



Resilience Index

Measurement and Analysis model

$$R_i = f(IFA_i, ABS_i, AA_i, NAA_i, APT_i, SSN_i, CC_i, EIE_i, S_i, AC_i)$$



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1. INTRODUCTION

By understanding the factors that make households resilient to food security shocks, FAO and partners can develop the most effective combination of short and long term strategies for delivering households from poverty and hunger.

Shocks such as drought or conflict reduce a household's resilience and increase its vulnerability to future shocks. Interventions that increase resilience by enhancing people's ability to manage risk over time are thus needed. Such efforts reduce the need for humanitarian intervention when future hazards occur.

Several definitions of resilience are being used in development and humanitarian work, which tend to share three common elements: (i) the capacity to bounce back after a shock; (ii) the capacity to adapt to a changing environment; and (iii) the transformative capacity of an enabling institutional environment.

In a food-insecure household with low resilience, even small changes can be devastating. As resilience declines, it takes a progressively smaller external event to cause a catastrophe.

In the context of food security, resilience measurement helps to understand and support the capacity of a household to recover from natural and human-induced shocks. Applied to food security, resilience measurement complements early warning systems by assessing the strength of the basic unit of the food system: the household.

Resilience is a key focus of the Food and Agriculture Organization of the United Nations' (FAO) work to achieve food security for all. Within its reviewed Strategic Framework 2010-19¹, FAO has prioritized resilience to shocks as one of its five Strategic Objectives: "Increase the resilience of livelihoods to threats and crises".²

This note is a summary of FAO's latest progress in resilience measurement. Section 2 illustrates FAO's Resilience Index Measurement and Analysis (RIMA) model and recent modifications, as well as describes profiling strategies. Section 3 provides a brief overview of ongoing exercises and technical development.

FAO defines resilience as:

"The ability to prevent disasters and crises as well as to anticipate, absorb, accommodate or recover from them in a timely, efficient and sustainable manner.

This includes protecting, restoring and improving food and agricultural systems under threats that impact food and nutrition security, agriculture, and food safety/public health."

¹ Adopted by the Council in 2012.

² FAO's five Strategic Objectives include: (1) Contribute to the eradication of hunger, food insecurity and malnutrition; (2) Increase and improve provision of goods and services from agriculture, forestry and fisheries in a sustainable manner; (3) Reduce rural poverty; (4) Enable more inclusive and efficient agricultural and food systems at local, national and international levels; and (5) Increase the resilience of livelihoods to threats and crises.

2. METHODOLOGY

The methodology described in this brief to measure resilience to food insecurity identifies and weights the different dimensions of households' resilience through an econometric model. The results of this analysis inform programme investment, targeting, design and impact evaluation.

The methodology³ was first applied in the West Bank and Gaza Strip to measure households' resilience to food insecurity. It was later applied in other countries as a:

- **diagnostic tool** (Ethiopia, Kenya and the Sudan) to empirically measure households' resilience to food insecurity according to their different livelihood strategies; and
- **impact evaluation indicator** (Somalia, South Sudan and the Sudan)⁴ to improve the design of future interventions and related accountability mechanisms.

There are primarily two ways by which the methodology is being improved: (i) **measurement** (dimensions; adoption of structural equation models; calibration of the model; modeling/dynamic analysis); and (ii) **profiling** (the way targeted households are profiled by vulnerability and assets). The improved methods in resilience measurement and profiling are detailed in Sections 2.2 and 2.3.

2.1 Analytical framework

In FAO's analytical framework, resilience explains why one household returns to a desired level of food security while a similar household does not. RIMA, therefore, explains the interaction between shocks and their effects on households, with resilience accounting for the difference in outcomes between two similar households exposed to the same shock. For FAO, the outcome examined is food security.

According to the RIMA model, the outcome for a given household is a function of (i) the probability of being reached by a natural crisis due to the geographical location of the household; (ii) the probability of suffering from a shock due to a particular set of household characteristics which determine a household's livelihood; and (iii) the resilience of the household.

Equation (1) shows the **interaction between a given outcome (e.g. food security) and resilience**.

$$Y_i^1 = f(Pr_g^0, Pr_{se}^0, R_i^0) \quad (1)$$

In (1), the dynamic of an outcome variable Y_i in time 1 is a function of Pr_g , Pr_{se} and R_i during time 0 – i.e. before the shock occurred.

- Pr_g is the probability of a household to be reached by a natural crisis due to its geographical location.
- Pr_{se} is the probability of a household to suffer from a shock due to a particular set of household characteristics determining its livelihood.
- R_i is the resilience of the system.

This stresses how resilience is part of the process that leads to an outcome and is not an outcome *per se*. Furthermore, (1) highlights how the outcome in year 1 depends on something which is available (or not) in year 0, with the distance between 1 and 0 being the time when a shock occurs.

³ This section builds on (Alinovi, Mane, & Romano, 2008) (Alinovi, d'Errico, Mane, & Romano, 2010), which are based in turn on (Pingali, Alinovi, & Sutton, 2005); these papers are part of the few studies that have aimed to assess quantitatively a household's resilience to food insecurity.

⁴ Somalia (Dolow district; Somaliland); South Sudan (Jonglei; Upper Nile); and the Sudan (South Kordofan).

Resilience is a related, but different, concept from vulnerability. Both share a common set of parameters, such as the shocks and stresses to which a social-economic system is exposed, and the response and adaptive capacity of the system. Nevertheless, vulnerability analysis often tends to measure only the susceptibility of a household to harm and the immediate coping mechanisms adopted.

Vulnerability is a function of a household's risk exposure and its resilience to such risks. This correlation between vulnerability and resilience is explained by equation (2) below. In (2), vulnerability of the household i is a function of the exposure to risk and resilience.

$$V_i = f(exposure_{risk}, R_i) \quad (2)$$

Resilience analysis aims to identify the different responses adopted by a household and capture the 'dynamic' components of the adopted strategies. A resilience approach investigates not only how disturbances and change might influence the structure of a system (for example, a household or a community), but also how its functionality in meeting these needs might change. Therefore, resilience analysis should not be seen as an alternative to vulnerability analysis, but as a complement.

In summary, the entire system that starts working as a reaction to a shock encapsulates *resilience*. As such, resilience is made up of different dimensions and the resilience of a given household at a given point in time (T_0) depends primarily on the options available to that household to make a living (e.g. access to assets, income-generating activities, public services and social safety nets). These options, therefore, determine the household's ability to handle a given risk.

2.2 FAO's Resilience Index Measurement and Analysis (RIMA) model

With respect to this overall framework, the household resilience index can be expressed as follows:

$$R_i = f(IF_A_i, ABS_i, AA_i, NAA_i, APT_i, SSN_i, CC_i, EIE_i, S_i, AC_i) \quad (3)$$

R = resilience; IFA = income and food access; ABS = access to basic services; AA = agricultural assets; NAA = non-agricultural assets; APT = agricultural practice and technology; SSN = social safety nets; CC = climate change; EIE = enabling institutional environment; S = sensitivity; AC = adaptive capacity.

FAO divides the above dimensions of resilience into two categories: (i) physical dimension and (ii) capacity dimension. The components of each are described below, followed by (iii) a more detailed description of the variables recently added to the RIMA model.

As resilience is a context-specific concept, dimensions change depending on the context. However, there is agreement over some determinants of resilience. These include physical dimensions (i.e. income and food access; access to basic services; assets; social safety nets; climate change; and enabling institutional environment), and capacity dimensions (adaptive capacity; and sensitivity).

(i) Physical dimensions of resilience

IFA	Income and food access These are aspects of a livelihood, showing a household's capacity to earn a living. Examples of indicators include income, caloric intake and food expenditure.
ABS	Access to basic services This shows the capacity of a household to rely on a valid infrastructural setting. Examples of indicators include access to school, markets, health facilities and other minimum requirements (e.g. toilets, water and electricity).
AA/NAA	Agricultural assets/Non-agricultural assets These are the key elements of a livelihood. In both rural and urban contexts, assets give a household the opportunity to have something tradable; something to build an activity upon; and assets to employ. Examples of indicators include land, livestock and durables.
EIE	Enabling institutional environment The presence of strong support from local and central authorities plays a key role in the ability of households to cope with shocks. Examples of indicators include rural communities' perception of the presence and quality of services provided.
CC	Climate change In rural areas, climate change can highly affect the capacity of a household to make a living (e.g. drought in the Horn of Africa). Examples of indicators include soil type, soil erosion and soil degradation.
APT	Agricultural practice and technology This dimension captures the different technological levels in farming activities. Examples of indicators include fertilizers, artificial insemination and pesticides, among other technological inputs adopted in agricultural practices.
SSN	Social safety nets Social safety nets are a crucial aspect of mitigating crisis. They include assistance from international agencies, charities and non-governmental organizations, as well as help received from friends and relatives.

(ii) Capacity dimensions of resilience

AC	Adaptive capacity This shows the capacity of a household to adapt to a new situation and develop new sources of livelihood (e.g. having more sources of income may decrease the negative effects a shock creates on a household).
S	Sensitivity Sensitivity has two complementary meanings: (i) the degree to which the household is actually affected by the shock (i.e. a household deriving a large part of its total income from shock-affected activities has higher sensitivity than others); and (ii) the degree to which the household has been affected by the shock in the recent past (i.e. whether a household has been struck by a shock for the first time in five years or struck every year has important consequences, with the household's sensitivity increasing and its capacity to react to the shock

decreasing in the latter case).

(iii) Dimensions recently added to the model

Natural environment and enabling institutional environment have recently been included in the RIMA model.

1. **Natural environment** affects the resilience of a household in two ways: exogenous and endogenous.
 - Exogenous factors mostly relate to where people live. For example, the aridity of an area where people live is an indicator of how much that area is prone to drought. Recent survey techniques, mainly adopted by the World Bank⁵, allow the inclusion of geo-referenced variables as indicators of the geo-vulnerability of a studied area. Thus, households can be profiled and the resilience of each profile estimated.
 - Endogenous factors affect a household's livelihood through climate change variables. Where data are available, these factors are included in the model with a dimension noted as CC. A first attempt to include endogenous factors in the model is ongoing in the "Building Resilience in Somalia" impact evaluation exercise. Variables used could include, for example, land degradation and erosion.
2. An **enabling institutional environment** can highly influence the capacity of a household to deal with a shock. The overall idea is to include some variables as proxies for a good and reliable institutional environment. In this case, data will be drawn from ad hoc surveys. The first case study is South Sudan, where an impact evaluation is taking place through an ad hoc primary data collection exercise. In this exercise, three modules provided by Tufts University have been added to the household questionnaire instrument being utilized. Currently, FAO and Tufts are assessing the possibility and relevance to include some of these variables to capture people's perception of institution functioning. A similar exercise is ongoing as part of the "Building Resilience in Somalia" impact evaluation.

2.2.1 Factor analysis and structural equation models

When it comes to measurement, resilience is not observable *per se* and is considered a latent variable depending on the terms on the right-hand side of the equation. To estimate R, it is therefore necessary to estimate separately the different dimensions, which are themselves latent variables because they cannot be observed directly in a given survey. Every dimension is separately estimated at time T_0 and then a composite index of household resilience is created.

There is a wealth of techniques in the latent variable literature that can be employed for this purpose, such as principal component analysis; multiple indicators multiple causes; factor analysis; and structural equation models. Initially, RIMA used factor analysis (e.g. Kenya; and West Bank

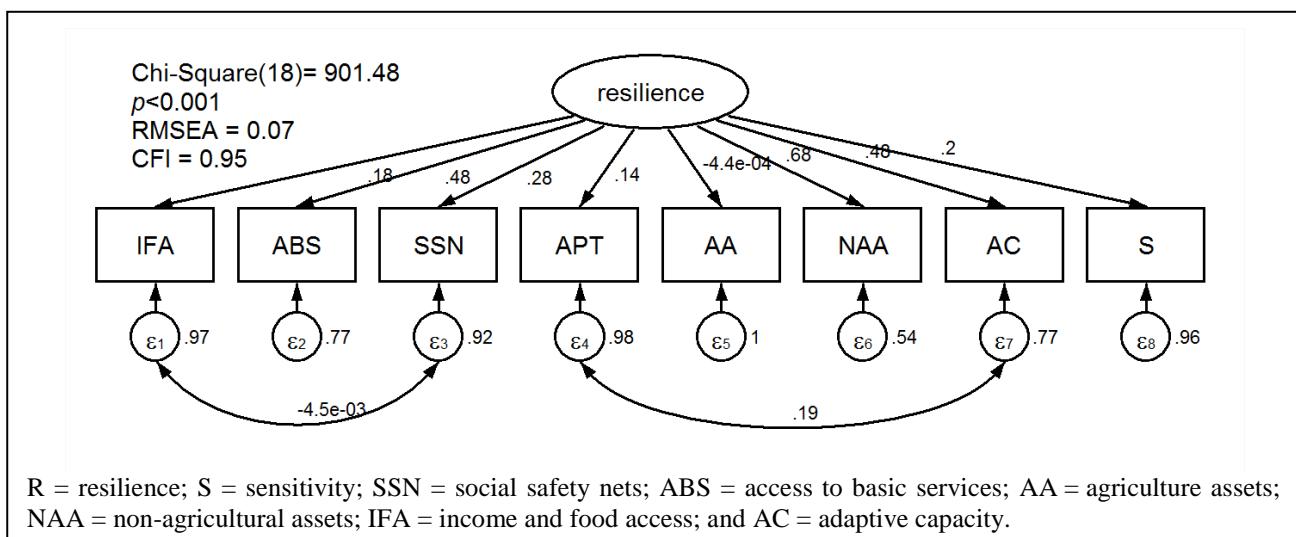
⁵ <http://go.worldbank.org/YPHB6EK7Q0>. In the case of ad hoc survey, the inclusion of a cheap GPS coordinates detecting tool allows for a subsequent integration with GIS information.

and Gaza Strip)⁶. To this extent, variables are selected that can be used as a proxy for each dimension of resilience⁷.

Recent exercises, however, make use of exploratory factor analysis (i.e. the measurement model of a structural equation model). Factor analysis assumes that the residual errors (i.e. unique factors) are uncorrelated with each other and are uncorrelated with the common (i.e. latent) variable. In the case of food security analyses, the latter assumption cannot be accepted, as the probability of intradimension correlation is high⁸. Thus, the measurement model of structural equation modeling is adopted, which includes correlation between residual errors. Although this method requires a greater number of computational efforts than during previous exercises, it allows for model calibration until a satisfactory level of goodness-of-fitting is achieved.

Figure 1 below shows the path diagram of the resilience model, drawn from an exercise in the Niger. Every dimension is correlated with the latent variable; the correlation score – also called factor loadings (FL) – is presented as the numbers above the arrows. Thus, IFA is correlated to R, with FL = .18; ABS is correlated to R, with FL = .48; and so on. Factor loadings represent how the variable is weighted with the factor. Numbers close to the ϵ are the residual errors; intracorrelation between errors is reported along the curves.

Figure 1. Example of a path diagram from the Niger exercise



In this example, resilience is represented as a function of both physical and capacity dimensions, and the intracorrelation between residual errors for IFA and SSN and for APT and AC have also been accounted for.

2.2.2 Modeling and dynamic analysis

Resilience may also be measured in a dynamic context. The different dimensions observed at time T_1 reflect how changes in these factors influence household resilience. This is very relevant in terms of impact evaluation and, therefore, policy responses.

⁶ For further details on why factor analysis has been chosen, see (Alinovi, Mane, & Romano, 2008).

⁷ Based on a literature review, empirical evidence and variables' behaviour.

⁸ For example, high correlation may be expected between income and access to social safety nets; or income and access to school; or access to agricultural inputs and access to markets.

In RIMA, modeling is possible through the use of panel data, allowing the control of a resilience dynamic over a variable outcome. The dynamic involves two aspects of resilience: how a change in resilience can affect a change in the variable outcome; and how a change in one of the components of resilience will influence the behaviour of resilience. FAO is conducting this type of analysis in the West Bank and Gaza Strip, where four rounds of cross-section surveys have been collected.

In the West Bank and Gaza Strip, FAO will replicate an interesting validation experiment that was undertaken recently based on data from Nicaragua (Ciani & Romano, 2011). This exercise (using panel data) supported empirical evidence in which households identified as less resilient suffered the most from Hurricane Mitch in late 1998. In the West Bank and Gaza Strip exercise, the dynamic of resilience will be analysed in two different ways. First, by controlling⁹ for the occurrence of a shock (endogenous or exogenous), the exercise will assess changes in resilience as well as the prediction capacity of the resilience index (i.e. the capacity to correctly predict which household's profile would have suffered the most from a shock). Secondly, by controlling for implemented interventions¹⁰, the effects on resilience will be tested, regressing the resilience differential against a set of independent variables.

2.3 Resilience profiling

Resilience is a context-specific concept. Profiling households allows for interesting cross-area analysis, such as analysing how different the resilience determinants are for each profile. FAO profiles livelihoods by cluster analysis, probability of being reached by a shock and vulnerability.

Cluster analysis

FAO runs a cluster analysis based on income determinants and other sources of living. In an exercise in Kenya (Alinovi, d'Errico, Mane, & Romano, 2010), the analysis has been enriched by the use of cluster analysis to classify the population in six subgroups corresponding to six livelihood strategies. This approach highlights how different livelihood groups are related to different dimensions of resilience and how these dimensions are relevant in determining the resilience of various livelihoods.

Probability of being reached by a shock

By estimating a probit model over a set of household socio-economic characteristics, those at higher risk of being reached by a shock are profiled. Next, resilience analysis is done at profile level (risk/non-risk populations) and more relevant resilience dimensions are estimated for each profile.

Vulnerability profiles

Vulnerability profiles are based on an asset index and geo-referenced variables showing which households in a given area are more at risk. Variables such as aridity index, length of growing period or distance from water sources may be employed in categorizing households according to where they live. In the Niger analysis, for example, an aridity index has been employed. Three categories were created – most arid, less arid and least arid – and resilience has been estimated at profile level.

⁹ I.e. differentiating between households that experienced a shock and households that did not.

¹⁰ I.e. differentiating between households that received assistance through a project and households that did not.

Qualitative analysis

The RIMA model will employ information from qualitative analysis. Qualitative analysis provides both stand-alone analysis and a set of information that feed and complement the quantitative analysis. Integrating this information has proven crucial in arriving at a clear understanding of poverty and resilience dynamics.

3. WAY FORWARD

3.1 Country-level application

The Niger

In collaboration with the World Bank, FAO is conducting a resilience analysis in the Niger, which employs data from the recent Living Standards Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). Households are being profiled according to three main profiles: vulnerability, livelihoods and probability of being reached by a shock. Analysing household resilience will help FAO to better target future interventions in the country. An attempt is being made to include climate change in the model.

Somalia

Under the framework of the joint UNICEF, WFP and FAO programme “Building Resilience in Somalia”, the resilience index will be employed as the major indicator of an impact evaluation. The data used are ad hoc and collected through a LSMS-type instrument. An attempt is being made to include climate change and enabling institutional environment in the model.

South Sudan

An impact evaluation is ongoing for an FAO project in Jonglei and Upper Nile, in which the resilience index will be used as the major indicator of project impact. Enabling institutional environment will also be included in the resilience analysis. Data used are ad hoc and collected through a LSMS-type instrument.

West Bank and Gaza Strip

The FAO Coordination Office for the West Bank and Gaza Strip Programme has been collecting rounds of cross-section data over the last eight years. These data will be employed to look at the dynamic of resilience. An attempt is being made to include resilience validation and to carry out a modeling of the resilience index.

3.2 Technical development

Developing, and building consensus on, resilience measurement and analysis standards and approaches requires strong multi-sectoral partnerships and highly specialized expertise.

The Joint FAO/IFPRI/WFP **Food Security Information Network** (FSIN)¹¹ has been a key initiative in this regard. The FSIN is a global community of practice that aims to improve food and nutrition security information in regions that are most at risk.

Within the framework of FSIN, a small task-oriented **Technical Working Group** (TWG) on resilience measurement has been established to support the technical development of resilience measurement and analysis. The TWG is composed of leading experts on resilience measurement (including qualitative and quantitative approaches) related to food and nutrition security, and will work under the overall supervision of the FSIN Steering Committee and with the support of the FSIN Technical Secretariat.

The primary **objectives** of the TWG are to: (i) secure consensus on a common analytical framework and guidelines for food and nutrition security resilience measurement; (ii) promote the adoption of agreed principles and ‘best’ practices on data collection and analysis tools and methods; and (iii) support the development of the community of practice.

The TWG’s main expected **tasks** are to: (i) support the development of resilience-related technical materials; and (ii) carry out a critical review and analysis of resilience measurement methods and approaches.

TWG activities are organized around **five main technical areas**:

¹¹ (<http://www.fsincop.net/>)

- 1. Existing Data Resources Cluster**
- 2. Scale and Systems Cluster**
- 3. Shocks and Stressors**
- 4. Qualitative and Subjective Measures Cluster**
- 5. Estimation/Explanatory Models Cluster**

4. CONCLUSION

The focus on resilience and capacity building has important policy implications. In the past, mainstream interventions undertaken in risk-prone areas often tended to estimate or forecast shocks (an exogenous variable that can be hardly controlled) and then tailor the intervention to provide timely but short-term support to affected populations. Such situations often result in repeated cycles of humanitarian assistance that do not address the real causes of the crisis. Conversely, a resilience-based approach builds capacity in dealing with shocks, thus enhancing the ability to manage risk over time, reduce vulnerability and diminish the need for humanitarian intervention when future hazards occur.

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