TRANSFORMATIONAL EVALUATION

FOR THE GLOBAL CRISES OF OUR TIMES

Rob D. van den Berg
Cristina Magro
Marie-Hélène Adrien
EDITORS

INTERNATIONAL DEVELOPMENT EVALUATION ASSOCIATION
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CHAPTER 16

A Complexity-Based Meta-Theory of Change for Transformation Towards Green Energy

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Abstract. This chapter draws from complexity science to present a meta-theory of transformation that can be applied to discrete theories of change constructed to guide model building, methodology and data interpretation for evaluation of change efforts. The focus is on six specific behaviours of complex systems – stigmergy, attractors, emergence, phase transition, self-organization and path dependence. These can be invoked singly or in combination to understand pattern, predictability and how change happens. The importance of both 'explanation' and 'prediction' is woven into the discussion. A definition of 'transformation' is offered in which a qualitatively new reality becomes the default choice that constitutes a new normal. Indicators of transformation include measurable ranges (as opposed to specific values) for level of energy use and the time over which the change endures. Because complex systems behave as they do, the recommended theory of change is sparse; it has few well-defined elements or relationships among those elements. There is already good progress in the application of complexity to the evaluation of transformation. An argument is made that these efforts should be strengthened by deliberately incorporating what is known about complex system behaviour, and that, by so doing, both prediction and explanation would better serve the purpose of practical decision-making.

Why a Complexity-Based Meta-Theory of Transformation?

What follows is a theory about commonalities among theories of change, irrespective of their specific content. Put differently, I will articulate a theory about theories of change (a meta-theory). The meta-theory I will present will draw heavily on complexity science and will focus on transformation to a green energy future. I do not use the term 'complexity science' lightly. There is a deep epistemological literature concerning why the study of complexity deserves to be called a science (Phelan 2001).

The discussion will present many notions about action, measurement and causality that you may find uncomfortable, at odds with common sense or both (Morell 2017). I hope to convince you that, despite the discomfort and the challenges to common sense, the meta-theory I am about to present is worth taking seriously.

Any theory underlying evaluation of transformation to green energy must be judged with respect to its predictive power, explanatory power[1] and value as a useful guide to practical action.

We evaluate for instrumental and conceptual purposes. Success at both requires thought and action based on theories that respect the complex nature of change[2]. To show why this is correct, I will proceed through three broad topics:

- concepts from complexity science that are relevant to evaluation theories of transformation
- the characteristics of 'transformation'
- how the previous two topics combine to form a meta-theory of transformation that can be applied to context-specific evaluations of transformation

Theories of action explain *how*. Theories of change explain *why* (Tyrrel 2019). This can be thought of as the difference between science and technology (Morell 1979). Technology turns to science when it is no longer able

[1] 'Explanation' and 'prediction' are not simple and obvious. For rigorous treatment, see Niiniluoto (2019) and Shmueli (2011).

[2] The argument made here is part of a larger literature that draws on complexity to drive social science theory and methodology. For instance, Marion (1999) reinterprets many well-known organizational theories using a chaos and complexity framework.

to achieve desired results (when the implicit theory of 'why' on which a technology is based is no longer powerful or correct enough). This is exactly the problem that those seeking to effect transformation face. Their theories of action do not respect the complex nature of change.

Complex Behaviour, Not Complex Systems[3]

Evaluators must make operational decisions. How should programme theory be represented? What form should a logic model take? What methodology should be employed? What data should be collected? How should the data be analysed? How should the data be interpreted? They also need to make fuzzier, but nonetheless critical decisions: How to communicate to funders and other interested parties about realistic expectations for programme outcomes. How to help people understand the causal dynamics that drive programmes. How to explain the boundaries of what can and cannot be known about a programme's consequences. Complexity-inspired answers to questions like these reside in knowing how complex systems *behave*, not what complex systems *are*.

The field of complexity is vast (Castellani 2009; 2014). It would be no more appropriate to say that 'complexity' is relevant to the evaluation of transformation than it would be to say that 'statistics' are relevant to the evaluation of transformation. What matters is: Which aspects of complexity are useful under which circumstances? There is no single answer to this question. This article is based on mine[4].

Three themes that cut across the complexity landscape are pattern, predictability and how change happens. The rows of table 16.1 list the complex behaviours that I believe are most useful for evaluating transformation to green energy. The columns remind us that each of these complex behaviours may have implications for understanding some combination of the complexity themes: pattern, predictability and how change happens.

[3] Three sources are particularly useful as entry points into the domain of complexity: New England Complex Systems Institute 2020, Santa Fe Institute 2020a, Systems Innovation 2020a.
[4] For another classification that is well worth considering, see Boehnert (2020).

Table 16.1 Cross Reference: Complexity Themes and Complex Behaviours Useful in Evaluation

	Theme in complexity science		
Complex behaviour	Pattern	Predictability	How change happens
Stigmergy			
Attractors			
Emergence			
Phase transition			
Self-organization			
Sensitive dependence			

Relevant Complex Behaviours and Their Evaluation Implications

How do complex behaviours provide insights into pattern, predictability and how change happens? What are the implications for understanding transformation? To answer these questions, I will start by providing intuitive explanations for each row in table 16.1. After each explanation, I will discuss the evaluation implications of each complex behaviour. I will end by showing how complex behaviours come together to help understand pattern, predictability and how change happens.

Stigmergy

Stigmergy is a concept that was first developed to understand insect behaviour (Theraulaz and Bonabeau 1999) but has since been generalized to many human-scale situations in which changes in an environment serve as cues to direct the behaviour of subsequent actors (Parunak 2006). In a stigmergic process, even though there is no direct interaction with previous actors and no overall plan that any actor follows, a goal directed–type pattern is manifest. This happens because the 'plan' is embedded in the history of activity that independent actors encounter.

It may be an error to assume that a goal-directed theory of change must include deliberate planning. An alternative approach would be to consider whether the context is one in which independent actors react in specific ways to their environment, resulting in activity that looks as if it were centrally coordinated. A stigmergic theory of change is particularly relevant to long timeline social changes that require multiple activities performed by multiple actors. This is because deliberate coordination among these actors is neither practical nor desirable (Morell 2018).

Attractors

Attractors are complexity's way of identifying 'where systems like to be', which is a loose anthropomorphic term, but one that provides an intuitive and accessible definition. More technically,

> In the mathematical field of dynamical systems, an attractor is a set of numerical values towards which a system tends to evolve, for a wide variety of starting conditions of the system. System values that get close enough to the attractor values remain close even if slightly perturbed (Systems Innovation 2020b).
>
> Social attractors define a specific subset of states that a social system may take, which corresponds to its normal behaviour towards which it will naturally gravitate (Systems Innovation 2020c).

It is critical to appreciate that there does not always have to be an attractor. Whether there is or not is an empirical question[5].

Here are two versions of the same question.

- What outcome will the programme have?
- What attractor space describes the programme's outcome?

The 'attractor version' leads to inquiry that does not fall naturally out of the 'outcome version'.

- Conceptualizing outcome as a value within an attractor leads to curiosity about the range of values the outcome can take (boundaries of the attractor) and what effort is needed to effect a change

[5] Understanding whether systems converge to an equilibrium or diverge in unpredictable ways is a major theme in the field of complexity. Two dynamics drive unpredictability. The first is sensitive dependence. The second is that a large number of low-probability events may cause a major disruption in a system. For a dramatic example, see Rumsfeld (2001). For an analysis of the high probability of at least one member of a set of low-probability events occurring, see Taleb (2010). This kind of behaviour is one of the main reasons that evaluators must pay attention to unintended consequences (Morell 2010).

from one set of outcome values to another (topography of the attractor, also known as sustainability, also known as resistance to change).

- Attractors provide a way to kick understanding of programme outcome up a level of abstraction and thus provide insightful comparison between seemingly dissimilar programmes. This is because similar outcome attractor spaces for seemingly dissimilar programmes raises suspicion that maybe those programmes are not so different after all.

As a simple illustration, imagine evaluating a programme designed to increase cooperation between a regulatory agency and industry as a means of improving safety. We know that neither enforcement nor cooperation alone is sufficient to ensure safety (Sparrow 2000). We also know that high-profile accidents push agencies to become more punitive. As a result, the behaviour of regulatory agencies can be visualized as a pendulum that swings over time between excessive cooperation and excessive enforcement. What does this dynamic mean for understanding sustainability in a programme that has successfully improved safety by increasing cooperation? It means that the more successful the programme, the more likely the agency is to reach the 'swing back' point. Note that this scenario has said nothing about which regulatory agency is involved or about any of the details of the safety programme. Rather, it describes the attractor shape for many different organizations and programmes. It allows us to consider similarities among many settings that exhibit that attractor.

Emergence

The whole is different than the sum of its parts. This truism has special meaning in complexity.

Imagine a cylinder in the internal combustion engine of an automobile. I can explain what a cylinder is, how it is constructed, how it fits into an internal combustion engine and so on. Yes, the automobile is different from the sum of its parts, but the uniqueness of the cylinder in the system called an 'automobile' remains. The same holds for organs in a human body or a graphics card in a computer.

Now think of a beehive or a traffic jam or an economy or the vitality of living in a dense urban area. It is *impossible* to explain a beehive in terms of the behaviour of each bee. It is *impossible* to understand a traffic jam in terms of the velocity of each car. It is *impossible* to understand an economy by breaking it down into the actions of each person and firm that makes up the economy. It is *impossible* to explain urban vitality by analysing the behaviour of each person living in a city. In all these examples, the whole is different from the sum of its parts in the sense that the parts lose their unique identity. When you see that, you see emergent behaviour.

Emergence touches on the question of what should be measured. It is natural to think of the consequences of interventions as being made up of constituent parts, each of which should be measured, but if what matters is the emergent property of many interacting parts, it may be difficult, or even impossible, to conceptualize an outcome in terms of the aggregate consequences of small achievements.

Phase Transition

Phase transitions are about qualitative change that results from small quantitative change.

> A phase transition may be defined as some smooth, small change in a quantitative input variable that results in an abrupt qualitative change in the system's overall state. The transition of ice to steam is one example of a phase transition (Systems Innovation 2020d).

Although the term 'phase transition' has its roots in the chemical and physical properties of matter, it can also be applied to human-centric contexts, as for instance the brief time it took the Republican Party in the United States to transform itself from a long history of pro-free trade, pro-immigration, internationalist inclinations to a U.S.-centric political philosophy as Donald Trump rose to prominence and position. Imagine the methodological and analytical differences in evaluating two different models – one that hypothesized quantitative change in the magnitude of an outcome and one that hypothesized a qualitative change that resulted from a small change in an outcome's magnitude.

Self-Organization

> Self-organization is a process in which pattern at the global level of a system emerges solely from numerous interactions among the lower-level components of the system. Moreover, the rules specifying interactions among the system's components are executed using local information, without reference to the global pattern (Santa Fe Institute 2020b).

The key insight in this definition is that a system can form a pattern without 'instruction' from the outside world. This does not mean that external events cannot perturb the system. It does mean that outside events do not control the system.

The possibility that self-organization is present has implications for sustainability and for its inverse – resistance to change. Meaningful evaluation questions include: Is the potential for self-organization present? Is self-organization operating? If a system is perturbed, how long does it take to evolve back into equilibrium? Is self-organization desirable?

Sensitive Dependence on Initial Conditions

Most of us have been schooled to worship at the altar of the general linear model. We have been taught to think in terms of groups – their means, variances and distribution shapes. Everything we do is focused on eliminating the influence of individual data points. We scan for outliers. We make sure our samples are representative of carefully defined sets. We endeavour to keep our variances tight. We base inference on the belief that error across observations will sum to zero. Sensitive dependence, which is a critical construct in complexity, offers a complementary analytical lens – one in which local variation can affect the long-term evolutionary direction of the whole system.

> A system's sensitivity to initial conditions refers to the role that the starting configuration of that system plays in determining the subsequent *states* of that system. When this sensitivity is high, slight changes to starting conditions will lead to significantly different conditions in the future (Santa Fe Institute 2020c).
>
> [Sensitive dependence] refers to the idea that current and future states, actions, or decisions depend on the sequence of states, actions, or decisions that preceded them – namely their (typically temporal) path. For example, the very first fold of a piece of origami paper will determine which final shapes are possible; origami is therefore a path dependent art (Santa Fe Institute 2020d).

Because of 'sensitive dependence', a system's overall behaviour can be understood in terms of how small changes within the system influence long-term trajectories as systems evolve over time. Because of sensitive dependence, it cannot be assumed that a sequence of relationships that exist at one point in time will repeat. Thus, although a causal path can be traced in retrospect, knowing that says little about where the path will lead next.

Combining Complexity Constructs to Explain Outcomes

The previous section addressed individual complex behaviours. Here I will illustrate how these behaviours can cluster to produce an intellectual orientation to pattern, predictability and how change happens.

Stigmergy and self-organization convey a sense that elaborate, seemingly deliberately planned, goal-oriented behaviour need not have central direction. One implication is that programme theories based on deliberate planning may be incorrect portrayals of how coordination takes place. A second implication is that, because theory guides methodology, evaluation will not provide data on the coordination process at play.

Phase transitions and emergence convey a sense that qualitative change can take place in constructs that have quantitative identities. The notion of phase transitions implies that conditions can remain little changed over an extended period and then change suddenly to qualitatively different states, and that of emergence implies that parts of a system lose their identity. Before emergence, it makes sense to observe and measure constituent parts. After emergence, the identities of those parts lose their meaning.

Complexity-Based Explanation

Much of the discussion so far has inclined heavily in the direction of instrumental action. If I know that emergence is happening, I should measure at the aggregate level. If I can identify an attractor, I should use the knowledge to assess resistance to change. And so on. There is a 'predictive' sensibility: 'If I implement this programme, what will happen?'

Evaluation is steeped in this predictive mindset. After all, the whole field is based on the belief that social science can give planners guidance[6]. Our work is technological, not scientific (Morell 1979). 'The aim of technology is to be effective rather than true, and this makes it very different from science' (Jarvie 1983). But what happens when the technology fails, when the predictive ability of evaluation fails to provide guidance to decision makers? Then the need arises to delve into explanation, to understand the science of why events occur (Feibleman 1983). When that need arises, complexity provides a productive framework.

6 Donald Campbell's (1991) classic piece on this topic is always worth reading.

I am not arguing that all evaluation of transformation should be based on complexity. I am only arguing that 'all models are wrong, but some models are useful' (Box 1979) and that complexity-based models are useful when transformation is being evaluated. What would a theory of transformation to green energy tell us if we invoked a complexity framework?

What Is Transformation?

An intuitive understanding of transformation is as a transition to a new normal, a default set of conditions that shape how we live[7]. Here are some examples.

- Wood to coal
- Animal to steam power
- Mercantilism to capitalism
- Horse to horseless carriage
- Long-distance fast communication, starting with the telegraph
- Mechanized transportation, starting with railroads and steamships
- The nation-state as a unit of relationships among geopolitical entities
- Income taxes as a legitimate way (at least in the United States) for a government to raise revenue

There were times before these new normals, for example, when people thought that a national surplus defined a nation's wealth, when it was inconceivable that a human could move 50 miles per hour and when information took weeks to move over long distances. What changed?

Let us take the example of the transition from wood to coal in England between the 17th and 19th centuries (Allen 2013; Rhodes 2018). (Yes, it did take a long time.) What needed to be present to effect this change? Steam power was available to drive engines to keep mines dry. Heating demand due to urban density denuded local forests. Patent law and the ratio of

[7] 'Default' is the operative word that makes 'transformation' different from 'sustainability'. One can think of this in terms of system maintenance. Does energy have to be put into the system to maintain it, or are equilibrium and self-organizational dynamics at play? There is an extensive literature on evaluating sustainability (Julnes 2019). To understand transformation, the concept of default conditions, and the reasons they may or may not arise, needs more attention than it gets.

labour to capital made invention appealing. The building boom in London was conducive to developing new chimney designs. And much else besides.

It is important to identify each of these factors, to assess their behaviour and to determine their interactions, but another useful perspective is to view these changes as a transition from one attractor regime to another, from an equilibrium condition that favoured wood to an equilibrium condition that favoured coal. Within each attractor, the self-organizing capacity of activity within the attractor would counteract any force that perturbed the attractor. That is a perspective that leads to speculation about the shape and depth of the attractor and raises questions that would not arise with traditional evaluation reasoning.

Why would it lead to different strategies? Because it would affect our theories of change. A complexity argument would claim that, within the attractor, it *may* be possible to identify all the relevant components but that it is *impossible* to understand the attractor in terms of relationships between each of those components. Why? Because the equilibrium condition that defines the attractor is an emergent phenomenon. It may be possible to know what the parts are, but it is not possible to identify the specific role of each part. Moreover, if we believe in sensitive dependence, we believe that, each time the attractor is perturbed, the self-organization dynamic might be different. All we can say is that the attractor is deep enough relative to self-organization capacity that, when the attractor is perturbed, it returns to its equilibrium condition.

Defining the Outcome: What Is Green Energy Transformation?

The complexity view tells us that, if there is a transition to green energy, many different factors must come together, but that we do not know (and probably cannot know) what they all are and that, whatever they are, they can come about in different combinations. How to evaluate a scenario like this?

A good place to begin is by defining the desired outcome by making as informed and data-based a guess as possible to answer the question: How much use of green technology is needed to make it the default choice for the foreseeable future? Here is an example of what might work as a definition of the transformation: 'We know that transformation has happened if, in geopolitical boundary X, approximately 80 per cent of energy use comes from green sources and has remained at approximately that level for five years'. I like this form because it includes different dimensions of whatever attractor space constitutes a green energy new normal, as shown in table 16.2.

Table 16.2 Elements of the Green Energy Attractor

Element	Description
Geopolitical boundaries	The existence of geopolitical boundaries implies a reasonably large geographic area. It is a proxy for availability of equipment, businesses and expertise to install and maintain systems; cost; political consensus; the reach of regulation and peer pressure.
Level of energy use	'Eighty per cent' is a level of energy use that would be truly different from the old way of doing things. It could only come about from a profound change in energy sources and their supporting constituents.
Time	'Five years' acknowledges that an indicator of profound change requires assurance that the construct it reflects will endure over time. It indicates that the attractor is stable.
Imprecision	The definition acknowledges that there is a range that defines the boundaries of the attractor.
Measurement	Everything in the definition can be measured.

What if the definition turned out to be wrong? That would be OK. It would mean that evaluation revealed a problem with stakeholders' programme theory and, it is hoped, guidance for correcting the theory.

Complexity-Based Models

Empirical inquiry requires an exercise in wilful ignorance (Weisberg 2014) because there will always be relationships we care about that are enmeshed in a multitude of relationships that complicate and obscure what we want to know. Therefore, any research enterprise, evaluation included, requires a model, a simplified version of reality that specifies the relationships we care about. Any model we use will be wrong, but some will be useful (Box 1979). Complexity-based models are wrong but useful in ways that our traditional models are not.

Comparing Complexity-Based and Non-Complexity Based Models

Compare the scenarios in figure 16.1.

- *Scenario 1.* Scenario 1 assumes that we know enough to specify all outcomes and relationships among their antecedents.
- *Scenarios 2, 3...n.* These scenarios (grey field in figure 16.1) depict different possible complex relationships between the programme and its outcomes. What is the message in these scenarios? (1) There is a connection between programme and outcome. (2) There is an exceedingly large number of paths that can elicit the desired outcomes. (3) Because of sensitive dependence, we cannot predict the precise path between programme action and desired outcomes. (4) Not all the known relevant factors must be equally important during each pass through the system. (5) No single intermediate factor leads directly to any of the desired outcomes. Rather, outcome stems from the emergent effect of all the networked intermediate elements. So, when designing an evaluation, which configuration should we pick? None. Why? Because whichever we choose, that configuration may be different in the future.

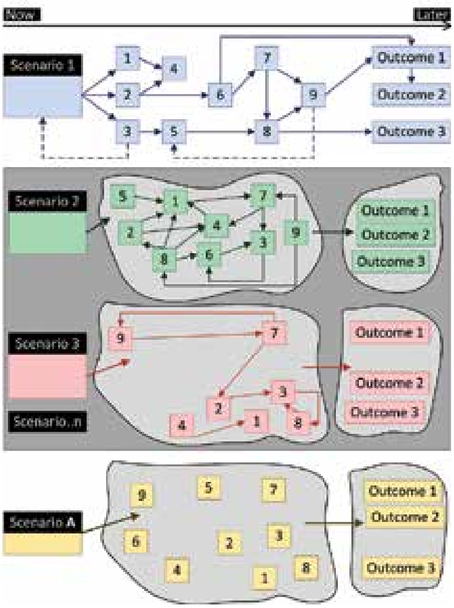


Figure 16.1 Traditional and Complex Models for the Same Programme

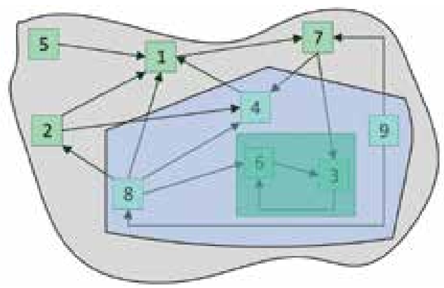
- *Scenario A.* Scenario A has a very simple logic: Do a lot here, and something will happen there. In a world driven by complex behaviours, this logic makes sense. I do not mean to imply that we can pick the internal elements of the model at random. It is important to specify categories that need to be included (e.g. economic conditions, technological capabilities, regulatory structures, culture). After all, we have domain knowledge based on experience, research and theory.

Possibilities for Prediction

I overstated the case and left the impression that highly specified models cannot be predictive. What is true is that the broader the scope of a model, the greater the likelihood that complex behaviours will replace the role of specific relationships. Put differently, a model might be everywhere correct locally but incorrect globally.

Figure 16.2 Illustrates this point. It is drawn from scenario 2 in figure 16.1. The simplest region (green rectangle) contains two elements connected with a single feedback loop and two direct connections with the outside. The next larger region (blue) contains five elements. It also contains nested feedback loops and three direct connections with the outside. Finally, there is the entirety of scenario 2.

Figure 16.2 Global/Local Model Correctness



I do not know how to quantify degrees of complexity, but it seems reasonable to subject the green region to a traditional evaluation. I am not sure I would do it for the blue region, but I could be convinced. I know I would not accept that tactic for the entire model.

It is also important to keep in mind that the argument above is about predicting a causal path rather than tracing a causal path that has already occurred. Nor is it about identifying all the elements in the model. When sensitive dependence is operating, what cannot be predicted for any given path through the model is which elements will be active and how they will relate to each other. Once the model runs its course, all can be identified.

A Meta-Theory of Transformation to Green Energy

Existing theories of transformation clearly engage complexity. Some engage complexity implicitly. Complex behaviour is contained within the model, but there is no explicit mention of complexity. Other theories explicitly draw on complexity. I will give an example of each and then make the case that theories of transformation should draw from complexity science in a systematic fashion.

Theories of Transformation That Do Not Explicitly Refer to the Field of Complexity

Reed and Jordan (2007) developed a systems theory for the U.S. Department of Energy's Energy Efficiency and Renewable Energy (EERE) programme. They confronted a classic complex system problem. EERE has the long-term goal of engendering a regime of efficient renewable energy. In doing so, it runs many discrete programmes that emanate from many different cubbyholes within the Department of Energy, all of which have different short- and intermediate-term goals and separate theories. With respect to the long-term goals, the theories employ the well-known logic: implement programme → accomplish short-term goals → magic happens → achieve long-term goals.

Reed and Jordan's proposal was that all the diverse programmes conduct evaluation based on Rogers' (2003) theory of innovation. That theory's constituent parts are applicable to a wide range of settings, making evaluation findings comparable across diverse contexts. Individual programmes may still need their own unique objectives, but by invoking Rogers, the diverse programmes can also share goals. Because of this commonality, the strengths and weaknesses of separate programmes can be compared. Reed and Jordan do not discuss their efforts in terms of complexity, but it is clear that stigmergy, emergence and sensitive dependence can provide complexity-inspired explanations about pattern, predictability and how change happens.

Stigmergy

Recall that stigmergy is a process in which a plan is embedded in the history of activity that independent actors encountered (Theraulaz and Bonabeau 1999). Now consider EERE's dilemma. Their various programmes have a common long-term goal and different short-term goals and are embedded in a bureaucracy that makes tight coordination difficult and counterproductive (Morell 2018).

EERE can use knowledge of common goals to make organization-wide decisions, but something else is also going on. Reed and Jordan have devised a mechanism that changes the information environment such that each programme can make independent self-interested decisions informed by what its surrounding programmes have, and have not, done. This is stigmergic change.

Implement programme → accomplish short term goals → magic happens → achieve long-term goals. Emergence and sensitive dependence explain the magic. Consider the EERE scenario in light of figure 16.1.

Many different programmes inhabit the same ecosystem. At any single decision point, an individual programme may make a decision that links to other programmes. But what linkages? And to which programmes? Those decisions will be based on judgments made at unique points in time based on demands of the moment. At other times, or under different perceived conditions, decisions will lead to a different set of linkages. Where does this leave evaluation of EERE?

- Because of previous research, we know what elements must be included. Evaluation can determine which ones have.
- Because of the common Rogers-based goals, some form of coordination might take place as each programme makes its own decisions. Evaluation can tell us the whethers, whats, whys and hows of that coordination.
- Complexity-informed programme theory tells us that:
    - Because of sensitive dependence, the chain of coordination relationships cannot be specified in advance or relied upon to endure over repeated planning cycles.
    - Success may be a function of the amount of coordination but not of what specific coordination took place.
    - Because network linkages are involved, success may be an emergent function of the linkages; that is, the overall effect cannot be explained in terms of the unique identity of each of its constituent parts.

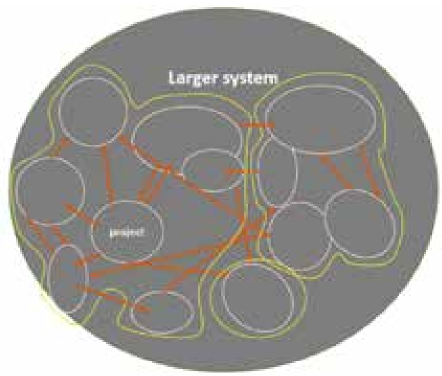
Complexity explains the 'magic'. It is not magic at all. It just seems like magic because complex behaviour may not conform to our common sense.

Theories of Transformation That Explicitly Refer to the Field of Complexity

Considerable effort is being made to draw on complexity when developing theories of transformation. What we need is to enrich and systematize this line of thinking. Three examples illustrate how current thinking about theories of transformation have drawn on complexity.

Example 1. Zazueta (2017) has proposed a theory of change that draws heavily on networking (figure 16.3). He identifies adaptive learning, feedback and emergence as behaviours of networks. He also specifies that 'agents' are operating and notes the importance of domains and scales of space and time. The graphic implies that there are nodes and edges, but precisely what they are and how they are connected is left undefined.

Figure 16.3 Theory for Transformational Development



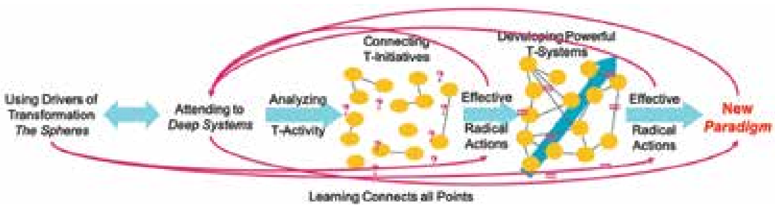
Source: Zazueta (2017).

Example 2. Figure 16.4 illustrates the theory of transformational change that the SDG Transformation Forum (2020) proposed. It relies on feedback loops and networks but acknowledges that specific elements of success are unknown, hence the unlabelled network nodes and the question marks that, presumably, are there to indicate uncertainty about network edges.

Example 3. Figure 16.5 is an adaptation of a model that Fisher and Roehrer (2020) developed to understand progress towards transformation. Individual elements (incremental inputs on the left side of figure) undergo a network development process that transforms them into transformational elements on the right (e.g. projects and portfolios).

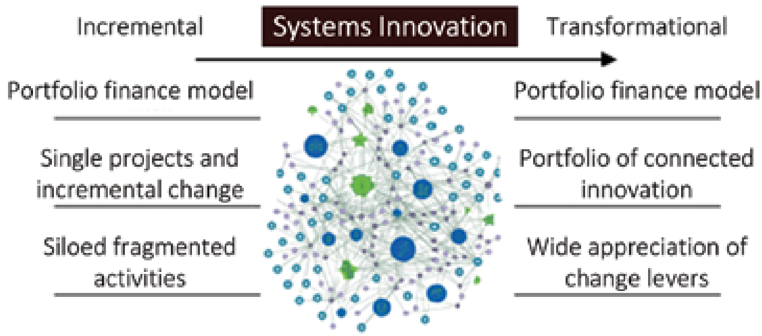
All three examples specifically identify network behaviour as crucial to transformation. All three acknowledge two domains of uncertainty – the specific identity of nodes (relevant variables) and the causal relationships among these nodes.

Figure 16.4 Theory of Transformational Change



Source: 2020 SDG Transformations Forum.

Figure 16.5 Model of Progress Towards Transformation



Source: Adapted from Fisher and Roehrer (2020).

Extending the Application of Complexity in Devising and Using Theories of Transformation

Table 16.3 identifies the complex behaviours contained in these theories.

The complex behaviours implicit in existing theories of transformation should be made explicit and considered in a deliberate manner. A meta-theory of transformation is useful for facilitating such deliberate consideration.

To produce a theory of transformation, it is necessary to begin by defining the outcome, in this case the criteria in table 16.2: geographical boundaries, level of green energy use, geographical spread, range not point estimates and making sure that it is all measurable.

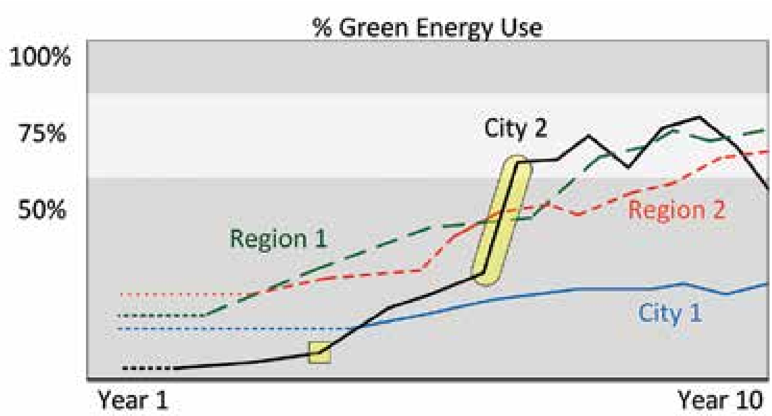
By defining outcomes this way, it will be possible to produce data as depicted (in the entirely fictional scenario) shown in figure 16.6. In the figure, colours represent geographical entities, dashed lines represent regions, solid lines represent cities and straight dotted lines show the time in each location before which any change might be expected. How might a complexity perspective interpret this data?

- For there to be a ‘new normal’, geographical spread matters because geography is a proxy for availability of equipment, businesses and expertise to install and maintain systems; cost; political consensus; the reach of regulation and peer pressure. Figure 16.6 shows which locations changed and when the changes took place.

Table 16.3 Complex Behaviours Implicit in Existing Theories of Transformation

Complex behaviour	Manifestation in theories of transformation
Emergence	Emergence can account for reasons to avoid explaining transformation in terms of linear combinations of discrete variables.
Phase transition	Phase transitions are common as edges grow in a network.
Attractor behaviour	Attractors allow for the fact that, despite the uncertainties of sensitive dependence, there are circumstances under which, if enough activities are done well, specific outcomes can be expected.
Sensitive dependence	Sensitive dependence implies that, even when a causal chain can be determined in retrospect, that same causal chain may not operate in the future.
Stigmergic and self-organizing phenomena	Stigmergic and self-organizing phenomena may drive activity in the direction of organized change even absent tight central coordination.

Figure 16.6 Illustration of Evaluation Data, Promotion of Green Energy Technology



If the data were paired with a map, evaluators would have a solid appreciation of how infrastructure support evolves.

- Complexity posits that, even if change is defined as space within an attractor, there is still the question of the topography of the attractor – how well can self-organizing forces 'hold' values within the attractor? Eyeballing the data suggests that the attractor seems stable for larger geographical areas (regions) even if it may not be stable for smaller areas (cities).
- The definition of success stated a range for percentage of green energy. Three of the four regions made it into that range but only into the bottom of the range, and one of those almost fell out. Perhaps the natural range for green energy use under the interventions implemented and in the environment in which they were implemented is lower than what was expected? This may suggest a change in programme theory or an adjustment in our understanding of realistic outcomes.
- To say that approximately 80 per cent green energy use is a new normal is to say that it is qualitatively different from lower percentages. This may be the case because all of the factors that affect energy use come together in a networked fashion to yield an emergent condition in which component parts lose their identity. Is our hypothesis correct that emergence takes place at approximately 80 per cent green energy use?
- Complexity tells us that phase shift behaviour is possible. It does not tell us that there *must* be such change or that the new normal cannot happen incrementally. See the yellow oval for city 2. It seems as if a phase shift may have taken place. Incremental change seems to be the case in the other scenarios.

What complex behaviours would have to be built into the evaluation to allow us to interpret the data in complex terms? The answer is summarized in table 16.4.

In addition to the implications of the specific complex behaviours described above, a complexity perspective constitutes a style of reasoning. Table 16.5 gives some examples. All of these examples speak to the themes in complexity that constitute the columns in table 16.1 – what pattern we can expect, what we can and cannot predict, how change happens.

Finally, drawing on complexity can help when efforts at transformation fail because the process of transformation is a complex system, and

Table 16.4 Complexity as It Applies to Theories of Transformation

Emergence	▪ Does the model identify what the emergent outcome is? ▪ Does the methodology consider the emergent behaviour as its own variable? ▪ Does the theory of change recognize the importance of individual elements without assuming that the consequences of those elements can be 'added up'? ▪ Does the model reflect when an emergent change will appear or for how long into the future the change will persist?
Phase transition	▪ Does the theory postulate a non-linear change in which little happens for an extended period of time? ▪ Do the theory and methodology (not to mention stakeholder expectations) acknowledge that the concept of 'intermediate stages of transformation' may not have much meaning? ▪ Does the model recognize timing, that is, does it identify a window within when the change can be expected?
Attractor	▪ Does the theory acknowledge that transformation may be defined as an attractor that can be explained as a condition in which self-organization resists changes to the status quo? ▪ Has any thought been given to how deep that attractor is, that is, how resistant the transformation state is to outside shocks? ▪ Does the methodology consider the stability of the attractor? Put in other terms, if the model predicts the appearance of an outcome attractor, for how long will that prediction remain accurate?
Sensitive dependence	▪ Does the theory specify relationships between discrete elements, or does it recognize the possibility of sensitive dependence, a condition in which multiple unpredictable chains of causation may lead to the same result? ▪ How does the evaluation engage this possibility in terms of metrics that specify what needs to be measured and a methodology that provides the logic of data interpretation?
Stigmergy	▪ Does the theory explicitly consider coordination among the actors involved in transformation activities? ▪ If so, does the theory consider the possibility of stigmergic processes in which independent choices are influenced to work towards a specific goal?

Table 16.5 Examples of Reasoning that Derives from Combining Complex Behaviours

Complex behaviour	Implication for understanding change
Emergence and phase transition	Combine to convey a sense that smooth incremental change is not typical behaviour
Sensitive dependence and attractors	Combine to convey a sense that clearly specifiable patterns should not be expected
Stigmergy, attractors and sensitive dependence	Combine to convey a sense that, even without high levels of process control, certain outcomes can be expected

therefore, the science of complexity is needed to explain success and failure when the theory of action (the technology) of effecting change fails.

Is There a Recipe for Applying Complexity to Evaluation?

No. There is no recipe. What I can offer is a set of questions to ask, put in a sensible order.

- *What are the characteristics of the desired state?* These need to be defined in terms of multiple measurable elements and levels of imprecision.
- *Is the desired state a 'new normal'?* Will the desired condition be the default, or will it need energy to sustain it?
- *Is the desired state qualitatively different or just more (or less) of what went before?* Is it more like an economy or a traffic jam or an overall health measure consisting of different kinds of health improvements?
- *What does the outcome chain look like?* Begin with a traditional deterministic model. Then ask: Is this the only path through the model's parts that will lead to the desired state? Are there other elements that *might* be operating even if I don't see exactly how they fit? Is it likely that elements I cannot foresee might become relevant? Might small local changes affect the entire path through the model?
- *How do the coordination mechanisms work?* Question whether direction is imposed or emerges from independent action.

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The COVID-19 pandemic has demonstrated the enormous challenges humanity is facing. It has been facilitated by other crises as climate change, biodiversity loss, economic exploitation, and increased inequity and inequality. The UN Agenda 2030 and the Paris Agreement on climate change call for transformational change of our societies, our economies and our interaction with the environment. Evaluation is tasked to bring rigorous evidence to support transformation at all levels, from local to global. This book explores how the future of the evaluation profession can take shape in 18 chapters from authors from all over the world, from North and South, East and West, and from Indigenous and Decolonized voices to integrative perspectives for a truly sustainable future. It builds on what was discussed at the IDEAS Global Assembly in October 2019 in Prague and follows through by opening trajectories towards supporting transformation aimed at solving the global crises of our times.

By combining practical experiences with perspectives drawn from new initiatives, this book offers invaluable insights into how evaluation can be transformed to support transformational change on the global stage.

Indran A. Naidoo, Director of the Office of Independent Evaluation of IFAD

Across continents, educational systems, and historical complexities, this book builds up the language we all should speak about our field. A mandatory read for all young evaluators.

Weronika Felcis, Board member of EES and Secretary of IOCE

After reading these chapters you will have a sharper look at what is relevant when managing or doing an evaluation, and you will notice that 'business as usual' will no longer be an option.

Janett Salvador, Co-founder of ACEVAL, Former Treasurer of ReLAC

This book offers original, visionary discourse and critical perspectives on the challenges evaluation is facing in the post COVID-19 pandemic era.

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