COSA Committee On Sustainability Assessment

FORD FOUNDATION

Simpler Resilience Measurement

Tools to Diagnose and Improve How Households Fare in Difficult Circumstances from Conflict to Climate Change

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Executive Summary

We are certain that resilience is a key factor to address poverty and inequality and yet work on this topic is currently severely hindered because it is very costly and requires substantial expertise. With the support of the Ford Foundation, we undertook to build on the best of current practices but in a fundamentally new way by streamlining and creating more pragmatic options to understand resilience.

From climate change to volatile markets, the world's smallholder farmers face a staggering array of risks. The ability to overcome disaster and setbacks is vital to the survival and wellbeing of farm families as well as to the viability of rural communities. This resilience is increasingly recognized as necessary and yet we have only a modest concept of how to understand it. When farmer resilience is not well understood, we lose important ways to help families cope or simply do not put the knowledge of what works to good use.

There are a number of recent initiatives that have undertaken to understand resilience and, while many are excellent in their concepts, most of them share two common shortcomings: complexity and high implementation costs. Many are impractical for widespread use by the majority of development projects or supply chain managers. Without a simple, low-cost way to evaluate and measure resilience, access to this vital knowledge is restricted to all but the most well funded projects that can afford to engage scientific or academic support.

The COSA Resilience Measurement approach takes a different path. It builds on the best current work to distil the optimal practices into a pragmatic and relatively low-cost process that permits a solid basic understanding while increasing broad access to these simpler tools. The COSA Resilience Measurement approach began with a thorough review of current global best practices and the growing literature on the topic. It then gathered a Working Group of leaders in the field to help filter and test the most vital practices so that resilience can be more readily measured, understood, and acted on.

With the generous support of the Ford Foundation and the Working Group composed of Lutheran World Relief, International Center for Tropical Agriculture, Conservation International, Sustainable Food Lab, Catholic Relief Services, and Root Capital, COSA developed these tools as a contribution to the public good:

- Resilience Tool comprised of an accessible and low-cost set of resilience indicators and accompanying metrics based on an accurate distillation from global best practices
- Guidelines for using the Tool in the field
- Field test protocols as applied in Kenya, Peru, and Nicaragua

The key results have been shared at several conferences and workshops including the COSA-led Resilience Learning forum in August 2017 with nearly 200 global participants. The Resilience Indicators are publicly available on our website.

Learning is particularly critical at this early stage of the science of resilience. The challenges and lessons learned while building and operationalizing these Resilience Tools are presented and discussed throughout this report and we suggest ways forward for future efforts. In brief, the key project lessons:

1. Many useful efforts have emerged in recent years however, with some exceptions, they have tended to operate in silos such that cross-learning is very limited.

2. We acknowledge the substantial cost and time needed to gently open the silos and have needed to evolve a well-managed sharing process so that it adds value to all.

3. Nearly every current approach requires substantial fieldwork that is made more costly and complicated by the intrinsic ad hoc approach requiring a person with substantial scientific or academic experience to design and interpret the research each time.

4. We cannot eliminate all complexity, but we can make resilience more accessible.

5. The Learning Group and other commentators have clearly noted substantial value in having agreement and standardization on commonly used indicators.

It is interesting to note that the lessons from the Field Research (see main text below) indicate that it will be faster to learn from projects that use simpler, common indicators. Such common approaches allow for comparisons and benchmarking as well as distinguishing trends to learn from.

The Path Forward

The topic of Resilience is clearly complex and we understand that there is still much to learn in order to improve access for all (communities, practitioners, etc.) and to advance current efforts in this field. Academic disciplines are vital to our overall understanding but must also be available in more streamlined and pragmatic approaches. We are certain that the creation and sharing of comparable and globally accepted metrics for measuring resilience constitute necessary steps toward this end.

Measuring results in a cost-effective and practical manner is critical for achieving this goal. To advance Resilience Measurement Tools, further attention should focus on:

1. **Integration of household and community systems for a clearer picture of resilience:** The COSA Working Group agrees on the necessity to integrate different levels of investigation to assess the multi-dimensionality of resilience. We wish to begin to develop a Community Resilience Assessment Tool to integrate household and community resilience.

2. **Applying the tool in other fields:** Our experience suggests that there are opportunities to use the COSA Resilience Measurement approach in many other fields such as livestock systems or even urban settings.

3. **Real-time, accessible resilience information:** COSA continues to pursue the development of cloud-based modules, more accessible presentation graphics, and real-time “dashboards” that improve the speed and understanding of the information for managers at every level. We could develop a resilience monitoring system with real-time information at farmer, community, and supply chain levels.

4. **Building a common resilience index:** An index facilitates general understanding and the COSA Working Group has developed a resilience index based on factor analysis. Broadening research and discussion should help refine insights in order to find a commonly accepted index approach.

5. **Sharing and scaling** much more widely across the current silo efforts and also to a much larger group of project and supply chain managers can improve conditions more quickly, and with a better understanding of the core issues and how to address them.

Over time, this process is designed to build iteratively and to engage thoughtful and informed dialogue to integrate diverse approaches. It will thus allow a more open and rigorous understanding of resilience. This Resilience Measurement approach will hopefully inspire more practical decision-making and help farm families and rural communities bolster their own viability and resilience.

Introduction

Today, the food supply of a large portion of the world's population comes from smallholder farmers. They are among the most vulnerable workers anywhere. The markets on which they depend are volatile; they have little support beyond what they earn in the fields; and now they are among the first victims of a crisis that will only worsen in coming years, climate change. They endure, but their position is fragile.

The development community increasingly recognizes the necessity of resilience in response to disaster and climate-change phenomena. However, understanding the resilience of farmers and their communities is currently very costly and requires expertise, both of which present major hurdles. Development practitioners lack even a common language and standardized metrics to measure resilience. The absence of a commonly accepted system for measuring resilience undermines the ability of the development community to objectively monitor and evaluate resilience-building programs. Further, access to this vital knowledge is limited to all but the most well-funded and professionally skilled projects because low-cost and readily applicable metrics are not available.

With the generous support of the Ford Foundation, COSA leads a Resilience Working Group of partners to build a more widespread understanding of the key facets of resilience by identifying and measuring those elements which determine it.

The work began with a thorough review of current best practices globally and the literature in the field. Building on its experience, COSA then instituted a systematic process of distilling the embedded knowledge and the indicators already in use. Part of the process involved filtering each indicator for SMART criteria and its policy relevance in relation to the Sustainable Development Goals (SDGs) and resilience global best practices. The results were shared with the Working Group and tested in different field locations.

The lessons learned from the field allowed us to define a set of Resilience Key Performance Indicators (R-KPIs) to create pragmatic knowledge on critical aspects of resilience and to address two main issues of the current resilience approaches: complexity and high implementation costs.

The Resilience Measurement Tool structured by the COSA Working Group assures easy accessibility for all stakeholders, including local institutions, development practitioners, civil society organizations, and business supply chains. The practical approach we took to the Resilience Measurement Tool means it can be applicable across projects of different scales, including many

Equal Access

The practical approach we took to the Resilience Measurement Tool means it can be applied across projects of different scales, including many groups or initiatives that have neither the budget nor the inclination to undertake in-depth scientific research.

initiatives or projects that have neither the budget nor the inclination to undertake in-depth scientific research that was previously required to get a sense of the level and scope of resilience in a community. COSA also hosted a learning forum (web-based) to review the tested versions and discuss those with leading practitioners from diverse development agencies including USAID, Catholic Relief Services, Sustainable Food Lab, and Root Capital.

Resilience and Its Measurement

The development community uses several variations of the resilience concept and there is an ongoing debate about how resilience is best understood and measured.

COSA and its Working Group apply a fundamental definition of resilience that encapsulates core attributes used by key development agencies (Box 1):

Although the importance of resilience in the face of increasing stresses is unquestioned, there are no pragmatic guidelines about how to optimally measure resilience and how to best approach it. Various institutions conduct valid, high-quality scientific research around resilience measurement (CIAT, FAO, USAID, Resilience Measurement Technical Working Group). COSA and its Working Group built the tool on this sound base. In other words, we did not reinvent any wheels, but we distilled indicators and metrics from the existing literature and investigated whether there was any room to simplify resilience measurement in order to obtain actionable results in an easy, low-cost way.

Box 1: Resilience Definition

The capacity of people, communities, or systems to prepare for and to react to stressors and shocks in ways that limit vulnerability and promote sustainability.

This definition reflects the attributes generally agreed upon in the scholarly literature by leading theoreticians (FSIN, 2014a):

Multiple scales: Resilience is observed at different levels: from individuals to households, communities, and systems.

Multiple capacities: Resilience is a combination of different capacities: (1) to recover after a shock (absorptive capacity); (2) to adapt to a changing environment (adaptive capacity); and (3) to transform (transformative capacity).

Disturbance specificity: Resilience is also the capacity to react effectively to a shock (idiosyncratic and covariate) and a stressor (degradation of natural resources, political instability, or diminishing social capital) that undermine the stability of a system (political, economic, social, or environmental).

Vulnerability and sustainability: The ultimate goal of resilience is to limit vulnerability and promote long-term sustainability.

Source: Serfilippi and Ramnath (2017)

These needs inspired the activity of the Working Group in all phases of the project, from the selection of the overall resilience indicators library, to operationalization in the field, to the identification of Key Performance Indicators for Resilience.

What the tool is and what it does

The main tool includes a full set of 76 indicators (resilience indicators library). A core set of 27 Resilience Key Performance Indicators (R-KPIs), identified through field tests, permit a more agile application. We also offer a simplified set of 11 critical KPIs that can be used even by low-budget projects that do not have a resilience focus. To facilitate adoption and use of the indicators, an accompanying guidance document was developed.

The tool can serve to:

- Provide diagnostic information to inform an intervention or initial design
- Inform policy and readily convey the major factors using a resilience index
- Identify and test strategies to improve household resilience
- Evaluate the relative impact of local interventions or services in building resilience

The five salient features of the tool are summarized below.

1. **Science based**
   COSA and its Working Group reviewed current best practices in leading institutions, interviews with noted experts, and conducted a review of published and unpublished literature on the topic.[1] This work led to the creation of the library of 76 resilience indicators at the household level.

2. **SMART**
   We applied SMART filters to the indicators. SMART indicators translate complex phenomena that are difficult to perceive or measure into simple, actionable metrics. These filters guarantee the **Specificity** of the indicators (so that people in different countries and contexts are comparing the same thing when they measure); their **Measurability** (data are required to

Box 2: Features of the Resilience Tool

1. Science based
2. SMART
3. Policy relevant
4. Accessible
5. Low-Cost

1. Resilience models consulted run the gamut from NGOs to academia to development agencies. They include work from the Food and Agriculture Organization (FAO 2013; 2014; 2016), International Fund for Agricultural Development (IFAD; 2015), Organization for Economic Cooperation and Development (OECD; 2014), OXFAM (2013, 2015), International Center for Tropical Agriculture (CIAT; 2015), Mercy Corps (2015), United Nations Development Program (UNDP; 2013), United States Agency for International Development (USAID 2013; 2015), Resilience Measurement Technical Working Group (FSIN 2014a; 2014b; 2016), Tulane University (2012) and Ciani and Romano (2013). Disaster and vulnerability indicators include sourcing from the University of Notre Dame Global Adaptation Index (ND-GAIN; 2015), World Risk Index (WRI; 2015), Livelihood Vulnerability Index (LVI; 2009) and the Environmental Performance Index (EPI; 2016).

support the indicator); **Actionability** (a specific action could be undertaken thanks to information provided by the indicator); their **Realism** (indicator isn't theoretical or naive); and **Trackability** (indicators should measure changes over time).

3. **Policy Relevance to Sustainable Development Goals (SDGs)**
   The value of the SDGs is, in part, predicated on the ability to measure the goals and progress in ways that are functionally useful and accessible to a large number of agencies or researchers. The transparency and comparability across geographies and sectors is a critical function of any metric.

   Resilience is integral to achieveing many of the SDGs even though the focus on resilience is mainly articulated in Target 1.5: "Build the resilience of the poor and those in vulnerable situations, and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters by 2030." The overall analysis linking resilience indicators with policy-relevant objectives indicated by the SDGs is presented in Appendix A.

4. **Accessible**
   This toolkit makes resilience more accessible because it is practical and can be applied by technicians, communities, and supply chains with minimal training. Indicators are standardized to permit comparability and allow for different persons conducting measurements. Simple guidelines assist the user in the field, thus enhancing the practicality of the tool.

5. **Low Cost**
   A basic understanding of resilience is possible without mounting a complex, long-term research project. In fact, core issues can be readily tracked throughout a project or intervention, or as needed by a community. The flexibility of the resilience Key Performance Indicators allows them to be used in low-cost projects that need to simply determine resilience areas of improvement, as well as in full-scale resilience interventions.

Looking Inside the Tool

The COSA Working Group has consistently aligned with the main systems of indicator classification that reflect the dominant conceptual understanding of resilience. Table 1 illustrates the classification of the core set of 27 R-KPIs. It takes into account the two dominant concepts of resilience:

1. Three capacities (adaptive, absorptive, and transformative) that reflect strategies employed to cope with stressors and shocks; and

2. A capitals approach often used for measuring sustainability (human, physical, socio-political, financial, natural).

Box 3: Indicators Classification

Capacity approach: The capacity approach was developed by Béné et al. (2012, 2015) and is founded on a belief that resilience is a dynamic construct described by three main strategies used to cope with stressors and shocks: absorptive, adaptive, and transformative.

- **Absorptive capacity:** This is the ability to reduce both risk of exposure to shocks and stressors and to absorb the impacts of shocks in the short term. We classify into absorptive capacity all the indicators necessary for risk prevention and risk mitigation.

- **Adaptive capacity:** Adaptive capacity is the ability to respond to longer-term social, economic, and environmental change. We classify all of the proactive choices about alternative livelihood strategies in light of changing conditions into adaptive capacity.

- **Transformative capacity:** Transformative capacity represents the ability to enhance governance and enable conditions that make households and communities more resilient. In other words, transformative capacity refers to system-level changes that enable a more lasting resilience.

Capital approach: The capital approach is founded on a belief that people require a range of assets to achieve positive livelihood outcomes. The Sustainable Livelihood Framework (DFID, 2000) inspired this vision.

- Human capital includes indicators referring to skills, knowledge, ability to work, and good health that are important to the pursuit of livelihood strategies.

- Socio-political capital includes the quantity and quality of social resources (e.g., networks, membership in groups, social relations, and access to wider institutions in society) from which people draw in pursuit of their livelihoods. It encapsulates good governance indicators.

- Natural capital includes all indicators that represent factors affecting households' livelihoods through climate-change variables (e.g., adaptation, mitigation, and sequestration practices) and through the human activity

- Physical capital includes infrastructure, services, and productive assets that enable people to maintain safety and enhance their relative level of well-being.

- Financial capital includes all indicators referring to the financial resources households use to achieve their economic and social objectives. It includes cash. and other liquid resources,(e.g., savings, credit, remittances, pensions).

Source: Serfilippi and Ramnath (2017)

An explanation of the two main approaches is offered in Box 3. The indicators are flexible enough to easily operate with either the “capitals” or “capacities” approaches or they can also be used independent of these concepts. In addition, they work within other perspectives such as social, environmental, and economic dimensions or important global themes that are further described in Appendix B.

Table 1: Resilience KPIs (Capacities and Capitals Approach)

Global theme	Indicator	Description
Shock and risk	Risk context information	The type of risks at which households are exposed to.
	Occurrence and severity of shocks	Occurrence of three major shocks (social, economic, or environmental) that led to a serious reduction in household’s income, assets, or consumption in the last production year. Shocks ranked in order of severity.
	Type of coping strategies and severity	Type of coping strategies that household applied to face the main shock experienced in the last production year (migration, aid, new sources of income, reducing expenses, using savings). Coping strategies ranked in order of importance.
	Individual preparedness strategies	Strategies implemented by the household to face shocks (stock of feed/seeds, storage of water, measures taken to overcome leaf rust, new seeds varieties/animal breeds, irrigation systems).
	Recovery ability	Perceived speediness and ability to recover from the main shock experienced in the last production year
	Early warning systems	Access, source (extension agents, government officials, ICT), and frequency of critical information about adverse events. Perceptions about quality of information.
Community and institutional environment	Perceptions around political environment	Perceptions about accountability and transparency of political process, feeling of safety in community life, and trust in institutions.
	Participation in decision making structures	Involvement and participation of household and minority groups (women, youth) in decision-making structures (village councils, tribal council, producer organizations).
	Access to safety nets	Availability of safety nets, both formal and informal, providing reasonable or ready support (food, work, cash) in case of necessity
Living conditions	Poverty status*	Progress out of Poverty Index score (PPI) and evaluation of poverty propensity; this compares household’s revenue to national (or regional, if available) poverty line.
Basic human rights and equity	Households’ adults level of education (primary, secondary, etc.)	Number of household members aged 15 years and older who have primary school or higher level of education
	Days without sufficient food*	Number of days in past year that any member of household cut food consumption due to lack of food and months/times of year of comparatively less household food security.

Learning and innovation	Access to information	Access to information about cropping and livestock practices through training programs (hours and type of trainings); access to market information (prices buyer receives, other local prices, global prices); access to weather information; access to health/nutrition information.
	Adoption of new technologies	Adoption of new cropping/livestock practices and new agricultural equipment in the last five years.
Basic services and infrastructures	Access to school	Availability (presence and affordability) of school within reasonable travel distance
	Access to medical care	Availability (presence and affordability) of medical care (nurse, doctor, or clinic) within reasonable travel distance.
	Access to electricity	Availability (presence) of electricity at home (private generator or public electricity supply).
	Access to water	Household access to water they consider safe to drink
Producers' livelihood	Diversification of income	Portion of total production net income from focus crop, other crops, livestock activities, business activities
Financial resources	Access to credit	Access to medium-sized production loan within a reasonable time (if needed); potential source of the loan.
	Productive assets	Number of agricultural productive assets (medium scale equipment and large vehicles), livestock, and hectares of land owned/rented.
Climate change	Soil and Water conservation	Measures taken to conserve soil and improve water use by plants (contour planting, soil cover, live fences, hedgerows, buffer zones, soil berms, etc.)
		Practices used to conserve water, such as drip irrigation, catchments, water-efficient processing, etc.
	Local nutrient cycle	Soil fertility management practices (composting, mulching, etc.) and recycling of organic matter and crop wastes
	Land use change	Conversion of natural land (e.g., prairie, forest, etc.) to land used for cultivation or pasture and forest, or conversion from cultivated or pasture land to natural land
	Fertilizer use	Nitrogen, phosphorus, and potassium amounts in synthetic fertilizers used and compared to focus crop yields. This indicates both efficiency and potential pollution.
	Pesticides use	Amount of natural or synthetic insecticides, herbicides, fungicides, etc. that are used on focus crop.
	Integrated pest management practices	Integrated pest management practices employed on farm

*Potential outcome indicator

Field testing the tool

As with any new approach to an issue as complex as resilience, it is necessary to see how the tool works in real-life conditions and in different realities or contexts. To this end, the COSA Working Group tested the tool in three locations: Peru, Kenya, and Nicaragua. The fieldwork offered useful lessons to help us refine and simplify indicators so as to facilitate wider access to an understanding of resilience. We summarize the main findings below. Complete country reports can be found on the COSA website.

What we have learned

Lessons gained from feedback portend a much faster learning when projects use simpler, common indicators. Such common approaches also allow for additional benefits such as comparisons, benchmarking, and distinguishing trends.

Practical Lessons

A sample of key outcomes or practical lessons on how we refined the tools to better serve the interests of development practitioners are discussed below. We distinguish between practical and technical lessons. A set of technical lessons from the application of indicators in three pilot projects under field conditions have resulted in a number of improvements that include more ease of use, comprehension, and usefulness. These are highlighted in Appendix D

1. How to solve resilience's aggregation needs: Due to the complexity deriving from the multi-dimensionality of resilience, it has been useful to design a resilience index to make the data more understandable, easily accessible, and to facilitate the comparison between different contexts. The procedure to build the index is described in Appendix C.

2. How to integrate resilience and sustainability: Resilience and sustainability share many common metrics. This is not surprising since resilience to adverse shocks can prevent people from falling into recurring cycles of poverty and preserve long term sustainability. The same tool, thanks to simple aggregation strategies, can be adapted to capture the core issues of both resilience and sustainability and track their interconnected changes over time.

3. How to simplify a library of 76 indicators: The field test allowed the COSA Working Group to agree on relevant resilience indicators and the need to also have a core set of Key Performance Indicators (KPI). The Insurance indicator offers a clear example. It can complement risk management approaches, and is included in the main resilience indicators' library, but it is not in the list of KPI since it depends on the presence of an insurance program that is not commonly available.

Recommendations and further development

The topic of Resilience is clearly complex and, in order to improve access and to advance current efforts, there is still much to learn. By respectfully combining and integrating many global best practices, this body of work funded by the Foundation can inspire thoughtful and informed dialogue to enhance more practical decision-making. Academic disciplines are vital to our overall understanding but their findings must also be available in more streamlined and pragmatic approaches. We are certain that the creation and sharing of comparable and globally accepted metrics for measuring resilience constitutes a necessary step toward this end.

It is important to note that while this tool represents a very substantive start, it will benefit from being more widely shared and further refined. In particular, we believe that it can serve as a common basis of understanding among many of the existing institutional silos of practice. Opening up the work and minimizing silos of knowledge is a core purpose of COSA. As former Foundation Director Frank DeGiovanni wrote: “COSA occupies an important niche among organizations focused on understanding the performance of agricultural value chains because its assessment tools are relied on by many organizations as the foundation of their measurement efforts.” COSA already contributes to the joint efforts of the development community around resilience including approaches supported by the Resilience Measurement – MEL Community of Practice, Rockefeller, and USAID. Our objective is to be able to collaborate on a common and widely recognized resilience measurement system. Measuring results in a cost-effective and practical manner is critical for achieving this goal. This seminal work can specifically advance the following critical factors:

1. **Integration of household and community systems for a clearer picture of resilience:** The COSA Working Group agrees on the necessity of integrating different levels of investigation to assess the multi-dimensionality of resilience. In addition to this household-level tool, we have only barely begun to develop a Community Resilience Assessment Tool to integrate household and community resilience investigation.

2. **Applying the tool in other fields:** Our experience suggests that there are opportunities for using the COSA Resilience Measurement approach in many other fields such as livestock systems or even urban settings.

3. **Real time accessible resilience information:** COSA continues to pursue the development of cloud-based modules, more accessible presentation graphics, and real-time “dashboards” that improve the speed

and understanding of the information for managers at every level. We could develop a resilience monitoring system with real time information at farmer, community, and supply chain levels.

4. **Building a common resilience index:** An index facilitates general understanding. The COSA Working Group has developed a resilience index based on factor analysis. Broadening research and discussion should help refine insights in order to find a commonly accepted index approach.

5. **Sharing and scaling** much more widely across both the current silo efforts and also to a much larger group of project and supply chain managers to more quickly scale up efforts that can improve conditions with a better understanding of the core issues and how to address them.

Conclusion

Nearly 1.5 billion people whose livelihoods depend on agriculture live in smallholder households in poor countries. These households account for some of the world's most vulnerable populations, with the highest incidence of people living below the poverty line.[2] Yet, the food supply of a large portion of the world's population comes from these smallholders, many of whom face increasing risks from external forces like volatile markets, climate change, and conflict. One of the key challenges today lies in establishing precise and practical ways to measure resilience in order to understand it. Without actionable measurement, any investments may miss addressing the key factors.

The COSA Working Group accomplished a first important step toward this end by creating a low-cost and easily accessible resilience measurement tool.

This tool will help us all to grasp the core issues and to track changes over time. By understanding the path of long-term sustainability and resilience to adverse shocks, we can prevent people from falling into recurring cycles of poverty that erode gains made toward development and well-being. These are among the articulated targets of the Sustainable Development Goals and we share them wholeheartedly.

2 http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDERS.pdf

Appendix A

Resilience Global Themes

We distinguish six global themes associated with the social dimension (Shock, Community and Institutional Environment, Living and Working Conditions, Basic Human Rights and Equity, Learning and Innovation, Services and Infrastructures), two global themes with the economic dimension (Producer Livelihood and Other Sources), and five global themes associated with the environmental dimension (Soil, Water, Biodiversity, Resource Management, and Climate Change). In the following, we explain the rational associated with the selection of the previously mentioned global themes.

Global Themes in Social Dimension

Dimension	Global theme	Core elements
S	Shock	Shock exposure
		Coping strategies
		Mitigation plans
	Community and institutional environment	Safety nets
		Inclusion
		Political environment
	Living and working conditions	Living conditions
	Basic human rights and equity	Education
		Food security
		Labor
	Learning and innovation	Individual empowerment
		New technologies
		Traditional knowledge
		Information
	Services and infrastructure	Basic services

- **Shock**: Occurrence, frequency, and intensity of shocks are at the base of the resilience analysis. Data on shocks may include widely experienced shocks (covariate shocks), local or individualized shocks (idiosyncratic shocks), and low-intensity stressors that can have a cumulative negative effect on development.

- **Community and Institutional environment**: Measuring political capital may include the effectiveness of local government in addressing the needs and priorities of the community, gender inequalities, social exclusion, marginalization, interaction between formal government and traditional authorities, transparency, and accountability among government officials.

- **Living and Working Conditions**: Extensive research over the past 30 years has revealed that it is generally the poor who tend to suffer worst from disasters (DFID, 2004; Twigg, 2004; Wisner et al., 2004; UNISDR, 2009b). Impoverished people are more likely to live in hazard-exposed areas and are less able to invest in risk-reducing measures. Poverty is therefore both a cause and consequence of disaster risk (Wisner et al., 2004; Shepard et al., 2013).

- **Basic Human Rights and Equity**: Education, food security, and access to work are important elements in measuring sustainability and resilience. Basic education is essential for developing the ability to adjust to changing environments, as well as gaining self-determination over one's future. Hunger and malnutrition are the most important risks to health worldwide and they have a significant impact on economic growth, governance, and education.

- **Learning and Innovation**: Innovation and learning are important processes for absorptive, adaptive, and transformative capacities at the household and community levels. These social dimensions imply the ability and willingness to take risks, exploit new opportunities, make errors, create new knowledge and make modifications based on new experiences (Oxley, 2013a; Levine, Ludi, & Jones, 2011; Longstaff et al., 2010; Berkes, 2007, USAID, 2013b).

- **Services and Infrastructures**: The resilience of a system is dependent on the availability of efficient and functioning infrastructures such as communications, health, and education.

Global Themes in Economic Dimension

Dimension	Global theme	Core elements
 Economic	Producer livelihood	Infrastructure
		Income
		Diversification
	Other resources	Credit
		Savings
		Productive assets

- **Producer Livelihood**: Diversification and access to credit is a key risk-reduction strategy in many arenas, from financial investment to disaster planning. Livelihood improvements can be directly linked to the options and opportunities of households to engage in a variety of sustainable income-generating activities.
- **Other Sources**: Assets contribute directly to the income-generation process (productive assets), and shocks can have different consequences and lead to different behaviors; i.e., selling assets or slowing down asset accumulation could have important implications for future income generation. Transitory shocks can have long-term consequences when income loss leads to changes in asset investment decisions. Households might reduce their consumption to preserve their assets (this is the case of asset smoothing) (Barrett and Carter, 2005; Zimmerman and Carter, 2003), or they can sell assets to protect consumption (consumption smoothing).

Global Themes in Environmental Dimension

Dimension	Global theme	Core elements
 Environmental	Water	Water quantity
		Water quality
	Biodiversity	Genetic diversity
		Plant diversity
		Tree density
	Resource management	Waste management
		Resource/input management
	Climate change	Sequestration and mitigation
		Adaptation

- **Soil**: The environmental conditions in which people live enable or limit their risk exposure and the opportunity to absorb, adapt, and transform in the face of shocks. Thus a range of environmental factors are considered, such as degradation of land, and its poor management.

- **Water**: Water is essential not only for basic drinking and cooking needs, but for hygiene, energy and production. Households contribute to water conservation and protection through integrated watershed management programs and regulation to prevent water waste and contamination.

- **Biodiversity**: The genetic diversity can be found in local and non-local crop varieties and animal breeds. These varieties, together with improved seeds, contribute to tolerance and resistance to pests and diseases. Loss in diversity decreases options for risk management and adaptation.

- **Resource management**: Households can complement proven traditional resource management practices and enhance resilience through the promotion of integrated watershed management, farmer-managed natural regeneration, drought-tolerant crop and livestock systems, integrated pest management, conservation and utilization of local genetic resources, breeding for local adaptation, and other climate-smart agricultural practices (FAO, 2010; Macek, 2011; Walker & Salt 2006). Communities can enhance sustainability through the promotion of natural eco-system forms of protection, conservation, restoration, and forestation.

- **Climate change**: Appropriate agricultural prevention and mitigation measures include a range of technologies, practices, and approaches that help to increase the resilience of rural communities and households and to prevent and mitigate the impact of future disasters.

Appendix B

Resilience Global Themes and SDGs

The value of the Sustainable Development Goals (SDGs) is, in part, predicated on the ability to measure the goals and progress in ways that are functionally useful and accessible to a large number of agencies and researchers. The transparency and comparability across geographies and sectors is a critical function of any metric. Table 1 associates each resilience global theme to a specific goal, and, in turn, to a specific resilience KPI. In the following table we describe how each resilience global theme, and in turn, resilience KPI, is connected to a specific SDG Target and how UNDP's instructions for target operationalization[3] have been used in the definition of COSA's resilience KPIs and global themes.

Table 1: Resilience: Global Themes and Indicators

Global theme	Reference to SDGs	Indicator	Description
Shock and risk	Target 1.5,11.5, 13.5,3d, 2.5	Risk context information	The type of risks at which households are exposed to.
		Occurrence and severity of shocks	Occurrence of three major shocks (social, economic, or environmental) that led to a serious reduction in household's income, assets, or consumption in the last production year. Shocks ranked in order of severity.
		Type of coping strategies and severity	Type of coping strategies that household applied to face the main shock experienced in the last production year (migration, aid, new sources of income, reducing expenses, using savings). Coping strategies ranked in order of importance.
		Individual preparedness strategies	Strategies implemented by the household to face shocks (stock of feed/seeds, storage of water, measures taken to overcome leaf rust, new seeds varieties/animal breeds, irrigation systems).
		Recovery ability	Perceived speediness and ability to recover from the main shock experienced in the last production year
		Early warning systems	Access, source (extension agents, government officials, ICT), and frequency of critical information about adverse events. Perceptions about quality of information.

3 (Report of the Inter-Agency and Expert Group on Sustainable Development Goal Indicators [E/CN.3/2016/2/Rev.1])

Community and institutional environment	Target 16.6, 16.7, 11.3	Perceptions around political environment	Perceptions about accountability and transparency of political process, feeling of safety in community life, and trust in institutions.
		Participation in decision making structures	Involvement and participation of household and minority groups (women, youth) in decision-making structures (village councils, tribal council, producer organizations).
		Access to safety nets	Availability of safety nets, both formal and informal, providing reasonable or ready support (food, work, cash) in case of necessity
Living conditions	Target 1.3	Poverty status*	Progress out of Poverty Index score (PPI) and evaluation of poverty propensity; this compares household's revenue to national (or regional, if available) poverty line.
Basic human rights and equity	Target 4.3	Households' adults level of education (primary, secondary, etc.)	Number of household members aged 15 years and older who have primary school or higher level of education
	Target 2.3 and 2.4	Days without sufficient food*	Number of days in past year that any member of household cut food consumption due to lack of food and months/times of year of comparatively less household food security.
Learning and innovation	Target 12.8 and 4.7 and 9c	Access to information	Access to information about cropping and livestock practices through training programs (hours and type of trainings); access to market information (prices buyer receives, other local prices, global prices); access to weather information; access to health/nutrition information.
	Target 8.2	Adoption of new technologies	Adoption of new cropping/livestock practices and new agricultural equipment in the last five years.
Basic services and infrastructures	Target 6.1,7.1-7.2, 3.8, 4.1-4.4 9c 11.2 2a	Access to school	Availability (presence and affordability) of school within reasonable travel distance
		Access to medical care	Availability (presence and affordability) of medical care (nurse, doctor, or clinic) within reasonable travel distance.
		Access to electricity	Availability (presence) of electricity at home (private generator or public electricity supply).
		Access to water	Household access to water they consider safe to drink
Producers' livelihood	Target 8.2	Diversification of income	Portion of total production net income from focus crop, other crops, livestock activities, business activities

Financial resources	Target 8.10	Access to credit	Access to medium-sized production loan within a reasonable time (if needed); potential source of the loan.
	Target 2.3	Productive assets	Number of agricultural productive assets (medium scale equipment and large vehicles), livestock, and hectares of land owned/rented.
Climate change	Adaptation (Target 13.1, 11b, 15.2, 15.5,15.9,12.4)	Soil and Water conservation	Measures taken to conserve soil and improve water use by plants (contour planting, soil cover, live fences, hedgerows, buffer zones, soil berms, etc.)
			Practices used to conserve water, such as drip irrigation, catchments, water-efficient processing, etc.
	Sequestration and Mitigation (Target 13.1, 13.1, 11b, 15.2, 15.5,15.9,12.4)	Local nutrient cycle	Soil fertility management practices (composting, mulching, etc.) and recycling of organic matter and crop wastes
		Land use change	Conversion of natural land (e.g., prairie, forest, etc.) to land used for cultivation or pasture and forest, or conversion from cultivated or pasture land to natural land
		Fertilizer use	Nitrogen, phosphorus, and potassium amounts in synthetic fertilizers used and compared to focus crop yields. This indicates both efficiency and potential pollution.
		Pesticides use	Amount of natural or synthetic insecticides, herbicides, fungicides, etc. that are used on focus crop.
		Integrated pest management practices	Integrated pest management practices employed on farm

*Potential outcome indicators

Shock

"**Shock**" as a global theme is directly associated to the resilience Target 1.5 that covers economic, environmental, and social shocks, and to the similar targets that apply only to "climate-related hazards and natural disasters" (Target 13.5 and 11.5)[4]. Those referenced targets are all related to the importance of early warning systems that can reduce exposure to risks and improve their management (Target 3d) and the importance of individual preparedness strategies also emphasized by Targets 2.5[5].

4 Target 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations

5 Target 2.5: "By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed." Target 13.2: "Integrate climate change measures into national policies, strategies and planning."

COSA identified six main KPIs for the Shock global theme: occurrence and severity of shocks, mitigation plans (individual preparedness strategies and early warning systems), recovery ability and coping strategies. These indicators permit the computation of a shock occurrence index that can relate the severity and incidence of each shock. Moreover, mitigation plans and coping strategies permit the definition of both the consequence of the shock and whether there have been individual or community preparedness strategies (early warning systems) in place. The definition of these indicators is coherent with the guidelines of the SDG Resources Website[6] that invites the operationalization of the targets mentioned using measures of economic losses (coping strategies) from disaster, the number of deaths and missing persons (incidence of the shock), and the number of countries that adopt Disaster Risk Reduction (DRR) plans (mitigation strategies).

Community and institutional environment

The global theme "**Community and institutional environment**" is associated with Target 16.6, "*Develop effective, accountable and transparent institutions at all levels,"* and Target 16.7, "*Ensure responsive, inclusive, participatory and representative decision-making at all levels."* The three indicators identified by COSA for these targets are perceptions around political environment and participation in decision-making structures, together with safety nets. The choice of these indicators comes from an accurate review of the UNDP's Virtual Network Sourcebook on Measuring Peace, Justice and Effective Institutions. The Network invites development practitioners to operationalize Target 16.6 through a perception indicator that is a straightforward citizen assessment of public services and performance and an administrative data indicator (expenditure and revenue vis-à-vis budget). COSA's household-level indicator mainly focuses on the first aspect.

Concerning Target 16.7, the Virtual Network suggested a number of indicators for this target. The first two indicators are an administrative indicator on representation in government positions by sex, disability, age, and ethnicity, or a survey indicator on the perceived inclusivity and responsiveness of decision-making. COSA's resilience KPI (participation in decision-making structures) mainly focuses on this second aspect. Concerning the safety nets, we mainly focus on two kinds of nets: wealth and financial ones. The financial safety nets will be explored in the financial resources' global theme, while the wealth safety nets refer to the all of the sources of help (food; cash) that farmers can receive in case of necessity. This KPI is strictly linked to Target 1.3 about the implementation of nationally appropriate social protection systems and measures for people. Our vision of safety nets extends this concept to look at safety nets provided through social protection initiatives and informal channels (NGOs, family, and friends).

6 https://medium.com/sdgs-resources/sdg-2-indicators-3a59a1c210b0

Living conditions

Poverty is at the center of the discussion about both the SDGs and resilience. This indicator is mainly viewed as an outcome indicator more than a resilience input. Target 1.1 explicitly refers to poverty alleviation: *By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than $1.25 a day*.

COSA adopts a traditional way of measuring poverty through the use of the PPI (Progress out of Poverty Index) and the computation of number of people living below national poverty line, as suggested by SDGs' operationalization.

Basic human rights and equity

COSA developed four main resilience KPIs related to the global theme "**Basic human rights and equity**": Adult and children's education, training, and food security. These resilience KPIs are strictly connected to SDG Targets. In particular concerning food security, Target 2.1 explicitly relates food insecurity to the vulnerability of people: *By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious, and sufficient food all year round.* Target 2.4 sees resilience as an instrument to create food sustainable systems: *By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality*. UNDP operationalizes these targets through the prevalence of undernourishment and the prevalence of moderate or severe food insecurity in the population, based on the food insecurity experience scale (FIES). COSA's food security KPI captures the ability of all members of a farm household to obtain adequate nutrition in a culturally appropriate and satisfying way each day.

The importance of basic education in the development of the ability to adjust to changing environments, as well as gaining self-determination over one's future, is reflected in Targets 4.1 and 4.3. These targets explicitly underline the importance of access to education for sustainable development. In particular, Target 4.1: *By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes* and Target 4.3: *By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university*. Resilience KPIs measure the education level of adults and children, following UNDP suggestions concerning the operationalization of these indicators: children in school at the appropriate grade level and the participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex, and adult literacy level.

Learning and innovation

The “Learning and innovation” global theme introduced by COSA’s Working group refers to the importance of information and training as an instrument to inform people and to determine capacity for change or innovation.

Target 4.7 captures the educational aspect of training programs: *By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture’s contribution to sustainable development.* As does Target 12.8: *By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.* COSA’s resilience KPI uses hours and type of training to reflect the intensity of participation in education programs.

COSA measures information access not only through training hours, but also through access to weather, health, and price-related information. All of these KPIs are directly connected to Target 12.8: *By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.* Access to new technology is another KPI within the learning and innovation global theme and it relates to the adoption of new seed varieties and new agricultural equipment. The need to innovate and diversify is identified by Target 8.2: *Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high value-added and labor-intensive sectors.*

In this regard, we believe that innovation and learning are important processes to absorb, adapt, and transform in face of shocks and stressors. These social dimensions imply the ability and willingness to take risks, exploit new opportunities, make errors, create new knowledge, and make modifications based on new experiences (Oxley, 2013; USAID, 2013).

Basic services and infrastructures

We believe that the resilience of a system is dependent on the availability of efficient and functioning infrastructure such as communication, water, electricity, and services (health and school) able to meet various community and household needs and aspirations. In the “**Basic services and infrastructures**” global theme, we consider the following KPIs: access to safe water, sanitation facilities, school, health, roads and information and communication technology (ICT). Water is essential not only for basic drinking and cooking needs, but for hygiene, energy, and production. Households contribute to water conservation and protection through water conservation and water waste practices; aspects behind the access to safe water are

explored in climate change global theme. The rationale behind the choice of safe water as a KPI relates to Target 6.1: *By 2030, achieve universal and equitable access to safe and affordable drinking water for all*. This Target has been operationalized by COSA in line with UNDP's recommendation: proportion of population using safely managed drinking water services. In regards to sanitation and hygiene, we refer to Target 6.2: *By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations;* in line with its operationalization: proportion of population using safely managed sanitation services. Moreover, access to health completes the sanitation indicator and is captured by the distance of nearest health center (Target 3.8: *Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all*.)

In order to measure progress toward access to ICT (Target 9.c)[7], the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDG) has selected the percentage of the population covered by a mobile network, broken down by technology. This indicator reflects a minimum requirement for information and communication technology (ICT) access, showing the population that can potentially subscribe to and use mobile cellular services to communicate. COSA adopted a simplified version of this indicator considering the number of people with access to ICT.

The other two KPIs included in the basic services and infrastructure are the access to safe, affordable, accessible transport systems for all (Target 11.2), and access to electricity, both in general terms and in terms of renewable energy (Target 7.1 and 7.2)[8]. The picture is completed by access to school represented by the distance to the nearest school.

Producers' livelihood and other resources

On the purely economic side, COSA identified four KPIs in the "**Producers' livelihood and other resources**" global themes: access to credit, assets, income and its diversification. Diversification and access to credit is a key risk reduction strategy in many areas, from financial investment to disaster planning. COSA proposes access to credit as a KPI in line with Target 8.10: *Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all* and Target 9.3: Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable

7 Target 9c: Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

8 Target 7.1: By 2030, ensure universal access to affordable, reliable and modern energy services measured as proportion of population with access to electricity. Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix.

credit, and their integration into value chains and markets. Concerning households' net income (Target 2.3)[9] and diversification of livelihood (Target 8.2)[10], we believe that livelihood improvements can be directly linked to the options and opportunities of households to engage in a variety of sustainable income-generating activities. To measure the exposure to different livelihood systems, we propose the use of a variation of the Composite Entropy Index (CEI); see Appendix 1 for a description.

Finally, assets are considered in the KPIs since they contribute directly to the income generation process (productive assets) and to the households' wealth (durables) (Target 2.3). Moreover, since shocks can have different consequences and lead to different behaviors, selling assets or slowing down asset accumulation could have important implications for future income generation. Transitory shocks can have long-term consequences when income loss leads to changes in asset investment decisions. Households might reduce their consumption to preserve their assets (this is the case of asset smoothing) (Barrett and Carter, 2005; Zimmerman and Carter, 2003), or they can sell assets to protect consumption (consumption smoothing).

Climate change

Appropriate agricultural prevention and mitigation measures include a range of technologies, practices, and approaches that help to increase the resilience of communities and households and to prevent and mitigate the impact of future disasters. Target 11.b invites "cities and human settlements to adopt and implement integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels." In other words, the environmental conditions in which people live enable or limit their risk exposure and the opportunity to absorb, adapt, and transform in the face of shocks. The same Target 13.3 suggests to improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning. Thus a range of environmental factors should be considered for the enhancement of resilience, such as degradation of land, restoration, and forestation as stated in Target 15.5: Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species and Target 15.2: By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and

9 Target 2.3: By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

10 Target 8.2: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors.

substantially increase afforestation and reforestation globally. Concerning biodiversity measures should be taken to increase risk management and adaptation as referred to in Target 15.9: By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes. In particular, the genetic diversity can be found in local and non-local crop varieties and animal breeds. These varieties, together with improved seeds, contribute to tolerance and resistance to pests and diseases. Loss in diversity decreases options for risk management and adaptation. Fertilizers, pesticide-use efficiency, water conservation, and protection from contamination (Target 12.4 and 6a) represent other essential environmental measures.[11] Households can complement proven traditional resource management practices and enhance resilience thorough integrated pest management, conservation and utilization of local genetic resources, breeding for local adaptation, and other climate-smart agricultural practices (Macek, 2011; Walker & Salt 2006).

11 Target 8.2: Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labor-intensive sectors.

Appendix C

Resilience Index

The measurement needs faced by the resilience agenda have been compared by Cissé and Barret (2016) to the poverty aggregation needs faced decades ago as elaborated by Amartya Sen (1979). In other words, in order to guide policy, the concepts of resilience, like those of poverty, need a clear ability for useful "identification" (i.e. who is resilient) and "aggregation" (i.e., defining how characteristics of the resilient can be combined into an aggregate indicator).

The method followed by COSA to build the index integrates several composite indices in a transparent manner. The indicators used reflect various manifestations of the multidimensional construct of interest, e.g. resilience. In particular, the resilience index is used to measure the resilience capacities at the household level in a rural context and it is based on indicators that fall under the three capacities (absorptive, adaptive, and transformative) identified by the literature (Béné et al. 2015).

In particular, in the first stage, using a large set of variables we estimate each latent intermediate variable (adaptive, absorptive, and transformative capacity) through multivariate techniques (factor analysis). These capacities are subsequently employed in the estimation of household's resilience index through factor analysis. The following formulas can easily express this mechanism. In the first stage, we estimate each capacity as a function of different variables V_{it}:

$$Absorptive_{it} = f^{1}(V_i^{1})$$

$$Adaptive_{it} = f^{2}(V_i^{2})$$

$$Transformative_{it} = f^{3}(V_i^{3})$$

In the second stage, we use the three capacities in the estimation of the resilience index in which the resilience index is a weighted sum of the factors generated using Bartlett's (1937) scoring method and the weights are the proportions of variance explained by each factor. This is the simplest method to weight each resilience capacity, and it has been used by Alinovi et al. (2009, 2010). We do not exclude that other weighting methods can be applied, but the use of this method avoids ad hoc weighting practices and cut-offs.

$$R_{it} = w_{abs}\,Absorptive_{it} + w_{adapt}\,Adaptive_{it} + w_{trans}\,Transformative_{it}$$

A resilience index ranges from 0 results, indicating a situation of total lack of resilience capacities, and 1 (max resilience) indicating an optimal level of resilience to shocks and stressors.

The overall procedure is the same as the one used by Alinovi et al. (2008, 2009, 2010) with the only difference that instead of re-grouping the variables

into five dimensions (Access to public services; Social safety nets; Income and food access; Assets; Stability; Adaptive capacity) we regroup them considering the three resilience capacities recently identified by the literature (Béné et al. 2012, 2015). The capacity approach used for the construction of the resilience index has been already implemented by USAID (2013) and CIAT (2015).

Applicability at other levels: The procedure used in the households' resilience index can be replicated at higher levels of investigation: cities, regions, districts, and nations. The pre-condition for this kind of analysis is to have a reliable number of observations sampled for each unit of analysis. Moreover, COSA's resilience index was built to investigate the resilience of households in a rural context. It follows that the extension of the analysis to cities and nations should include other variables so as to capture characteristics of urban resilience.

Other estimation techniques: We use factor and polychoric factor analysis within a multi-stage estimation strategy to generate resilience capacities and, in turn, the resilience index. In the literature, there are other estimation techniques. The main one is proposed by FAO (2016) and it is based on a Multiple Indicators Multiple Causes approach (MIMIC), which is applied in the computation of the resilience index (RIMA II). The logic behind this computation is that it introduces some changes in the estimation techniques. It proposes an indirect measure of resilience that adopts regression analysis and, consequently, allows causal inference. In this approach, the resilience latent variable is jointly estimated by its causes and indicators. This new technique overcomes two limitations: endogeneity problems (i.e., the risk of causality between independent and dependent variables); and impracticality in the analysis of shocks since they are included in the estimation procedure. Following Alinovi et al. (2009), there are two main reasons for adopting the two-stage factor analysis technique: measuring the different components separately makes the model more flexible, allowing the inclusion of prior information and thus reducing the parameter identification problem, and (in case of two time periods) the presence of panel data helps us in overcoming the endogeneity problems. Further research can be conducted in order to determine the best estimation technique.

Appendix D

Technical Lessons

We review the lessons associated to main resilience indicators.

Shocks and Stressors

The shock analysis in Kenya revealed the main shocks affecting households in the production year before the data collection. The results suggested the necessity to extend the analysis to risks to capture their severity. In order to identify the main hazards and record locations of historical events that have had a negative impact on household well-being, the analysis in Peru and Nicaragua was based on the risk-mapping approach (Smith et al., 2000; Quinn et al. 2003; Inskip et al. 2013; Barid et al. 2009), applied to both the analysis of **risk and shocks**. This analysis provided simultaneous information about the number of people affected by each shock (or facing each risk) and its severity in relation to other negative events. This information, integrated with data on frequency, allowed us to determine if the shocks were recurring or isolated phenomena, and covariate or idiosyncratic. Such data can assist development agencies in designing resilience interventions for the most common and severe source of shocks, and to investigate the lack in coping strategies and other resilience capacities in relation to these shocks and risks.

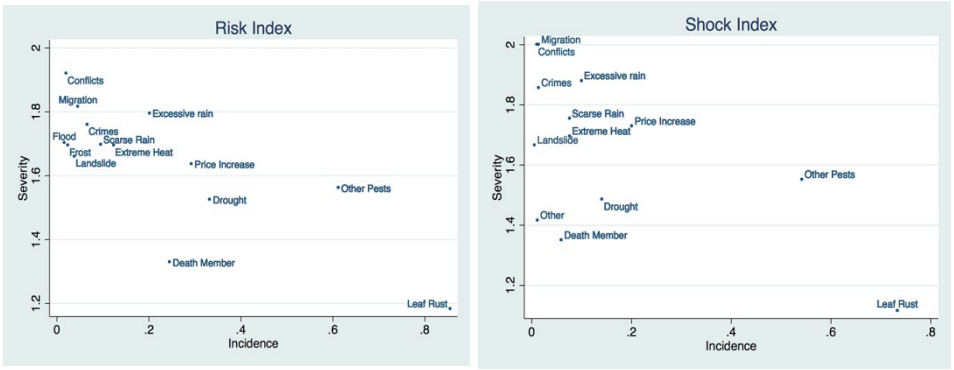
In addition, if disaggregated by region, this information allows implementers to design interventions with a special focus on zones that are particularly vulnerable. Table 2 reports the results of the Peru and Nicaragua case studies and it shows how the information can be easily summarized by a graph reporting severity of the shock on the *y* axis (from 2, less severe, to 1, most severe) and its incidence on the *x* axis (from 0 to 1).

The information on shocks and risks, integrated with an analysis of the degree of **recovery** from the shock, allowed us to address whether households bounced back from the shock, and to identify the level of well-being reached (better, same, worse than before the shock). The recovery ability was measured through perception questions, but it could also have been measured through proxies such as recall questions about the level of income or yields before the shock.

Table 2: Risk and Shock Index

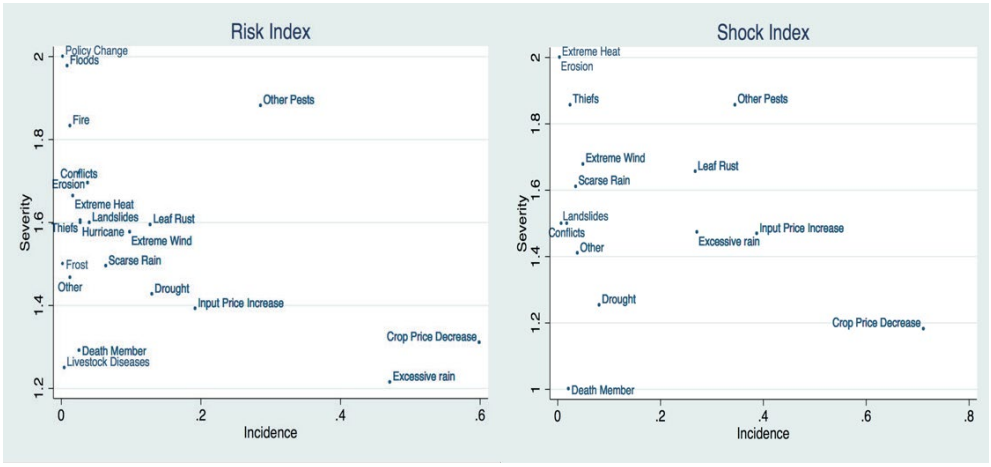
Table 2 captures risk (exposure to potentially unfavorable circumstances) and shocks (actually occurred unfavorable circumstances). Through the risk mapping technique, farmers first identify risks and shocks and then they rank them by order of severity. The information collected on incidence and severity of shocks can be combined to generate a risk and a shock index.

Peru



Source: Peru case study (2017)
Note: In Peru, the main source of risk and shock was represented by a specific type of coffee pest, well known in the Central and South America as *roya,* leaf rust.

Nicaragua



Source: Nicaragua case study (2017)
Note: In Nicaragua, the main source of risk and shock was represented by the volatility in coffee prices.

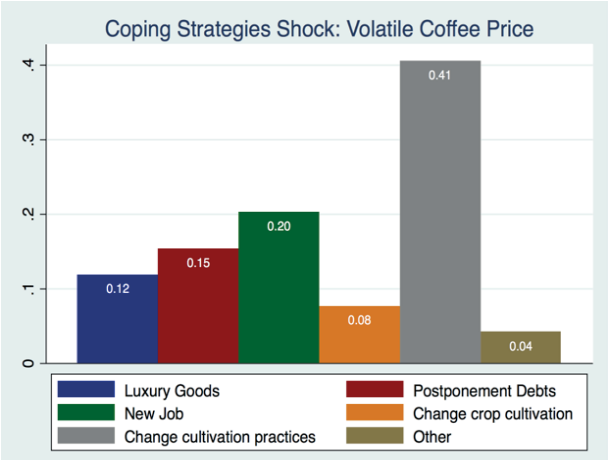
Coping strategies

Coping strategies are actions taken by farmers in order to absorb the impact of shocks in the short term. Examples of positive coping strategies include the use of savings and the consumption of food stocks or reliance on aid from formal and informal safety nets (i.e., external aid). Negative coping strategies are a divestment of productive assets, reduction of food consumption, and reliance on risky livelihood activities; in practice all strategies that debilitate a household's capacity to face future shocks and stressors. But what happens if the household says that it has not experienced a shock at the moment of the survey? Can we measure this recovery ability or coping strategies? The COSA Working Group solved this issue by not only considering shocks-specific information, but also including an analysis of risks. It follows that for those households that did not experience a shock, questions relative to coping strategies and recovery ability were linked to the main source of risk instead of the main shock, with the result that these questions refer to a risk instead of a shock that occurred. Moreover, we observed different attitudes of farmers toward shocks and risks. In Nicaragua, we noticed that the main source of shocks and risks were exactly the same (volatile prices), but the coping strategies applied to face them were different, with a change in cultivation practice as a main coping strategy when the shock occurred and typically reduced food consumption in case of risks, as reported in Table 3.

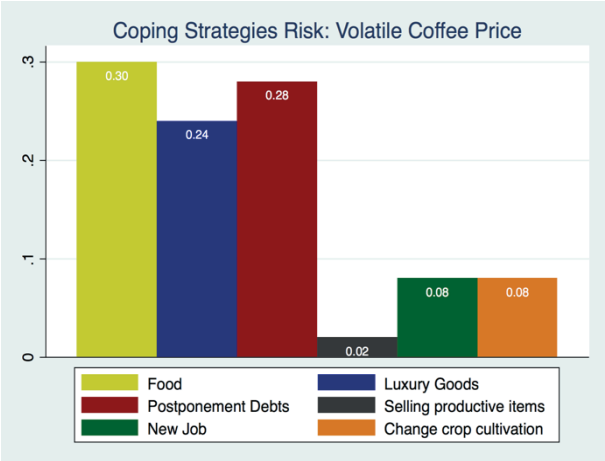
The different attitudes of farmers toward shocks and risks can be a challenge for development practitioners when questions refer to hypothetical shocks rather than occurred ones. Further investigations will see COSA applying propensity score matching techniques to exclude other factors (e.g. household characteristics) as determinants. Optimally, a complete assessment of shocks and risks should include the analysis of coping strategies and recovery ability relative to both the main shocks and risks.

Table 3: Real and Potential Coping Strategies

Coping for Shocks



Coping for Risks



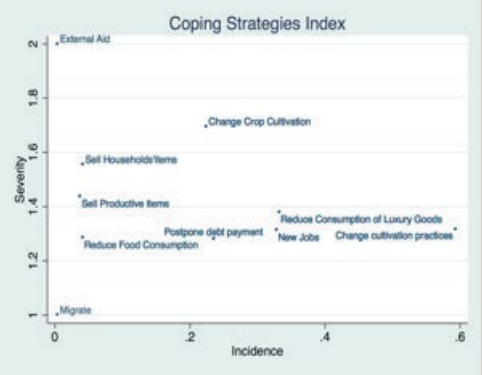
Source: Nicaragua case study (2017). Farmers experiencing a shock in the year before the survey were 65% of the sample. For the farmers who did not face a shock, we asked questions about their coping strategies and recovery ability, referring to their potential source of risk and asking about potential strategies if this risk would have become real.

Although the collected information provides a clear description of the ways in which households cope with shocks, we believe that this approach does not consider an important component: the perceived severity of shocks associated with each coping strategy. All types of coping behaviors indicate strategies applied in the face of a shock, but they are not necessarily strategies of the same severity. In other words, some strategies could be looked at as perfectly normal behavior in some contexts—and as great sources of shame (and therefore only be practiced in the most extreme circumstances) in other places. We combined incidence and severity to generate the coping strategies index in Box 5.

Box 5: Coping Strategies Index

The analysis of coping strategies can be extended by the use of a coping strategies index (CSI) as an indicator of absorptive capacity. We propose an index that relates severity and incidence of coping strategies and relies on counting coping strategies that are not equal in severity. In other words, different strategies are ranked differently, depending on how severe they are considered to be by the people who rely on them. This method resolves one of the main limitations related to the indicator of coping strategies that otherwise would have been simply represented by the number of coping strategies used by the household.

The field test in Nicaragua allowed us to test this index. We first gave a list of coping strategies to the households and asked them to rank them in order of severity. We then cross checked this information with tone relative to the coping strategies used to face the main shock experienced in the previous year. The coping strategies index is given by the ratio of severity over the incidence of the shock. We understand that there could be other methods to build a coping strategies index, but the main challenges faced in the resilience context is to find a method of aggregation easily applicable to a list of very different coping strategies related to types of shocks ranging from economic to social and climatic ones.



Source: Nicaragua case study (2017)

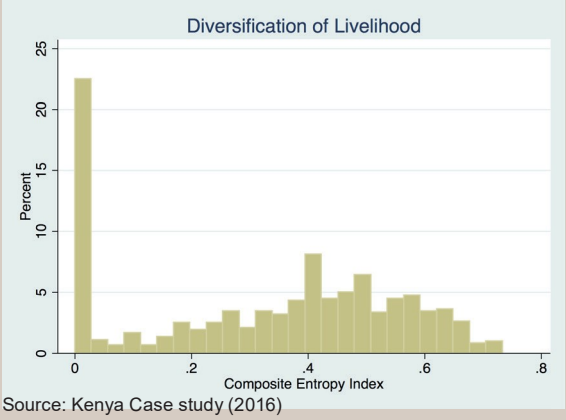
Diversification of livelihood

The main method used by the resilience literature to measure the diversification of livelihood is represented by a simple count of the number of income sources (FAO, 2016, USAID 2013). Our field experience shows two main problems associated with the use of this proxy: It does not account for the amount of money generated by alternative livelihoods sources, and it does not consider the risks to which this alternative income-generating activity is exposed. In particular, assuming that the diversification involves another crop, if producers are producing three crops, but all the crops are highly exposed to the shock, then perhaps those producers are more at risk than producers farming a single crop. We tried to account for the first of these problems through a revisited version of the Composite Entropy Index (CEI). This analysis allows us to understand whether farmers depend on sources of income different from the main crop, and considering how these alternative livelihoods' sources contribute to the total households' net income. More details about this method are presented in Box 6. Moreover, concerning the problem associated with the risks, we propose classifying each activity by the risks affecting it in order to determine whether it is a good diversification strategy depending on the shock that occurred. This is the first step; further investigation can be developed in a way to systematically integrate an analysis of risk in the investigation of the diversification.

Box 6: Diversification of Livelihood: A revisited version of the Composite Entropy Index

In general, the Composite Entropy Index (CEI) is used to compare diversification across farmers having different and large number of crops since it gives due weightage to the number of crops. We re-adapt and extend the CEI in order to consider diversification depending on the overall income sources (not only the crops' related ones). The original formula to compute the CEI considers area cultivated with i-esimo crop, the number of crops cultivated, and the total area cultivated. We re-adapt this index by simply replacing the area and the number of crops cultivated with the i-esima income generating activity, and the total income sources. The value of Composite Entropy Index ranges between zero (no diversification) to one (full diversification). It increases with the decrease in concentration and rises with the number of income- generating activities.

An example of the index is reported in the following Figure in which we observe that 22% of farmers did not diversify their livelihood. The value of the CEI in this case is 0.33, on a scale between 0 and 1. This corresponds to a low level of diversification.



Source: Kenya Case study (2016)

Environmental and other adaptive capacities

Concerning the adaptive capacities, interesting insights came from environmental indicators such as the use of pesticides/fertilizers, adoption of drought-resistant seed varieties, and integrated pest management practices. These variable are between the ones contributing the most to the formation of the resilience capacities. But we came to the conclusion that the time dimension is crucial to classify them as either absorptive or adaptive capacities. In our field studies, it became necessary to collect information on the timing of the adoption of these practices in order to discern whether they were short- or long-term resilience strategies. In particular, we collected data on the use of fertilizer and pesticides, and the timing of the introduction of

drought-resistant seed varieties. In practice, these variables are considered absorptive capacities if they were already in use at the moment of the shock. However, they are outcomes of the adaptation process if we register them as a change with respect to the period before the shock. The same reasoning holds for other resilience indicators such as diversification of livelihood, credit and similar variables.

Governance and transformation

The transformative capacity is a complex measure since it involves multiple levels of investigation. In particular, the literature on transformation and transformative capacity highlights that transformation may relate to both the government level (for example, governmental policy changes) and the individual level (for example, empowerment of a marginalized group). The information collected by COSA on access to basic services, infrastructure, and decision-making structures allows us to investigate the individual side of transformation, but it should be integrated into a further investigation of policies, governmental investments, and good governance.

COSA and its Working Group have collected information on good governance using questions that capture perceptions about government and build an index of good governance. The index presented in Box 7 provides information on households' perceptions of different facets of governance, ranging from **Accountability**, **Transparency,** and **Regulatory Quality** to **Inclusion** and **Safety**.

Box 7: Governance Index

The index was built using a simple factor analysis to get a governance index based on questions about the topics listed below. A Likert scale from 1 (Strongly agree) to 5 (strongly Disagree) was used.

Accountability: Perceptions on the extent to which a country's citizens are able to participate in selecting and communicating with their government; **Freedom of expression:** Perceptions on freedom to express opinion in public**; Inclusion:** Perceptions on the tolerance for diversity and minorities**; Transparency:** Perceptions on accessibility and visibility of government's activities and policies; **Safety**: Perceptions on feeling of safety in the community and prevention against abuses; **Regulatory Quality:** Perceptions on the ability of the government to include citizens' priorities in the development of the municipality. The index should be extended in order to include **Government effectiveness:** Perceptions of the quality of public services, quality of the civil service, and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.

In addition, useful information on transformation can be captured through recall questions and desk research to determine whether the country/region has been affected by policy or government change.

Qualitative and quantitative information: COSA's resilience analysis follows both qualitative and quantitative approaches. Following FSIN (2015), we distinguish between qualitative and subjective information. In particular, qualitative information has been detected with the use of a context assessment that took place before the survey that allowed us to obtain information about social relations and power, assets, and trade-offs.

Subjective information has been collected in the survey through the use of perception questions. Some subjective measures result in quantitative data (e.g., Likert scales) that have been employed in the analysis (e.g., positive

perceptions around the future of young generations, the quality of basic services and infrastructure). Other subjective measures have been used to evaluate the perceived severity of the shocks and the coping strategies used. These measures have been implemented in the construction of a risk and shock index and in the analysis of the coping strategies.