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Core Indicators for Resilience Analysis: Toward an Integrated Framework to Support Harmonized Metrics

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Abstract

An increasingly complex configuration of risks associated with climate change, agro-ecological stressors, political conflict, and economic volatility has created a new set of challenges for vulnerable populations who live in developing countries. As a strategic response to such challenges, the concept of resilience is now regularly used as a point of reference for an array of policies and programmes. Initially, investments in resilience-focused policies and programmes outpaced the ability to measure the effects of those investments. While much progress has been made in filling this measurement gap, the plurality of resilience measurement approaches now in circulation has introduced a different problem. The proliferation of approaches and metrics associated with resilience makes it difficult to compare the results of one study to the next. At a more applied level, attempts to speak with a unified voice about the collective impact of resilience investments is hindered. By specifying core indicators for resilience analysis, the present paper offers a framework on which harmonized metrics for resilience measurement may be based. The framework is comprised of four elements: 1. Foundational resilience concepts, 2. Resilience measurement domains- which includes Resilience Measurement Focus (RMF) and Resilience Measurement Sensitivity (RMS), 3. Integrated resilience measurement, and 4. Actual resilience indicators. Central to the ambition of formulating a core indicators framework for resilience are the details associated with RMF and RMS. RMF, which draws attention to the content of measurement, highlights the importance of well-being, shocks, stressors, enabling characteristics, and systemic contexts as core indicators for resilience. RMS, which draws attention to the properties of measurement, highlights the importance of threshold sensitivity, spatial sensitivity, and temporal sensitivity as features of resilience indicators. The idea behind integrated resilience measurement is to emphasize the interplay between RMF and RMS. To illustrate how the CIRA can be applied to an actual setting with actual indicators the paper provides an empirical example using a resilience-focused study conducted in Tanzania. In a conclusion section, the paper discusses the benefits and the challenges of advancing a common indicators framework for resilience analysis.

Introduction

Climate change dynamics, stressed agro-ecological systems, political conflicts, mass migrations, and volatile economic conditions are commonly viewed as risks that threaten food security and undermine the general well-being of the world's poor. Over the past five to ten years, recognition of a more complex configuration of risks that threaten food and nutrition security has fueled interest in using the concept of resilience as a strategic orientation on which an array of policies and programmes may be based[1]. Large and sustained investments in resilience have been made by the Humanitarian Aid department of the European Commission (ECHO), by the United States Agency for International Development (USAID), and the Department for International Development (DFID). Resilience has also been highlighted by various United Nations organizations as those organizations seek to enact resilience focused elements of "The 2030 Agenda for Sustainable Development[2] (United Nations, 2015). Following the 2011 crisis in the Sahel, the Global Alliance for Resilience (AGIR) was formed in 2012 with an initial regionally-focused investment of approximately 1.3 billion Euro. In an inception period for its urban resilience programming, The World Bank invested approximately US $9.7 billion dollars in urban resilience between 2012 and 2016. In its 2018 annual report, the World Bank stated that it raised between $45 and $55 billion a year, much of which is targeted toward "... help[ing] clients manage risk and build resilience". Although some initial questions were raised about the utility concept, a commitment to resilience is now firmly established as priority among international organizations and policy makers.

As interest and financial investments in resilience have grown, so too has the need to measure the effects of associated policies, programs, and interventions. In response to this need, various policy statements on resilience measurement have been made and a number of initiatives have been launched. Early position statements on resilience measurement have, for example, been produced by the United Kingdom's Department of International Development (DFID, 2011) the United States Agency for International Development (USAID, 2013), the Organisation for Economic Cooperation and Development (OECD, 2018), and the European Union (EU, 2017). In 2013 The Food Security Information Network (FSIN) formed the Resilience Measurement Technical Working Group (RMTWG), an effort whose work focused on the articulation of principles and the development of analytical frameworks on which rigorous resilience measurement may be based. In that same year, FSIN formed a community a practice on resilience measurement. With membership soon approaching 1,000 members, FSIN's community of practice was an early signal of demand-side interest in resilience measurement among field-based practitioners. In 2016, the Rockefeller Foundation formed a resilience-focused Measurement Evaluation and Learning Community of Practice.

While early work on resilience was dominated by policy and programming[3], more recent work has underlined the importance of resilience measurement. Over the past few years, one can observe a new generation of work that describes how resilience may be theorized for international development (Barrett and Constas, 2014), conceptualized for measurement (Constas, Frankenberger, and Hoddinott, 2014) and effectively modelled in empirical studies (Denno-Cisse and Barrett, 2018; d'Errico and Di Giuseppe, 2018; d'Errico and Pietrelli, 2017; Smerlak and Vaitla; 2017; Smith and Frankenberger, 2018; Vollenwieder, 2015). One could now reasonably conclude that the concerns once raised about inattention to measurement within the resilience discourse (see Bene, 2013; Gall, 2013) are no longer warranted.

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[1] While a range of definitions resilience are in circulation, all reflect a shared interest in addressing the problem of how people (in households, villages, or larger groupings) can deal with the challenges introduced by shocks and stressors that threaten their welfare.

[2] Goals nine and eleven of the SDGs make specific mention of resilience. Elements of several other goals and the overall vision of sustainable development goals framework also highlight the importance of resilience.

[3] The one notable exception to this trend can be found in the Food and Agriculture Organization's early empirical work on resilience (see Alinovi, Mane, and Romano, 2008).

While the increased activity in resilience measurement can be viewed as a positive sign, the increased activity also presents a problem. The proliferation of approaches and metrics makes it difficult to communicate with stakeholders who may seek to measure resilience, aggregate findings across settings and over time, or compare the results of one study to next. A review commissioned by the United Nations Development Programme, for example, cited 18 measures of measures of resilience that could potentially be applied across four scales - household, sub-national, national, and global (see Winderl, 2014). A review of frameworks of indicators for resilience measurement published by the Overseas Development Institute in 2015 identified 17 separate indicator frameworks (see Schipper and Langston, 2015). The effort to draw comparisons across settings and/or aggregate finding across studies requires an overarching measurement framework. The absence of such a framework will impede the ability to draw conclusions about the effect of resilience as a coherent strategic approach. The attempt to draw high-level inferences that policy makers and donors might want to make about the impact of resilience investments will be hindered by the lack of empirical convergence. Looking forward to the possibility of a systematic review, the effort to estimate effects via meta-analysis, for example, will also be hindered by the lack of convergence.

To help counter the potential confusion associated with the proliferation of measurement approaches that are in circulation, the purpose of the present paper is to propose a simple methodology under which a shared set of indicators for resilience analysis may be organized. The approach, referred to here as the **Core Indicators for Resilience Analysis (CIRA)**, is offered as a strategy that can be adapted to meet the needs of any measurement task for which an understanding of resilience dynamics is the intended analytical objective. While the specific data collection tools used within a given study will naturally vary from one context to the next, the existence of a core set of resilience indicators is designed to support the aspiration for harmonized metrics. It is important to note from the outset that CIRA represents an aspiration rather than a final product. With this qualifier in mind, we believe that the best way to make progress toward the aspiration of harmonized metrics for resilience is to put an idea in circulation - one that can be criticized, debated and improved upon. This paper represents one such idea.

The paper is organized into three sections followed by a conclusion. Intended as brief background on the concept of resilience, the first section provides a concise statement on the theories and disciplinary perspectives that inform resilience measurement. The second section introduces the framework on which core indicators for resilience analysis approach may be based. To introduce the logic of the framework, a simple graphic depiction is offered to show how CIRA proceeds from high-level dimensions based in ecology to specific indicators that may be applied in practice. The third section demonstrates how the CIRA framework may be applied to an actual measurement task. This is accomplished by describing how resilience measurement was carried out in a resilience-focused study conducted in Tanzania. The paper concludes by discussing how the CIRA methodology and a common metrics may be linked to other efforts such as data harmonization, large-scale aggregation, and cross-agency collaborations. The value of creating a coordinated program of work on core indicators for resilience analysis are also discussed.

Resilience Concept: A Theoretical Synopsis and Motivating Questions

As a shared topic of research applied to the challenges of food security and poverty reduction for shock prone populations, resilience is relatively new. The emergent literature on resilience for development applications is, however, rooted in several disciplines with longer histories. Key points of reference on which fundamental ideas for resilience measurement may be based include ecology (e.g., Folke, et al., 2010; Hollings, 1973), engineering (Hollsnagel, Woods and Leveson, 2007), and psychology (Masten, Best, and Garmezy, 1999). What is shared across the disciplinary perspectives on resilience is an interest in understanding how a given entity is able to regain, and possibly improve upon, its function and recover in the face of shocks and stressors. In the field of ecology, for example, the entity of interest might be a pond, a forest, or the larger eco-system in which a pond or forest is located. The shock might be a pest outbreak or the growing presence of an invasive species that threatens the biodiversity of a forest. A pond, or a marine ecosystem, may be threatened by increasing levels of nitrogen and phosphate caused by fertilizer run-off from agriculture. The health of both forests and ponds may be threatened by increasing levels of sulfur dioxide and nitrogen and resulting effects of acid rain. Presentations on resilience within the field ae are typically focus on the ability of some entity to recover its function (or status), in response to shocks and stressors, as observed in a given context. Resilience thinking (Walker, Salt, and Reid, 2006) also suggests that the recovery sensitive to temporal and spatial aspects of recovery. Kinzig et al. (2006) highlight the need to consider thresholds and tipping points as part of resilience.

When studying resilience in development settings, the entity of interest might a household, a village, a community, or a larger aggregate such as state or an entire country. Because of the dependence on agriculture-based livelihoods strongly linked to food security in developing countries, shocks to ecological systems affect the agro-ecological conditions on livelihoods, food security and the overall welfare of households and communities. Making matters worse, those living in development settings have to deal with the effects that set of shocks and stressors have on a range of socio-economic circumstances and structural conditions that underwrite welfare. Most developing country settings, for example, must also deal with food price volatility, stressed markets, inefficiencies in supply chains, dysfunctional (or non-existent) institutions, failed or failing governments, political conflict, and pressures created by growing numbers of refugees and internally displaced persons.

Motivating Questions and Theoretical Perspectives

Resilience measurement is concerned with the tasks of collecting and analyzing data in a manner that allows one to examine the dynamic (i.e., time-dependent) relationship among selected variables so as to explain heterogeneity of well-being following (and perhaps during) shock exposure event and/or in context of ongoing stressors. In development settings, the measurement task is driven by the need to answer to a series of important questions such as the following: Why is it that some households or communities recover more fully and/or more rapidly than others? In what ways does the structure of livelihood practices differ between those households and communities who appear to be more resilient compared to those who do not? What types of social safety nets, for what types of shocks and/or stressors, provide the most effective protection? In what ways, and to what extent, do a given set of agro ecological conditions, either support or interfere with the ability to be resilient? How do the effects of climate change affect the capacity of households and communities to be resilient in the face of shocks and stressors? The opportunity to provide evidence-based answers to questions of this kind is what drives the measurement agenda.

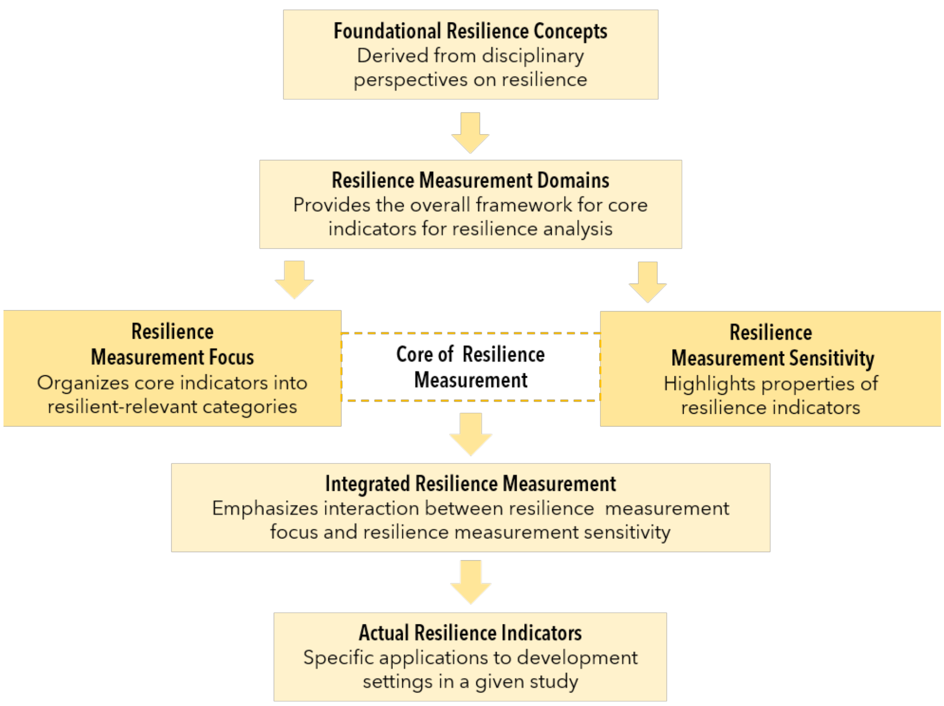
Insights about how to construct a core indicators framework for food security in development settings can be informed by relevant theoretical perspectives and analytical approaches. Building on Foster-Greer-Thorbecke (FGT) (1984; 2010) poverty measure, Barrett and Constas (2014, p. 14626) introduce a theoretical perspective on resilience that is tailored to development. The theory they outline defines development resilience as "…the capacity over time of a person, household, or other aggregate unit to avoid poverty in the face of various stressors and in the wake of myriad shocks. This theoretical perspective on resilience informs measurement by pointing out the need for indicators on capacities, shocks and stressors, and avoid of poverty or well-being." Leveraging the probabilistic approach pioneered by FGT, the theory also emphasizes the need to observe well-being over time.

Advancing a common analytical model for resilience measurement, (Constas, Frankenberger, and Hoddinott, 2014) specify a causal framework that organizes indicators under three components (an ex-ante component, a disturbance component, and ex-post component) and contextual factors. Signally the importance of observing change over time in the face of shock and stressors, both the ex-ante component and the ex-post component highlights the need to measure well-being, and the capacities that ensure well-being, in the face of shocks and stressors. The disturbance component is focused on shocks and stressors that include wide-spread disturbances (covariate shocks and stressors) and more localized or individual disturbances (idiosyncratic shocks and stressors). Consistent with the resilient literature based in ecology, the common analytical model for resilience measurement also makes references to a set of indicators that represent contextual and systems level variables. Indicators representing contextual variables might, for example, include political situation, cultural factors, and agro-ecological conditions. Indicators representing systems level variables might include indicators that represent, for example, the functional integrity of governments and institutions, and the structure of markets, and transportation systems on which both access to markets and the movement of food goods and other goods depend.

The Core Indicators for Resilience Analysis Framework

Before providing a detailed explanation of CIRA, it is perhaps useful to make transparent the overall logic of the approach. The driving questions for a project on core indicators is as follows: **What are the fundamental characteristics of data that have the capacity to describe and/or explain resilience dynamics?** In response to this question, Figure 1 provides a simple illustration of the four elements that reflect the logical structure of CIRA.

Figure 1. Logic of core indicators for resilience analysis



Following the logic of Figure 1, the ability to generate (in the case of primary data) and/or select (in case of secondary data) the strategy for CIRA is be described in terms of: 1. Foundational resilience concepts,

2. Resilience measurement domains, 3. Integrated resilience measurement, and 4. Actual resilience indicators. These four elements are offered as an ordered set of considerations that underwrite the effort to generate core indicators for resilience analysis.

Foundational resilience concepts, which are derived from the primary disciplinary perspective on resilience (i.e., ecology), provide the building blocks for resilience measurement. It is here that basic ideas on what needs to be measured to understand resilience are introduced. As noted above, the foundational literature highlights the importance of functioning (or status), shocks, and stressors, and the ability to recover functioning, and the importance of a systems perspective as part of resilience measurement. The foundational resilience concepts also highlight the need to more closely consider temporal, spatial, and critical thresholds into our accounts of recovery.

The **resilience measurement domains** element of CIRA is comprised of resilience measurement focus and resilience measurement sensitivity. Resilience Measurement Focus (RMF) draws attention to the content of indicators that need to be included in resilience measurement. In this sense, the RMF domain is concerned with the question of what data needs to be collected as part of resilience measurement. **Resilience measurement sensitivity (RMS)** draws attention to the properties (i.e., temporal, spatial, and threshold-related) of resilience measurement. The RMS, which is based on the resilience thinking literature (Gunderson et al., 2010; Walker, Salt, and Reid, 2006) and on measurement guidance for food security (Constas, Frankenberger, and Hoddinott, 2014), describes properties or resilience measurement. The RMF and the RMS constitute the substantive core of CIRA.

Resilience measurement that is well integrated pays close attention to both RMF and RMS. RMF and RMS are necessary parts of resilience measurement. Each one alone, however, is not sufficient. Integrated resilience measurement the result of a successful effort to explore and measure the interaction between RMF and RMS. The interaction of RMF and RMS is a topic that will be discussed in a subsequent part of the paper and is reflected in Tanzania study that is used as an empirical example of CIRA. As core elements of CIRA, resilience measurement focus and resilience measurement sensitivity require further explanation. The next two subsections provide this detail and include the first component of CIRA – the resilience matrix for development applications.

Resilience Measurement Focus: From Dimensions to Indicators

As a focus of measurement, resilience draws attention to the need to obtain and analyze data that will help one understand the **dynamic relationship that explains how and why a given entity is able to retain its fundamental functions, bounce back, or bounce back better in the face of persistent stressors and/or in the face of a catastrophic event. In the context of development and humanitarian relief, the goal of resilience measurement is to generate evidence and analyses needed to describe the extent to which households or different units (e.g., individuals or communities) are able to retain, regain, and/or improve well-being in the face of shocks and stressors.** As a basic point of departure, resilience measurement is also informed by the extensive empirical work on poverty analysis work (Alkire and Foster, 2011), where it has been demonstrated that complex constructs are best represented as a series of dimensions under which different types indicators may be organized. Guidance on what dimensions need to be included in resilience measurement are drawn from both Foundational Resilience Concepts and from a common analytical model of resilience measurement (Constas et al., 2014), the latter of which will be important as we work to translate fundamental resilience concepts into resilience indicator categories for development.

On a substantive level, seminal work in ecology (see Holling, 1973; Gunderson and Holling, 2002) highlights the importance of five dimensions of the resilience construct: 1. critical outcomes, 2.

disturbance events, 3. threatening conditions, 4. disturbance modifiers, and 5. systemic contexts. **Critical outcomes** reflect the status of some entity and/or its functions. **Disturbance events** are conspicuous incidents that threaten the status of some entity and/or undermine its fundamental functions. **Threatening conditions** represent ongoing set of sub-optimal, perhaps less pronounced, conditions that threaten the status of some entity and/or undermine its fundamental functions. **Disturbance modifiers** are hypothesized as enabling some entity to block or minimize the effects of disturbances, or to adapt or transform in the face disturbances. In ecological literature, these disturbance modifiers are typically characteristics of systems on which the health of some object (lake, forest, or soil) depends. In development setting, the disturbance modifiers may be a function of characteristics, capacities, strategies, and practices that households or other units (e.g., village or community) can draw upon when exposed to shocks and stressors – or in preparation for a shock or stressor. The **systemic contexts** dimension represents the structural conditions (both natural and human made) that may facilitate or hinder the ability to respond to disturbance events and threatening conditions.

Drawing on both conceptual (Barrett and Constas, 2014; Constas et al, 2014) and empirical work on resilience for development (d'Errico and Pietrelli, 2017; Smerlak and Vaitla; 2016; Smith and Frankenberger, 2018), the five above noted dimensions of the resilience may be translated into a corresponding set of resilience indicator categories (RICs). In development settings, **critical outcomes** are represented by well-being (see McGillivray and Clarke, 2006) indicators that reflect the status and functioning of households or other unit of interest. Sample indicators associated well-being may include, for example, food and nutrition security, poverty, and health (both physical and mental health), personal safety, and a sense of agency or self-efficacy.

Disturbance events*,* which are typically referred to as shocks in development contexts, are characterized by fast onset and large magnitude effect such as an earthquake, an outbreak of political violence, or the loss of a family member. Shocks may be experienced by single household or small number of households (idiosyncratic shocks) or by large population and over more expansive geographies (covariate shocks).

Threatening conditions are referred to as stressors have a slower onset and include conditions such as low water quality and/or poor sanitation practices, degraded agro ecological conditions (e.g., loss of biodiversity, soil erosion), challenging household structure (e.g., dependency ratio, migration of a family member for work with little return), health stress (e.g., family member with a chronic illness), or degraded social capital. It is important to note here that the accumulated effect of a stressor, or the effect of combination of stressors may, reach a threshold that results in its effects having negative effects on well-being that are worse those created by shocks.

Disturbance modifiers are frequently represented as enabling conditions and capacities that provide protections and help some entity withstand a shock, adapt or transform in the face of shocks The idea of resilience capacities has received much attention in development (see Bene et al., 2016; d'Errico and Pietrelli, 2017; Smith and Frankenberger, 2018). Following ideas first expressed in the ecology literature (Folke et al, 2004), resilience capacities for development are now conceptualized as exhibiting one or more types of capacities: absorptive coping capacity, adaptive capacity, and transformative capacity. In short, absorptive capacity refers to the ability to persist or cope in the face of shocks without making substantial adjustments to livelihoods or to the functions on which livelihoods and food security depend. Adaptive capacity refers to incremental changes made to manage the effects of shocks and stressors. Transformative capacities refer to a major structural change that enables a household, community to better respond to shocks and stressors.

The **systems** aspects of resilience are expressed as systemic contexts. Grounded in the seminal work on systems theory (von Bertalanffy, 1956; 1968) and informed by more contemporary discussion in development contexts (Erickson, 2007; Pingali and Sunder, 2017), the inclusion of systemic context as part of CIRA acknowledges the importance of food systems on which food security and welfare depend. Of the five dimensions introduced here as part of CIRA, the reference to systemic is perhaps the most complicated and least well defined. As Erickson noted, (2007), "[using a systems perspective, food security is a complex issue with multiple environmental, social, political and economic determinants. Adding some clarity on the issue, FAO (2018) noted "[t]he food system is composed of sub-systems (e.g. farming system, waste management system, input supply system, etc.) and interacts with other key systems (e.g. energy system, trade system, health system, etc.)." Making decisions about which systems and sub-systems to include as part of resilience measurement should ultimately be based in a causal theory that suggests a plausible connection between the characteristics (including functioning) of some system(s) and well-being and the and/or between the characteristics of some system(s) and their effect on enabling characteristics.

Resilience dimensions provide a foundation of ideas that can inform decisions about how to focus resilient measurement. Presented as a resilience measurement matrix for development applications, Table 1 provides a summary of five basic dimensions of resilience, a corresponding set of resilience indicator categories (RICs), and examples of resilience indicators.

Table 1. Resilience Measurement Matrix for Development Applications

Resilient Measurement Matrix for Development Applications		
Resilience Dimensions	**Resilience Indicator Categories**	**Example of Resilience Indicators**
Critical Outcomes The status and/or functioning of some entity that reflect its overall qualities and viability	**Well-being** Fundamental features of a household or community that are used to define its well-being (e.g., food security, health) and/or functioning	• Food security • Physical and mental health • Secure and stable physical dwelling • Personal safety • Agency and self-efficacy • Functionings and capabilities
Disturbance Events Pronounced events that threatens the status of one or more critical outcomes and functions of interest	**Shocks** Events that have an immediate and significant negative effect on the well-being of households & communities	• Death of family member • Major weather or geologic event • Marked political conflict • Drastic food price increase • Significant policy event
Threatening Conditions Ongoing condition that threatens the status of one more critical outcomes and functions of interest	**Stressors** Chronic pressures and/or low to moderate-level periodic events that increase vulnerability and effect the well-being households and communities	• Persistent food security, poverty • Poor health and poor sanitation • Lack of access to clean water • Crop and livestock pests- diseases • Poor agro ecological conditions • Diminishing social cohesion • Social/political unrest and conflict
Disturbance Modifiers Factors that positively influence the ability of an entity to respond effectively to a disturbance	**Enabling Conditions and Capacities** Resources, protections, adaptions, and transformative strategies available to households and communities to minimize the effects of shocks and stressors	• Assets as buffers and/or as self-insurance • Human capital and social capital • Livelihood strategies • Risk-diversified income sources • Social safety nets • Social cohesion in communities
Systems	**Systemic contexts**	• Governance and institutions

Natural and human made systems that may have a positive or negative effect	Systems found in development contexts that affect well-being and influence the impact of shocks and stressors	• Water and sanitation • Medical services • Market structure and functionality • Transportation infrastructure • Information/communication systems

As noted above, the **resilience dimensions** shown in the first column of Table 1 reflect what are largely agreed upon concepts associated with resilience. **Resilience Indicator Categories (RICs)**, also shown in column two, reflect the specific content of the focus of indicators around which CIRA will be structured.

To meet the goal of generating core indicators for resilience, it is important to think about categories of indicators rather than specific indicators. Consistent with the theoretical foundation of resilience, a comprehensively constructed set of indicators used for a given resilience measurement task would cover all five RICs of well-being, stressors, shocks, enabling conditions and capacities, and systemic contexts.

Resilience Measurement Sensitivity: Properties of Resilience Measurement

To be aligned with the resilience concept, an approach for core indicators should be complimented with ideas based on properties of resilience measurement. While the **focus of resilience measurement** highlights areas for which data on resilience may be collected, **resilience measurement sensitivity** draws attention to details related to how data collection and data analysis are designed and conducted. Decisions about when (including with what frequency) data are collected, the conditions of data collection, and methods used for data analysis allow one to investigate the functional relationship among indicators that are constitute the RMF – namely well-being, shocks, stressors, enabling conditions and capacities, and systemic contexts.

Consistent with the foundational work in resilience (Holling, 1973; Gunderson and Holling; 2002) and aligned with how change is observed over time (Abbott, 2001), resilience draws attention to collecting and analyzing data so that resulting measurement data are sensitive to three properties: 1. Thresholds and tipping points (threshold property), 2. Rates of change and trajectories (temporal property), 3. Cross-scale dynamics (spatial property). Although the importance of any one of these three properties of measurement is not unique to resilience, formulations of resilience from ecology and socio-ecological studies have consistently (Folke, 2006; Holling, 1992; Sterke, van de Leemput, and Peeters, 2017) argued that all three properties are important to consider as an interrelated set of properties that should be considered as part of resilience measurement.

Threshold property. Sensitivity to thresholds as a part of resilience measurement directs attention to phenomena such as tipping points, regime shifts, cascade effects (Folke et al., 2004; Kinzig et al., 2006). Recognition of thresholds is important because it signals the potential of critical points at which the behavior of some system or the values of some values shift significantly. One example from climate science is the heat-sink effects of increased ocean surface caused by the decreased coverage of the polar ice cap. Concerns about the measurement of threshold is useful because it helps identify the existence and consequence of precipitous points. Once a precipitous point is passed, the rate of change accelerates and the consequences of this acceleration may be very difficult if not impossible to reverse.

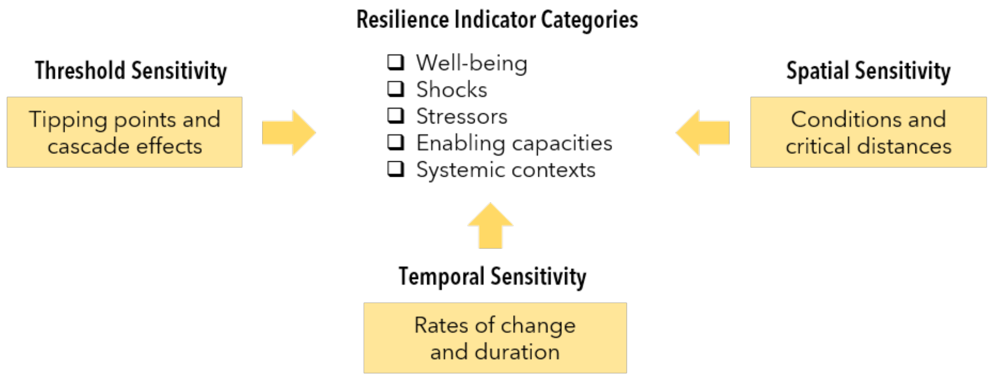
Temporal property - Placing importance of rates of change and trajectories draws attention to two interrelated concepts for resilience measurement is based in the fact that well-being and the conditions that support well-being are rarely time-invariant or monotonic. Ecologists whose work is concerned with resilience have highlighted the need to consider the differences between what they refer to as "fast" and "slow" variables (Ludwig, Jones, an Holling, 1978, Walker et al., 2012). The idea of differently speeded variables is important to consider because it provides insights on when and with what frequency data might be collected. Measurement that is sensitive to trajectories uses the notion of differently speeded variables to hypothesize about expected rates of change and non-linearity. From an analytical perspective, sensitivity to trajectories also draws attention to rates of change observed over time. The application of linear models to measurement data that is inherently non-linear would result a failure to detect change that may have taken place. On a practical level, the importance of rates of change and trajectories as part resilience measurement sensitivity can be illustrated by several questions: How long will it take for the effects of intervention emerge? At what point(s) does it make sense to collect data to observe change? How best can measurement findings be modelled to most accurately reflect change over time?

Spatial property - Ecologists introduced the notion of differently speeded variables. This notion refers to the fact that small units typically exhibit faster rates of change than larger units. For work in development, this idea would suggest that different rates of change should be considered in the measurement of households than might be applied to the measurement of communities. Larger units, such as institutions and governments will likely take longer to change and therefore require a longer period of measurement. From analytical question, sensitivity to trajectories and rates of change compels one to consider if it is best to use models based on assumptions of linear on non-linear relations. Ecologists have long recognized the need to understand and measure across different scales, particularly how it applies to adaptation. The importance of cross-scale dynamics is illustrated most directly in the idea of panarchy, an idea that is used to describe different phases of an adaption (Gunderson, Allen, and Holling, 2010). Thinking about and including cross-scale dynamics as part of resilience measurement provides an empirically tractable way of including a systems perspective. As Walker et al. (2006) have argued, it is not possible to the ambition to understand resilience is best served by measuring over multiple scales, rather than within a single scale. In development settings, sensitivity to cross-scale dependencies emphasizes the need to collect data take spatial factors into account as part of measurement. This translates into collecting data at the household level, at the community level, and possibly higher levels.

Integration of Resilience Measurement Focus and Resilience Measurement Sensitivity

As discussed above, paying attention to the idea of RMF answers questions about what **needs to be measured**. Paying attention to the idea of RMS draws attention to questions related to the properties of what is measured. While each of these constitutes a necessary part of resilience measurement, neither one alone is sufficient. To design a measurement activity that reflects a commitment to measuring resilience requires one to consider how the **focus of measurement** and the **properties of measurement** may be integrated. Figure 2illustrates how the five resilience indicator categories detailed above as part of the RMF domain of CIRA might be conceptualized in a way that reflects sensitivity to the properties of measurement that are important for resilience.

Figure 2. Integrated resilience measurement



The most comprehensive forms of resilience measurement approaches will cover all RICs and display sensitivity to all three properties of measurement noted in Figure 2. **As a foundational measurement axiom for effective resilience measurement we propose that all resilience measurement approaches should include indicators related to the five RICS - well-being, shocks, stressors, enabling conditions and capacities, and systemic contexts**. Resource limitations may, however, prevent this from happening. It is also the case that a given measurement approach may not be fully sensitive to the four properties of measurement – threshold sensitivity, spatial sensitivity, and temporal sensitivity.

The idea of integrated resilience measurement model shown in Figure 2 represents an aspiration to have indicators that are comprehensive across resilience measurement focus and across resilience measurement sensitivity. The utility of the framework, however, is more than an aspiration. The effort to advance the idea of integrated resilience measurement also helps one assess the completeness of a given resilience measurement approach. The concept of measurement shown in Figure 1, along with the RICs and sample indicators shown in Table 1, provide a shared point of reference on resilience measurement.

Empirical Illustration of CIRA: Case Example from Tanzania

To illustrate how CIRA can be applied to an actual measurement task, the empirical example introduced here is based on the Resilience Index Measurement Analysis (RIMA) approach (FAO, 2016) for a study that was conducted in Tanzania (d'Errico, Romano, and Pietrelli, 2018). At the center of the RIMA approach is a widely used index of resilience, FAO's Resilience Capacity Index (RCI). The study in Tanzania illustrates how the RIMA methodology reflects aspects of CIRA approach. Tanzania has been selected for the CIRA illustration because of the value of the resilience perspective in such country. While the poverty has declined and education and income have gained in the last decade,[4] many source of shocks and stressors continue to threaten the population wellbeing. Among the others, the country is at high risk from the impact of climate change due to the expected increase of the country temperatures (Rowhani et al. 2011). From a methodological point of view, the Tanzania study (d'Errico, Romano, and Pietrelli, 2018) has the advantage of being representative of a standard resilience analysis to food insecurity by employing a set of variables used in different RIMA applications and not coming from an ad-hoc data collection. Therefore it can be used as an exemplificative study enough of the RIMA approach.

To build the case example that illustrates the utility of CIRA, an overview of the RIMA approach is first provided, followed by a description of the data sources. A third sub-section illustrates how the focus of is measurement element of CIRA is manifest in the resilience indicator categories (RICs) used in the RIMA approach. A fourth sub-section shows how the resilience measurement sensitivity aspect of CIRA is

[4] More information are available on the World Bank webpage: https://www.worldbank.org/en/country/tanzania

reflected in the RIMA approach. As noted above, it is not realistic to assume that a given measurement task will demonstrate all three areas of resilience measurement sensitivity across all RICs.

Overview of RIMA Approach

RIMA is an econometric approach for estimating household resilience to food insecurity at the household-level. Early attempts were originally proposed by Alinovi, Mane, and Romano (2008) and Alinovi et al., 2010. The focus on households – proposed in these early studies - has been maintained until the today version of the approach. The household is the entry level of analysis because it is the decision-making unit; it is there, in fact, where the most important decisions are made on how to manage risks, including those affecting food securities. Additionally, the households are the main target for interventions and assistance.

The estimation process, however, has gone through a substantial revision. The revision process led to the second version of the methodology, the so called RIMA-II. The main improvement involved substituting structural equation modeling[5] to factor analysis as method to estimate the resilience index (see figure 3) and the use of a combo of regression and latent variable models (FAO, 2016).[6] Furthermore, the shocks have been excluded from the estimation of the RCI while food security indicators are used both for the estimation of the RCI to anchor resilience to an outcome and for regression analysis.

The RCI is now including only the components (so called pillars): access to basic services (ABS), assets (AST), social safety nets (SSN) and adaptive capacity (AC). The access to basic services, such as water, electricity, schools, health centers, and markets, is a fundamental factor that influence the ability of a household to effectively manage disturbance events. Ex ante, basic services play a key role in determining the risk exposure of the households. For example, "risk of illness is often closely related to particular environmental risks, linked to inadequate waste disposal, water supplies, and sanitation" (Dercon et al. 2008). On the other hand, after the occurrence of a shock, the access to services, such as road and markets, may facilitate the provision of assistance and consequently the household recovery capacity. Empirical evidence supports the association between access to basic services and the rate of recovery after a natural disaster (Khan 2014).

Productive and non-productive assets can directly influence the household ability to maintain the food security level when facing disturbance events. Known as consumption smoothing, households can decide to accumulate – in good years - and deplete – in bad years - their asset to protect consumption (Morduch, 1995). More generally, assets can be considered a proxy of household income[7], being the latter a key factor when facing shocks. Precautionary saving, for example, can be persuaded by wealthier households and be used for maintaining the household consumption and food security in case of shocks.

Besides being one of the major source of poverty alleviation and food security (Hidrobo et al., 2018) in a more general welfare support system, social protection - social safety nets - can allow households affected by negative events to maintain or recovery their food security when such measures are specifically targeted to respond to hardships. In fact, the access to formal transfers, whether cash or in-kind, can help households hit by shocks to avoid or minimize the food security loss. The same applies to informal transfers (from family, friends, associations, networks) that can act as insurance mechanisms in face of shocks.

[5] Multiple Indicator Multiple Causes (MIMIC) model.

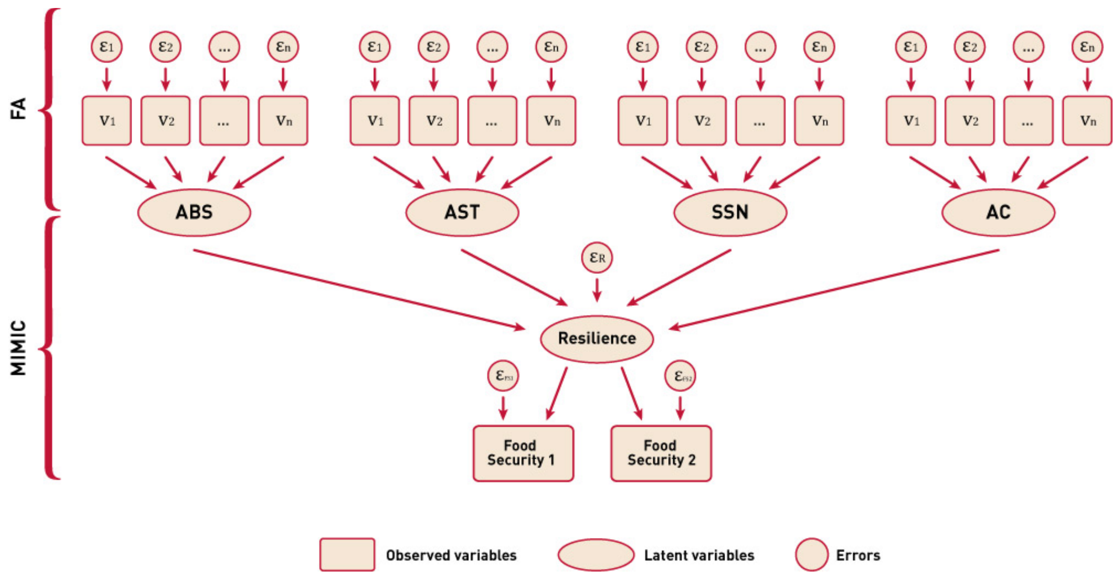
[6] The RIMA methodology has been validated by academic researchers through the publication in peer-reviewed journals (d'Errico and Di Giuseppe, 2018; Brück, d'Errico and Pietrelli, 2019; d'Errico and Pietrelli, 2017; d'Errico, Grazioli, and Pietrelli, 2017). This allows the RIMA methodology to explore additional aspects linked to household resilience, as the natural environment and the enabling institutional environment, and subjective aspects, as subjective well-being and social inclusion.

[7] FAO (2016, page 10) addresses the issue of measuring income at household level and employing asset variable and income in the estimation model for resilience.

In the RIMA framework, resilience involves not only the capacity of the household to absorb disturbances but also the capacity to reorganize themselves in a new and sustainable livelihoods in order to minimize the effect of disturbance events on food security (adaptive capacity). The adaption to perturbations and shocks is connected with being able to learn as well as with technological progress (Gallopin 2006). Therefore, the higher the education level, the higher the capacity to reorganize after the shocks. Additionally, the responses to perturbations can be both reactive and proactive (Gallopin 2006). For example, a farmer's households can improve its condition in relation to its environments by diversifying the crops produced or by producing drought-resistant crops in order to reduce the potential negative effect of crop pests and diseases or drought. More generally, the income diversification can reduce risk and increase income-generating options in face of shocks.

Shocks and stressors are considered exogenous to resilience and employed in regression analysis in order to establish a causal relationship with determinants while food security indicators are employed for the estimation of the RCI as outcome of resilience and for regression analysis.

Figure 3. RIMA approach



Since the original attempts, RIMA has been widely used by FAO to perform resilience analysis in fifteen Sub-Saharan countries – mostly in Sahel and the Horn of Africa – and Palestine.[8] The aim of RIMA is to provide evidence on household resilience for more effective (i) design / delivery and (ii) evaluation of assistance to populations. On one side (i), the identification of the most in need through RIMA help targeting the priority needs. On the other (ii), ex post the delivery of the interventions, RIMA can be used to assess the effect of interventions on the resilience of beneficiary populations.

In the Tanzania study (d'Errico, Romano, and Pietrelli, 2018) used for the empirical illustration of CIRA, the RCI is estimated according to RIMA approach. Table 3 in the annex shows the indicators used for estimating the RCI by pillar. Then the study uses the estimated household RCIs to test whether or not it captures household resilience to food insecurity. This is done assessing (i) whether RCI is positively related to future food security outcomes and recovery capacity after a shock, and (ii) analyzing the role of RCI in dampening the impact of such shocks.

Data Source

A panel dataset from the World Bank Living Standard Measurement Studies Integrated Survey on Agriculture (LSMS-ISA) is employed in the study: the 2008–2009, 2010–2011 and 2012–2013 Tanzania National Panel Survey (TZNPS). The dataset is nationally representative and offer a unique opportunity to study and compare household resilience across diverse regions. The LSMS-type questionnaire, including both household and community modules, was administered to the entire sample. Furthermore, an additional module collecting detailed agricultural information was administered to agricultural households.

Each observation was also geo-referenced, allowing for matching with other data sources providing geographically referenced information. Two additional datasets were merged with LSMS – ISA by exploiting the geographic reference of each household in this dataset. A climatic dataset was created by using the Normalized Difference Vegetation Index (NDVI) and the Palmer Drought Severity Index (PDSI).[9]

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[8] For a complete list of countries please visit the following webpage: http://www.fao.org/europeanunion/eu-projects/informed/en/

[9] The US Department of Commerce National Oceanic and Atmosphere Administration (NOAA) Center for Satellite Applications and Research provides gridded (at 4 square kilometer resolution) Normalized Difference Vegetation Index data derived from its Climate Data Record since 1981 (cf. https://data.noaa.gov/dataset/noaa-climate-data-record-cdr-of-normalized-difference-vegetation-index-ndvi-version-4). The Palmer Drought Severity Index is created using historical precipitation and temperature data incorporated into a hydrological model on a 2.5 degree spatial grid. This index data can be accessed at http://www.cgd.ucar.edu/cas/catalog/climind/pdsi.html.

Both indexes provide information on the health of vegetation in different regions across the world and were used to describe local conditions and to build weather and agro ecological shock variables. A second dataset, providing long-term (1997-2015) data on conflict episodes in African countries (Carlsen et al., 2010) was used to build a conflict intensity index as in Bozzoli, Brück, and Muhumuza (2011).

Focus of Measurement: Application of Resilience Indicators Categories

Well-being. Different food security indicators have been used in the analysis. In order to estimate the RCI by the FAO-RIMA approach, the study employs the household food consumption and the Simpson dietary diversity index.[10] The first indicator expresses the monetary value (in US dollars) of per capita monthly **food consumption**, including expenditure on food, the monetary value of auto-produced food, received for free food and stored food. The **Simpson dietary diversity index** is a measure of diet quality that is computed by considering the contribution of various food groups (cereals, roots, vegetables, fruits, meat, legumes, dairy, fats and other) to the overall caloric intake. For the estimation of the RCI, food consumption and dietary diversity are employed. In addition, the analysis of the probability of decreasing and recovering food security over time employs caloric intake and FCS.

To explore the relationship between resilience and food security over time, several indicators have been employed: an **indicator** for suffering a **decrease in the caloric intake** between t and t+1; and a **recovery** between t+1 and t+2; an indicator for suffering **a loss in the Simpson dietary diversity index** between t and t+1; and a **recovery** between t+1 and t+2.[11] To robust the results, the same indicators have been computed with the **Food Consumption Score** (FCS) and per capita monthly **food expenditure** as an alternative indicators of food security. The FCS is composite dietary diversity score based on food groups, taking into account food frequency and the nutritional importance of the different food groups.

Disturbance shocks. In order to capture shocks related to personal and asset losses and income events, the analysis uses a set of self-reported indicators.[12] They include indicators to assess if a household was affected in the last five years by **death of household or other family members, break-up of the household, household members jailed; livestock died or stolen, loss of land, fire, robbery, dwelling damage; rise in price of food, rise in agricultural input prices, fall in sale price for crops; business failure, reduction/loss of salary**. The indicators are all collected at household-level.

For capturing the weather and geological covariate shocks, in addition to a self-reported indicators for **drought/flood** and **severe water shortage,** a set of four indicators is employed, considering extreme events (flood/wet or drought/dry) and employing the NDVI or PDSI: **wet anomaly** (average NDVI of the growing season above one standard deviation from long-term average), **dry anomaly** (average NDVI of the growing season below one standard deviation from long-term average), **flood** (average PDSI of the growing season above one standard deviation from long-term average), **drought** (average PSDI of the growing season below one standard deviation from long-term average). Data on NDVI and PDSI covers a period of 25 years; the shock variables have been calculated as anomalies (distances from average) with respect to the overall trend.

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[10] The choice of food security indicators largely depends on data availability. It is widely recognized (Pangaribowo, Gerber, and Torero, 2013) that there exist many food security indicators; those employed in this analysis are not exhaustive nor the best possible indicators.

[11] A decline in caloric intake and dietary diversity between time t and t + 1 is defined as such only if the household food security indicator in time t + 1 is less than its value in time t minus 5%. Consistently, we considered that a household recovered the loss suffered between time t and t + 1 if its food security indicator in time t + 2 was greater than or equal to its value in time t minus 5%.

[12] The specific questions used are the following: "Over the past five years, was your household severely affected negatively by death of household members?" By drought or flood? And so on for all shocks and stressors. Yes or no answers are collected for each different shock or stressors.

For the political conflict metric, a **conflict intensity index**, as in Bozzoli et al. (2011), is built from data on conflict episodes in African countries (ACLED project). The data reports, for each conflict episode, the date of the event, the type of the event, the actors involved, geographical information on where the event happened (description of exact location, latitude and longitude), number of fatalities and the source of information. The conflict intensity index aggregates the events happened in a given year discounting them by their distance from where the household lives.

Stressors. Looking at the stressors, the Tanzania study includes household-level indicators for poor health, capturing whether the household was affected in the last year by **illness of household members**, and for livelihood, namely a self-reported indicator for having experienced **crop disease or pest.** A note of caution should be raised concerning the classification of the indicator for crop disease or pest as a stressor. In fact, no details are available on the length and severity of the events that allow a univocal categorization under shock or stressor. Finally in the Tanzania study, **long-term averages of the PDSI and NDVI** measure agro-ecological conditions (stressors) at a higher level of aggregation rather than household-level.

Enabling Conditions and Capacities-Predictors of well-being in the face of shocks. A comprehensive set of variables is employed in the study as predicting indicators of well-being (food security). In terms of the assets metric, both productive and non-productive assets are considered in the study. Among the productive assets, the study includes the **agricultural index** (an index created through factor analysis considering a list of variables assuming value 1 or 0 depending on whether or not a household has specific agricultural tools, such as plow, barrow, etc.); the value of **land** (in hectares) owned by the household; and the **Tropical Livestock Unit** (TLU), that standardizes different types of livestock owned by the household into a single unit of measurement.[13] To take into account non-productive assets, a **wealth index** is created combining a list of variables equal to 1 or 0 depending on whether the household owns a lists of specific assets, such as a television, a radio, a lamp and so on. Additional indicators of non-productive assets are: **home owned**, indicators for the **dwelling cement roof, brick walls and non-dirty floor**.[14]

The Tanzania study includes the **average years of education of household members** to measure the educational metric. The information on education is first collected at individual level in the household roster and then aggregated at household level as average.

An indicator for **income diversification**, counting the number of different income sources (as wages from agriculture and from other activities, farming production, non-agricultural business, and other income sources) the household relies on, is used in the Tanzania study. This indicator can measure both risk-diversified income sources and the non-agricultural source of income. While the link with the latter is straightforward, the income diversification indicator can also measure whether the household is relying on income-generating activities exposed to different sources of risk, such as farming production and wage employment. Additionally, the **income earners' share** (constructed as number of active household members older than 15 and younger than 64 years divided by the household size) is included in the analysis to measure the household capacity to generate income taking into account the household size the age composition of its members. To measure the social safety nets the household can rely on in case of shocks, the Tanzania study takes into account the monetary value of the **formal transfers** received by the household in per capita terms as well as the monetary value of the **informal ones**.

[13] TLU is a weighted sum of the number of different livestock owned by the household. The conversion factor (weights) adopted is: 1 camel; 0.7 cattle; 0.55 donkeys/mules/horses; 0.1 sheep/goats; 0.01 chickens.
[14] This indicator is part of a larger infrastructural index. More complete information on the index, which was created using principal component analysis, may be found in d'Errico, Romano, and Pietrelli (2018).

Systemic context. For the Tanzania study, systemic context was measured in terms of infrastructure conditions and services that may be taken into account as part of the resilience analysis. First, for transportation infrastructure, the case example uses indicators for **distance to school and distance to markets**, expressed in Km. These indicators can only partially cover the availability of infrastructures with the consideration that households living in communities where public infrastructures are more developed need to travel shorted distance to reach the service they need. On the contrary, the physical distance between household and service does not reflect the conditions of the road network neither the public system of transportation available. Second, for basic services infrastructure, sanitation is represented by an indicator that assess if a household had **access to a toilet** in the household dwelling. Additional indicators for basic services infrastructure are the **access to running water and to electricity**. While access to a toilet, running water and electricity are experienced at the household level, their availability can be viewed as reflecting the broad systemic contexts in which people live.

Properties of Measurement: Resilience Measurement Sensitivity

Consideration of the indicators represents just one part of the CIRA framework. To view resilience measurement more comprehensively one should also consider the properties of measurement. As suggested by the graphic portrayal of this intersection displayed in Figure 2, it is useful to explore how indicators used in resilience analysis are sensitive to temporal, spatial, and threshold related aspects of measurement. The measurement goal is integrative in the sense that one should consider the way in which the focus of resilience-related indicators intersects with certain properties of resilience measurement The operational question posed in connection with this goal can be expressed as question: In what ways does the collection and/or analysis of data allow one to draw inferences that reflect sensitivity to the temporal dynamics, spatial features, and critical thresholds? Table 2 show how the ideas of resilience measurement focus and resilience measurement sensitivity intersect in the case of the Tanzania study.[15]

Table 2. Application of CIRA to the Tanzania study

Properties Resilience Measurement Tanzania Study	
Resilience Indicator Categories and Actual Indicators Applied for Measurement	**Properties of Resilience Measurement**
Well-Being	
Food security - Food consumption, Simpson dietary diversity index, indicators for decrease and recovery of per capita caloric intake over time, indicators for loss and recovery of Simpson dietary diversity index, indicators for decrease and recovery of food expenditure , indicators for decrease and recovery of Food Consumption Score	**Temporal Sensitivity** Food security measured over time to examine trajectories following shock exposure and at points in time that reflected expected change **Spatial Sensitivity** Food security measured at household level but modelled to reflect spatial dynamics (regional trends might capture population density, food prices, etc.) **Threshold Sensitivity** Food security measured with reference to normative threshold: a fixed (percentage) variation of the indicator value measured at time t-1

[15] The table also apply to the Uganda case presented in the same analysis (d'Errico, Romano, and Pietrelli, 2018).

Properties Resilience Measurement Tanzania Study	
Resilience Indicator Categories and Actual Indicators Applied for Measurement	**Properties of Resilience Measurement**
Shocks	
Personal loss - Death of household members, death of other family members, break-up of the household, household member jailed **Asset loss** – livestock died or stolen, loss of land, dwelling damage, robbery, fire **Weather** - Wet NDVI anomaly (AG); Dry NDVI anomaly (AG); Severe water shortage, PDSI flood; PDSI drought (AG); Drought and flood **Conflict** - Conflict intensity index **Income flows** - Rise in the food prices; fall in sale price for crops; rise in agricultural input prices; business failure; reduction or loss of salary	**Temporal Sensitivity** Perceived effect of shock measured at initial time t and with reference to thresholds based on long-term patterns **Spatial Sensitivity** Perceived effect of shocks at household level, and secondary data evidence of covariate shocks that reflect across agro-ecological zones **Threshold Sensitivity** Self-reported idiosyncratic indicators without reference to thresholds and weather covariate shocks measured with reference to a threshold based on long-term patterns: one standard deviation from the long-term average.
Stressors	
Health and sanitation - Illness of household members, **Livelihoods** - Crop diseases or pests, PDSI long-term average (AG), NDVI long-term average (AG)	**Temporal Sensitivity** Stressors measured at initial time t and over long-term. **Spatial Sensitivity** Measured at household level and secondary data associated to agro-ecological zones **Thresholds Sensitivity** Continuous or dichotomous stressor indicators without reference to a normative threshold
Enabling Capacities	
Economic assets - Agricultural asset index, land owned, TLU; wealth index; home owned, home with cement roof and brick walls and non-dirty floor **Human Capital** – Education level of the household members **Diversification and income flows** - Number of income-generating activities (HH), income earners' share; per capita informal transfers, per capita transfers	**Temporal Sensitivity** Capacities are measured at initial time t to test the link with food security worsening (at t+1) and recovering (at t+2) over time **Spatial Sensitivity** Measured at household level **Thresholds Sensitivity** Continuous indicators measured without reference to normative thresholds
Systemic Context	
Transportation infrastructure – Distance to school, distance to markets in Km **Basic services infrastructure** – Access to running water, access to toilet and access to electricity	**Temporal Sensitivity** Measured at point at initial time t **Spatial Sensitivity** Access to services is measured at household level but reflect broader contexts where households live (infrastructures and services) **Thresholds Sensitivity** Continuous and dichotomous indicators measured without reference to normative thresholds

The Tanzania application shows that the RIMA methodology reflects all the five RMS with attention to the three RICs:

- Food security: the food security indicators are used for the estimation of the RCI and for regression analysis;
- Enabling conditions and capacities: indicators are used for the estimation of the Asset, Adaptive Capacity and Social Safety Nets RIMA pillars, employed for the estimation of the RCI;
- Systemic context: indicators used for the estimation of the Access to Basic Services RIMA pillar, used for the estimation of the RCI;
- Shocks and stressors: not employed for the estimation of the RCI but for regression analysis.

The CIRA approach sheds a light on potential areas of further development of the RIMA methodology, especially for what concerns the application of the RMS to the RCI. While RMS directly applies to some RIMA indicators, a methodological extension can involve the identification of a resilience threshold for the RCI. The paper by d'Errico et al. (2019) goes in this direction and proposes a methodology for the estimation of the thresholds of the RIMA RCI below which the households are not able to absorb the negative effect of temperature anomalies on food consumption growth.

Conclusion

One of the aims of this paper is to provide a framework demarcating resilience as an area of measurement that places specific demands on the measurement. This is accomplished through a logic of resilience measurement that integrates two domains for resilience measurement-resilience measurement focus and resilience measurement sensitivity. The RMF and the RMS, each in its own right, helps clarify the distinctive demand of resilience measurement. The RMF underlines the importance of having indicators for well-being, shocks, stressors, enabling conditions and capacities. When considered together, these two domains help elucidate the claim that resilience measurement introduces a special set of empirical demands on measurement. When considered together, RMF and RMS highlights the ways in which resilience places a special set of demands on measurement in development settings.

An additional aim of this paper was to promote approaches resilience measurement that support the ambition for harmonized metrics. CIRA achieves this objective by providing a framework that can guide resilience measurement as a convergent enterprise, one that allows various sets of indicators to be organized under resilience indicators categories. **On practical level, the CIRA framework may be used as a tool to guide the creation of new indicators (in the case of primary data collection) or and/or as a tool to select a set of indicators for forms of resilience analysis that draws upon secondary data.**

It is important to note that point the ambition to specify core indicators for resilience does not require verbatim or uniform expression of questions or items that might appear on a household survey. Rather, **the value of a protocol for core indicators is to ensure that data for resilience are consistently collected in the four primary RICs of well-being, stressors, shocks, enabling conditions and capacities, and systemic contexts.** This strategy for CIRA is similar to what is followed in a public health measurement initiative of the World Health Organization (WHO). WHO has identified a list of 100 core indicators organized under four primary categories of health status, risk factors, service coverage, and health systems (see WHO, 2015, 2011). Within the WHO framework, four primary categories are further represented by a set of 24 sub-categories with each primary category represented by a minimum of four sub-categories (for health status) and a maximum of nine subcategories (for service coverage). The potential value of the CIRA approach, and the WHO approach that specifies a general set of indicators, is that the existence of core indicators enables comparability and does so in way that provides flexibility needed to work across settings, across populations, and over time. The exact indicators used may vary based on data sources drawn upon (i.e., primary or secondary data). Problems of indicators having different scales or being collected from populations with different distributions are problems that can be solved through basic (e.g., z-scores) or more complex standardization procedures (e.g., factor analysis or principal component analysis)

Clearly, the task of reaching agreement on core indicators for resilience measurement will require more than conceptual frameworks, graphics, and empirical demonstrations. Because active debate is a natural consequence of the effort to reach agreement, it is important to identify ways to frame shared and dissenting opinions about common indicators for resilience. We believe that exploring the resilience measurement focus and resilience measurement sensitivity represents a starting point in such discussion.

Annex

Table 3. Tanzania study indicators used for the estimation of the RCI

Pillars and Food security:	Variables:
Access to Basic Services	Infrastructural index: home owned, dwelling cement roof, brick walls and non-dirty floor, access to running water, toilet and electricity. Distance to school Distance to market
Assets	Agricultural asset index Wealth index Tropical Livestock Unit Land
Adaptive Capacity	Income diversification Education Income earners' share
Social Safety Nets	Private transfers Public or other transfers
Food security	Per capita food consumption Household Dietary Diversity

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