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Measuring Resilience in the Horn of Africa

REPORT 2

The development of **baseline datasets, indicator selection and analytics** to assess the impact of investment for IGAD member states

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technical consortium
Building Resilience in the Horn of Africa

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1 Introduction

The Technical Consortium for Building Resilience in the Horn of Africa (TC) is a project of the CGIAR, which was formed in 2011 following the effects of the 2011-2012 drought. The main aim of the Technical Consortium initially was to provide financial and technical support to the Intergovernmental Authority on Development (IGAD) and its member states (Djibouti, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda) to formulate regional and national investment programmes for the long-term development of ASALS and to follow this with technical support, with particular focus on monitoring and evaluation and the targeting of investments within these plans. These investment plans became the Country Programme Papers (CPPs) for drylands projects for the Member States and the Regional Programming Framework (now the IGAD Drought Disaster Resilience Sustainability Initiative (IDDRSI)), which focused on investment plans to address regional issues for IGAD.

The focus of the TC's work at present is to collaborate with different partners, specifically including the governments in the region as their plans develop, to provide tools for measuring the impact of investments on enhanced resilience and to develop decision support tools for better targeting and prioritization of investments or projects. These tools will not only be useful for monitoring the impact of interventions within the national drylands investment plans and provide evidence for rational decision-making and prioritization, but will be applicable for donors, developments, NGOs and civil society when measuring or targeting their projects.

It has been noted that there is a gap between the strategies that decision makers use to allocate policy-related investments for ASALs and the analytical techniques that researchers use to model the conditions of ASALs and assess the impact of related interventions. To help bridge this gap, the TC has been working to develop and apply approaches to support evidence-based decision-making and investment prioritization to enhance resilient development trajectories in Horn of Africa (HoA).

The result will be a toolbox of methodologies and application processes that facilitate the capacities of the IGAD member states to identify the investments with greatest potential for the highest impact to build resilience to shocks and stressors, in particular to drought, in the HoA. The toolbox will be tailored to elucidate the implications of more focused interventions, for a more specific sub-population of interest, as those details are specified by IGAD or the member states. It will also be able to test how well investments perform under different conditions (climatic and otherwise) and over varied time horizons. The toolbox will be of use to multiple audiences, but the primary focus for application will be to provide tools for the Government of Kenya (GoK) National Drought Management Authority (NDMA), to assist with decision analysis and prioritization for investment proposed in the Kenya Ending Drought Emergencies Common Programme

Framework (EDE CPF) drylands investment plan. It is also assumed, however, that the conceptual analysis and knowledge gained in the provision of tools to the GoK NDMA will also be of use to other clients such as NGOs, donors and development partners to assist with their decision making processes and that these tools will also have potential for replication in the remaining IGAD member states.

The activities detailed in this report form part of the work necessary to provide a foundation upon which to develop these tools. In addition to providing the IGAD member states with baseline datasets and appropriate resilience-sensitive indicators against which to measure the impact of investments, projects, interventions and activities on enhanced resilience of populations in the HoA, the TC also strives to identify methodologies which can provide the analytical framework with which to measure impact.

How do we define resilience?

Resilience is defined as the capacity that ensures stressors and shocks do not have long-lasting adverse development consequences[1] and that enables support to trajectories enhancing growth and prosperity[2]. As such, resilience has become increasingly integral to the transition in development strategies from short-term solutions, to interventions that develop a longer-term capacity to mitigate and absorb environmental/social challenges and shocks. However, because resilience encompasses different spatial scales (individuals, households and communities) and temporal scales, across various systems and at different rates of change[3], it is a non-static concept that is difficult to measure and monitor.

What we would we like to know

- Can we develop a framework that will help national governments understand whether the investments they have planned in their drylands investment plans will contribute to enhanced resilience of their target populations?
- How can we, as researchers, scientists and development partners providing technical support to national governments in the region, assist planners with a rationale for the prioritization of investments?
- Can we develop a suite of tools which will help national government planners target their investments for optimum results?
- Do we know which investment (or even which sector) is most important in contributing to an individual's or a community's enhanced adaptive capacity – will investments in education, health, nutrition or income-generating activities make the most difference? Or, is the optimum result produced from a combination of different investments in different sectors? How do they interact, and which investment contributes what to the overall impact?
- Are donors and development partners able to understand the return they should expect for an investment? How much time will the impact of the investment take to manifest change? How much money will that cost?

[1] Barrett, C.B. & Constas, M.A. (2014). Toward a theory of resilience for international development applications. Proceedings of the National Academy of Sciences, 111, pp. 14625-14630.

[2] Definition by the Technical Consortium for Building Resilience in the Horn of Africa.

[3] Maxwell, D., Vaitla, B., Tesfay, G., & Nigussie, A. (2013). Resilience, Food Security Dynamics, and Poverty Traps in Northern Ethiopia: Analysis of a Biannual Panel Dataset, 2011-2013. Somerville, Massachusetts, USA: Feinstein International Center, Tufts University.

2

Developing a framework **for measuring resilience**

In developing a framework for measuring resilience, the Technical Consortium considered past research and experience of both systems' resilience and development resilience, as well as the requirements for application of national governments and development partners.

Among these considerations is the need to monitor resilience outcomes and impacts with respect to determinants and constituents of resilience. Furthermore, in the context of the Horn of Africa, it was necessary to also consider a wider conceptualization of achieving resilience that encapsulates resilience as enhancing well-being, prosperity and capacity. This includes factors related to ecosystems, governance, household assets and household characteristics, and how these factors combine to influence well-being, prosperity and the capacity of individuals to enhance their livelihoods.

In the context of measuring and evaluating the impact of investment on resilience, this focus on wider development consequences can be more accurately reflected as 'resilience as an adaptive capacity' towards the attainment of well-being and prosperity of livelihoods - a more suited set of proxies in the context of the Horn of Africa (HoA). In addition to a focus on the reflection of indicators for livelihoods and well-being as adaptive capacity, it is also necessary to understand the dynamics of the systems that support the primary livelihood and income-generating activities in the HoA – outputs from extensive livestock production systems[4].

The success of pastoral production and the ability to generate income from extensive livestock production systems depends largely on management strategies involving continuous adaptation and response to shocks and stresses. Although new forms of pastoralism are emerging which still have mobility and response to non-equilibrium systems at their core, it is important to monitor key indicators from dynamic rangeland ecologies and understand thresholds for adaptation, particularly when access to essential resources such as grazing and drought reserves is compromised[5].

If we consider resilience as an adaptive capacity, we can apply an outcomes-based focus on the causal relationship between investment and impact, which lends itself to being measured and monitored across a timeframe or trajectory – specifically through an impact pathway.

[4] Aklilu, Y. & Catley, A. (2010). Livestock Exports from the Horn of Africa: An analysis of benefits by pastoral wealth group and policy implications. Feinstein International Center - Tufts University - Gerald J and Dorothy R Friedman School of Nutrition Science and Policy.

[5] Oba, G. (2013). The Sustainability of Pastoral Production in Africa. In A. Catley, J. Lind, & I. Scoones (Eds.), Pastorlism and Development in Africa - Dynamic Change at the Margins. London and New York: Routledge Earthscan.

One approach to **linking investments to impacts**

3

The impact pathway as a medium for M&E

An impact pathway is developed in part by discussions between project staff and stakeholders, in order to facilitate the development of long-term strategies and investments, as well as monitor and evaluate their impact. It maps out how research and investment actions must scale out[6] and up[7] in order to achieve the defined outcome[8], and reflects the dynamic changes in behaviour, relationships, networks, activities, people and organizations along the timescale of the project[9]. These potential changes illustrate 'cause and effect' shifts, and the value of the impact pathway is being able to iteratively evaluate and examine individual actions (and potential influencing factors) on both mid-term outcomes and final outcomes. In this way, an impact pathway is able to form an evolutionary and iterative process where lessons learned and identified gaps all inform future measures to enhance resilience efforts.

As a continually evolving and revisited process between parties, developing an impact pathway forms a non-linear approach to mapping a resilience investment that allows for the monitoring and evaluation (M&E) of ever-changing dynamic interactions across varied systems, in an equally dynamic and responsive way[10]. For the purposes of mapping resilience, the Technical Consortium has termed this a resilience pathway – or a pathway to resilience.

The premise of the resilience pathway lies in understanding how elements such as increasing capacity and prosperity can act as proxies that contribute to existing development metrics used at a national scale. The focus on an extended timescale integrates the need for resilience analysis track livelihoods over an extended period of time – going beyond short-term causes of risk or crisis in communities to an insight into changes in livelihood strategies, held assets and livelihood institutions (social, political, economic norms) over a longer-term[11].

Ultimately the resilience pathway approach, Figure 1 on the following page aims to show an operational example of how resilience measurement and metrics can be applied into a workable system for IGAD Member States to use in programming toward enhanced resilience.

[6] via the horizontal spread of knowledge between stakeholder groups

[7] via the vertical spread of knowledge between different levels of governance and/or aid

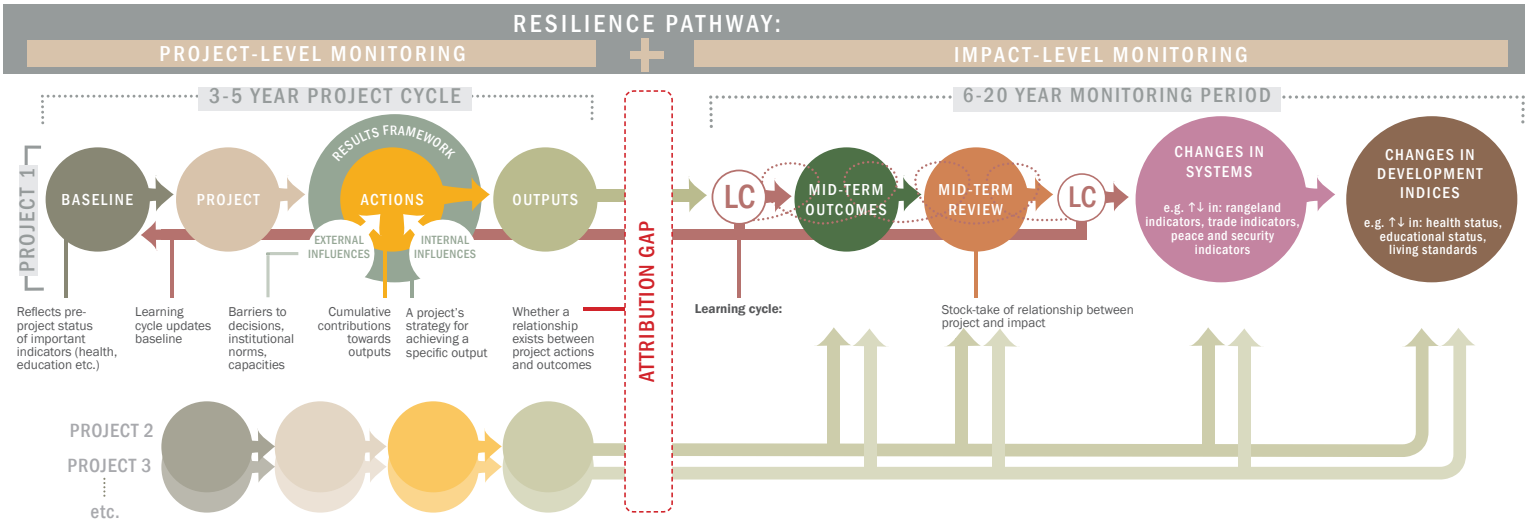
[8] Alvarez, S., Douthwaite, B., Thiele, G., Mackay, R., Cordoba, D., & Tehelen, K. (2010). Participatory impact pathways analysis: a practical method for project planning and evaluation. Development in Practice, 20, pp. 946-958.

[9] Roduner, D., Schlappi, W., & Egli, W. (2008). Logical Framework Approach and Outcome Mapping: a Constructive Attempt of Synthesis. AGRIDEA and ETH Zurich.

[10] Aulin et al. 2012

[11] Maxwell, D., Vaitla, B., Tesfay, G., & Nigussie, A. (2013). Resilience, Food Security Dynamics, and Poverty Traps in Northern Ethiopia: Analysis of a Biannual Panel Dataset, 2011-2013. Somerville, Massachusetts, USA: Feinstein International Center, Tufts University

Figure 1: A resilience pathway illustrating short-term project and longer-term impact monitoring towards sustainable development outcomes



Attribution or Contribution

It is critical that both attribution and contribution of individual projects, actions and processes are understood in their role toward achieving outcomes along designated impact pathways. The conceiving of these pathways needs to be supported by clear processes, actions and projects that can show verified contributions toward the pathway and transparent attribution in enhancing resilience. An ex post impact assessment, once an individual project is completed, allows an understanding and 'plausible' bridge linking a projects direct benefits with wider level impacts. This requires a 'persuasive case', requiring triangulation with multiple data sources, quantitative analysis, qualitative data and verbal testimony to illustrate attribution toward resilience.

Using system indicators to evaluate impact of investments

Key to evaluating projects and interventions aimed at enhancing resilience through an impact pathway, are indicators: qualitative or quantitative measures derived from a series of observed facts that can identify change over time and act as a benchmark[12]. Indicator-based analysis provides a useful methodology to assess the performance of a policy or project towards a set of goals[13], and enables a more empirically-informed process to justify and evaluate resilience investments[14]. Outcome-based indicators aim to define an explicit outcome or end point of the resilience intervention action, creating a 'downstream' approach where indicators are focused on the longer-term effectiveness of resilience interventions.

Indicators also enable resilience pathways to be more succinct, synthesising data in a digestible way that may have a direct influence on

[12] Nardo, M., Saisana, M., Saltelli, A., Tarantola, Hoffman, A., & Giovannini, E. (2005). Handbook on Constructing Composite Indicators: Methodology and User Guide: OECD Statistics Working Paper

[13] Chesterman, S. & Ericksen, P. (2013). Monitoring adaptation to enhance food security: A survey of approaches and best practice. Copenhagen, Denmark: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS).

[14] Miller, F., Osbahr, H., Boyd, E., Thomalla, F., Bharwani, S., Ziervogel, G., Walker, B., Birkmann, J., Van der Leeuw, S., Rockstrom, J., Hinkel, J., Downing, T., Folke, C., & Nelson, D. (2010). Resilience and Vulnerability: Complementary or Conflicting Concepts? Ecology and Society, 15, pp. 11.

the quality of the interpretation[15] by possible investors, agencies and government bodies.

Although the focus is on implementation and more toward development resilience, the Resilience Pathway takes into consideration a systems-oriented framework for indicator selection, defining indicators through the overarching social, economic and ecological systems that influence the adaptive capacity of the individual, household or community[16]. Indicators are populated by collected data specific to the region under observation that also acts as a baseline for monitoring and evaluating the impact of the resilience investment.

Indicators of each system play an important part in assessing and monitoring a region's resilience:

- Ecological conditions (such as rainfall and population density) define the susceptibility of a particular location to the impact of a shock, such as severe drought.
- Social (non-material) conditions and economic (material) conditions affect the adaptive capacity of a particular location/community to bounce back from the environmental shock once it has occurred, and form an important means of evaluating the time a community needs to rebuild or bounce back after the shock has occurred.

Harley & van Minnen (2009)[17] add a valuable set of questions to consider when conceptualizing and selecting relevant indicators:

- Availability – do appropriate data and indicators already exist?
- Potential availability – is reliable data available where indicators have not yet been developed?
- Representativeness – do the indicators measure progress on determining factors rather than less significant aspects?
- Continuity – are indicators readily rather than intermittently available?

Ultimately, the selection should 'reflect the objectives and the particular context' and permit the inclusion or withdrawal of specific indicators (from a defined indicator pool) appropriate to that purpose[18].

[15] Deprez, S., Van Ongevalle, J., & Huyse, H. (2007). Learning the way forward: Adapting to St2eep's planning, monitoring and evaluation process through Outcome Mapping. Outcome Mapping Learning Community.

[16] Bahadur, A.V., Ibrahim, M., & Tanner, T. (2010). The resilience renaissance?

[17] Harley, M. & van Minnen, J. (2009). Development of Adaptation Indicators. European Topic Centre on Air and Climate Change, Bilthoven.

[18] Pangaribowo, E., Gerber, N., & Torero, M. (2013). Food and Nutrition Security Indicators: A Review. Bonn: University of Bonn.)

4

A practical application: Kenya's Ending Drought Emergencies Common Programme Framework

Figure 2 illustrates the process of rationalising indicators to allow the various investments that have been selected in the Country Program Papers. The example focused on the Kenya EDE Common Programme Framework[19] and shows the need to rationalise both proposed project actions with mid-term outcomes, the three key systems that interplay and the scale of indicators required.

The challenge of causal inference: a limitation to indicators as an evaluation of investment impacts

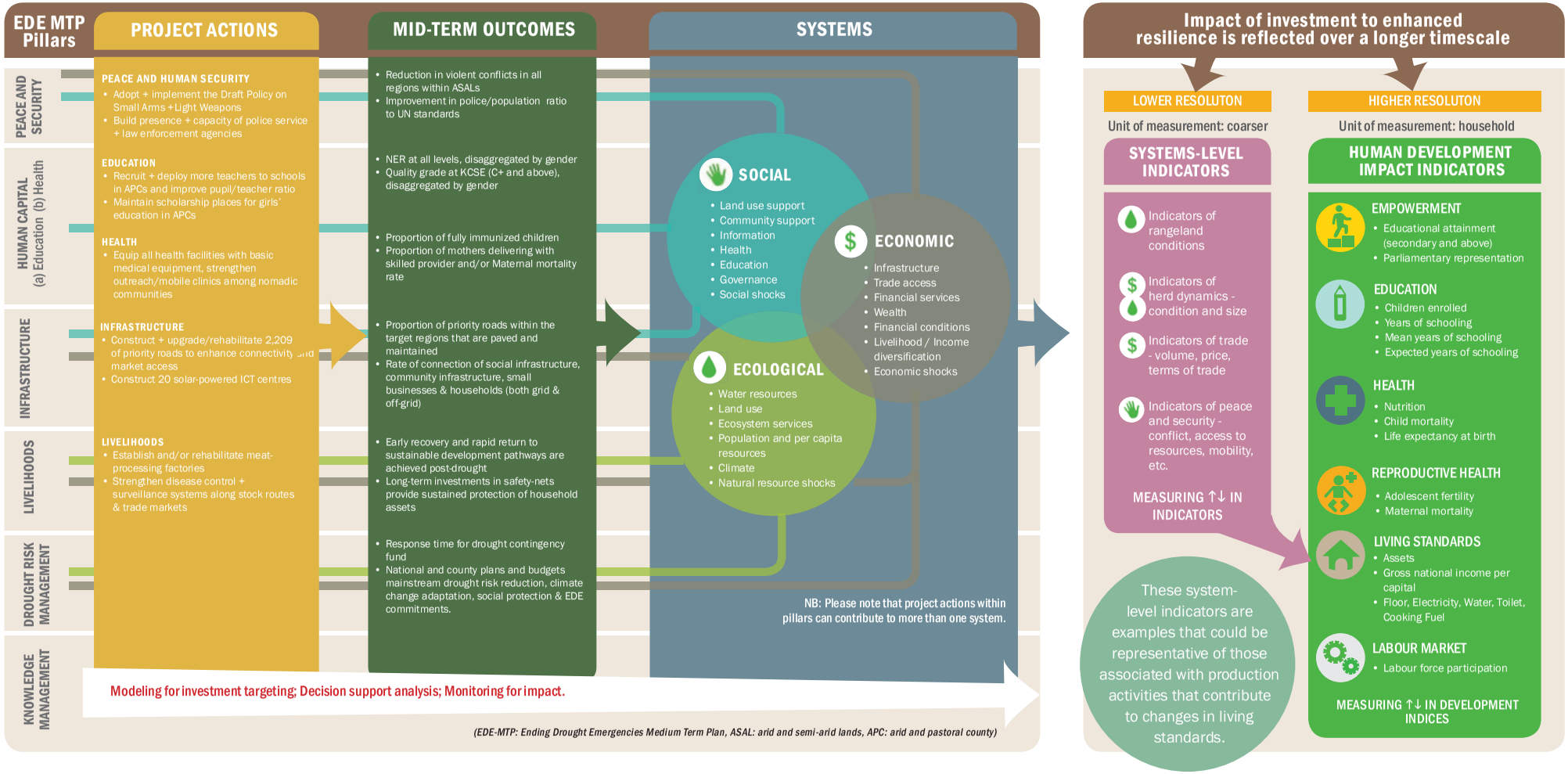
Moving beyond measuring inputs, a first advance is to have a baseline appreciation of the conditions on the ground in a given location and then temporal coverage of improvements in outcome measures of interest over time, which typically requires follow-up individual-level surveys of project beneficiaries about whether their yields or incomes have gone up, school attendance of their children has gone up, diets are improved, etc.

While such measures are an improvement over the historic practice of measuring project inputs, such studies themselves are still not dispositive of a causal connection between a project investment and those outcome measures. Improvements or deteriorations in living conditions of intended beneficiaries might have occurred in the absence of project interventions, for other reasons. Indeed, the project's contribution could have accelerated or even dampened the improvements (or deteriorations) that would have taken place anyway.

One cannot know that the project itself was responsible for the changes unless one can distinguish between the outcome measures of program participants and non-participants and establish that the two groups are statistically comparable in all ways except participation in the evaluated project. The best and most elegant way to ensure statistical comparability is to randomly select participants from a pool of eligible participants. This randomization in itself ensures that the two groups are statistically the same in all respects except participation in the program. Then, assuming that no unforeseen confounding factors affected one group and not the other during the life of the project, one can be confident that differences in outcome measures can be attributed to the intervention. Thus, so-called randomized control trials (RCTs) that have long been implemented in other scientific fields have recently become the state-of-the-art in the development arena as well.

[19] http://www.dmikenya.or.ke/downloads/func-startdown/164/

Figure 2: The process of rationalising indicators to allow the various investments that have been selected in the Country Program Papers.



5

Implementing a **systems-based approach** to categorise indicators

Adaptive capacity can be seen in the light of specific activities, and longer-term responses over a temporal scale. According to Bene et al. (2014)[20], adaptability is "the capacity of a system (or parts of this system) to learn, combine experience and knowledge, adjust its responses to changing external drivers and internal processes, and continue developing within the current stability domain or basin of attraction". Assessing resilience from a systems perspective captures this temporal scale, by enabling us to not only consider specific activities but to evaluate how those isolated variables feed into a larger system over time[21].

Resilience is commonly viewed from a household and livelihoods perspective, in the context of the social system incorporating social variables such as human capital and community support structures. However, a household's resilience may also be influenced by remote yet highly influential factors such as economic market trends.

In the context of the Horn of Africa, where people rely heavily on natural resources for their livelihood, resilience is equally linked to the condition of the environment and the status of its resources[20]. The ecological system provides the natural resources that human livelihoods depend on such as freshwater to drink, or sustenance in the form of natural pastures for livestock. Many can be seen as material assets or natural capital that are provided by nature rather than engineered by humans (economic system). Ecological resources may be valued in terms of what it would cost people to replace these services, but for the most part are available to people free of charge. Ecological conditions (such as rainfall and population density) also define the susceptibility of a particular location to the impact of a shock, such as severe drought.

According to Umetsu (2012)[22], "a society may be able to cope well with change from a social perspective (e.g., improving irrigation technology and increasing agricultural subsidies), but an evaluation of overall resilience must also include the sustainability of the adaptation from an ecological perspective (e.g., the ecological impacts of increased farming and groundwater pumping)". When analyzing a houshold's adaptive capacity and the role within that social, economic and ecological systems play, one cannot be considered in absence of another, but must instead be understood as being linked inextricably together; as related, coupled systems.

The goal of sustainable development is to create and maintain prosperous social, economic, and ecological systems. These systems are intimately linked: humanity depends on services of ecosystems for its wealth and security. Moreover, humans can transform ecosystems into more or less desirable conditions. (Folke et al., 2002)[23]

[20] Bene, C., Newsham, A., Davies, M., Ulrichs, M., & Godfrey-Wood, R. (2014). Resilience, Poverty and Development. Journal of International Development, pp.

[21] Nelson, D.R., Adger, W.N., & Brown, K. (2007). Adaptation to Environmental Change: Contributions of a Resilience Framework. Annual Review of Environment and Resources, 32, pp. 395-419.

[22] Umetsu, C. (2012). Resilience of Social-Ecological Systems for Food Security. Paper presented at the JIRCAS International Symposium 2012.

[23] Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L.H., Holling, C.S., & Walker, B. (2002). Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. AMBIO: A Journal of the Human Environment, 31, pp. 437-440.

Assessing resilience through a combination of social, economic and ecological variables provides a key insight into adaptive capacity as a household's initial vulnerability to a shock and the time needed to recover from the shock:

- The state of variables within the ecological system (such as low or high rainfall and population density) can help define the susceptibility of a particular location to the impact of a shock and
- The state of variables within social and economic systems (for example, easily transferable assets to be sold or good links to markets) can provide insight into the time that might be required to rebuild following the shock.

This notional organization of systems into risk and vulnerability and time to recover was employed by the Technical Consortium to synthesise key variables/indicators with which to monitor and evaluate resilience, with the intention of developing a pilot spatial tool that would use the indicators to measure the resilience of particular geographical regions. While in many cases, indicators may be relevant both during and after a shock, and may overlap across all three systems; it was expedient for the purpose of creating categories to break the various indicators into the system categories.

6

Data scoping

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In order to populate indicators within the social, economic and ecological systems in the Horn of Africa with datasets that were relevant to enabling governments, donors and NGOs to measure the impact of their interventions and projects, the Technical Consortium conducted a preliminary inventory of datasets available in the Horn of Africa.

The premise for this inventory was that these comprehensive baseline datasets would contribute towards an enhanced representation of initial vulnerability or susceptibility within a geographic region and the subsequent time to recover from a shock. Subsequent to this initial scoping and evaluation, these datasets would form the basis for the Technical Consortium's work to establish catalogues containing baseline datasets for the IGAD member state countries M&E processes to enhance resilience.

These datasets will be organized into catalogues, providing governments and others with meta-data on indicators that have been recognized as resilience-sensitive, or that play a role in measuring changes in resilience.

Over a six-month period, a robust scoping for available datasets was undertaken, entailing extensive consultation with agencies, NGOs and governments in the Horn of Africa to collate available information on data sources at multiple levels. The data scoping resulted in the acquisition and standardization of 452 datasets, identified to be comparable and scalable between values representing highest and lowest resilience and organized by system (ecological, social and economic).

The development of a draft catalogue has been designed using a range of themes across different scales; regional, national, county / district according to the organization of administration units within each country in the Horn. The foundation for these themes was the pillars or priority intervention areas (PIAs)[24] articulated within the IGAD Drought Disaster Resilience and Sustainability Initiative (IDDRSI) which governs the sectoral organization for regional investments. This structure of themes is relatively consistent across the IGAD member state countries, with slight variations in the number of pillars for some countries.[25]

The catalogue was developed using a consultative process with ILRI scientists familiar with ASAL areas and the geo-political landscape of the Horn to generate an extensive list of possible themes from which to scope and review available data sources and specific data sets. A selection of themes, reflected best in three of the IDDRSI PIAs is shown on the following page.

[24] PIA 1 - Natural Resources and Environment Management, PIA 2 - Market Access, Trade and Financial Services, PIA 3 - Livelihood support and Basic Social services, PIA 4 - Disaster Risk Management, Preparedness and Effective Response, PIA 5 - Research, Knowledge Management and Technology Transfer, PIA 6 - Conflict Prevention, Resolution and Peace Building and PIA 7 - Coordination, Institutional Strengthening and Partnerships

[25] For example, the Kenya Ending Drought Emergencies Common Programme Framework articulates six pillars: Pillar 1: Peace and Security, Pillar 2: Climate-proofed infrastructure, Pillar 3: Human Capital, Pillar 4: Sustainable Livelihoods, Pillar 5: Drought Risk Management and Pillar 6: Institutional Development and Knowledge Management

Table 1: Example of how datasets could be organized and categorized by theme, sub-theme and indicator

NRM	Livelihood	Markets
Biophysical ■ Climate data ■ Agro ecological zones ■ Aridity index (AI) ■ Potential Evapo-transpiration (PET) ■ Drylands ■ Agro-climatic zones ■ Length of Growing Period ■ Landforms ■ Soils ■ Water sources ■ Water use ■ Land cover *Natural resources & environment* ■ Biodiversity coverage ■ Protected areas ■ Drainage & irrigation ■ Desertification rates *Agriculture/Plant production & protection* *Livestock Types, Numbers and Densities*	*Demographics* ■ Human Population ■ Health ■ Gender ■ Education *Geo-political* *Government administration* *Economics & Policy* ■ Access to safe water ■ Access to sanitation ■ Rural & social development ■ Poverty ■ HIV/AIDS and *Contraceptive use* *Animal production & health* *Rural & social development*	*ICT Technology* ■ Power (Energy) ■ Transportation systems ■ Rural and Urban markets *Distances information* ■ Relief ■ Other infrastructures ■ Livestock trade routes ■ The distribution and characteristics of stockists of agricultural inputs

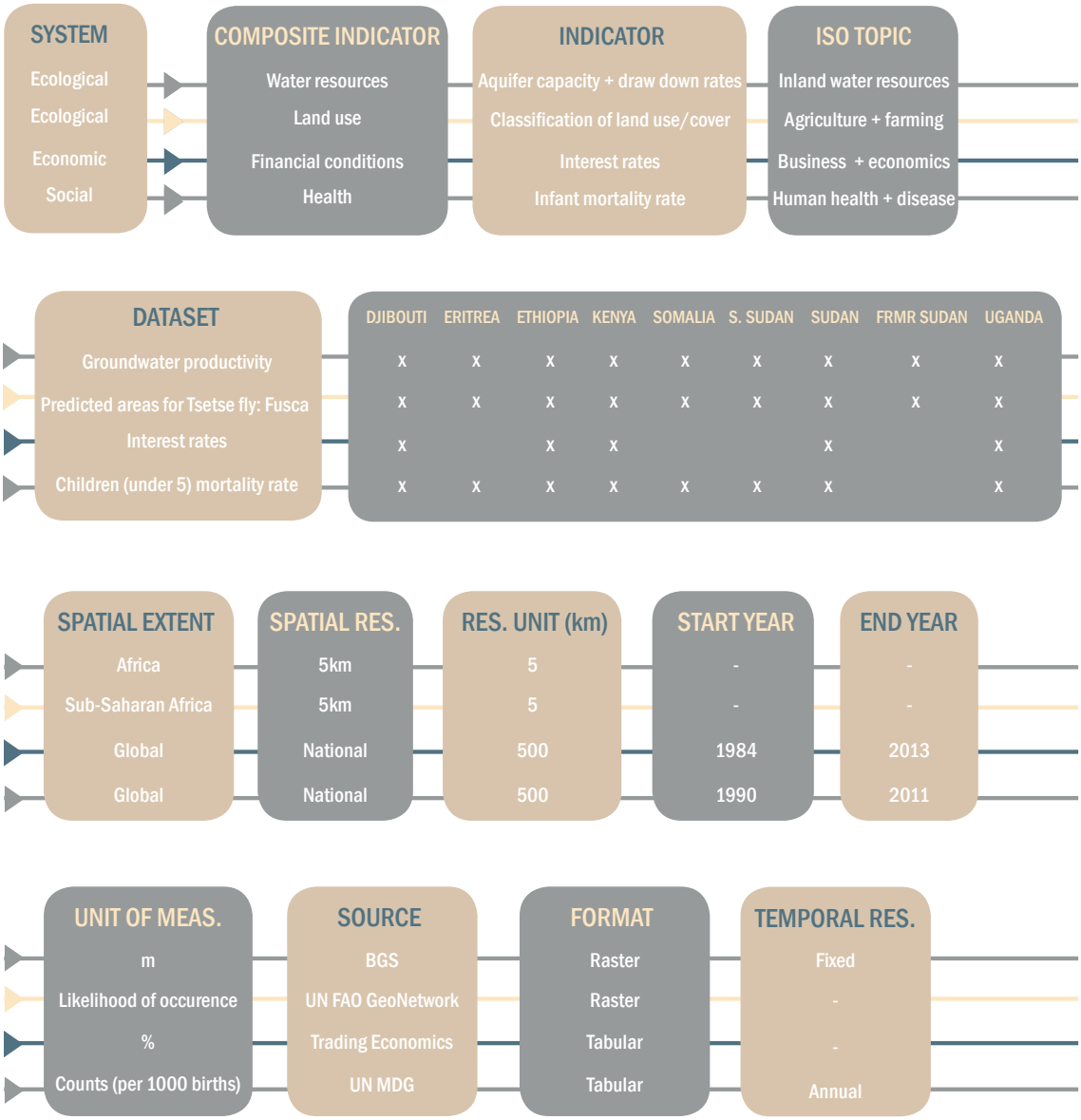
The cataloguing was done on a country-by-country basis, as a way of integrating key stakeholders and carrying out a robust scoping. The initial cataloguing was completed by Habitat Info and ILRI. A total of 452 datasets are described and documented in an excel format data catalogue. The schema of the catalogue contains the following fields (see Figure 3 for a visual schematic of this):

1. **Dataset No.**	number for the dataset derived from the data classification system
2. **System**	respective resilience system
3. **Composite Indicator**	respective composite indicator
4. **Indicator**	respective indicator
5. **In Geodatabase?**	whether the data has been acquired in a geodatabase, or simply described in this catalogue

Continued on following page

6. **ISO Topic**	class of information from the ISO standard (essential for management of metadata by Geoportal)
7. **Dataset**	the descriptive name of the dataset
8. **Djibouti**	a. whether the dataset is relevant for Djibouti b. start year for temporal data in Djibouti c. end year for temporal data in Djibouti d. note field for data relevant to Djibouti
9. **Ethiopia**	a:d same as above
10. **Eritrea**	a:d same as above
11. **Kenya**	a:d same as above
	a:d same as above
13. **Somalia**	a:d same as above
14. **South Sudan**	a:d same as above
15. **Sudan**	a:d same as above for (new) North Sudan
16. **Former Sudan**	a:d same as above for both countries when monitored formerly as one
17. **Uganda**	a:d same as above
18. **Spatial Extent**	Global / IGAD / Kenya etc
19. **Spatial Resolution**	as described in metadata e.g. 5 arc-minutes / National
20. **Resolution Unit (km)**	the approximate resolution in km that the above description corresponds to
21. **Start Year**	start year for a period of monitoring
22. **End Year**	end date for a period of monitoring
23. **Temporal Resolution**	e.g. Annual
24. **Unit of Measurement**	e.g. kg/ha
25. **Source**	the organisation which provides the data
26. **URL**	hyperlink to the data source
27. **Purpose**	a brief summary of why the data is gathered / used
28. **Description**	a more detailed description of the data, including methods
29. **Format**	e.g. Raster / Vector Point / Tabular
30. **Constraints**	any constraints specified by the provider on the use of the data, if any
31. **Comments**	supplementary notes made during assimilation

Figure 3. Example of how the data catalogue is arranged



Various tests of the utility value of the datasets in terms of their scale, resolution, integrity and other attributes, were carried out. One of these tests involved the production of 10 maps at different scales (regional, national and subnational), looking at spatially representing basic indicators such as distance to water, livestock numbers, access to education and health etc. From this exercise, the limitations of the available spatial data were better understood and the requirements to generate more useful data were recognised. These maps can be found in: Davies, R., Wroblewski, T., Downie, K., Chesterman, S. 2014. Gaps in spatial data for social, ecological and economic systems. Report prepared by the Technical Consortium, a project of the CGIAR. Technical Report Series No 1: Measuring Resilience in the Horn of Africa. Nairobi, Kenya: International Livestock Research Institute (ILRI).

7

Selection of indicators

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Multiple mechanisms such as correlation analysis, factor analysis, regression, and other methods can help with choices regarding which indicators to include or how to group them. Expert opinion on indicator selection and weighting is another tool that has been employed[26,27]. Theory can also be an important guide as well, with clear conceptual groupings and a causal narrative of why certain indicators are included[28,29].

From the pool of 452 datasets documented in the data catalogue, 165 indicators were selected that best represent resilience. The 165 resilience indicators were selected[30] using the following underlying criteria:

- relevance to the region's resilience,
- data quality and
- availability of the data on a regional and national level.

The indicators were then divided amongst the three systems: social (51), economic (73) and ecological (41). A preliminary listing of key variables chosen to characterise the resilience of ecological, social and economic systems is provided in Table 2, 3 and 4, from which the indicators for each system were populated.

Table 2: Key variables for assessing ecological resilience
('+' = Positive influence at high values, '-' = Negative influence at high values)

ECOLOGICAL RESILIENCE VARIABLES	
+ Water discharge	+ Biodiversity value
+ Irrigation potential	+ Forest resources
- Distance from water	- Deforestation
+ Rainfall per person on agricultural land	- Slope
+ Rainfall data from remote sensing	+ Length of the growing period
+ ENSO index	+ Net primary productivity
- Crowding on agricultural land	- Soil degradation
- % people in water stress	+ Available soil moisture
- Human appropriation of net primary productivity	+ Rangeland condition
- Population density	- Livestock mortality data
- Projected population growth	- Invasive plant occurrence
	+ Food web complexity
	- Tsetse fly occurrence

[26] Adger, W.N., Brooks, N., Bentham, G., Agnew, M., & Eriksen, S. (2004). New Indicators of vulnerability and adaptive capacity. Norwich, UK: Tyndall Centre for Climate Change Research.

[27] Brooks, N., Adger, W.N., & Kelly, P.M. (2005). The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. Global Environmental Change, 15, pp. 151-163.

[28] OECD. (2005). OECD Factbook 2005: Economic, Environmental and Social Statistics.

[29] de Sherbinin, A., Levy, M., Zell, E., Weber, S., & Jaiteh, M. (2014). Using satellite data to develop environmental indicators. Environmental Research Letters, 9, pp.

[30] This selection of indicators and the datasets to populate them has to date been based largely on expert opinion. Further efforts will have to be undertaken to more rigorously evaluate these indicators if their inclusion is to be validated.

Table 3: Key variables for assessing social resilience
('+' = Positive influence at high values, '-' = Negative influence at high values)

SOCIAL RESILIENCE VARIABLES	
- Conflicts	+ Life expectancy
+ Governance	- Orphans
+ Change in leaders	- Infant mortality
- Crime rates	- Disease metrics (malaria, HIV etc.)
- Displacement migration	+ % Expenditure on health
+ Circular migration	- Distance to health centres
+ Policing	+ Education
+ Community management	+ Equitable society indicators
+ Availability of support networks	+ Inclusivity indicators
+ Representation in parliament	+ Role and participation of women
+ Property rights and legal indicators	+ Access to info - early warning
+ Agricultural system	+ Access to info - crop prices etc.
+ Own food production	+ Sustainability of heating etc.
+ Access to improved water	

Table 4: Key variables for assessing economic resilience
('+' = Positive influence at high values, '-' = Negative influence at high values)

ECONOMIC RESILIENCE VARIABLES	
+ Lights at night infrastructure	- Inflation rate
- Travel time to the nearest city	+ GDP national
+ Road and rail infrastructure	- National debt
- Distance to the nearest port	+ GDP household (income)
+ Electrical infrastructure	+ Household assets
- Distance to the nearest airport	+ Livelihood diversity
- Distance to the nearest marketplace	+ Crop diversity
+ Telephone infrastructure	+ Livestock diversity
+ Cell phone users per 1000 people	+ Agricultural assets
+ Access to internet	+ Agricultural inputs
+ Price stability	+ Crop storage facilities
+ Flexible exchange rate policy	- Agriculture as % GDP
+ Integration with other markets	- % reliance on cash crops
- Trade regulations / + Trade openness	+ Industry trade as % GDP
- Tax regulations	+ % land under irrigation
+ Access to credit	- Water withdrawals
+ Access to savings	- Poverty (infrastructure)
+ Access to insurance	- Malnourishment
+ Access to local enterprises	+ Calories pp pd
+ Access to development projects	+ Protein consumption pp pd
+ Tourism	+ Diet diversity
- Interest rates	+ Employment-to-population ratio (Male and female)

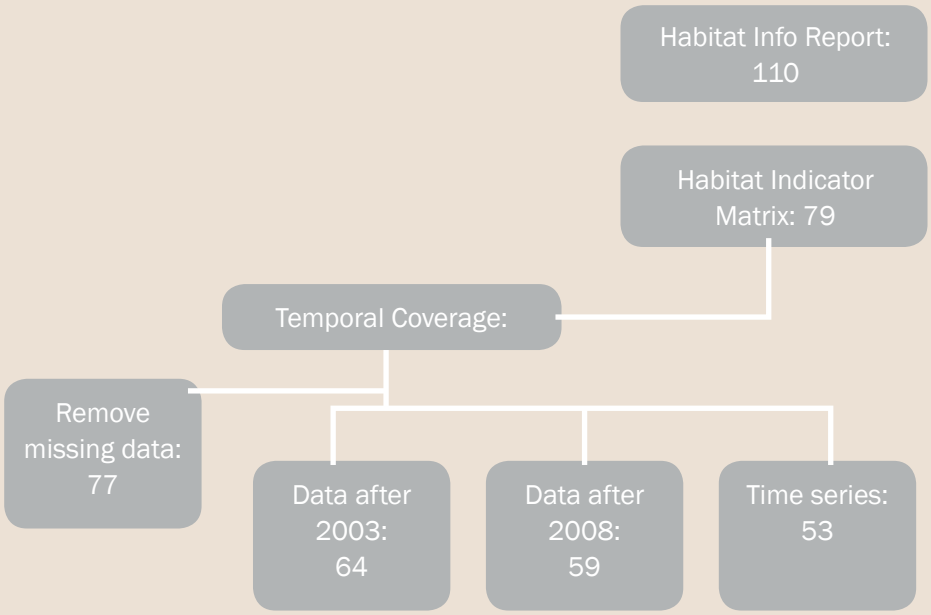
Review of indicator selection: Temporal and Geographic Coverage

Josh Busby, Todd Smith. University of Texas, Austin

A team at the University of Texas carried out an exhaustive review of the existing set of indicators, as selected by habitatINFO for the Technical Consortium, to examine them for geographic specificity and temporal coverage. The objective of this review was to determine whether temporal information was available for all the indicators, how old the data is, and whether some indicators were available for some countries and not others.

The findings were as follows:
1. some indicators lack temporal coverage,
2. some of the data is dated, and
3. a large number of indicators do not have subnational variation.

For example, as the figure below shows, if data that precedes 2003 is excluded, (ie,data that is roughly more than ten years old) the number of available indicators drops to 64. If only relatively recent data is included, (ie., within the last 5 years), the number of available indicators drops to 59. And, if only data for which time series information was available is included, that number would drop to 53.



All of these indicators for which there is data are included in the model, but a number of reasons that one might exclude some of the data sources based on their temporal coverage have already been identified. The presence of more dated data sources is especially prevalent among the ecological indicators, 34% of which pre-date 2003.

In terms of geographic coverage, while it is not necessary to have subnational data for all of the indicators, 20 of the 79 are only available at the national level. That is especially true for social and economic indicators which both rely on national level data for roughly one-third of the indicators.

8

Weighting of indicators

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Once the indicators were separated into the three systems, careful consideration was then given in assigning weights to each indicator in order to compose an overall index of resilience. Each indicator was weighted using an ArcGIS Model Builder, which allows for easy changing of weightings at two classification levels for future sensitivity analysis.

The method of combining these datasets involved standardizing the scale of each to vary in integer values ranging from 1 to 9, and then a simple summation of the layers could take place. However, datasets which were considered to be more crucial to vulnerability, from a more reliable source, and at sufficient geographical resolution, were allowed to have more influence on the final summary layers (weighted up to *3) than datasets which were considered to be less crucial, less reliable, and of a crude resolution (weighted * 1).

Recommendations for improved weighting process

Josh Busby, Todd Smith. University of Texas, Austin

Going forward, a clearer justification of the 1 to 9 scale on the individual indicators and the 1 to 30 scaling on the sub-composites is required, given that a wider dispersion loses less resolution in underlying data.

Furthermore, it may be preferable to use the geographical resolution of the phenomenon as a more indicative weighting than the geographical resolution of the data. Different phenomenon, natural and social, occur at different geographic resolution and insufficient consideration was given to whether the resolution of the data is representative of the resolution of the phenomenon. Variation in an indicator may be lost if the indicator is aggregated to an overly coarse resolution.

Likewise, using a “confidence” weighting implies that an indicator is given a higher weight simply because of data availability, which is unrelated to the level of household vulnerability that the weighted indicators are hoped to depict. Moreover, any population statistic inferred from a sample inherently has a certain amount of uncertainty based on the sample size and variation in the sample data. One should endeavor to use statistics for which the confidence interval is reasonably narrow and there may be methods to calculate the uncertainty in the composite based on uncertainty in the individual indicators.

9

Future recommendations: a sparer model

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While logical, the grouping into ecological, social and economic systems may be overly inclusive so that some indicators are likely to be highly correlated with others, resulting in the potential overweighting of certain attributes in the overall index. A sparer model with a limited set of indicators that are regularly collected may provide a more practical basis for building up a measure of drought resilience that could be useful for identifying areas in need of attention.

A number of other considerations influence choice of indicators, including data availability and spatial resolution. Our general tendency is that parsimony is important; models should only be as complex as they need to be. The original Human Development Index, which was intended to bring in indicators other than per capita GDP to reflect on countries' development performance, incorporated just four indicators including life expectancy, two indicators of education (adult literacy and the combined school enrollment ratio), and standard of living.[31] The Global Hunger Index, which charts national level hunger, uses three indicators: undernourishment, child hunger, and child mortality.[32]

A sparer model is less onerous for data collection and updating and may be easier to understand. Of course, a simple model that leaves out key attributes is problematic, but any model is necessarily a simplification of the world. Therefore, a model needs to justify why inclusion of an additional indicator is necessary, why its absence would fundamentally affect the model output or miss something especially important. If a host of indicators are all highly correlated, widely available, and show similar patterns, there may be some paring that is possible, based on measurement, temporal coverage, spatial resolution, and how often the data is updated.

[31] See http://hdr.undp.org/en/statistics/hdi

[32] See http://www.ifpri.org/ghi/2013/concept-global-hunger-index/

The International Livestock Research Institute (ILRI) works to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock. ILRI is a member of the CGIAR Consortium, a global research partnership of 15 centres working with many partners for a food-secure future. ILRI has two main campuses in East Africa and other hubs in East, West and Southern Africa and South, Southeast and East Asia. www.ilri.org

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