Mapping the Mess:

Planning for the unprecedented in a complex, dynamic, and interconnected world

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Abstract

We live in an increasingly interconnected world— environmentally, technologically, socially, economically, and financially. Such a world is inherently dynamic, which may render traditional planning tools, especially those that rely on assumptions of constancy, useless or even dangerous in the face of unprecedented trends and challenges. The interconnectivity that marks the many systems around us makes us vulnerable, but also offers new opportunities. If we are bold enough to do the messy work of mapping the uncertain, we can make use of interconnectedness by identifying systemic weaknesses early on, and determining those influential points in a network where efforts will yield optimal impact. Doing so means venturing into territory in which we don't always possess reliable past data, and where we have to rely on human insight more than we might have grown comfortable with. Tools to facilitate planning amidst complexity include expert elicitation, network theory, scenario analysis, and system dynamics modelling. This document describes how the combination of the first two tools, expert elicitation and network analysis, can help governments determine strategies towards the Sustainable Development Goals, and sustainable development in general. Expert elicitation would function as an advanced methodological and equitable stakeholder engagement, while the network analysis would ensure that the dynamics of the societal system are optimized for effectiveness. The expected results are inclusive, forward-looking strategies and policies with limited unintended consequences and long term impact.

Keywords: Interconnectedness, complex, dynamic, network, systems thinking, expert elicitation, network analysis, sustainable development goals, collapse.

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In the 1972 book *The Limits to Growth*, commissioned by the Club of Rome, the authors Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens III presented their conclusions on the future of humankind based on a global systems representation called the World model. They found that although a pursuit of economic growth without much regard for environmental costs would at first lead to a higher standard of living, this dynamic could not continue. Standards of living would no longer rise along with economic growth once natural resources availability had started to become the limiting factor in production and labor productivity. At that point, continued attempts to boost economic growth without adapting to the new scarcity constraint of natural capital was found to likely reduce living standards, because these efforts would further deplete resources (Meadows, Meadows, Randers, & Behrens, 1972).

Figure 1. Systems depiction of the limits to growth principle. Own work.

The book received much criticism at the time (Cole, Freeman, Jahoda, Pavitt, 1973; Kaysen, 1972; Solow, 1973). Empirical updates, however, have shown that the general forecasts of the World model track the current global state. Economist M. Simmons said in a 2002 update on the book and model (Meadows, Meadows & Randers, 2018): “The most amazing aspect (…) is how accurate many of the basic trend extrapolations (…) still are some 30 years later.” A 2014 update study, based on data from the United Nations (UN) department of Economic & Social Affairs, Unesco, the Food and Agriculture Organization (FAO), and the UN statistics yearbook, shows the same results (Turner). The author of the study report further postulates that the global financial crisis (GFC) of 2008 and general economic difficulties could be related to mechanisms of breakdown as described in *The Limits to Growth*.

Unless humankind would drastically transform its definition of progress, *The Limits to Growth* team estimated the global standard of living to level off around present time, followed by a (steep) reversal around 2030, ending in global collapse. The World model's indication of 2030 as the reversal point coincides with the timeline for the UN Sustainable Development Goals (SDGs). But the model does more than add to the Global Goals' imperativeness. The World model was the most impressive example at the time of a tool from a new field; a way to understand the world around us as a complex, interconnected system.

Planning in the 21st century

Many statistical models that produce the metrics that world leaders base decision on, rely on assumptions of some form of constancy, e.g., homoscedasticity (constant variance), independence (constant zero covariance), or at least general constancy of patterns ("past behavior is the best predictor of future behavior"). These models can be very informative in the context of relative certainty and a short horizon, such as a controlled experiment or another situation of unusual stability. This explains in part the popularity that these models have enjoyed over the past few decades. The data series used to validate many of today's popular statistical models came from an unusually stable financial period, often referred to as the "Bretton Woods" period (Reinhart & Rogoff, 2009). We do not live in this stable environment today.

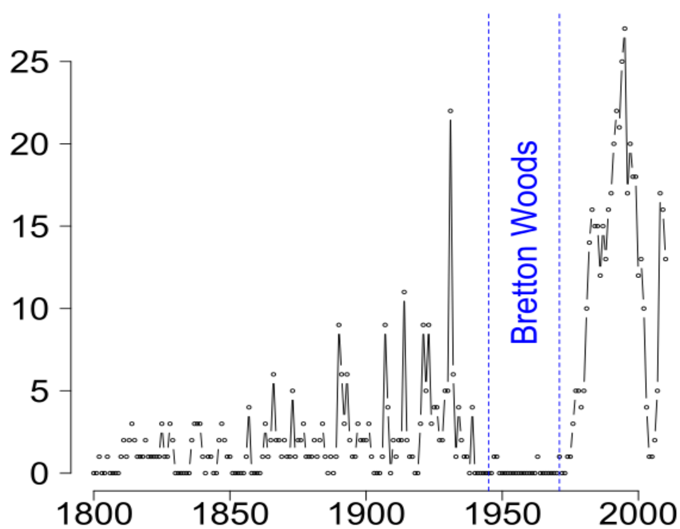

Figure 2. Number of countries having a banking crisis in each year since 1800. Work of David MCEddy (n.d.), used under CC BY-SA 3.0. Note the stability during the period of the Bretton Woods agreement, 1945 to 1971. This chart is similar to Figure 10.1 in Reinhart & Rogoff (2009, p. 205).

The beginning of the 21st century has been marked by unprecedented technological, financial, economic, environmental, and social interconnectedness, with equally unprecedented challenges. Global trends include ever increasing pressures on natural resources, changing weather patterns, rapid technological change, demographic shifts, rising wealth inequality within and between countries, urbanization, financial innovation and financialization, economic power shifts, rising populism, high levels of private and public indebtedness, and ineffective monetary policies (Gabbi & Ticci, 2014; KPMG International, 2014; Burns, Chanda, Nicol, & Reid, 2017). Such a world is inherently dynamic; there is often no sound reason to assume constancy. The tools of the latter half of the past century work well in a complicated world; a world where one can sit down, think hard about a problem, find the answer, and stick to it. In a complex world, however, the right answer can continuously change. For governments, with a longer horizon and broad benefit-seeking mandate, this means that without additional tools to factor in this dynamism, important opportunities and risks might be missed.

Interconnectedness exposes us to contagion. This offers opportunities for those able to gauge the system workings enough to make use of its flow-on effects, but it also introduces new risks; events can spread through a system that we are part of, yet from a source over which we have little control. As the World Economic Forum (WEF, 2018a) recently wrote in its flagship Global Risks report (emphasis mine):

> "Humanity has become remarkably adept at understanding how to mitigate conventional risks that can be relatively easily isolated and managed with standard risk-management approaches. But **we are much less competent when it comes to dealing with complex risks in the interconnected systems that underpin our world**, such as organizations, economies, societies and the environment. There are signs of strain (…), and when risk cascades through a complex system, the danger is not of incremental damage but of "runaway collapse" (…)."

Thinking in Systems

Systems thinking is a way of viewing and discussing the world around us not just by the parts that form our reality, but on how these parts interrelate. A system can be either natural or human made, examples include an ecosystem, a nation's societal system, or the global financial system. Behavior in systems is often not linear, but rather displays exponential growth or decay (Meadows, 2012), "tipping points" (Gladwell, 2002), and general non-constancy of interactions (Meadows, 2012). This makes the tools that fall under the broad umbrella of systems thinking different from models that rely on above mentioned assumptions of constancy. In certain situations, this also makes them more appropriate policy tools.

The "linear" policy response to events can be reactive, i.e., aimed at symptoms (Forrester, 1971). Reactive solutions are sometimes necessary, but other times can cause significant unintended effects and/or make a situation worse in the long run (Stroh, 2015). With a systems approach, governments can map how economic, social, and environmental factors interact within society. This allows policy-makers to forecast more accurately. Additionally, such maps enable decision-makers to find "leverage points" that a rule-setting body like the government can use to start changing the system itself, and thus the patterns and events it produces.

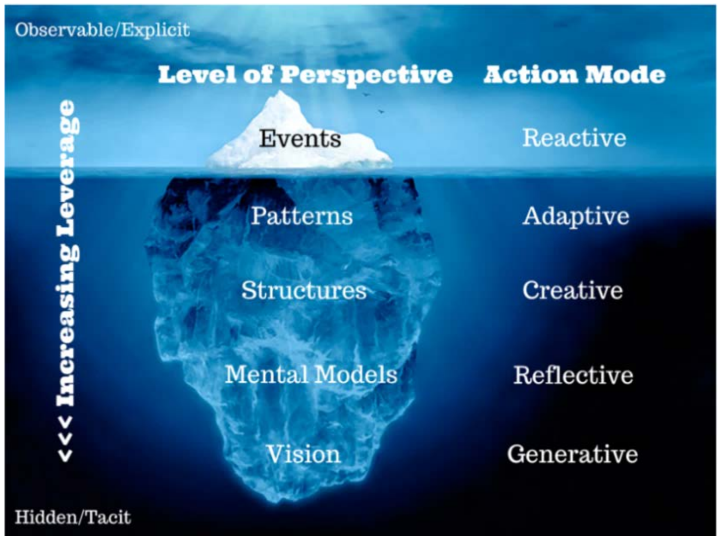

Figure 3. Levels perspective in systems thinking. Reprinted with permission from J. Muehlberg (2018).

What follows are some tools to help organizations, including governments, put the above into practice. I feel it necessary to point out here, however, that systems thinking is not just a new set of tools and models[1]. Part of systems thinking involves reevaluation of one's own conceptual frameworks, and the acknowledgment that although models can be helpful to test our mental assumptions, ultimately these models all are wrong (Sterman, 2002). Systems thinking means acknowledging that our well-intended actions might have negative consequences beyond our imagination and sphere of influence. It means getting comfortable with the idea that underlying

[1] Accessible first reads into systems thinking are David Kim's free online document (1999) *Introduction to Systems Thinking* or Donella Meadows' book *Thinking in Systems* (2012). Many systems scientists have applied systems thinking, amongst others, in the fields of sustainability (Meadows, 2012), social policy-making (Stroh, 2015), economics (Eisler, 2008; Keen, 2015), business (Ford & Sterman, 1998a), computer modelling and engineering (Forrester, 1975), and organizational management (Kim, 1999; Senge, 2006).

structures strongly influence our own and other's behaviors. In short, systems thinkers need to let go of the illusion of control. Unavoidably, this makes systems thinking an emotional and spiritual journey. Government and indeed humankind will not achieve the societal transformation that is needed to realize the SDGs without a collective shift in our attitudes, priorities, and values.

Planning tools today for tomorrow

Analyzing a system can feel overwhelming; if everything is connected and continuously in motion, how can we know where to start with making effective and lasting changes? How can we incorporate interconnectedness in our planning activities? How do we go from backward-looking to forward-looking without resorting to mere guess work? The SDG framework is a prime example of this conundrum. With 17 interacting goals and dynamic national and international circumstances, it may not be obvious where to start with new policies, and what those should look like if one is to avoid significant undesirable consequences.

According to systems scientist Sterman (1994), effective methods for learning in and about complex dynamic systems must include: (a) tools to elicit participant knowledge and create maps of the feedback structure of a problem; (b) simulation tools to assess the dynamics of those maps and test new policies. Four tools in particular have proven useful here; *expert elicitation* and *network analysis* for a), *scenario analysis* and *system dynamics modelling* for b).

Scenario analysis is a process of analyzing possible future combinations of events (or: storylines) by considering multiple alternative trend developments (International Institute for Sustainable Development, 2018). Thus, scenario analysis is not based on extrapolation of the past, and therefore advocated by many organizations as a tool to gain insights into uncertain futures (UNCTAD, 2013; TCDF, 2017; WEF, 2017). System dynamics modelling is a more precise quantification of systems once they are defined by a systems map (Forrester, 1971). The World model is one such example, but there exist many more today.

The other two tools, expert elicitation and network analysis, are explained more fully below. In my experience with consulting governments, multinationals, and other organizations on operating effectively in the system of their specific interest, these tools in combination can form a powerful method to decide relatively quickly and in an inclusive fashion where to best allocate limited means in order to gain optimal results.

Expert elicitation

Expert elicitation is the synthesis of opinions from a group of expert authorities on an issue that is surrounded by uncertainty due to insufficient or a complete lack of data, for example because it involves a rare or unprecedented event (Ford & Sterman, 1998b; Surowiecki, 2005). Expert elicitation is a scientific and forward-looking planning method to assess emerging trends in their context. The experts will have informed themselves with available data, of course. Emerging technologies like Big Data, Internet of Things, and machine learning will serve as useful enablers to the experts. However, by themselves real-time data and adaptive algorithms cannot provide us with a vision, or tell us conclusively where to start and focus efforts. For that, we need human insight (McAfee & Brynjolfsson, 2012). Knowledge of systems is practically never completely available in data, but stored to some extent in the mental models of people that are part of the system. Expert elicitation facilitates the mapping of complex systems because it helps explicate the tacit knowledge of the experts (Ford & Sterman, 1998b). This tapping into people's *sensing capacity* for emerging issues (Sharp, 2017) also makes the use of expert elicitation accord with the latest insights on how to spur much needed innovation in organizations (Senge, 2006).

Naturally, people come with their personal biases, which is why working with human forecasters might feel a bit messy compared to the precise prediction models that we're used to. To cancel out people's inherent biases in the aggregate, including anchoring bias, confirmation bias, and observation bias (Mihajlovitz, 2009), the expert group should be sufficiently diverse in background, field of expertise, years of experience, gender, and other socioeconomic and cultural traits (Surowiecki, 2005). Academic uses of expert elicitation include climate change (Usher & Strachan, 2013) and environmental health impact assessments (Knol, Slottje, Sluijs & Lebret, 2010). The WEF (2018b) uses it for its Global Risks Interconnections map.

Given the complex and unprecedented nature of the sustainable development challenges that we face (KPMG International, 2014), applying expert elicitation in policy-making would be good practice, if not indispensable. It also aligns with society's increasing demand for inclusivity, iterative policy-setting, and working across departments, functional and government levels, sectors, and country lines. Government can fit an expert elicitation into the general process of stakeholder management; in essence, expert elicitation facilitates the collection, processing, and presentation of stakeholder's input equally and in a methodological way.

Network analysis

Network analysis allows us to not just take into account the interrelations between events, but to help make use of them. Many excellent books have been written about network theory and its promise for real-life applications (Amini, Boroojeni, Iyengar, Pardalos, Blaabjerg & Madni, 2018; Barabási, 2003; Barabási, Newman, Watts, 2005). The following three concepts can prove useful in making that promise reality in the context of government strategy setting:

- **Centrality.** This indicates the most systemically important single events within a network.
- **Clusters**. A cluster is a group of events that tend to occur together.
- **Velocity.** The speed with which an event might impact a nation, region, or city.

Centrality: The most influenced and influential events

Centrality indicates how connected an event (or: a node) is. In the context of government policy-making, centrality identifies the systemically important events, i.e., the ones that are more likely to affect a larger part of society to a significant extent (Barabási, Newman, Watts, 2005; Liu, Slotine, & Barabási, 2011; Cinner & Bodin, 2010). In a directed network (meaning a connection between nodes A and B can be both A→B and B→A), one can distinguish nodes that are central in that they connect to many other nodes (i.e., have a high *out* degree), and those nodes that are highly connected in that many other nodes flow towards them (i.e., have a high *in* degree).

The most central nodes in terms of flow *out* to other nodes are the influential events. These are the causal nodes, the events that trigger other events. In a resource-limited environment, mitigating these events (if they're negative, i.e., risks) or investing in them (if they are positive, i.e., opportunities) will show the greatest societal benefit per money unit.

The most central nodes in terms of flow *in* from other nodes are the most influenced events. These are the effect events, the nodes most vulnerable to other nodes in the network. These events should not be mitigated (when they're risks) or stimulated (when they're desired) first, because government would be working against the flow of the system. These are areas where the government would want to work with other parties—countries, private businesses, or NGOs, for example— that may have more influence in that particular area.

Clusters: Events that move together

Cluster are groups of nodes that show a relatively strong level of interconnectedness compared to the rest of the network. When one event in a cluster materializes, alert government action would be to consider the other events in that cluster as having become more likely to materialize as well. An example is the financial risk cluster of credit risk, market risk, and liquidity risk. Each of these risks were managed and regulated separately, but during the GFC we saw how these risks can trigger and significantly reinforce one another (Senior Supervisors Group, 2009; Judge, 2012). Another example is the water-food-energy nexus (Biggs et al., 2015; FAO, 2018).

Velocity: The speed of events or clusters

Velocity is still often left out of traditional risk management or strategic planning, even though its relevance is intuitively clear. Our response to climate change is an illustration of how events with an uncertain velocity tend to stay under prioritized. Adding velocity explicitly to an assessment will allow for some level of quantification of the aspect, which may then facilitate its incorporation in decision-making processes in a standardized and adequate manner. Because the velocity of a cluster is the minimum of the velocities of each single event in it, network analysis also helps avoid underestimation of how soon impacts from an event will materialize.

Recommendations for Government to incorporate the network view in their practice

A high level of precision can only be obtained by leaving out all information that is not certain and quantitative. In complex situations where the possibilities for implementing effective policies are strongly dependent on human social and behavioral factors, leaders should opt for accuracy (a messy move in the right direction) over precision (a clean move in the wrong one). The below 2-step process helps to somewhat quantify uncertainty and provides an overview of interrelations, allowing decision-makers to interpret stakeholders' forward-looking insights in a way that translates into actions[2]. They form the beginning of mapping the mess:

1. Use expert elicitation, for example as part of general stakeholder engagement, to come to a view of how aspects of a sustainable development issue are interrelated in their country at that point in time.
2. Use network analysis on centrality, clusters, and velocity to improve accuracy of risk/opportunity assessments, and determine leverage points, systemic risks, and synergies.

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[2] The ground-breaking research of Dr. Andries B. Terblanche into this field is gratefully acknowledged.

A network is a stylized depiction of a system. Because it assumes more constancy than a system dynamics model—it does not allow for delays or changes in connection strengths, for example—it should be updated regularly, preferably on an annual basis. It should also be noted that the metrics obtained through network analysis are mostly relative ones. Centrality, for example, is a ranking; nodes are more or less connected compared to other nodes in the network. Once civil servants have grown more familiar with thinking in systems, internal capabilities and analysis practices could be expanded to increase levels of quantification and precision of their assessments. This means going from relative metrics to absolute ones, by using scenario analysis and system dynamics modelling. The network and its flow dynamics can be used to construct high quality scenarios for the scenario analysis. The network characteristics could also form a basis for the parameters in a system dynamics model (which, assuming it is high quality, offers the most precision), although another expert elicitation would prove very useful for this too.

Example: Mapping Climate Change

A practical example is the risk assessment that KPMG facilitated for the City of Sydney (2015), Australia. KPMG applied the above 2-step process to help the Sydney government understand the interdependencies between different climate change effects for the city. Influential and vulnerable climate change-related risks were identified in order to devise the city's Climate Adaptation Plan, which also noted predominant clusters that needed to be managed together.

Application to the SDGs

During years of facilitating strategy setting or risk management with the above 2 steps in Australia, China, Europe, Japan, New Zealand, and the United States, KPMG has sometimes applied the process to organizations' internal scales or frameworks. The SDG framework would lend itself excellently for this as well. The process then becomes:

1. Expert elicitation to come to a forward-looking view of the national opportunity or risk that each SDG poses to the country, and how these are interrelated at that point in time.
2. Network analysis to determine which SDGs are most influential and influenced, which group together, and with what speeds they're likely to impact.

Below is a hypothetical example of one output of such an SDG network analysis: a cluster map.

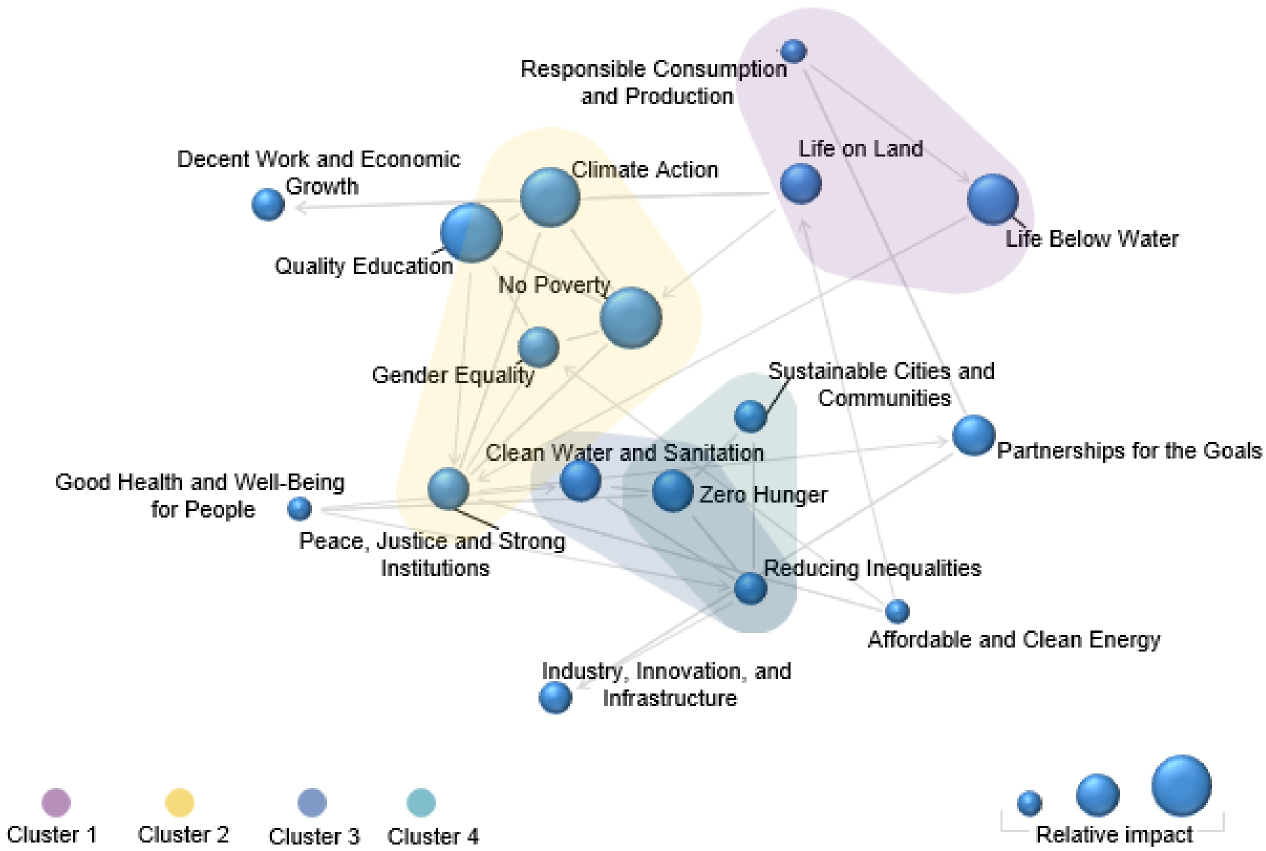

Figure 4. Illustration of an SDG network analysis cluster map for a country. No expert elicitation was used for this illustration's creation. ***Node positions in the network have been selected randomly, and so no reasonable conclusions can be drawn from this example****. KPMG Australia copyright.*

Conclusion

In order for governments to achieve the SDGs, they must determine where to focus their efforts, taking into account the interrelated nature of the Global Goals, national or local economic, social, financial and environmental circumstances, as well as their relations and place in a world that has become increasingly dynamic. Expert elicitation can help policy- and decision-makers harness a unique source of foresight —human imagination. This form of wisdom of the crowd can then serve as input for network analysis, and, depending on necessary level of precision, subsequent scenario analysis and system dynamics modelling. The output of the network analysis would enable governments to make strategic decisions for a complex societal system, as it provides an overview of leverage points; areas of strong synergies, and optimal opportunities for partnerships. The result of the 2-step process of expert elicitation and network analysis would be an inclusive and effective strategy and implementation plan towards the SDGs.

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