SPACES MERL

SYSTEMS AND COMPLEXITY WHITE PAPER

(abridged version)

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DISCLAIMER

CONTENTS

1. INTRODUCTION AND BACKGROUND

The Strategic Program for Analyzing Complexity and Evaluating Systems (SPACES MERL) project is an activity funded by USAID's Global Development Lab and the Bureau for Policy, Planning and Learning (PPL). This three-year activity aims to bring a variety of tools and methodologies that decision-makers can use (alone or in combination) to provide comprehensive systems analysis. The activity is being implemented from 2015 to 2018 by a consortium of organizations expert in systems and complexity, including the Global Obesity Prevention Center (GOPC) at Johns Hopkins University (Prime), Global Knowledge Initiative (GKI), LINC and ResilientAfrica Network (RAN).

This Systems and Complexity White Paper is a collaborative effort of the SPACES MERL team, designed to frame the international development landscape, with particular reference to USAID-funded activities, for application of systems and complexity approaches to design, monitoring and evaluation. Customized to the systems and complexity layperson with in-depth knowledge of international development practice, the objectives of this white paper are three-fold:

- Provide an overview of systems and complexity practice, its current state of application and relevance to international development practice;
- Establish a taxonomy of systems and complexity tools, highlighting the fit of those offered by SPACES MERL within the wider landscape; and
- Review and provide information on application of SPACES MERL tools, their purpose and construction, required data, and their applicability to specific contexts.

This paper is partially based on interviews with numerous experts in USAID from various Bureaus (including the US Global Development Lab; the Bureau for Policy, Planning and Learning; the Bureau for Global Health; the Bureau for Democracy, Conflict and Humanitarian Assistance; the Bureau for Food Security; the Bureau for Middle East; and the Bureau for Economic Growth, Education, and the Environment) as well as missions (including Uganda). Some of the tools described might not necessarily be strictly speaking "complex systems" tools, but were still identified and suggested as such. The paper does not attempt to capture the universe of existing complex tools, but aims to represent examples within categories.

In addition to producing this white paper, we aspire to identify and develop pilot use cases for application of SPACES MERL's systems and complexity tools. On the basis of this combined research and piloting from 2016 to 2018, the SPACES MERL activity will culminate with the development of a systems and complexity toolkit for reference and application by international development practitioners, both within and beyond USAID. The toolkit will be enriched by a series of use cases and insights derived from our research and piloting activities. Beyond enabling USAID decision makers to effectively and accurately utilize the different tools within the SPACES MERL Toolkit, the consortium aims to cultivate a broader appreciation of the many ways in which complex systems analysis and understanding can deliver long-term benefits through systems mapping and modeling; early-detection of successes and failures; and future-oriented innovation impact assessment.

2. WHAT IS A COMPLEX SYSTEM?

The international development landscape is a complex place. Actors are prone to unpredictable behavior, are governed by ever-changing sets of rules/norms, and roles. These complex systems dynamics are continuous, over the course of decades, years, and indeed, day-to-day. Complexity confounds the traditional analyst's bias toward categorization, standardization, grouping and neat linear thinking. Engaging myriad social systems with dynamic roles, norms and behaviors, the international development program designer and manager is constantly challenged by complexity.

2.1 Definition
Definitions of complex systems abound. In the USAID context, complexity is defined as "where cause and effect relationships are poorly understood, ...where expected results may require refinement and revision as strategies and projects unfold. [This includes] projects (or parts of projects) that rely heavily on adaptive management to steer effectively in dynamic contexts, and projects that seek to influence social change or innovate to discover solutions." Systems are defined as "those interconnected sets of actors—governments, civil society the private sector, universities, individual citizens and others—that jointly produce a particular development outcome."

In our research we have encountered multiple conceptual paradigms to refine our understanding of complex systems, with the following systems features being most useful for the purposes of SPACES MERL:

- *Elements*– These are actors within a system. They can be both formal and/or informal, and are often referred to as "stakeholders" in the international development context.
- *Interrelationships*– Interrelationships refer to the ways elements of a system are connected, and the resulting consequences of the nature of the relationship. This includes: dynamic aspects, such as the way interrelationships affect behavior of a situation over time; nonlinear aspects, oftentimes known as "feedback"; sensitivity, where the same intervention in different areas has varying effects; and finally, entanglement of relationships, distinguishing between simple, complicated and complex ones.[1]
- *Perspectives* – Perspectives incorporate *how* ones look at the picture, as people will see the same interrelationships in different ways. This includes investigation of: the different ways a situation can be understood, the ways different understandings affect how people judge success of an activity, and the ways that people's different understandings affect their behavior.[2] This allows for systemic inquiry on interconnections.
- *Boundaries* – Boundaries provide parameters and limits on the system. They help determine what is "in" and what is "out". Issues of power may arise when boundaries are set and it is important to understand: how the situation is being frame, who is drawing the boundary and what are the practical and ethical consequences of this framing and what do the consequences imply for action.[3]
- *Function or purpose*– The function or purpose is the intended result. Since a system is more than the sum of its parts it is necessary to understand: how the functions of the elements within the system differ from/add- up to the system's function, how the system differs from its initial appearance, what we think it is or what it should be. Function is often the most crucial determinant of the system's behavior.[4]

USAID uses a results-oriented lens, defining a "local system" (where local refers to actors in a partner country) as "those interconnected sets of actors -- governments, civil society, the private sector,

1 Williams, B. and Hummelbrunner, R. (2011). Systems Concepts in Action: a Practitioner's Toolkit. Stanford: Stanford University Press.
[2] Williams, B. and Hummelbrunner, R. (2011).
[3] Williams, B. and Hummelbrunner, R. (2011).
[4] Meadows, D. H. (2008).

universities, individual citizens and others -- that jointly produce a particular development outcome."[5] USAID highlights the "Five Rs" of local systems: Resources, Roles, Relationships, Rules, and Results. The use of "Resources" and the ensuing "Results" can be seen as the purpose of a system; "Roles" describe the functions of individual actors; and "Relationships" are types of interconnections and "Rules" govern the interconnections.

3. FRAMEWORK OF SYSTEMS APPROACHES TO DESIGN, MONITORING AND EVALUATION

Results-based management approaches predominate the international development landscape, characterized by familiar logical frameworks, performance management plans, and clearly defined indicators. What do all of these things have in common? They provide the program designer / implementer with a means of bounding their activities to dynamics within a system that they can control. Most of these familiar project design and performance monitoring tools acknowledge the complexity of the systems within which they operate, typically in the form of an "Assumptions" or "Risks" column, box or narrative. However, they neither attempt nor succeed in capturing and adapting to them.

For the international development practitioner, the problem is further compounded by the very nature of international development assistance. International development programs typically operate in highly fragile and disaster-prone environments, oftentimes lacking predictable governance frameworks and norms. Sources of human capital and funding are external, oftentimes not allocated through traditional means, meaning tremendous potential for systems catharsis, or conversely, disruption. Further, programming tends to be designed, monitored and adapted by relative outsiders, in many cases being expatriates unfamiliar and external to the system they are engaged with. This in itself provides strong justification for the imperative of utilizing systems analysis in international development context, and grounds the linkage between systems-based and locally-led approaches.

3.1 Utility for Design, Monitoring and Evaluation

SPACES MERL takes systems approaches as not only helpful for program design, but instrumental for dynamic monitoring, evaluation and learning. In this regard, employment of systems tools is central to good adaptive management practice, and should be accompanied by project / activity-level flexibility and means of adaptation.

USAID and implementing partner landscape are experiencing a shift toward systems approaches to design, monitoring and evaluation, including a first-time acknowledgement in the revised ADS and multiple instances of piloting and testing across missions. So, what then is the utility of complex systems approaches to program design and adaptive management?

<u>Informing design</u>: Familiar approaches to program design include qualitative pre-project needs assessment, typically shortlisting a group of stakeholders for consultations on constraints and opportunities. Done systematically, this can be an effective strategy. However, such assessments most often miss the larger system, artificially bounding their focus (and by extension, "the system") to particular actors and behaviors

[5] Fowler, B. & Dunn, E. (2014). "Evaluating Systems and Systemic Change for Inclusive Market Development Literature Review and Synthesis." LEO Report No. #3. June. http://pdf.usaid.gov/pdf_docs/PBAAC412.pdf

of interest. All too often, the larger system is only accounted for in a set of risks and assumptions, for which the subsequent program design makes no attempt to control or adapt to.

A good design-level systems approach starts by mapping the broader system, including as many actors and dynamics that may impact on a program's area of interest as possible. Multiple analytical tools may then be used to establish boundaries of the system, identify stakeholders, opportunities and constraints, anticipate behaviors, prioritize interventions, establish a flexible management plan, and design-in strategies to track dynamic systems change and adapt programming accordingly. There are numerous such tools at the disposal of the systems designer.

<u>Guiding adaptation</u>: While good systems-based program design may be *a priori* to good programming, we are still only part way there. A fundamental tenant of complex adaptive systems is that systems are ever-changing and consist of multiple levels. While our systems-level program design challenges us to anticipate emergence as a result of our programming, dynamic systems change requires tracking once programs are underway. Systems tools that are appropriately selected, and reinforced by a management plan and orientation that accommodates adaptive management, are a powerful means of guiding adaptation as we go.

3.2. Categorizing Systems Tools and Approaches
Categorizing systems tools and approaches is a significant challenge, and the subject of much debate among academics and practitioners.

3.3 SPACES MERL Taxonomy of Systems Tools
Recognizing that systems tools present categorization challenges, have tremendous overlap and reinforcing qualities, SPACES MERL suggests a taxonomy roughly aligned with USAID's own, but including some key modifications:

Category	Visualization methods (Mapping)	Visualization methods (Modeling)	Narrative-based approaches	Indicator-based approaches
Examples of Tools and Approaches	• **Social Network Analysis** • **Systemigram** • Participatory Systemic Inquiry	• International Futures • Causal Loop Diagrams • **HERMES** • **RHEA** • **JANUS** • TreeAge	• Most Significant Change • Outcome Harvesting • Scenario Planning • **Innovation System Analysis** • **Innovation System Enablers and Barriers**	• **The Dynamic Project Trajectory Tracking Toolkit** • Process Monitoring of Impacts • Sentinel Indicators • Outcome Mapping Approaches

**Tools / approaches represented by the SPACES MERL team are in bold above*

While not all tools fit exclusively in one category, it is useful to provide a framework to facilitate understanding of the unique utility of each category and tool. Each complex system tool or approach has its strengths and weaknesses, so it is necessary to emphasize that people use the tool or approach that is relevant to the issue of interest. The following sections provide in-depth descriptions of the taxonomy laid out above, as well as profiles of complex systems tools within each category.

4. VISUALIZATION METHODS (MAPPING)

4.1 Definition

A systems map is a tool that can be used for thinking and communication, typically formed of shapes and words, illustrating a system of interest and employing a hierarchy of groupings. Systems mapping and visualization methods are one of the most effective and compelling means of enabling program designers, managers, evaluators and local stakeholders themselves to understand a system and their place within it. Systems mapping serves as a powerful approach for engaging diverse stakeholders, infusing greater understanding of the role that they have to play, and infusing ownership among them for development interventions and policy change.

Systems mapping techniques are diverse and varied, all attempting to gain a more holistic understanding of the system, and in many cases, track emergence within it. Some popular visual systems mapping techniques include community mapping, social and transactional network analysis, Systemigrams, Causal Loop Diagrams, and Participatory Systems Inquiry, many of which are addressed specifically in this section.

When used for planning, this approach involves first visually mapping the system of interest and then identifying which parts and relationships are expected to change, and how. This process can occur in various ways. For example, it may involve key informant interviews or other forms of data collection to capture what the system looks like and how it is functioning. Alternatively, it may be co-constructed using a facilitated group process. Systems maps may focus on and capture a number of systems features, which can sometimes be difficult to disentangle and require coding on a single map. Such features may include systems actors, relationships, perspectives, commercial transactions, resources, locations, among others.

When utilized to track emergence, systems mapping is often repeated at multiple intervals. These intervals are most often associated with a project or activity, ideally one which incorporates adaptive management practices to infuse learning associated with changes in the map, feed the learning back into project management processes, adapt and report back. More sophisticated mapping applications may employ a means of assessing causality of systems change, and attribute such causality to impact measurement activities.

4.2 Subcategorization of Mapping Methods[6]

Within a system are stakeholders that can include individuals, organizations, networks of organizations, the range of their actions, their ways of thinking about the issue, and the natural and human-created environmental factors that influence the system. Stakeholders may or may not identify themselves as participants in the system. One of the challenges of developing an issue system is to build participants' identity with it; this is critical to creating effective action to realize opportunities, address needs and respond to challenges.

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[6] This section excerpted from: http://beth.typepad.com/beths_blog/2009/10/guest-post-by-steve-waddell-systems-mapping-for-nonprofits-part-1.html

A core concept in systems mapping is "purpose". Generally, there are three types of purposes for mapping activities undertaken in the international development sector, including analysis of production systems, issue systems and mental models.

Production System: The purpose here is the actor itself, and the maps describe relationships and roles in realizing their purpose; this commonly models how organizations and individuals do their work. The production system maps aid an organization to understand how work actually gets done, in comparison to formal org charts. This analysis can assist in bringing greater alignment between the two, which in turn reduces conflict and enhances productivity.

Issue System: This system is where actors are one of many entities that are working to address an issue such as health care, maize production, deforestation, peace, and community development. Issue mapping allows actors to understand key leverage points in the bigger system it is trying to influence. These are points that, when focused upon, have a large ratio of amount-of-effort to desired-change. The focus can involve application of resources, or actually reducing resources.

Mental Models: These visuals describe how people (individuals, groups) think the world works, such as theories of change, power structures, and cause-effect models in general. Mental model mapping can uncover conflict, make it discussable, and enhance effectiveness. People can understand why someone else is doing what they are doing. Often this helps people understand that their mental model may be important, but incomplete in relation to the change goal – and therefore help people's respective efforts connect much more effectively.

4.3 Uses and Types of Questions that Can Be Addressed

Systems mapping activities are most typically undertaken by development practitioners in the early stages of engaging with a system. In this regard, systems mapping techniques can be understood to be an effective first-step, enabling stakeholders to gain a better understanding of the system and their place within it. Nonetheless, the technique can also be utilized to understand emergence and dynamic systems change over time. In these cases, the method is most frequently applied in multiple iterations. Systems-based development programming will oftentimes hard-wire in adaptive management practices in order to quickly respond to shifts within the system as they are detected. Some of the most frequent uses of systems mapping are outlined below.

Stakeholder mapping (design stage application): Stakeholder maps focus on actors and their place within an issue system or environment. They are often devised to gain a preliminary understanding of the most effective means of engagement within them. Techniques can range from basic "community mapping" processes conducted with a group of stakeholders assembled together in a room for just a few hours, to highly sophisticated quantitative network analysis employing enumerators, analysts and taking place over the course of several months. Stakeholder mapping does well to highlight key actors, enables the mapper to identify prominent features, potential resources, and bottlenecks within the system. It, however, requires a high degree of contextual knowledge of the system, is subject to the biases of those participating / leading, and success rates will often depend upon levels of participation.

Program and policy design (design stage application): Systems maps can be an effective tool for program design, another popular utilization of them. While stakeholder mapping data oftentimes contributes to this, program design applications will frequently push into a greater level of depth, identifying specific opportunities and constraints within "first-cut" systems maps, and drilling down to increasing levels of detail. This assists program and policy designers to identify key leverage points within the mapped system, assess systems change that may result from a specific policy or intervention, and subsequently take action through program or policy initiatives.

Project monitoring (longitudinal application): Mapping techniques that capture systems change over time can be powerful tools when linked to adaptive project implementation modalities. In this case, maps will be generated prior to the outset of a project, policy change, or intervention, constituting a static baseline. As interventions get underway, mapping processes can be repeated (oftentimes with the same participants), and changes in the system highlighted. At this stage, causality is assessed to the extent possible, oftentimes linking any observed changes in the system to interventions undertaken by a project. Interventions may in-turn calibrate activities to achieve desired results, provided that the systems mapper has a reasonably confident understanding of cause and effect relationships within the system being analyzed.

Program impact assessment (longitudinal application): A higher level function absent in most systems mapping tools, impact measurement requires an experimental method. One mapping tool that demonstrates strong potential for experimental application is social network analysis. SNA does this by applying the analysis with the same populations in multiple iterations before and after specific program interventions, examining differences in specific metrics between actors targeted by the intervention (treatment) and control groups. This approach generally requires an understanding of which stakeholders will and will not be engaged by the project prior to its initiation, and careful selection of indicators and attributes at the research design stage.

4.4 Overall Strengths

Visual format: While systems maps can be complicated, they provide a compelling medium to convey understanding of complex systems. Such visual representations can break down barriers between systems experts and laypersons, overcome linguistic and literacy constraints, and greatly increase the accessibility of systems approaches as a whole. This creates a greater ease of understanding and addresses a key constraint of systems approaches more generally: their levels of complexity.

Participation: Visual mapping approaches extensively utilize participatory approaches to data collection, visualization of the maps themselves, and assignment of meaning / analysis. This approach is capable of bringing diverse actor groups together to understand a particular system and, jointly or separately, develop solutions. This can be a key to the success or failure of subsequent development interventions, particularly in the international development context where programs are oftentimes designed by relative outsiders.

Excellent first-step: A multitude of systems tools and approaches have mapping hard-wired into their preliminary attempts to understand the system. Virtually all systems mapping techniques do well to facilitate understanding of the most prominent or influential features of a system. While greater detail and rigorous analysis is often required following these first steps, systems mapping is a highly effective "ground-zero" tool to begin understanding the system.

Diversity of approaches: Systems mapping approaches are myriad, and are flexible enough to be employed rapidly or in great depth. Systems mapping techniques can visualize a host of systems features, including actors, roles, relationships, perspectives, experiences, transactions, human and capital resources, among others. The trick oftentimes comes in selecting the most appropriate systems mapping approach for a given situation.

<u>SNA has quantitative capabilities</u>: Social Network Analysis is a particularly promising visual systems mapping approach, combining the visual appeal of systems mapping tools overall with a high degree of analytical rigor that can be applied at multiple stages of the program cycle.

4.5 Overall Weaknesses

<u>Vulnerable to haphazard application:</u> While the wide diversity and variance among systems mapping approaches can create an appealing menu for program designers, managers and evaluators, systems mapping tools are frequently applied in a way that is not fit-for-purpose. As discussed elsewhere in this section, only a limited number of systems mapping tools are capable of being applied for monitoring, impact evaluation and other purposes in a reliable way, and in many cases need to be augmented by a rigorous data collection and analytical process to ensure their validity. There are numerous hazards involved in representing incomplete application of systems mapping processes as a comprehensive systems approach, or sufficiently valid to make judgements on program design or success in application.

<u>Oftentimes not data-driven</u>: The specific systems mapping tools featured in the profiles in this text tend to be rigorous ones that are driven by meaningful data and quantifiable. This is not the case with many other systems mapping approaches, or ones that have been incorrectly applied. Examination should go into the extent to which reliable data is required and available to successfully apply a tool prior to embarking upon it.

<u>Difficult to incorporate into results-based management approaches</u>: Unlike indicator-based systems approaches, visual systems mapping tools can be difficult to incorporate into traditional results based project management approaches (e.g. logical frameworks, PMPs, workplans, etc.). Adaptive project management approaches are most conducive to accompany systems mapping tools.

<u>Limited predictive value in free-standing application</u>: Systems mapping tools generally rely on contextual knowledge, other data sources and stakeholder input to devise the most appropriate interventions and anticipate resultant actor behaviors and emergence within the system. In this regard, systems mapping approaches should always be scrutinized on their method of analysis prior to making important programming decisions. As well, experimental modelling techniques bear strong potential for application in concert with systems mapping. Important actors, entities, and influences identified via systems mapping can inform what needs to be represented in an experimental model. Similarly, mental model maps can be adapted into decision making models for experimentation.

<u>Impact measurement</u>: With the exception of SNA, we are not aware of visual systems mapping techniques that are capable of being applied utilizing experimental methods.

5. VISUALIZATION METHODS (MODELING)

5.1 Definition

While Systems Mapping techniques establishes the players and their interconnections, mathematical and computational modeling techniques fills in all of the other relationships, processes, actions, and other factors that comprise the system. Modeling can incorporate dynamics to the system, allowing users to see how the current system may evolve and how changes to the system may affect it over time. There are many ways to approach modeling from simple *Mathematical Modeling* to more complex *Simulation*

Modeling. *Mathematical modeling* establishes a set of mathematical equations that represent the system. *Simulation Modeling* creates a prototype of a physical system that mimics the system's real behavior. *Computational modeling* refers to techniques which formulate a model digitally and uses a computer to determine the outcomes of a model. An important distinction is that a model is not a replica. A replica is an exact copy of something. By contrast, a model is a simplification of the actual system, representing the elements, factors, relationships, and processes of the system that are relevant to the questions, decisions, and actions of interest to the user.

Models can be *Deterministic* or *Stochastic*. *Deterministic* models have outcomes that are fully determined by the initial conditions and inputs. Many *Mathematical Models* are *Deterministic* and given the same inputs and parameters, the outcomes are identical. *Stochastic* models have outcomes that are subject to some inherent randomness and given the same set of initial conditions and inputs, the model may produce different results. *Stochastic* models are required to be run as ensembles so that proper statistical sampling can be done to produce meaningful outcomes. *Simulation Models* of populations are generally *Stochastic* as there is a great deal of randomness in the system.

Models can help better understand a system and also serve as "virtual laboratory" to test various changes in the system, replacing the costly process of trial and error in improving systems performance. The obvious benefit of modeling is the ability to model scenarios and outcomes from the current and changed system, but there is a myriad of other benefits. Building a model gives one a better understanding of the system for it involves mapping important components and relationships in the system. Models are also a place to tie all of the system's disparate data sources together in one place and can guide data collection by elucidating data gaps and the relative importance of different data elements. Finally, models provide a very effective means of communicating the complexities of real-world systems and can be used as evidence-based advocacy for improvements.

Building a model consists of the following steps:

- Map the system: Determine the components of the system and their connections/relationships. This is the step where techniques such as *Mapping* described in Section 4 Above can be very useful.
- Develop equations or algorithms to represent the relationships, processes, and actions in the system.
- Populate with data: Assign parameters in the model based on literature values or data collection.
- Calibration: Tune unknown parameters of the model to match known data.
- Verification: Ensure that the model is producing expected results based on its formulation.
- Validation: Analyze whether model outcomes match known data that was not already used to parameterize and calibrate the model.
- Modeling experiments: Change parameters or inputs to explore how changing the model results in different outcomes.
- Sensitivity analyses: Systematically change one or multiple parameter(s) or input(s) in the model to determine trends in model outcomes.

It is important to note that these steps are not done in isolation, but are a part of a larger iterative process. Once a model is completed and experimentation is completed, the knowledge about the system evolves and that knowledge can be fed back into mapping the system and improving the model.

5.2 Subcategorization of Modeling Methods
Modeling methods can fall into the following categories. These categories are not completely distinct but can be used as a guide to organize models.

Decision analytic models – Decision analytic models focus on an individual's decision or actions. Decision analytic models systematically map out all of the relevant factors or influences involved in a decision. These influences include external pressures, internal beliefs and values, and environmental constraints. The model also identifies all possible outcomes of the decision situation. This type of model elucidates the salient factors involved in the decision.

Markov models – Markov models are useful when an individual faces the same possible decisions or actions again and again over time. They represent an individual's progression through different conditions and events. Markov models can also include interdependencies between different progression paths.

Compartment and Systems Dynamics Models **–** Compartment and system dynamics models divide all the parts of a system into what would be analogous to rooms in a house and then represent how components like people would flow like a mass or liquid through the different rooms. Relationships between the rooms or compartments dictate how people move between rooms. Compartment models demonstrate how impacts to one compartment can cause unforeseen consequences in other compartments. Users can view population trends over time and observe compartment size breakpoints

Network models **–** Network models define in greater detail the connections between different players (e.g., people or organizations) in the system and how the players influence each other. In this manner, network models tend to account more for the heterogeneity of players in a system.

Agent-based models **-** Agent-based models, sometimes called Individual-based models, give individual players autonomous decision making ability and complex adaptive behavior (the ability to learn over time). Computational entities known as "agents" are given individual state and decision making abilities that allows them to interact based on their individual situation and rules. The agents can interact with each other and the environment. Once the rules for how agents interact are determined, the system is simulated by allowing these rules to dictate the evolution of the system over time, and therefore the outcomes of an agent-based model are "emerged" from the sum of all of its parts. Agents can also evolve their own state over time based on their experiences throughout a simulation. For example, agent-based models are widely used to represent populations, where each individual person is represented by an agent.

5.3 Uses and Types of Questions that Can Be Addressed
The results of computational models help researchers determine factors and relationships and forecast future scenarios in response to changing conditions in a particular system. Models can also aid in the design and development of relevant policies and interventions. Relatedly, models can assess the potential impacts of policies and interventions, including their potential secondary and tertiary effects and unintended consequences. Additionally, models can guide and prioritize data collection by identifying gaps and demonstrating the effects of having better information.
Models can address the following types of questions:

- What is the likely impact of introducing new technology on a system?
    - Example: New products, storage and monitoring
- What happens when you change the characteristics of products, agents and other technologies?
    - Example: Packaging size, agent preferences
- What happens when you alter the configuration and operations of a system?

    - Example: Impact of new policy for schools, impact of increasing vaccine coverage
- What are the effects of differing conditions or circumstances on a system?
    - Example: Inclement weather, delays in implementation
- What is the most cost-effective investment or allocation of resources?
    - Example: most cost effective technology to increase food supply
- How can you optimize product delivery?
    - Example: minimize cost, maximize demand satisfaction

Computational Simulation models are applicable at all stages of the program cycle:
- Country and Development Cooperation
    - Can identify strengths and vulnerabilities of system
- Project Design and Implementation
    - Test different options
- Monitoring
    - Simulate the impact of different measures
- Evaluation
    - Project to various outcomes
- Learning and Adapting
    - Test how system may change over time and conditions

5.4 Overall Strengths

Modeling is a bridge to translation. Modeling can and does occur at different time points along the research path from idea inception to policy or intervention implementation. It can help plan retrospective and prospective studies. It can extrapolate results from one circumstance to another and can extend information from one place to answer questions in certain locations when data comes from another source. Additionally, modeling can save time and effort normally associated with trial and error.

Below are strengths of modeling tools matched to the USAID program cycle.

- Country and Development Cooperation
    - **Help decision-makers map out the components and relationships in complex real-world systems.** Real-world systems are complex, with many interrelated and interacting components that can be difficult or impossible for a person to fully understand or comprehend in their head. Modeling can be used to represent these components and their relationships systematically, with each relationship mapped out. Just by creating a model, one can gain a greater understanding of the system, in a way that is not possible otherwise.
- Project Design and Implementation
    - Project Design
    - **Help decision-makers determine which relationships and factors are most important.** Models allow one to explore the most important factors effecting a system. With a complex system, it is difficult to tease out what factors truly effect the state of the system and which are less important. Many try to perform data driven statistical correlation analysis, which can be useful, but cannot guaranteed to produce the truly important aspects of a complex system. Also, it is very difficult to see the synergy between multiple factors simultaneously and a model allows users to perform one-way, two-way, three-way,

etc. sensitivity to change any component of the system in a systematic manner, giving the model the ability to not only determine the importance of individual relationships, but combinations as well.

- Implementation
- **Give decision-makers a "virtual laboratory" to test improvements to the system instead of the costly process of trial and error.** Models can serve a "virtual laboratories" which allow users to assess the current state of a system, change aspects of the system, and explore external stimuli. In the real-world system, if one wants to test an intervention that may change a system, costly and time consuming pilot studies are done. A model can be used prior to, or in conjunction with implementation to explore a myriad of possibilities, helping to narrow down which interventions may have the most impact.

- Monitoring
  - **Help decision-makers see non-intuitive or unintended consequences of changes to the system.** With a dynamic model, especially mechanistic models, outcomes from the complex systems become emergent (i.e. they are not predetermined, but instead a consequence of the rules and inputs of the model). This will allow for the possibility of seeing unintended consequences of the interactions between various aspects of the system (e.g. increasing availability of healthy food at a location but getting the timing of such availability wrong may not improve the population health). Such effects are very difficult to see through data-centric analysis or static modeling techniques. Users can model interventions that are in the process of implementation to understand the future impact of the intervention to better understand how the rest of the project will unfold which provides unique insight and allows users to adjust accordingly.
- Evaluation
  - **Help decision-makers understand how a system and the resulting outcomes and impact change over time.** Real-world systems are dynamic, with all of the components interacting throughout time. A dynamic simulation model can show how these relationships truly evolve temporally. Dynamic simulation models are able to represent the interactions in a system that will not necessarily be the same given the conditions changing in complex ways over time.
- Learning and Adapting
  - **Help guide costly data collection efforts by targeting data that is going to have the most impact.** Collection of data can be a difficult and costly process, and performing sensitivity analysis with a model can be used as a guide to drive data collection toward factors that will have the greatest impact rather than blindly collecting data based on subjective decisions.
  - **Help decision-makers communicate more effectively about the system.** A model is a very effective means exchanging ideas because a model is a very explicit collection of components, relationships, and assumptions about the complex system. It is a means of "putting everything out on the table" from the data used to parameterize it, to the methodology used to represent aspects of the system, to the assumptions one needs to make to create the model. Sharing models can lead to iterative improvement and more learned discussion about the system.

- **Help decision-makers produce evidence base for advocacy.** Models can be an effective means of advocacy. A model can be used to show the benefits, costs, and effort associated with trying to improve a system. It is an evidence-based approach that can make very clear how a change to the system may or may not improve it, and more importantly, to what extent.

5.5 Overall Weaknesses

- **Simplification of a real-world system.** Models are a representation of reality, and therefore can never truly capture every single aspect that could affect a complex decision. Ultimately, building a model requires one to make decisions and assumptions about which factors are important. Different modelers may make different decisions, which is why using multiple models to explore a system and performing iterative improvements based on evolving knowledge can help to gain greater confidence in the results produced.
- **Do not replace human decision-making.** Models can be used as decision support tools, but do not ultimately preclude human decision-making. Models are can help identify the relative effects of certain scenarios on a system, but since they cannot capture every single factor, they should be a tool, not a crystal ball.
- **Models can vary in transparency and understandability.** As there is a wide range of models, you might have the following issues with some of them:
  - **As some models get more complex, it may become challenging to communicate outcomes.** As models grow more complex, so do the outputs. This can make it challenging to assimilate the results in a meaningful way. Techniques in scientific visualization and data analysis become critical to understanding the output of the models. Additionally, scientific communication becomes key to translating results from modeling to other audiences. Graphical user interfaces and visualization tools can help to automatically present the outcomes in digestible forms.
  - **Some models may require training and expertise to use.** As models grow more complex, the expertise required to create them also increases. Many models require a large number of inputs and may not be written to facilitate naive users to be able to run them. Additionally, few models can be used without some expertise in the system they are meant to represent (e.g. a nurse may not have the required training to parameterize and run an immunization supply chain model). Training is not only important for people who want create and run simulations experiments with the models, but also consumers of modeling output (e.g., decision makers).
  - **Some models may require larger amounts of data as models grow more complex.** As models grow more complex, so do the data requirements for parameterization. Complex models can require a large number of variables, which need to be parameterized or matched to real world data collection. Sensitivity analysis can help to mitigate this and exhibit which factors are most important.

6. NARRATIVE BASED APPROACHES

6.1 Definition

Narratives are collections of assumptions, beliefs, phenomena, outcomes, and mindsets that people use to make sense of the world. They help users understand complex systems, often through the eyes and perspectives of key system stakeholders. Composed of "language and metaphors…[narratives] are attractors around which whole systems organize; [they are] part of the 'glue' that connects multiple levels of a system and also the 'grease' that makes the system run."[7]

Narrative systems tools are those tools that utilize descriptive inputs to capture key system features, including actors, interactions, resources, and outcomes.[8] They are unique in their ability to integrate a variety of perspectives to interpret and analyze a complex, dynamic system. Moreover, narrative tools help users capture system changes over time to measure the likely past and future impacts of system interventions.[9] Some narrative tools are constructed by eliciting the perspectives of system stakeholders. In such instances, the tools represent varying perspectives on the nature of complex challenges as well as the method of addressing those challenges. Alternatively, narratives offer a way to aggregate data deriving from expert sources, literature, and other data to illuminate the dynamic nature of systems in ways particularly suited to decision making.

Narrative tools are especially useful in systems with "random, unorganized, or unknown system dynamics," meaning "there are no clear patterns of interaction between system parts or actors, and no clear understanding of how to move forward."[10] Moreover, these tools are useful in evaluating complex systems at very different scales, from small communities to whole regions. This is due to the fact that narrative tools can be applied to a very direct, narrow focus, such as small focus groups, or used to examine the perceptions of society at large, for example through country-level surveys. Technological advances have further enabled this large-scale sourcing of narratives for system-wide analysis.[11]

6.2 Subcategorization of Narrative Tools

A variety of narrative-based systems tools are in use both within and outside of USAID. Diverse with regard to their inputs, their outputs, and their method for organizing data, these tools may be categorized along a variety of spectra, which helps in selecting from among the many options available:

<u>Data-gathering methodology:</u> Data-gathering methods that support the use of narrative systems tools can differ in approach. Bingley (2014) explores the practice of distinguishing research methods or tools by data-gathering approaches. In international development specifically, she notes that the nature of "participative" approaches that engage stakeholders in the process of generating data differs from initiatives that are "analytic (defined as desk-based research and analysis by an individual or group)."[12] On

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[7] Dynamical Systems Innovation Lab. "Non-Linear Impact Assessment: Challenges, Approaches and Tools." (2014). Web. 25 January 2016. <https://conflictinnovationlab.files.wordpress.com/2014/03/impact_eval_draft_briefing_paper_16jul2014.pdf>.

[8] U.S. Agency for International Development. "Measuring Systems Change: USAID's Current Thinking." (2015). Web. 25 January 2016. USAID Learning Lab. <http://usaidlearninglab.org/sites/default/files/resource/files/systems_and_capacity_usaid.pdf>.

[9] Dynamical Systems Innovation Lab 2014.

[10] Hargreaves, Margaret B. (2010). "Evaluating System Change: A Planning Guide." Mathematica Policy Research, Inc. <http://www.mathematica-mpr.com/~/media/publications/PDFs/health/eval_system_change_methodbr.pdf>.

[11] Dynamical Systems Innovation Lab, 2014.

[12] Bingley, K. (2014). A Review of Strategic Foresight in International Development. Evidence Report. *Policy Anticipation, Evaluation and Response*. No 94.

one end of the data-gathering spectrum lie experiential approaches that source ideas, personal experience, opinions, and observations from a range of individuals to weave together narratives constructed from the perspectives of stakeholders. For example, Scenario Planning is among those many tools that draw from stakeholder perspectives to produce narratives. At the other end of the spectrum exists expert-written, data-driven approaches in which the users of a tool may source information from a variety of evidence-based publications or data sets. For instance, the Innovation System Analysis, assembles a wide range of data points on the actors and phenomena that make up the innovation system, which may be sourced from academic literature or published studies (e.g., OECD National Innovation System series). Further, researchers at the International Institute for Impact Evaluation consider the value in specifying the degree for which data gathered for narrative tools is integrated, specifying the distinction between "aggregative" versus "interpretive" approaches.[13]

Time Orientation: Narratives are necessarily descriptive of a context and a time frame. They may be oriented toward the past, the present, or even the future. These three temporal perspectives serve as a helpful way to parse the universe of narrative-based tools. For example, Scenario Planning is among many Strategic Foresight tools that use narratives to frame and depict the future, thereby helping users grapple with uncertainty about systems and with how systems might change over time. By contrast, tools such as Outcome Harvesting gather stakeholder perspectives that describe both the past and the present to demonstrate how a situation has changed, or what "outcomes" have been achieved within the scope of a system intervention. Kalvo-oja (2006) explores how different tool types may be used in different sequences according to user interest in exploring the future, making sense of the past, or informing the present.[14] Thus, beyond offering a method for categorizing tools, one can consider possible sequences of tool use according to each tool's time orientation. With regard to the comparative importance between systems tools' time orientation, the author further explains, "systems thinking requires the ability to synthesize or integrate elements rather than breaking them into parts for the purpose of analysis. That is why we should pay attention to potential roles of foresight [one field of futures-focused tools] in relation to innovation process" in particular.[15]

Evaluative versus descriptive: Systems tools may also be categorized according to the purpose of the resulting narrative. Tools aim (1) to evaluate successes and failures in a given system, or (2) to describe and interpret the actors and interactions that compose a given system. Affirmed by McClintock (2004) among other scholars, the distinction between evaluative and descriptive tools allows users to hone in on the purpose that guides their tool selection.[16] For example, a user seeking to measure system change against various benchmarks or project targets may choose an evaluative tool such as Most Significant Change, Outcome Harvesting or the Success Case Method, a tool that gathers narratives about positive and

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[13] Birte Snilstveit, Sandy Oliver & Martina Vojtkova (2012). Narrative approaches to systematic review and synthesis of evidence for international development policy and practice. Journal of Development Effectiveness, 4:3, 409-429, DOI: 10.1080/19439342.2012.710641.
[14] Kaivo-Oja, J. (2006). Toward Integration of Innovation Systems and Foresight Research in Firms and Organizations." Finland Futures Research Centre. FFRC Publication 2/2006.
[15] Kalvo-oja 2006.
[16] McClintock, C. (2004). "Using Narrative Methods to Link Program Evaluation and Organization Development." The Evaluation Exchange. Harvard Family Research Project, Harvard Graduate School of Education. 2003/2004.

negative outcomes.[17] Such tools might prove useful in later stages of a program cycle, to evaluate whether or not a completed program was successful. Alternatively, descriptive narrative tools including the Innovation System Analysis and Scenario Planning do not measure system change against specific targets or milestones, but may be used to optimize the earlier stages of program design and development by offering robust systems descriptions.

6.3 **Uses and Types of Questions that Can Be Addressed**

Narrative-based tools can be used to help development practitioners and decision makers answer key questions throughout the program cycle. The steps of the USAID program cycle follow, augmented with key questions that may be answered by employing narrative-based systems tools:

Country Development and Cooperation Strategies

At the beginning of the program cycle, narrative-based tools can help users answer questions pertinent to the problem at hand (e.g., food insecurity in a particular country or infant mortality within a certain population), such as:
"What is the current state of the problem we are trying to solve?"
"What are the many pieces of this complex problem, and how do they fit together?"
"What is the broader system context surrounding the problem?"

Project Design and Implementation

Narrative-based tools can help users better design their project by answering questions such as:
"What is the best method for intervention?"
"Who are the key actors who have the ability and willingness to take action on this problem?"

Narrative-based tools can help users better implement their project by answering questions such as:
"What factors might serve to either enable or hinder this approach?"
"What features of the system enable or thwart innovation aimed at this problem?"

Monitoring

In the Monitoring phase of the program cycle, narrative-based tools can be particularly useful in helping answer questions such as:
"What changes (if any) have the many stakeholder groups observed?"
"How are the system actors and interactions shifting over time?"
"How do our intended beneficiaries feel about the state of the problem?"
"Are stakeholders observing changes within a system that were not intended?"

Evaluation

In the Evaluation phase of the program cycle, narrative-based tools can be particularly useful in helping answer questions such as:
"How closely did our activities match to stakeholders' voiced needs?"
"How might we adjust our activity design to better meet stakeholder needs?"

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[17] Brinkerhoff, R. (2003). The Success Case Method: Find out Quickly What's Working and What's Not. Berrett-Koehler Publishers.

"How have stakeholder emotions, beliefs, biases, judgments, etc. shifted over the course of the intervention?"

Learning and Adapting
In this final phase of the program cycle, narrative-based tools can help practitioners answer questions such as:
"Where in the system did innovation deliver solutions to address the problem at hand?
"How might we optimize innovation impact to design better interventions going forward?"
"What indicators of systems change can we identify to adapt and attune our programs to the future?"
"What aspects of system change were unexpected or unintended, and how can we use those learnings to adjust our future monitoring and evaluation?"

6.4 Overall Strengths
A number of strengths illustrate the power and benefit of integrating narrative-based tools into monitoring and evaluation approaches. Five of these strengths are noted below.

Contend with complexity in a way that more traditional M&E approaches cannot
When analyzing the differences between the categories of systems and complexity tools reviewed in this White Paper, one can find an "inherent tension between indicator-based monitoring and complexity: indicators are based on what we expect might change, but complex aspects of a situation make it difficult to predict what will change and how…[therefore, indicator-based tools] may need to be supplemented by more open-ended inquiry with a range of stakeholders."[18] Thus, narrative-based systems and complexity tools are uniquely valuable in their ability to describe and analyze the many facets of complex systems in a way that more quantitative methods cannot.

Support participatory approaches to development
By sourcing and analyzing narratives, users can adopt a more participatory approach to development. Through tools like Most Significant Change, SenseMaker, and Outcomes Harvesting, users engage meaningfully with stakeholders such that their opinions and experiences can both shape program evaluation and allow for adaptive management to ensure programs better meet those stakeholders' needs. Moreover, sourcing and analyzing narratives is well-suited to diverse, complex programs that involve many stakeholder groups and multiple funders. That narrative-based tools typically feed cleanly into organizations' structures for planning, evaluation, and decision making only adds to their list of strengths.[19]

Possess a high level of utility
Monitoring and evaluation is not only useful at the level of an activity or project; rather, M&E data is often used to support high-level, organizational decision making. As such, the value of M&E data is only useful if its meaning and its analysis are well understood. While computational models and methods can be quite difficult for high-level decision makers to fully analyze, it is often much easier to translate the intent of narrative-based tools into insights that are accessible to decision makers. Thus, narrative-based tools

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[18] Dynamical Systems Innovation Lab, 2014.
[19] J.J. Dart, R.J. Davies. "A dialogical story-based evaluation tool: The Most Significant Change technique." *American Journal of Evaluation*, 24 (2003), pp. 137–155.

boast a level of accessibility to individuals in all organizational levels and/or departments, fueling their broader uptake and impact.

Validate key voices that speak to systems change
As stories and storytelling have continued to gain credence as methods for assessing international development systems, narrative-based tools have elicited increased recognition for their ability to validate stakeholder voices. Tools that help users hear stakeholders' voices and organize their perspectives so as to see patterns within systems facilitate deeper systems thinking and enhanced systems-based decision-making. As the recognition of these valuable methods grows, international development practitioners acknowledge that quantitative and computational models and approaches paint an incomplete picture of complex systems if used without the richness afforded by stakeholder participation, which so many narrative tools offer.

Express systems features that cannot be understood by modeling alone
In terms of the benefits of narrative tools, they differ according to category (e.g., Time Orientation, Evaluative versus Descriptive, etc.) as well as the degree to which the tool selected matches to the purpose intended by the user. With respect to narrative tools that source information from stakeholder discourse, these often offer the benefit of highlighting attitudes, beliefs, biases, and shared knowledge. These stakeholder-centered system elements may allow for the examination of the emotions behind them, an often-neglected consideration in more data-driven approaches to systems research.[20] Furthermore, an abundance of systems researchers, including Checkland and McDermott, note the necessity of using narrative approaches to express problems, issues, and opportunities that are poorly understood by computational models alone.[21]

6.5 Overall Weaknesses
Like all tools, narrative-based tools present certain weaknesses, four of which follow. However, with care and attention these weaknesses can be overcome. Importantly, no single tool perfectly assures systems- and complexity-awareness in performing monitoring and evaluation. Rather, many of these weaknesses are readily addressed by matching various systems tools and methods together to assure a comprehensive, useful, and feasible approach to systems-based work.

Challenges with quality control
Quality control can be harder when sourcing narrative viewpoints or experiences than it is when gathering more quantitative data. Moreover, the process of verifying personal viewpoints can be complicated as well as time-consuming. Verification is sometimes impossible, especially when one adopts a vantage point from which all stakeholder perspectives are valid and therefore cannot be "right" or "wrong." Furthermore, narrative tools can vary widely in their methods of data collection and analysis, and ensuring a level of rigor and consistency is critical for a thorough evaluation of system-wide features.

Perceived supremacy of numbers over words
Today's largely Western-dominated research culture values research in which hypotheses are supported with facts and figures. The prevailing assumption, therefore, is that numbers are more important and narratives are less valuable, which can limit the use / uptake of narrative-based tools. Combining

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[20] *Ibid*.
[21] McDermott, Tom. (2014). "Soft Systems Approaches for Constructing Complex System Models."

narrative-based tools with more quantitative indicator-based tools and/or visual tools can help address this issue by adding a more fact-based, quality-controlled element to the monitoring and evaluation endeavor.

Time- and human resource-intensive
Using participatory approaches that source stakeholder perspectives takes a time and labor. Sourcing narratives can be quite difficult, especially when stakeholders reside in remote areas and must be interviewed in person.

Potentially perceived as extractive
Narrative-based tools can rely on extracting sensitive information from stakeholders. Moreover, methods of data-gathering often require those stakeholders to willingly give their time, which could otherwise be used performing their work, taking care of their children, etc. Thus, users of narrative-based tools as with any monitoring and evaluation tool must take caution when asking beneficiaries to engage with those tools.

7. INDICATOR-BASED APPROACHES

7.1 Definition

An indicator is a specific and objectively verifiable measure of change or results brought about by an activity or a set of activities. Indicators are variables that help to measure changes in a given situation in a given period of time. They are tools for monitoring the effects of an activity and are designed to provide a standard against which to measure or assess or show the progress of an activity against stated targets. Setting targets depends on many factors including resources that will facilitate attainment of the desired objective. Much as a set target guides the implementer, a low target can be a source of complacency while a high target may bring about unnecessary stress and demotivation. It is therefore upon the researcher or designer to set realistic targets that will be attained in line with the desired objectives. Indicators can be direct or indirect, shorthand or proxy. Effective Indicators should be determined by the nature of the objectives, intended effects and impact of the Project and must be i) valid, ii) reliable, iii) relevant, iv) sensitive, v) specific, vi) cost effective, and vii) timely.

Traditional M&E systems predominantly employ static indicators. These types of indicators are set ex-ante and are used to set fixed targets about the desired change at different stages of a project. They tend to remain static over the course of the project, unless reviewed during process evaluation. Static indicators are often selected to follow program logic. The most commonly used of the static indicator systems is the Logical Framework Approach (LFA) and its variants. In the LFA, indicators are layered in a hierarchical logic, from: Inputs to Processes, Outputs, Outcomes and Impacts or selections of these. The presumption is that activities and indicators at one level in the hierarchy will contribute to attainment of the next level, if certain assumptions hold true, and forward on until the desired impacts are realized in whole or in part. The assumptions that ought to be met for the expected deliverables to be realized are also determined at the beginning of the project and included in the log-frame. Some projects then prepare risk mitigation plans targeting these assumptions. The LFA is not the only approach to static indicators. The US Global Development Lab for example which is mainly involved in catalyzing Science and Technology innovations to solve global development challenges uses an ‘innovation pipeline’ approach to monitor outputs and outcomes from its innovations ecosystem. Indicators are selected in a hierarchy of 5 key dimensions that culminate in hierarchical outcomes: Design, Pilot, Early Adoption, Transition to Scale, and Wide-scale adoption. Within each of these outcome stages are some milestones based on standard practice in innovation pipelines and tagged to outputs.

However, modern MERL has opened up to the realization that static indicators are far from sufficient to enable understanding of complex systems. Projects (whether innovation projects or social interventions) often operate in complex systems. There are many system level variables that interact with the project, moreover in a dynamic and changing way. These variables may substantially affect its course and the extent of attainment of key targets. The effect of these variables on attainment of desired results might be as important as the project activities themselves. And these variables are not captured by traditional static indicator systems. While LFAs attempt to cater to external factors by including ex-ante assumptions and mitigating factors, environmental factors that affect project implementation, diffusion of interventions and attainment of outcomes cannot be fully predicted ex-ante. This reality therefore necessitated the development of dynamic indicator based M&E tools. The LFA can be extended to include systemic features that divert the linearity of the logframe by allowing feedback loops which enable iterative adjustments to the assumptions and mitigation factors to reach the desired goal.

7.2 Subcategorization of Indicator-based Approaches

To understand complex systems using indicator-based approaches two categorizations have been applied: the top-down and the bottom-up approaches[22]. In the top-down approach a complex system is broken down into smaller components or subsystems to which measurable variables or indicators are attached for monitoring specific aspects of the subsystems that highlight a whole system. On the other hand the bottom-up approach considers the relevant indicators and these are grouped to fit into the different subsystems that are representative to bring about comprehension of the whole complex system.

In defining criteria and indicators for sustainable forest management Khadka and Vacik (2012)[23] describe the top-down approach as expert-driven while the bottom-up approach is community-driven. In the top-down approach, experts adapt a predetermined set of indicators to a local situation. In the bottom-up approach, the community actively participates in formulating indicators bringing their perception of the situation into perspective.

In assessing sustainability of agricultural systems Binder and Feola (2012)[24] elaborate further on the above approaches into three classifications: top-down, farm assessment; top-down, regional assessment with some stakeholder participation; and bottom-up, integrated participatory or transdisciplinary approach. In the top-down, farm assessment the farmer himself or industry working with farmers groups have the mandate to derive the indicators and determine how they will be measured without participation of other stakeholders. The top-down, regional assessment allows involvement of a limited number of stakeholders in the indicator development and targets multiple stakeholders who are likely to use the results. The

[22] Yu, D. and Yin, J. (2011) Internet GIS and System Dynamic Modeling in Urban Public Safety and Security Studies: A conceptual Framework, in Luo, Xiangfeng; Cao, Yiwei; Yang, Bo; Liu, Jianxun and Ye, Feiyue (eds), *New horizons in web-based learning - ICWL 2010 workshops : ICWL 2010 workshops: STEG, CICW, WGLBWS, and IWAKDEWL, Shanghai, China, December 7-11, 2010 : revised selected papers*, pp. 207-216, Springer, Berlin, Germany

[23] Khadka, C., and Vacik, H, (2012). Comparing a top-down and bottom-up approach in the identification of criteria and indicators for sustainable community forest management in Nepal. An international journal of forestry research, 85 (**1**): 145-158

[24] Binder, C.H., and Feola, G. (2012). Normative, systemic and procedural aspects: a review of indicator-based sustainability assessments in agriculture. Methods and Procedures for Building Sustainable Farming Systems, 33-46

bottom-up integrated or transdisciplinary approach focuses on engaging stakeholders throughout the process, from goal setting to indicator formulation, measurement and use of the results.

In the case where all subsystems of a complex system can be identified, the top-down approach would be ideal to give a full understanding of the complex system. However, in reality identification of all the subsystems may not be achievable rendering the bottom-up approach more tenable in such situations[22]. Khadka and Vacik (2012)[23] advocate application of both approaches in order to enhance mutual learning and sharing experiences. While top-down formulated indicators may lack acceptability and ownership on the part of the stakeholders, the bottom-up approach can be applied as a complement since by allowing stakeholder involvement it increases the likeliness of the results being applied and the stakeholders ownership in the monitoring and evaluation process.

7.3 Uses and Types of Questions That Can Be Addressed

Different sectors use different questions through different types of indicators that are of interest to the sector. However, in most cases the common goal for asking the questions points to quality improvement purposes. Some of the questions that can be addressed using indicator-based approaches include, but are not limited to the following:

- What is happening in my system in a given context? What matters most?
- What is the implementing partner doing and how well are they doing it?
- Why specific implementing partners achieve particular outcomes?
- What is the progress of interventions towards desired results according to predetermined implementation plans?
- How do capacity development efforts influence the lives of beneficiary communities? The answers to this question are used as a measure of the changes in organizational performance that are the outcome of strengthened policies, procedures and skills.
- How are students progressing in learning to reach a desired benchmark for success? These questions are often used by teachers to identify those students that will most likely require more intensive instruction early enough in the school year in order to pave a way on how best to help the students catch up.
- What behavioral patterns influence development impacts?
- How best can we share the progress towards achieving desired results with multiple audiences including managers, donors, partners, members, and the general public?

7.4 Overall Strengths

Indicator-based complex systems tools have the following strengths:

- They cater to the changing nature of the implementation environment. With the complex systems tools the outcome is not limited to a pre-determined measure but through continuous collection and analysis of information flexibility is allowed that the implementer is free to adopt to the system environment.
- They foster a deeper understanding of the interaction between the intervention and the environment, helping to clarify better the link between activities and their outcomes in the system
- They help to identify external factors affecting project implementation so that corrective action can be taken early enough.
- They provide signals for deeper changes in the system, enabling implementers to dig deeper for these effects. Quantitative measures are usually used to capture the surface features in the system. However, for in-depth insight an application of qualitative indicators can capture other essential elements in the complex system that cannot be addressed quantitatively.

7.5 Overall Weaknesses

Although indicator based systems tools have made it possible to monitor and evaluate projects in dynamic, complex and changing implementation contexts, there are some characteristics of complex systems that are still not captured by existing tools. In particular, the following gaps in existing indicator based tools are observed:

1. There is a scarcity of tools that connect dynamic indicators to static indicators within the complex systems in which projects are implemented. Currently a lot of emphasis is based on reporting of outputs when monitoring and evaluating programs compared to outcomes and impact. This is not surprising to bigger extent since the outputs are easily captured numerically and the available tools can handle such information. On the contrary, capturing systemic features requires more explanations that are not incorporated with existing tools.
2. There is a shortage of tools that facilitate capture of 'emergent' indicators. Existing tools tend to emphasize ex-ante search for indicators that change over time (e.g. dynamic indicators, sentinel indicators). We need tools that facilitate forward-going capture of emerging non-predetermined indicators that affect attainment of static milestones
3. There is also a need for tools that go beyond current 'calendaring based approaches' used in project management soft-ware to capture 'time to attainment of milestones' in a way that enables the tracking of 'rates of progress' of projects, and using their trajectories to enhance project performance

8. TOOL INTEGRATION AND ADDED VALUE OF SPACES MERL

The categories of tools presented in this White Paper are organized around those techniques that each grouping of tools most prominently employs. Mapping approaches within Visualization Methods identify prominent system features and relationships among them, modeling approaches incorporate dynamics, demonstrating how system features might change given different circumstances, policies and interventions. Narrative tools bring constituent experience and perspectives to the fore and highlight system areas poised for successful interventions. Indicator-based tools do well to capture specific change within a program or intervention, directly attributable to such interventions and accounting for emergence within the broader system as a whole. These techniques are ripe for integration, building off one-another depending upon the extent to which such information is readily available, and the overall objectives of the research. Therefore, the user should not focus on choosing a single tool. Rather, users are advised to focus on identifying tools that are poised to work together to answer users' systems and complexity questions and/or to support decision-making at all stages of the program cycle.

While there are many different opportunities for integration among systems tools, we will describe one potential way for the tools to fit together to enhance the work of a particular project.

To start, **Narrative Approaches, such as GKI's Innovation System Analysis** can produce a system-wide diagnostic to infuse **Mapping Approaches, such as LINC's Social Network Analysis**. The Innovation System Analysis, and other narrative-based approaches such as the Systems Influence and Incentives Matrix can provide a qualitative analysis of the system, enabling the SNA researcher to better understand key actors and interactions within the system, triangulating this information with observations on stakeholder incentive structures and the broader network structure. By combining specific narrative methods with social network analysis, the user can gain a "snapshot in time" of the phenomena, actors and interactions that compose the chosen system. However, some narrative based tools, such as the Enablers and Barriers Scoring table, look beyond the present to identify where best to intervene for maximum impact. **Modeling approaches, such as the GOPC's HERMES platform**, can build from these approaches to anticipate emergence within a system. By applying computational modeling methods to robust SNA datasets (enhanced by narrative techniques such as Innovation System Analysis, Influence and Incentives Matrix, Enabler and Barriers scoring table etc.) the user can identify a particular set of intervention and policy options, modeling their potential impact on the system or network. Furthermore, the user can test the validity of results by conducting an ex post facto SNA assessment of actual versus projected network change. Once the user has begun project implementation, they can employ **Indicator-Based approaches, such as RAN's Dynamic Project Trajectory Tracking Toolkit**, to detect which emergent system-level factors affect the attainment of anticipated results for a project portfolio, thus allowing for adaptive management and a higher success rate across project activities. This is simply one description of how complex system tools of different categories can complement each other; however, there are many additional formulations and opportunities for the tools to work together and build off one another.

The SPACES MERL consortium aims to provide a suite of tools that cover each of the complex system tool categories and offers packages of synergistic tools, tailored to specific program needs. Combined, SPACES MERL tools provide deeper insights into the behavior of the systems in which a program operates which enables smarter design and more impactful projects at all levels of the program cycle.

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