the level of assets and what it could have been. They estimate only the rate of recovery, that is, the slop of the curve (what they call the post-shock asset growth – see their equations (1) and (2).

Revisited with a resilience lens, these results are extremely relevant for several reasons. First, although this was not the initial objective of their research, Carter's paper was one of the first empirical attempts at 'quantifying' resilience (or more correctly some part of it) at the household level. Second, their results provide some very clear directions on where to look next. They offer in particular three very specific hypotheses that need to be tested across a much wider range of situations, namely: (i) the richer are not less likely to be hurt than the poor in the same communities, (ii) the poorest are however the ones that are likely to be hit proportionally harder (i.e. to lose a larger proportion of their assets), and (iii) the poorer are also the ones who are slower at recovering.

Lastly – and of even more direct relevance for our discussion – Carter's work captures and illustrates concretely the essence of what we proposed above. By looking at the impacts of shocks and the costs of recovery, they had generated information that can be used to judge the likely level of resilience of households and communities. In particular the points (ii) and (iii) above would suggest that the poorer are less resilient than the better-off, an outcome which is often asserted –but rarely demonstrated- in the literature.

2.2 Typology of resilience costs*

Carter's study, however, focuses only on the ex-post nature of households' responses, and measures only assets dynamics. As we will emphasise below, measuring resilience is not simply about ex-post responses, it should also account for ex-ante anticipation, such as community investment in protective actions and infrastructure. Similarly, resilience is not simply about change (loss) in assets, it is also about individual's psychological stress following a disaster (Almedom and Glandon 2007); and about the role of reciprocal (informal) risk management mechanisms in helping individual households recovering more rapidly and preventing them from engaging in some detrimental coping strategies (Hoogeveen 2002; Barrett *et al*. 2006). What is needed therefore is to expand Carter's analysis beyond the asset dynamics in order to capture these other dimensions and other components of resilience. In order to help us in structuring this process, we refer to the earlier 'equation' of resilience costs* we proposed above:

resilience costs* = anticipation costs* + impact costs* + recovery costs*

We need in particular to consider the different types of costs* that incur at individual, household, community, and system levels, in relation to these three broad categories. Roughly, those include:

(i) **Costs of anticipation** and preparedness activities, such as the building of a dike by the community as an attempt to protect their village from the next flood; or the building of a grain storage by a household in order to improve its ability to manage crop fluctuation. By nature, these actions, initiatives, investments are ex-ante costs;

(ii) **Impact costs***, including the tangible destruction of individual and collective assets and infrastructure, but also other costs* such as the psychological stress engendered at individual and collective level by the shock;

(iii) **Costs* of recovery activities**, including rebuilding of destructed assets and infrastructures at household, community or system levels (e.g. water distribution system), but also the engagement in any coping strategies such as, e.g., asset selling or borrowing money from the local money lender to replace the destroyed assets. This component also includes humanitarian assistance (if any). Ex-post investments that are undertaken to adapt to the new situation or to the post-shock conditions should also be included. For instance, the costs of switching to a new crop for farmers as an attempt to respond to the decline in yield of their traditional system would have to be included here. Also included is the (mal-

adaptation) strategy that consists in exploiting more intensively the natural resources after a shock, as an attempt to maintain household food security. The phenomenon of adaptive preference, that is, the deliberate or reflexive process by which individuals adjust their aspirations when trying to cope with deteriorating changes in their lives should also be considered as resilience costs*. At the collective level, change in relational wellbeing (degradation of intra- or inter-households) due to additional stress or e.g. competition for more scarce resources will need to be considered.

At first sight the list seems endless and confusing. However, with the exception of adaptive preference, the different costs* of resilience which should be considered in the calculation are those which refer to processes, initiatives, actions or decisions that will be identified during interviews, at both households, and community level.[5] The list is therefore bounded, and is space-, livelihood- and shock-specific.

Conceptually these different costs* can be grouped under five categories: economics, ecological, social, psychological, and nutritional. **Table 1** provides the (non-exhaustive) list of costs* that are included in these five categories. The important point is that by incorporating these different costs*, the framework does satisfy one of the major challenges raised by resilience, namely that resilience includes processes of different natures: social but also ecological, economic, nutritional and psychological into the measurement of resilience.

Table 1 Categories of costs* associated with resilience

Categories	Description
Economic– financial	investments in infrastructure (ex ante), income loss – asset loss (shock) – reconstruction (ex post), asset depletion (coping) – debt contracting (coping)
Ecological	resource mining, environmental degradation (coping)
Social	[relational wellbeing] : social relation degradation, conflicts (recovery)
Psychological	[subjective wellbeing]: stress (shock), adaptive preference (recovery)
Nutritional/food security	(impact of shock) Coping strategy Indicators

Some of these costs* are easier to quantify than others. Clearly, assessing the financial costs of the assets or infrastructures destroyed or lost during a particular disaster does not raise any methodological challenge. Similarly estimating the investment costs of some preparedness activities such as the investment made by a community in building a dike to protect the village against flood should be straightforward. Similar calculation can also be done at a national level (**Box 3**).

Likewise, coping strategy indicators (CSI) such as these developed by Maxwell and Caldwell (2008) may not 'measure' the exact effect of a given shock on nutrition and food security (as these actual effects would be measurable only later), but they have been widely accepted as good and reliable 'status indicators' of the impact of a shock on people's nutrition and food security. As far as psychological costs* are concerned, there are specific indexes that can be used such as the Post Traumatic Stress Disorder (PTSD). To refer to the example of Hurricane Mitch again, Kohn *et al*. (2005) estimate that 492,000 adults in Honduras out of an adult population of 3.3 million suffered from PTSD following that event. Another alternative is the Center for Epidemiological Studies Depression Scale (CES-D) – see, e.g., Macours and Vakis (2009) for an example.

[5] When it occurs, adaptive preference is not necessarily consciously recorded. Specific questions need therefore to be included in the questionnaire to elicit the magnitude of this phenomenon.

Box 3. Assessing the ex-ante and ex-post costs of disasters

It is possible to assess the costs of preparedness, impacts and recovery at national level. Bitran (2008) assessed recently the ex-ante and ex-post investment costs of Mexico in relation to disasters for the period 1998-2008, and de la Fuente (2010) extended the exercise to Nepal, Indonesia and Colombia (only for the period 2002-2007 for the last two countries). Completing these data with the costs of damage for Mexico and Nepal – using the International Disaster Data-Base (EMDAT) – we obtain the following table.

Table: ex-ante and ex-post costs of disasters (in million USD) in Mexico and Nepal over the period 1998-2008

	Mexico				Nepal			
year	ex-ante expend.	exp-post expend.	damage	Tot Costs per cap	ex-ante expend.	ex-post expend.	damage	Tot Costs per cap
1998	114.60	428.50	611.70	12.29	12.8	31.20	27.00	3.06
1999	140.62	857.30	942.90	20.43	12	13.40	2.00	1.15
2000	173.85	255.90	1.00	4.44	12.9	8.40	6.30	1.13
2001	196.59	223.40	401.00	8.38	14.2	8.20	0.00	0.90
2002	293.31	600.80	1,050.00	19.64	11.1	25.00	0.00	1.42
2003	289.72	321.90	216.30	8.20	11.9	27.60	0.00	1.51
2004	252.28	146.40	3.60	3.94	13.7	23.70	0.00	1.40
2005	287.94	1,460.10	7,910.00	93.77	15.7	28.90	0.00	1.64
2006	262.63	461.60	2.70	6.96	16.1	26.50	0.00	1.53
2007	215.86	1,891.70	3,600.00	53.84	19.8	14.20	2.40	1.29
2008	387.10	1,142.20	75.00	14.85	24.2	30.20	0.03	1.88

Calculated from Bitran (2008), de la Fuente (2010), EMDAT (2013)

The trickiest is probably the ecological costs* induced by a shock and the costs of coping strategies and/or (mal)adaptations that are adopted by households and communities as part of their attempts to bounce back from this shock (Eriksen *et al*. 2011). One of the difficulties lies in that those impacts may not be visible or measurable immediately. Yet a good understanding of the local ecological dynamics should permit the identification of relevant indicators which can then be monitored (Béné *et al*. 2011).

In addition to these individual impacts, shocks may also affect the social harmony of the community or more broadly the inter-relations between the members of that community. These impacts may seem at first sight less easy to capture. However, methods and indicators exist. The Relational Wellbeing Assessment (RWA) for instance has been developed by the Wellbeing in Developing Countries (WeD) research group at the University of Bath (www.welldev.org.uk/) and can be adapted to generate robust indicators of the impact of shocks on inter-personal relationships.[6] Adaptive preference may be slightly more difficult to assess/quantify but techniques are available in the literature – see e.g. Manski 2004; Delavalande, Giné and McKenzie 2011; Krueger and Schkade 2008 for some critical reviews.

It is also important to put some time boundaries around these different costs*. In particular, there is a need to limit the ex-ante actions/investments which will be included in the analysis

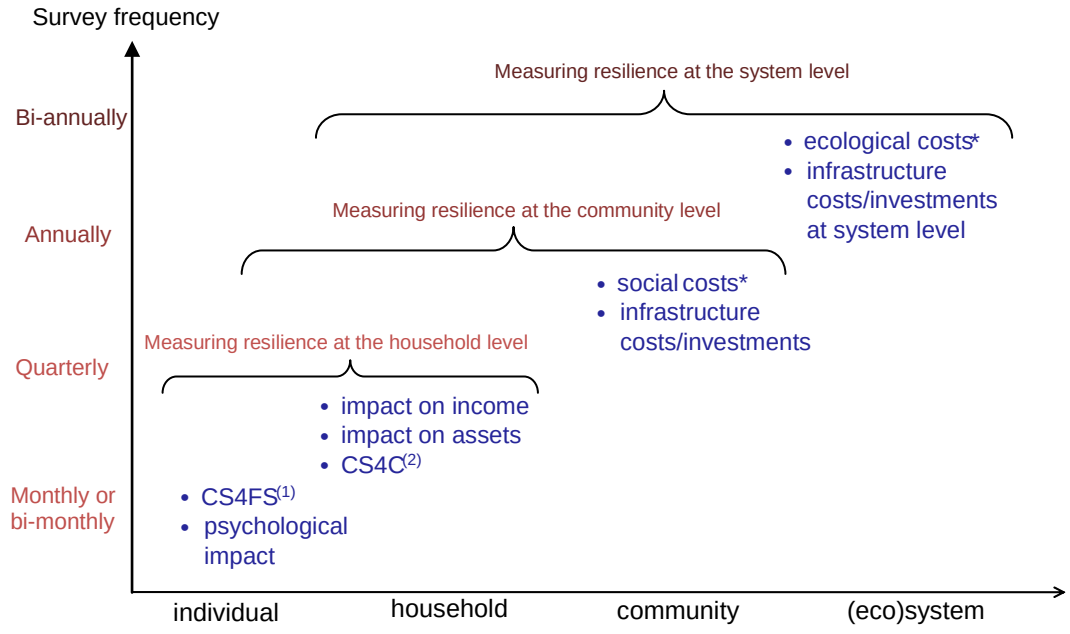
[6] While many different approaches and indicators are now available in the literature on wellbeing (e.g. the Personal Wellbeing Index), the WeD framework is particularly relevant as it has been specifically designed for developing countries.

to a certain time period (e.g. five years prior to the event?)[7]. Similarly, we are not trying to evaluate the long-term ex-post impacts of resilience strategies. As such, the impacts of environmental degradation or the impacts of the coping strategies adopted by the households on their health or education are not to be included. What we are evaluating is only the short term direct costs* of these (see subsection 2.3. just below). This also means that some arbitrary decisions will have to be made on the time boundary of the analysis.

2.3 The multi-scale and multi-component nature of the framework

One of the potential strengths of this approach is its multi-scale nature. This is represented on X-axis of **Fig. 3.** At an individual level, resilience would be captured through the Coping Strategies for Food Security (CS4FS) and the measure of the psychological impact (through the PTSD or the CES-D indexes). Moving up to the household level we would add the changes in income and assets induced by the impact of the shock (e.g. losses) and any subsequent ex-post strategies adopted to ensure the recovery including the Coping Strategies for Cash (CS4C) (if any) undertaken by the household in order to pass through the shock. Scaling up the resilience measurement to the community level would be achieved by considering the social costs* of resilience assessed through the RWA and the costs and/or investments made in infrastructure at the community level.

Figure 3 The multi-scale nature of the resilience measurement framework and the associated sampling frequencies. Notes: (1) CS4FS: coping strategies for food security; (2) CS4C: coping strategies for cash



Finally, at the system (or eco-system, e.g. watershed) level, we would take into consideration the ecological costs* (measured in changes in relevant ecosystem services' indicators) induced by the households and the community's impact on the resources/ecosystem as a result of their coping strategies and/or adaptation/transformation strategies, and the ex-ante or ex-post costs and/or investments made at the system level in relation to infrastructure

[7] This issue of time boundary (or time horizon) is not specific to our framework. It is a well-known issue in cost-benefit analysis literature, recognized by both academics (e.g. Fuguitt 1999) and practitioners (WHO 2006).

(see, e.g. Box 3 above). The fact that this approach seeks to measure resilience costs* from the individual up to the ecosystem level using the same framework offers great promise as a methodological innovation as it provides a way out of one of the most frequent flaws affecting the existing approaches.

Fig. 3 also highlights that our resilience measure is a multi-component indicator which focuses on two components at the individual level: a food security coping strategy component, and a psychological component; three components at the household level: the income, assets and cash coping strategy; at the community level social costs* and infrastructure costs/investment; and finally at the system level the ecological and infrastructure costs/investment. The underlying consequence is that, like any other multi-component (or multi-dimensional) entity, measuring resilience cannot be reduced to a one-single dimension or indicator without losing important information. In particular reducing the multiple dimensions of resilience through, for instance, principal factor analysis is not the appropriate approach. Instead all the components need to be kept in a multi-component resilience profile.

2.4 Monitoring resilience

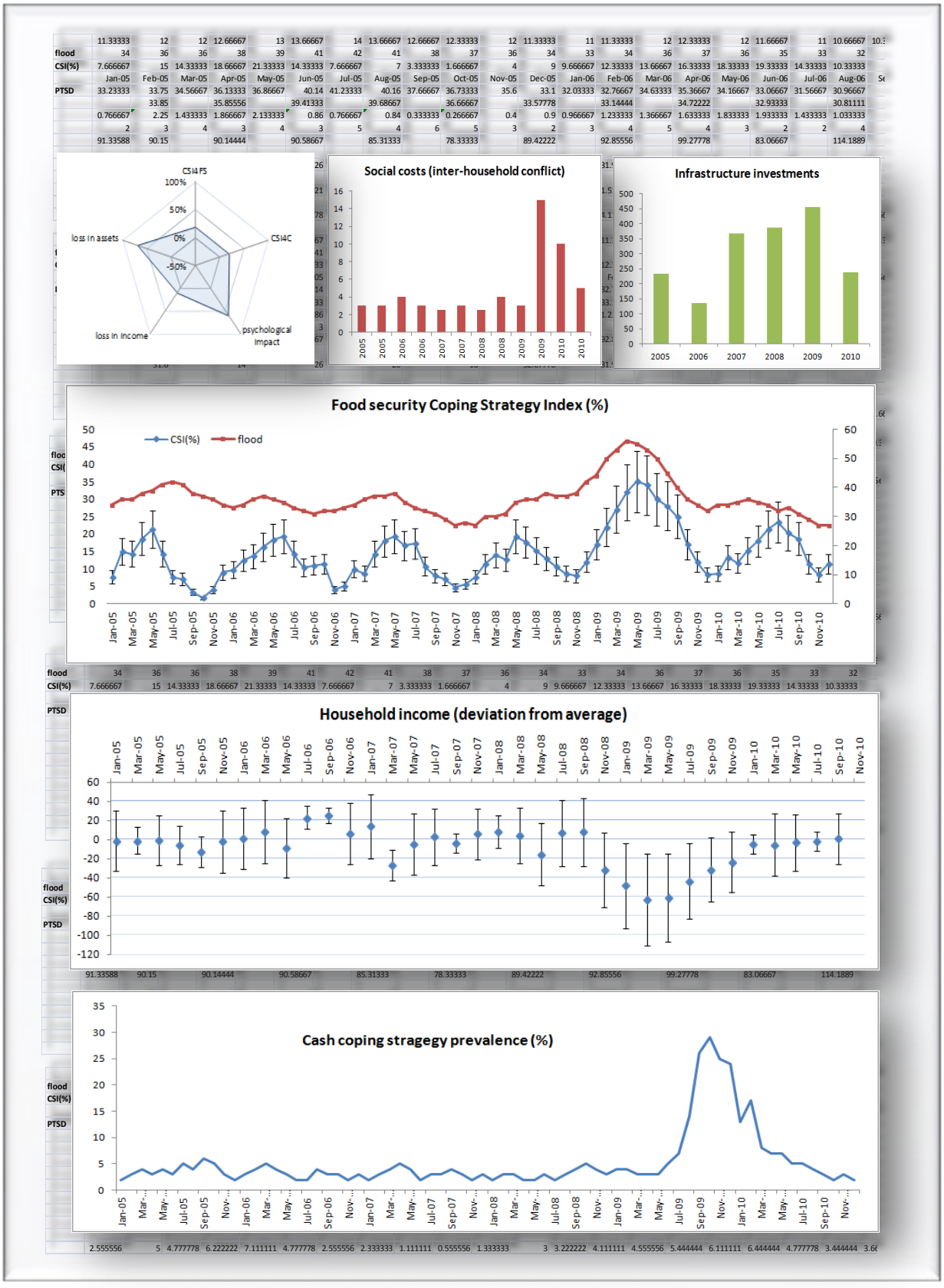
The unpredictable nature of shocks makes measuring resilience much more difficult and complex than measuring poverty, or even indicators such as child malnutrition or infant mortality. In the case of these more chronic welfare measures, occasional snapshots from household surveys usually suffice to give a general pattern of poverty across regions and countries, as well as basic trends. These standard household surveys are generally too infrequent, however, to assess the consequences of shocks (except by coincidence) occurring at the household level, and large panel surveys in developing countries are still relatively rare. This suggests that measuring resilience requires methodologically different approaches. In particular, an important prerequisite for resilience measurement is the need for higher frequency surveys, as stressed by Barrett and Constas (2012) or Béné, Healey and Haddad (2013). Though still rare, high frequency measurement (e.g. monthly or bi-monthly surveys) are fundamental for understanding resilience dynamics at the household level because of (a) 'dynamic initial states' (e.g. seasonality, cyclicality and exposure to idiosyncratic shocks) after these households, (b) complex dynamics of household coping and adaptation mechanisms (e.g. households may first exhaust one coping mechanism before adopting others), and (c) complex threshold effects of inter-state transitions (Barrett and Constas 2012).

Such high frequency may not be necessary however for higher level (community or ecosystem) processes. For these, annual or bi-annual surveys should be sufficient to capture the changes in the relevant indicators (inter-households relationship, investment in infrastructures at community or system level, change in ecosystem services). These various frequencies are represented on the Y-axis of Fig. 3 above.

Altogether these different indicators can be organised into a dashboard which displays the changes occurring over time for each indicator recorded at different frequencies. **Fig. 4** presents a theoretical example of what this dashboard could look like. In this particular illustration, the resilience indicators are monitored at the household and community levels. In addition to time series, the different indicators can also be organised into a multi-component resilience profile (top left radar diagram) that shows, for a particular month, a snap-shot of the level of resilience (in that case at household level), using a simple percentage scale maximum (%SM)[8] multi-criteria diagram.

[8] Using the %SM score allows for comparison between scales with different numbers of choice-points as it reflects the extent to which a score approximates the maximum score that could be obtained. %SM is equivalent to normalisation.

Figure 4 Theoretical example of a dash board displaying the different indicators used to measure and monitor resilience at individual, household and community level.



3 The explanatory power of the framework

Although the way these resilience profiles are presented in Fig. 4 is not necessarily different from some other approaches[9], the fundamental distinction is that in the present case the resilience components have been constructed *independently* from households or community characteristics such as education, skills, knowledge, assets level or level of participation. The critical advantage is that we can now use this resilience data to explore some of the fundamental questions which could not be answered so far due to the non-independent and case-specific nature of the existing resilience measures.

First, the framework would enable us to compare households and/or community resilience and investigate in particular whether certain types of shock influence more significantly the type of resilience response than others. For instance, we could assume that an unexpected rapid-onset shock (such as an earthquake or a landslide) is systematically associated with a resilience profile disproportionally skewed toward psychological costs* compared to a longer-onset stress (such as drought) which, itself, may be associated with more severe food security costs*.

This type of analysis would have some commonality with the specific literature which attempts to 'compare' the impacts of shocks of different nature on various dimensions of societies (see e.g. Otero and Marti 1995; Rodriguez-Oreggia 2008), but the present framework would offer a more systematic and consistent way to explore these links.

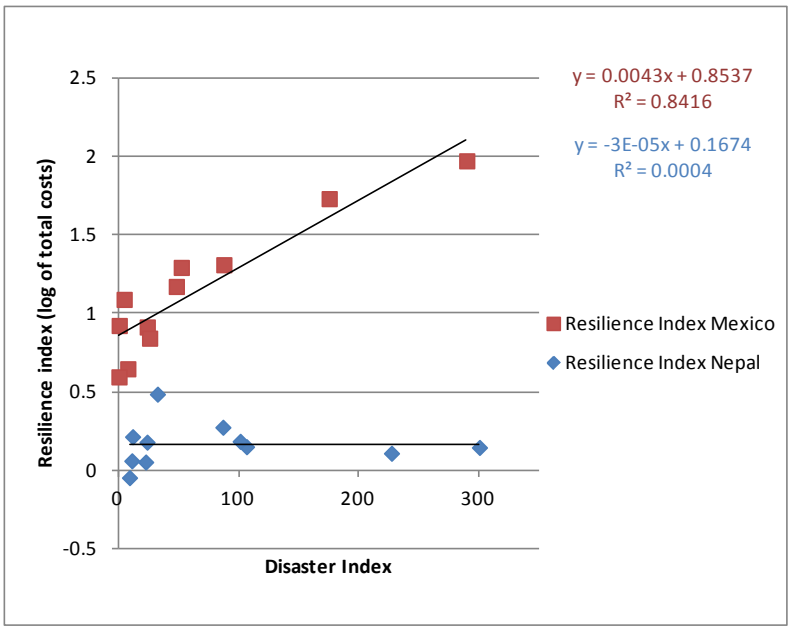
Second, because the different components of resilience can be compared using a %SM approach, the framework would enable us to investigate potential relationship or trade-offs between different dimensions of resilience. Alternatively we could also compare resilience components between households, communities, or even countries. In **Fig. 5** for instance, we use the data presented in Box 3 above to compare Mexico's and Nepal's respective resilience to disasters at a national level. For this we combined the 1998-2008 annual levels of ex-ante and ex-post government expenditures and the costs of damage, and expressed the resulting total costs of resilience[10] as a function of the level of disaster (measured by the number of persons affected and/or displaced) observed for these two countries over the same period (1998-2008). The resulting scatter-plot indicates clearly the strong ability of the Nepalese institutions at national level to 'go through' disasters at much lower costs than their Mexican counterparts, suggesting that Nepal's resilience to disaster impacts is far greater than that of Mexico.

Another promising area where the framework will generate extremely policy-relevant information is the investigation of potential correlation between levels of resilience and households and/or community characteristics. For instance, is the level of resilience correlated to the level of education of the household head? Does strong social cohesion or good governance explain high levels of resilience at both household and community level? Is asset level a critical factor affecting resilience? Since we can aggregate households by income or assets level and construct a resilience measure independently from these household characteristics,[11] we are now in the position to explore more rigorously questions such as: other things being equal are low income households more likely to show lower levels of resilience than better off households? Is income inequity amongst members of a community affecting their ability to build resilience at community level? All these questions

[9] For instance for the radar graph, see e.g. Alinovi et al. 2010; Tulane and UEH 2012.
[10] In that particular case the comparison only includes the financial dimension of resilience at national level.
[11] Alternatively we can include these characteristics as co-variables to control for the level of income and/or assets, and run series of regressions in the way Sanders *et al*. (2008) did.

which are fundamental to the 'resilience-building' narrative that is being promoted or even implemented by an increasing number of NGOs, bi-lateral and multi-lateral donors and development agencies could be investigated under this framework. The policy implications of many of these questions are important.

Figure 5 Resilience Index of Mexico and Nepal as a function of disaster impacts. Resilience index estimated through the total (financial) costs of resilience to disasters –Source: Bitran (2008), de la Fuente (2010), and EMDAT 2013). Disaster Impact data source: EMDAT (2013).



From the donors' perspective and their current emphasis on value for money (Venton *et al*. 2012), the framework also provides a new way of organising and interpreting information as it would encourage the design and implementation of proper monitoring and evaluation of interventions and projects. It would enable us, for instance, to distinguish between interventions which claim to improve resilience and those that actually do it. It would permit us to establish what form of interventions are more 'resilience-effective' than others -for instance whether asset building interventions, for instance, are more effective at strengthening resilience than interventions targeting community capacity building.

Eventually the quantifiable measure of resilience indicated by this framework should also put us in a better position to start answering some of the key questions that have been raised elsewhere (Béné *et al*. 2012) such as: is there any systemic link between resilience building and poverty reduction and if so, under which conditions is resilience interventions really reducing poverty. Or, are resilience interventions more (or less) impact-effective than more traditional poverty or human development interventions (e.g. gender, or education, or health direct interventions)?

4 Conclusion

The objective of this paper was twofold. First we identified and discussed some of the challenges and limitations that affected at different degrees a large number of resilience indexes that are currently proposed in the literature. Building on this analysis, we then proposed a new framework that attempts to address some of these concerns and limitations. The main postulate of this framework is that, in order to be useful as an 'analytical' tool from which lessons can be derived for development interventions, a resilience indicator needs to satisfy a certain number of characteristics:

- ***Multi-scale***: Resilience indicators should be able to capture change in resilience at different scales: individuals, household, community, (eco)system, national levels;
- ***Multi-dimension***: resilience is not simply about coping strategies that help households to 'survive' a shock; resilience is also about adaptive strategies or even transformative strategies. It is about ex-post but also ex-ante (anticipation) strategies. An appropriate resilience indicator would be one that captures all these different dimensions.
- ***Objective and subjective***: resilience is as much about what people do to go through a harsh period, than about how they feel about it. Resilience indicators should therefore aim at monitoring both objective changes and subjective perceptions – including stress.
- ***Generic***: Although we recognise that indicators are relevant only if they can capture and reflect the specificity of the situation they are applied to, too many indicators are currently built on specific circumstances or specific agenda. An appropriate resilience indicator is one that can be scaled out and replicated.
- ***Independently built***: to be analytically useful, a resilience indicator needs to be defined and measured independently from the factors and processes that are (presumably) affecting its level, such as income, assets, level of participation or social coherency. Only when these factors are not incorporated in the resilience index can we explore and test rigorously the actual effect of these characteristics on resilience.

The new framework we propose builds on others' work – e.g. Carter *et al*. (2007); Sanders *et al*. (2008); Frankenberger and Nelson (2013a); or Barrett and Constas (2012). But it is also based on a totally new approach, where the key innovation is the recognition that resilience can be measured by its costs*. The underlying principle of our framework is indeed that the more resilient a system (or a component of this system) is, the lower the costs* that this system (or the component of this system) will experience to pass through a shock or a tough period. Based on this principle, resilience can be measured and monitored simultaneously at different levels, for different components of a system, and include both objective and subjective costs*.

Beyond the important aspect related to its multi-scale and multi-dimensional nature, the fact that this new resilience metrics is constructed independently from the household or community characteristics which are usually assumed to be constitutive elements of resilience, offers an explanatory power that can be used to test in a rigorous manner the potential causalities between resilience and these household / community characteristics. The policy implications that these new causality analyses offer are substantial.

Finally let's point out that the definition of resilience proposed on p.11 of this paper –where resilience is defined "any capacity and skills, and action, strategy, investment and anticipation, which helps individual, households and communities to anticipate, absorb, accommodate, or recover from the impacts of a particular adverse event (shock, stress, or (un)expected changes)"- is an operational, technical, definition, which was useful in particular to introduce the resilience metrics proposed in this paper. Conceptually however a more appropriate definition would be one that highlights the multi-dimensional nature of resilience, and define resilience as an ability; something alone the line of: "resilience is the ability to

persist, adapt or transform in the face of a shock or changing environment". As such this definition can be applied to an individual, a household, an ecosystem, or a country as a whole, and the 'shock or changing environment' is generic enough to refer to any idiosyncratic or covariate event: flood, drought, harvest failure, forced migration, death, environmental degradation, economic crisis, etc.

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