Transformation for U.N. Sustainable Development Goals (SDGs) achievement: The critical role of adaptive and integral public policy.

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Abstract

As the complexity in the world increases due to increased interconnections, new communication technologies, and the widespread internet of things so too is the complexity of the public policy space changing. However, much of public policy analysis, formulation, analysis and monitoring and evaluation is being done like it was for the last 80 years or more since the beginning of the policy sciences as the formal study of public policy as a social science. The SDGS (UN Sustainable Development Goals) are unlikely to be achieved with this traditional approach. Over the last 2- or 3-decades complexity science ideas have been increasingly applied in the social sciences to deal with social systems and other arenas of interest to public policy which displayed complex adaptive systems characteristics such as ecosystems. This has resulted in some refreshingly new ways of thinking of wicked policy problems and even in some new social science sub-disciplines like complexity economics. Yet a chasm exists between these developments and the use of complexity sciences in the teaching and practice of public policy. This paper brings together in a selected way a lot that has been learned in the use of complexity thinking in public policy and summarizes the practical tools that can be used for policy and program design and evaluation in complex situations.

Keywords: public policy, complex adaptive systems, SDGs.

1. Introduction

The public policy space in many countries is being contested in ways that do not reflect traditional policy analysis. As this is being written in early 2021, the world seems crazy with political divisiveness and racial division in the United States of America, 'Brexit' or the United Kingdom's withdrawal from the European Union, Hindu fundamentalism in India, China's growing global hegemony, Brazilian populism, and Turkish, Hungarian and Saudi Arabian dictatorial tendencies. Casteism and other forms of social exclusion continue to be prevalent in many countries including the USA and India[2]. These are overlaid by devastating global challenges like climate change and the Covid-19 pandemic, revealing and exacerbating long standing social and economic inequalities, whether hidden or ignored. Global and national wicked policy issues include: poverty, hunger, species extinction and slow progress towards the Sustainable Development Goals, especially in Fragile and Conflict Affected Situations (FCAS) in the Middle East, Africa and Asia. We are living in what has been described as a "VUCA" world—one that is volatile, uncertain, complex and ambiguous. The paradox of the public policy world is that as the amount of data

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[2] See for example Wilkerson (2020).

increases exponentially, the levels of uncertainty increase similarly and our capacity to formulate policy solutions seems weak and insufficient.

At the same time, the world is increasingly interconnected by global supply chains, cheap and mostly free communication technologies, the internet of things, big data, and pervasive artificial intelligence algorithms, all of which result in emergent challenges and opportunities for public policy to support human flourishing. The list of vexing public policy problems is long and growing. These problems are worsened when there is a breakdown in trust among people and between people and national governments and public institutions as is the case in many of the world's democracies from India to the USA. For example, in the USA, 75% of people think trust in government is shrinking and 64% feel that trust in each other is declining (PEW 2019). The issues themselves have no clear answers as there is much social contestation about what is to be done while, at the same time, the technical solutions to the problems are far from certain. These issues have been called "wicked problems" and they occur in a zone of complexity as described in the next section. Rittel and Weber (1973) described wicked problems in public policy as having many causes and sources, imprecise ways of addressing them, and as being tamable but ultimately unsolvable. Not only do conventional processes fail to tackle wicked problems, but they may exacerbate situations by generating undesirable consequences. Every wicked problem is essentially unique**.** An ordinary problem belongs to a class of similar problems that are all solved in the same way. A wicked problem is substantially without precedent; experience does not help to address it. As Rittel and Weber (1973) say in the abstract of their paper of policy problems in general:

> Policy problems cannot be definitively described. Moreover, in a pluralistic society there is nothing like the undisputable public good; there is no objective definition of equity; policies that respond to social problems cannot be meaningfully correct or false; and it makes no sense to talk about "optimal solutions" to social problems unless severe qualifications are imposed first. Even worse, there are no "solutions" in the sense of definitive and objective answers.

This kind of situation will require non-traditional thinking including additional tools and frameworks to replace or complement our existing public policy toolkits. In his recent book, *We the Possibility*, Mitchell Weiss (2020) echoes the call for public entrepreneurship (or Possibility Government), which was earlier made by Osborne and Gaebler (1993), in *Reinventing Government: How the Entrepreneurial Spirit Is Transforming the Public Sector.* That was a call for a revolution that, while it is yet to happen, is likely to follow the somewhat dismal motto of the dominant New Public Management (NPM): "Markets, Managers, Metrics", unless the NPM's shortcomings are addressed. This is discussed in the Section 7 of this paper.

The challenges facing the world are not only increasingly complex and interconnected in ways effect dynamic change, but some like climate change, are civilizational in scale. If we are to successfully navigate these turbulent times (this "VUCA world") we need to marshal all of our

ingenuity. We humans learn about the world around us though our direct sense experiences and observations, with instruments that aid our senses (telescopes, microscopes, medical imaging, laboratories etc.); with models of world, and through intuition, reflection and contemplation. While individual striving for betterment is important, more effective public policy is critical for the needed speed and required scale to effect global change.

The purpose of this paper is to assess the potential of complex adaptive systems' (CAS) theory, approaches and tools to help address the challenges of public policy analysis, design, monitoring and evaluation in support of transformation towards the SDGs. It is based on a review of selected relevant literature as well as on the author's own experience over the last three decades. In order to explain the value added by the CAS approach, a brief review of the existing approaches to public policy analysis, formulation, implementation and monitoring and design is first introduced. As not all situations require a CAS approach, this paper will first discuss an approach to sense-making in the rather confusing existing policymaking space, which will help to decipher how to select the right methods and make optimal use of available resources. This sense-making approach draws from the Cynefin framework developed by Dave Snowden and colleagues (Brougham 2015); and the Stacey Matrix (Stacey 2002). The introduction to the sense-making section will segue into an introduction to CAS intended primarily to provide an alternative way to conceptualize cause effect relationships and change management in public policy. This is followed by an illustration of complexity in various public policy settings. Next is a brief review of tools for public policy design in the CAS context. The final section discusses policy monitoring and evaluation in complex situations and provides practical guidance.

2. Sense-making in Today's World

The way humans have historically interpreted the world, our *weltanschauung*, can be framed as classical, modernist or post-modernist. It can now be argued that none of these frames is adequate and we are better off thinking of a non-modern era characterized by VUCA conditions. In the context of social sciences and public policy, modernism refers to the period between at least 1900 and 1940 in which industrial development, grand designs, universal truths, value-free hypothesis testing, centralized decision-making, and concepts of progress as a linear phenomenon were all common. Later in the 20th century, ideas of modernism were heavily criticized and alternatives put forward. These alternatives were post-modernist in nature, characterized by skepticism and irony, and included the criticism of Enlightenment rationality, advocating that knowledge claims and value systems were socially conditioned. Post-modernism is often associated with cultural studies, feminist theories, literary criticisms, deconstruction, and similar bodies of thought. The modernist and the early part of the post-modernist eras can be characterized as normal science, but later the contingent nature of reality as defined by social values at the time was reflected in an approach called "post-normal" science (Funtowicz and Ravetz 1993) in which social concerns were being

reflected. We will now examine some pragmatic frameworks for sense-making to aid the policy- and decision-making processes, including the Cynefin framework and the Stacey Matrix.

2.1 The Cynefin Framework

The Cynefin framework shown below in Figure 1 was derived from action research into the use of narrative and complexity theory in organizational knowledge exchange, decision-making, strategy, and policy-making. In the 'simple' domain, problems and solutions are known. There is a one-to-one relationship between cause and effect. The connection between system components is strong and centralized. In the 'complicated' domain, problems and solutions are knowable. Here, knowable simply means that deeper investigations are needed, as the problems and solutions are not obvious. There is a one-to-many relationship between cause and effect. The connection between system components is strong and distributed. In the 'complex' domain, problems or solutions are unknown. There is a many-to-many relationship between causes and effects. The relationship between causes and effects can only be identified with hindsight, referred to as "retrospective coherence". The connection between system components is weak and distributed. 'Chaos' is the realm of the unknowable and feedback loops. In essence, nothing makes sense.

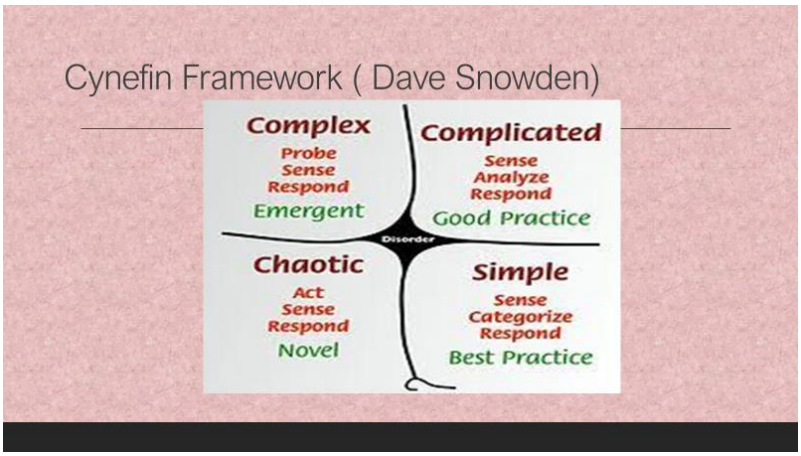
The Cynefin framework is a sense-making framework, not a categorization framework. Systems or situations can overlap and move between different domains. In fact, visualizing these movements within the Cynefin framework helps to make sense of changes within systems. Furthermore, there is no domain deemed intrinsically to be a better place than the others. For instance, being in the simple domain is not necessarily, rather counter-intuitively, the best place to be for an organization because the risk of falling into 'chaos' due to complacency is very high. Most policy situations fall in the complicated or complex domains, or both, which is perfectly fine as long as the tools used are adapted to the domain. The most common pitfall in these domains is entrained thinking: re-applying what has worked before, without ensuring that the ontology remains the same.

In more recent renditions of the Cynefin framework, the zone in the centre previously labelled 'disorder' in now labelled 'confusion': not knowing which domain you are in. It is divided into *A = Aporia,* in which state you are aware that you are confused or not know which zone you are in; and *C,* in which state you do not know that you are confused. This zone is best avoided but can be approached with the deliberate creation of paradox and puzzlement to get people thinking differently.

Take for example the insurrection at the United States Capitol on January 6th, 2021, which occurred as Congress was in session to certify the results of the recent U.S. Presidential election. Prior to the attack, the congressional session was in what would be the simple zone of the Cynefin framework, following well-established rules, using well-structured actions, and cause and effect were direct. The sudden attack launched them into a chaotic zone, resulting in complete confusion for a while, requiring police action—sensing and response. As reinforcement of police and national

guards were mobilized, a high degree of uncertainty prevailed, but after the initial shock, Members of Congress and security forces could probe, sense and respond leading to the resumption of the congressional session. The security situation was still complicated however, requiring combined security and the Federal Bureau of Investigation's forces to sense, analyze and respond, which included laying charges.

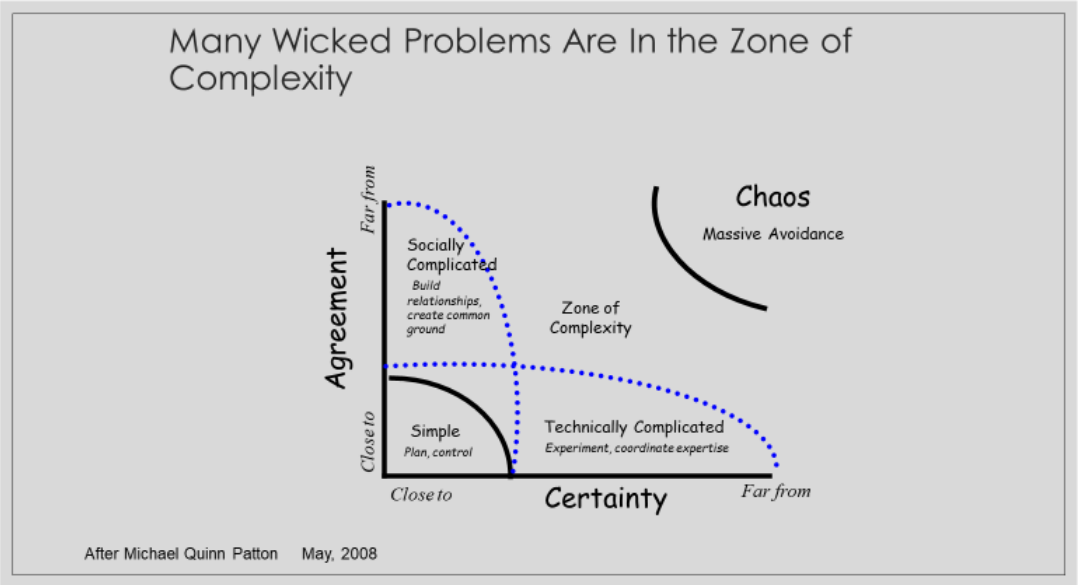
Figure 1. The Cynefin Framework



2.2 The Stacey Matrix

The preferred way for policy making – as shown by approaches like New Public Management and evidence-based policymaking – is to rely on complexity reduction approach which works in the zone closest to the bottom left in Figure 2. The Stacey Matrix shown below is a guide for navigating complexity concepts and is a method used to select the appropriate management actions in a complex adaptive system based on the degree of certainty and level of agreement on the issue in question (Stacey 2002). As indicated, close to certainty and close to agreement regarding policy development is the commonest assumption for policy design and its implementation. However, such assumptions are not fulfilled for complex policy issues. These can be or are 'wicked' issues. Zones 2 and 3 require some changes in work process not least in terms of understanding the environment, but do not fundamentally change the policy 'landscape'. However, this changes significantly in Zones 4 and 5. In the chaotic zone the major achievement may be to understand and translate the environment into actionable patterns which is a kind of 'order' that moves issues from chaos to the complexity zone, where action still has to be characterized by presencing, co-creation, applying design thinking and similar approaches.

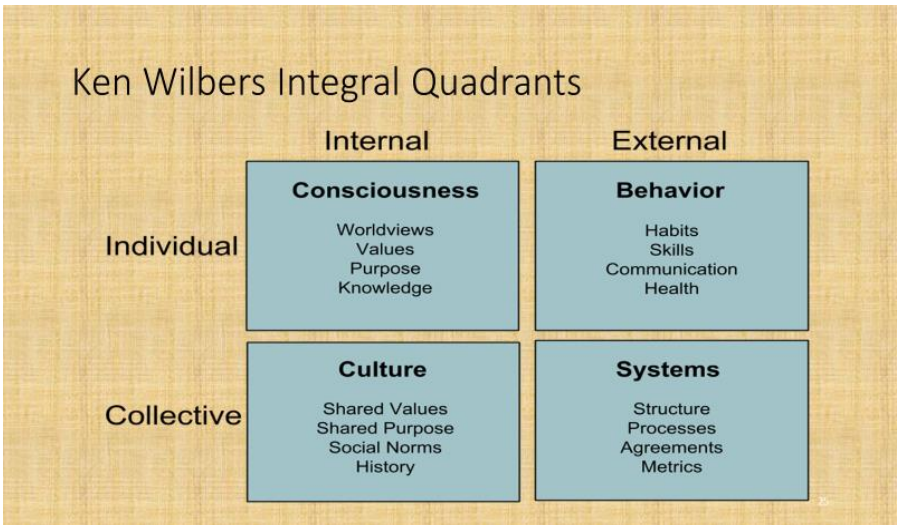
Figure 2. Stacey Matrix; Wicked problems in the zone of complexity



***2.3** Integral (Meta) Theory (Ken Wilber)*

The frameworks discussed so far deal with the observed world that we seek to change through public policy interventions. They omit the conditions of the observer or the policy maker, the lenses through which they view the world, their world views, their mental models, and their biases and prejudices. These approaches are based on a premise that there is a real objective situation independent of the observer that can be acted upon without reference to the observer. Increasingly however, whether from quantum physics, consciousness studies or contemplative spiritual practices, we are learning that this premise is often false. In any case, in the social sciences and in research (though not in the practice of public policy), participatory approaches have become an important aspect of good practice. Participatory approaches use more systemic and inclusive approaches and engage us as individuals but also as the communities or collectives with whom we work. The perspectives of each of us (I) as individuals and also as collectives (We) need to be recognized. Ken Wilber developed a very useful approach to being truly inclusive and holistic in which perspectives of observers and observed and the important notion that we are not separate from the systems in which we intervene, whether human or natural. This is briefly described below from the perspective of public policy.

Figure 3. The 4 Quadrants of Integral Theory



Complex adaptive systems provide a holistic systems approach to dealing with policy issues in the zone of complexity. However, they deal only with the collective exterior where public policy issues commonly reside. Issues in the individual external quadrant are now increasingly being addressed in behavioral economics and behavioral science and public policy (see for example, Sunstein 2020)[3]. Also, occurrences in collective internal are being addressed in anthropology research related to policy. While much relevant work is ongoing in the individual internal quadrant, such as consciousness studies, world views, mental models and mindfulness practices are not yet being linked to public policy work. This is an area that needs attention. In this paper, however, our focus is on the collective external while bearing in mind the need to address issues in the other quadrant.

3. Complex Adaptive Systems (CAS) and How they Add Value to Public Policy

Public policy is likely to seek change in systems which could be described as physical, social or ecological. Physical systems cover infrastructure of all kinds including communications, transportation, construction, energy and those areas typically covered by the study of physics. These systems as such would typically be dealt with approaches in the simple or complicated domains. Social systems include all people-based systems like those dealing with education, health, economics, finance, culture, and arts, and their interactions with physical systems or ecological systems. Policy situations in these domains could be in any of the four Cynefin domains and indeed shift from one to the other quite often. Policy interventions in the complicated and simple domains are more readily elucidated and much more attention is required when they are in the complex zone. Ecological systems whether they be forests, fisheries, wildlife, mangrove swamps, parks and protected areas are typically complex adaptive systems. In reality, of course, public policy is important when people are involved and engaged with all these systems at the same time. Issues arising might be in any of the Cynefin domains, but our focus in this paper will

[3] Sunstein, C.R. 2020. Behavioral Science and Public Policy. Cambridge University Press.

be on those in the complex zone. The reasons are that, as explained earlier, this is the zone in which public policy problems are increasingly encountered, and at the same time strategies to address them continue to be poorly understood.

Examples of situations or structures of importance to public policy which can benefit by applying CAS thinking are all around us. These include cities, villages or communities; pandemics, health and education systems, or public sector organizational behavior more generally; and complex conflicts like in Syria or Yemen. A major area of relevance is that of sustainability in which we seek some balance among social, economic and ecological systems— each of which is themselves a CAS. Sustainable Development and the transformations required to achieve the United Nations Sustainable Development Goals (SDGs) will require public policies informed by socio-ecological systems thinking and adaptive co-management.

A complex adaptive system is comprised of many interdependent but autonomous agents interacting with each other and dynamically adapting, co-evolving and self-organising over time and space (Singh 2021). As such they are characterised by attributes such as non-linearity, adaptability, attractors, emergence, adjacent possible, self-organisation, inherent or ontic uncertainty, feedback loops and non-Gaussian fat tails distribution.

It is important to note however, that not all CAS must have all of the above characteristics, but many will commonly be found as they link and overlap with each other.

3.1 Why Complex Adaptive Systems Thinking is Important to Public Policy

Public policy takes place in the public or political milieu and deals with the allocation of public resources to solve public problems. Harold Laswell defined politics as "who gets what when and how" (Laswell 1936). Public problems can be considered as those which affect people in communities as distinct from those within a family or corporate or other organizational structure, except to the extent that people feel that such problems need public action. Public policy then, is the business end of political science. It is where theory meets practice in the pursuit of the public good. The sources of public policy, at least in democracies, are widely varying and can include political party manifestos, crises and disasters, media, social movements including through social media, and vested interest lobbying groups, among others. When a government decides to take action on an issue of concern, the process tends to follow phases such as data and information collection and analysis, consultations with stakeholders, formulation or design of policy options, political level decision-making which selects the option to be implemented, implementation, monitoring and evaluation and sometimes feedback and course correction.

Such an approach seems logical and scientific and indeed it is as these characteristics provide advantages of clarity, rigor, and ease of communication to the public as to what is being done, and how, with what resources, and with what expected results. The approach is linear in the sense that it assumes inputs such as human and financial resources coupled with activities that will

lead to tangible outputs. These outputs, when used by the would-be beneficiaries would lead to the intended policy outcomes. It is also highly deterministic, implying that the outcomes can be determined upfront with high degrees of certainty. This view of the world as being linear and deterministic provides a sense of comfort to policymakers as they feel they are in control of the process and can demand accountability from those entrusted with implementation.

Beneficiaries also get a sense of comfort as they feel they can trust their government which is in control of solving their public policy issues whether these be in services such health, education, security, financial regulation, etc. or in economically productive sectors of energy, industry, agriculture, transport, tourism, forestry, mining, etc. This approach has served us well from the time of Newton and Descartes and continues to do so but with increasing recognition of its limitations. These limitations were always present but could be ignored because most people were comfortable with the established world views and the results were spectacular. However, upon entering the Anthropocene and with rapid growth in the complexity of social, economic systems as discussed earlier, limitations can no longer be ignored.

Much of the world's public aspirations are now captured in the 17 SDGs which cover a range of issues referred to earlier from poverty and hunger, to health and education, through gender equality, economic inequality and social exclusion to climate change, oceans governance, and peace. There are widespread calls for systems transformation without which the goals will not be achieved. And while systems thinking has always been present in policy processes the view of the world as linear and deterministic was also present. Increasingly we are coming to the recognition that social, economic and ecological systems exhibit characteristics which are far from linear and deterministic and more closely resemble complex adaptive systems (CAS) in many ways. Fortunately, over the last three or four decades we have learned a lot about the inherent complex and adaptive behaviours of these systems from complexity theory and CAS research.

3.2 Value Added of CAS to Public Policy

The most important value added of complex adaptive systems thinking to public policy is the shift in our mental models of the world, or as the Germans would say, our *weltanschauung.* This shift is perhaps more important than the computational models associated with CAS work, because important as the quantitative models are to public policy analysis, their results will be misapplied by analysts and policymakers alike, if they continue to use traditional linear deterministic world views. This shift can be difficult because of our conditioning from childhood to think in terms of linear cause and effects, the success of this characteristic in our evolution, and finally the influence of our education and the pervasive use and success of Newtonian/Cartesian linear deterministic thinking. To be clear, this is not a call to abandon this way of thinking that has been so successful, but rather is one to complement with a novel approach, the CAS approach. Why? Because so many of our current and emerging problems can no longer be adequately addressed by the traditional methods alone. This has now been recognized by the Organization for Economic Cooperation and Development (2009, 2017, 2020) and addressed in several books including *Drift*

into Failure (Dekker 2011), *Embracing Complexity: Strategic Perspectives for an Age of Turbulence* (Boulton et. al. 2014), *Complexity and the Art of Public Policy: Solving Society's Problems from the Bottom Up* (Colander and Kupers 2014), *Complexity and Public Policy Handbook* (Geyer and Cairns 2015), *Complexity and Public Policy: A new approach to 21st century politics, policy and society* (Geyer and Rihani 2010) and *Embracing Complexity in Health Policy* (Sturmberg 2019). Journals dedicated to the field include the *Journal on Policy and Complex Systems*.

The importance of this shift can be illustrated by reference to the collapse of the Nova Scotian fisheries in Canada. A dynamic, multi-species, multi-fleet model (Allen and McGlade 1987) predicted the collapse of the fisheries. These models took a complex adaptive systems approach which was quite new and different from the traditional kind which tended to seek equilibrium and investigate single species. These latter models were consistent with past best practice and with linear deterministic thinking with which decision makers were more comfortable and so the former models were ignored. About 5 years later the Nova Scotian cod fisheries collapsed. An important lesson to be learned, beyond the shortcomings of the modeling, is that the results of the CAS model threatened the short-term interests of some of the players, and was unsettling to those with traditional mindsets. So, it is important at the outset that stakeholders understand that models are experiments which can tremendously aid our understanding, that the strengths and weaknesses are shared, and that the stage is set for the results to be used and in the right way.

One of the uses of models is to provide insights to policymakers, but there are always higher-level questions related to values which determine what to include and exclude in your models. Currently, most modeling is done by academics and researchers and there appears to be a chasm between the outputs of these models and their use for policy. Some notable exceptions are the current pandemic and climate change where much policy action is being determined both by modeling and political considerations. The understanding that models are experiments, that they are intended for learning and that their limits need to be clearer will help in their judicious use. The most common model used in CAS is Agent Based Models (ABM) in which local agents are assigned local behavioral rules and links to others. As we know, CAS is characterized by ontic uncertainty and so for the model to be helpful, it must *be* the system, which can require significant human and other resources. Fortunately, much good policy work can de designed without sophisticated computational models, though using them when they are available can be quite helpful.

The linear deterministic mindset leads to hierarchical organizational structures, command and control structures and the need for leaders and managers to be in control. Indeed, at the level of the individual we are all conditioned to want to be in control even when we are dealing with a dynamic complex situation. Learning to know when you cannot be in control and giving up control in these circumstances while adopting other approaches more consistent with CAS is very valuable. These other approaches include adaptive and iterative planning, as well as being alert to adjacent possible opportunities and unintended effects, and being aware that sudden tipping points

can be reached that may evoke massive change, including collapse. These and other related techniques will be discussed later in this paper. Examples of the use of CAS thinking for public policy can be illustrated in a range of social sciences as in economics, politics and law, and policy domains such as sustainable development, international development cooperation, health, education, international trade, and urban planning.

4. Applications of CAS Public Policy

In this section the use of complexity thinking in several common pubic policy areas such as economics, power and politics, law, health, education and sustainability science are addressed.

4.1 Economic transformation for the SDGs.

In economics the old debate between laissez-faire and government activism is well known. What that debate typically missed was that policy interventions based on either approach or even a mix of the two would change the system, as well as people's choices and preferences, so that a new system would emerge with new opportunities and unforeseen circumstances. From the CAS point of view the economic system is an evolving system beyond the control of government or anyone. On the other hand, it is not a self-steering system requiring no government action. As a complex adaptive system, it is endogenously creating control mechanisms which make it work. Government is one of the control mechanisms. The role of government is norm influencer, encouraging people to adopt positive social norms like self-reliance and care for others. Complexity economics provides mathematical models that can capture the interconnections between the view points of liberals and market advocates as well as the characteristics of the economic system which behaves more like a living system than a mechanical one.

In the complexity frame there is no compass for policy except the highly educated mind. Such education should include at least a basic understanding of complexity, mathematics and humanities. Scientific models provide half-truths at best (Colander and Kupers 2014). Brian Arthur, one of the main exponents of complexity economics, has well described the economy as a complex adaptive evolving system driven by both endogenous and exogenous factors. When these result in self-reinforcing feedback loops (positive feedback) the economy sees increasing returns from certain technological innovations or investments (Arthur 2014). In terms of policy, Hirschman (1958, 66) illustrates this approach in which he advocates for, instead of balanced development across sectors, policies which create tensions, disproportions and disequilibria among sectors. Investments on one front can then, if carefully chosen, leverage developments on other fronts. Schumpeter's gales of creative destruction is another example of CAS systems thinking at work in the economy.

4.2 Power and Politics

While power and politics are at the heart of public policy, complexity theory and one of its most important tools, Agent Based Models (ABMs), are more concerned with patterns and data analysis and as such tend to omit these critical factors. It is timely to remind ourselves that evidence is only one input into policy making and is not always as or more important than power, politics and the resulting contestation among vested interest groups which decide the policy outcome. Complex systems allow bottom-up emergent activity by people and groups at the microlevel to unwittingly result in macro patterns that are greater or lesser than the sum of their parts. Looking at power and politics through the lens of complexity theory allows for opportunities for making power a positive sum game instead of the traditional zero sum that linear dynamics will point to. Positive sum games allow significant social change such as self-empowerment of the poor to take place, which would otherwise be impossible from a hierarchical, top-down control by the powerful. An examination of real politics and of what facts and data realism is based on reveals epistemological and ontological gaps. The revelation that we cannot know with any certainty what constitutes realist politics on what people will base their decisions, opens up space in complex adaptive systems that can generate useful insights, the "real" being a highly contingent and transient phenomenon.

4.3 Law

Law can provide a basis for policymaking by prescribing certain broad limits. However, policy does not necessarily require law. All laws are policies but not all policies are laws. The inter-relationships between law and policy are therefore dynamic and variable but they are both categories of rules which seek to guide the behavior of human society. This is a complex adaptive system, as CAS societies demonstrate emergence in which order can be generated without a centralized controlling agent and in which the system outputs are greater than the sum of its parts. Human societies demonstrate high levels of self-organization although the attractor state in which they sometimes settle is not desirable from a standpoint of social and economic justice, ethics, or inclusion. Reductionist approaches are the converse of emergence.

Take for example, the notion that more specific rule making leads to better control, and that the character and capabilities of rule-making and rule-administering bodies can be reduced to the sum of their parts (Geyer & Cairney 2015). Reductionism in environmental law in the United States, for example, seeks certainty through the proliferation of granular rule structures and seeks to avoid risk through more regulation. From a CAS perspective the certainty they seek is likely to be elusive and on the other hand, risk to be embraced and a risk-based management approach would make more sense. The hyper-regulatory climate depends on a top-heavy administrative structure for implementation. The result is that the system cannot manage and deal with novelty and shock (Geyer & Cairney 2015). The answer is clearly not deregulation, which leaves the environment unprotected, but an adaptive risk-based approach consistent with CAS principles.

4.4. Health

Health policy can be seen in terms of upstream and downstream components. The upstream component or macro level dealing with social determinants of health, and the downstream or micro

level with delivery of health care services. Complexity theory can add valuable insights at both levels but more significantly it seems at the micro level. Plsek and Greenhalgh (2001) acknowledged the complex nature of health care in the 21st century, and emphasized the limitations of reductionist thinking and the "clockwork universe" metaphor for solving clinical and organizational problems. To cope with escalating complexity in health care, they concluded that "we must abandon linear models, accept unpredictability, respect (and utilise) autonomy and creativity, and respond flexibly to emerging patterns and opportunities" (Plsek and Greenhalgh, 2001).

In a special issue of *Social Science and Medicine*, Tenbensel (2013) documents several case studies of the application of complex adaptive systems thinking to health and health care. A few are used here as illustration. They include two instances of 'scale-up and spread' of improvement initiatives – the use of mobile phone messaging to improve adherence to anti-retroviral treatment for HIV in Kenya, and measures to reduce the incidence of MRSA infection in hospitals in the United States. The question was how to achieve scale-up and spread efforts across a range of organizations and settings with a wide variety of local contextual features. The researchers found that "understanding self-organization is critical to understanding variation across local contexts", and understanding the role of interdependencies within and between organizations as well as the sense-making of participants, are crucial features of what they term "productive self-organization" (Lanham, et.al. 2013). There is an investigation into London TB services to illustrate the ways in which the macro context of health services based on New Public Management principles and procedures serves to enable and/or in most cases inhibit the opportunity for productive self-organisation to occur. In this way, there is an attempt to explain "the London TB control system's (in)ability to respond" to the epidemic (Trenholm & Ferlie 2013).

The complexity of local, 'micro' responses to disasters is employed in order to develop a prescriptive model "to identify potential points of intervention to promote population health and resilience" (O'Sullivan, et.al. 2013). Using a community-based participatory research design, some key principles are extracted to inform local responses to disaster that eschew a 'one size fits all' approach, and advocates the development of flexible, adaptive intervention designs which 'must emerge from the complexity of the situation and be tailored to the community context at any point in time. Others apply a systems dynamic modelling (SDM) framework to model the impact of a range of interventions that aim to address social determinants of health status in Toronto. SDM shares a conceptual ancestry with complexity theory. This contribution is notable for its incorporation of positive feedback loops into predictions regarding the efficacy of policy interventions and combinations of these interventions.

A recent comprehensive review of system dynamics applied in health and medicine provide an excellent illustration of the use of this complex adaptive systems tool in health policy and interventions. The SDM approach has been increasingly recognized as a powerful method for understanding and addressing complex health issues. Over the past four decades, SDM has been applied to a wide range of health care problems, including the prevalence of major infectious or

non-infectious diseases and the performance of health care delivery systems. The approach has also provided decision support for national and global policy-makers (Homer, et. al. 2016; Thompson, et. al. 2015). Consequently, several influential domestic and international organizations have encouraged and supported SDM applications for understanding the causes of illnesses and associated trends as well as for the design of prevention, treatments, and policy interventions (De Savigny & Adam 2009; Mabry, et. al. 2008).

"When you change the way you look at things, things you look at change"[4]. It is high time for healthcare professionals to embrace the challenge of complexity. The linear reductionist view of health and disease is failing to deliver the best health care for our societies. The four main components contributing to our health and disease experience are our somatic (or bodily) condition, our social connectedness, our emotional feelings and our semiotic (or sense-making) abilities—these four domains define the *somato-psycho-socio-semiotic* model of health and disease as discussed in Sturmberg's recent book *Embracing Complexity in Health* (2019).

From a public policy perspective, the health portfolio is typically one of many disconnected policy segments as the health portfolio itself is segmented into many discrete disease/condition-specific silos. Each has its own budget line, promotes its own agendas and priorities and competes against others in the continuous competition to gain/maintain funding. The policies for the delivery level are twofold: *monetary*–applying incentive payments around clinical targets or service delivery modes, and *directive*–demanding the uniform micromanagement of discrete diseases/conditions at the community and/or service delivery level. From a complex adaptive systems perspective, the health system will be organized around its attractor state—i.e., the needs arising from the patient's illness or disease experience. Such a system constantly learns how to best work together to achieve the best possible outcome for the individual patient, the local community and the nation as a whole. From an organizational perspective, it presupposes a collaborative culture between members at every functional unit within the system. Such complex adaptive dynamics at each system level result in the spread of skills and knowledge among and across members of functional units. The diversity in perspectives, interpretations and experiences are respected, which ultimately achieves better outcomes. Greater resilience emerges from the mastery of challenges and reinforces shared learning, adaptation and self-organization (Sturmberg, et.al. sel2012).

4.5 Sustainability, SDGs and Complexity

A recent comprehensive review of sustainability science towards a synthesis concluded that "compelling evidence has accumulated that those (society-nature) interactions should be viewed as a globally interconnected, complex adaptive system in which heterogeneity, nonlinearity, and innovation play formative roles. The long-term evolution of that system cannot be predicted but can be understood and partially guided through dynamic interventions" (Clark and Harley 2020).

[4] Variously attributed to Max Planck and Wayne Dyer.

The review shows that recent research in sustainability science has demonstrated how thoroughly the elements of nature and society are intertwined in deeply coevolutionary relationships. An immediate consequence of these findings it deduces, is that "talk of environmental-sustainability, or social-sustainability or other forms of "hyphenated-sustainability," is fundamentally misleading and at odds with the integrating aspirations of sustainability science. A research-informed use of the term sustainable should therefore always—and only—refer to the integrated pathways of development resulting from nature–society interactions in the Anthropocene System" (Clark and Harley 2020).

The term socio-economic subsystem is used to describe the social and economic actors and processes and the complex interactions among them. The social aspects include the political, cultural, emotional and spiritual dimensions and the related institutions and rules by which human society is organized and functions. The economic aspects include those actors and processes primarily involved in the production and distribution of goods and services to satisfy some need or demand. In many instances, the actors and processes in the social and economic spheres are the same, there is an intimate relationship between them and hence the term socio-economic (Singh 1996).

The ecological system refers to the earth's natural systems either as single ecosystems such as a coral reef, a mangrove swamp, a stand of Douglas fir, one of the Great Lakes, or planetary systems such as the ocean-atmosphere coupling. An ecological system is comprised of various interactive groups of species, genera, families and communities of organisms. In certain regions ecological features are present which define the region as a bioregion. We use the term "ecozone" to describe these planetary subregions which include coastal zones, arid and semi-arid lands (including the prairies), mountains, forests, large agricultural plantations, and towns and cities[5].

The search for sustainable development or sustainable livelihoods is a search for harmony between the activities and inherent evolutionary processes and tendencies of the linked socio-economic and ecological systems. This linked socio-economic and ecological construct is what we refer to as the socio-ecological system. This could equally be called a socio-natural or society - nature system. In this arrangement, the socio-economic subsystem is embedded in and dependent on the natural or ecological system. Because of this dynamic interactive process, we need to consider the community in this environment as a single system which can be described as a socio-ecological system. An understanding of the attributes of a socioecological system then becomes a fundamental pre-requisite to a region's perception of community adaptation and how such adaptation can provide a basis which can result in sustainable livelihoods as a desirable outcome.

Socio-ecological systems display all or most of the characteristics of CAS discussed earlier. In this particular context these features arise as diversity, categories, measures of association, non-linearity, resilience, co-evolution, learning capacity and community participation. These features as well as guiding principles to be used in public policy and programing for sustainable livelihoods are described by Singh (1996). The value of understanding these basic issues and principles include:

[5] *Ibid*.

- Help understand the reality of the community with its vast array of beliefs, knowledge, strategies and practices situated in a dynamic and interlocking social and ecological system from which livelihoods are derived.
- Establish an epistemological basis for policy making in the face of uncertainty, constant change and complexity.
- Develop an approach to identifying entry points and interventions, which when made at these leverage points lead to massive amplification and self-organization within the system to significantly increase the sustainable livelihood options.
- Help transform intuitions and anecdotes into a deeper understanding of the complexity of socio-ecological systems.

5. Program Design in Complex Systems

In Section 2 on sense-making it was shown that in general we face situations which could be simple, complicated, complex or chaotic, and not knowing which of these is occurring can result in some confusion (See Figure 1 Section 2.1.). Let us consider how these ideas might be applied in a practical situation like promoting more sustainable livelihoods in a poor community. The approach will be quite different from design using a linear logical framework in which you first carry out a needs assessment and design a project in which inputs and activities lead to outputs, which when used by the beneficiaries, lead to outcomes that over time, translate into impacts. Instead, the design will codeveloped through a facilitated process involving the community. The steps would include the following:

- Multidimensional assessment of the assets/activities and coping/adaptive strategies of would-be beneficiaries of development cooperation. Assets include human, social, physical, natural, economic and political capital.
- Establishment of the vision of a life worth living, or a more sustainable livelihood.
- Define what the communities can/will do on their own to get to their vision.
- Then finally define what help they need from outsiders such as development agencies.

This simple sequence of steps can, in the hands of a skilled facilitator help build on the dominant log frame to incorporate several dimensions of CAS. For example, the starting point is not needs but assets. This helps set the stage for building on local strengths and endowments and encourage innovation. Human capital assessment, for example moves us away from the common assumption that the only form of human capital that the poor have is labour, and opens up a wider conversation that includes their creativity. Similarly, each of the forms of capital assessment opens up a wide range of avenues through which alternative pathways to the local vision can be pursued. The indicators to be used in the program design emerge from the communities themselves during the visioning exercise in which they define a better life. Yet the need to a have a framework with action plans and goals which the funders would ask for is not lost.

6. Dealing with Complexity in Policy Design

Almost by definition public policy must include statements of future desirable social goals and so must have a degree (preferably a high degree) of predictability. On the other hand, uncertainty in CAS is high and predictability low. So, a contradiction arises, requiring careful management. It will be unwise to suddenly abandon well accepted traditional tools of policy analysis such as cost benefit analysis. As in the case of evaluation it will be better to gradually bridge the gap between policy making assumptions of a deterministic clockwork universe to an evolutionary adaptive and uncertain world. A few practical strategies of making such a transition are described in this section. This followed by some more recent tools which are currently being used.

In terms of strategy, the first step is to start with existing policy analysis tools and make change incrementally. For example, start with Cost Benefit Analysis, the work horse of assessing public policy options. Strengths and weaknesses of alternatives can then be used to determine options which provide the best approach to achieving benefits while preserving savings, and can be used to compare completed or potential courses of actions, or to estimate (or evaluate) the value against the cost of a decision, project, or policy especially public policy. CBA helps predict whether the benefits of a policy outweigh its costs (and by how much), relative to other alternatives. It also allows for the ranking of alternative policies in terms of a cost–benefit ratio. Generally, accurate cost-benefit analysis identifies choices which increase welfare from a utilitarian perspective. Although CBA can offer an informed estimate of the best alternative, a perfect appraisal of all present and future costs and benefits is difficult; perfection, in economic efficiency and social welfare, is not guaranteed. CBA has been applied to a wide range of public policy issues in health, education, and environmental issues. It depends on predicting outcomes over a time and so uses time value of money, discount rates and various risk analysis methods.

In order to deal with complex situations in which outcomes cannot be predicted CBA might be strengthened or even replaced by tools derived from complex adaptive systems teaching such as agent-based models (ABMs); causal-loop diagrams; social network analysis; data mining; scenario analysis; horizon scanning; group model building; SWOT analyses; cognitive mapping; qualitative case study methodology; leverage points; sensitivity analysis; and non-linear dynamical systems modelling. Newer techniques including anecdote circles, chaos dynamics, participatory systems mapping; behavioral insights; and human-centred design thinking have recently come to the fore. Among this rather long list, ABMs and other non-linear dynamical computational models, data mining, network analysis, design thinking, and scenario and strategic foresight are commonly used.

7. Monitoring and Evaluation in Complex Situations

The monitoring and evaluation of change in complex adaptive systems or complex situations in general require some fundamentals in what we measure, how we measure these, and what indicators and tools we use. Under the New Public Mangement (NMP) approach, still the dominant

style of public service management, performance management is linked to outcomes-based performance management which in turn rests on Results Based Mangement (RBM). RBM relies heavily on the linear logical framework design method (log-frame) in which desired outcomes are precisely defined upfront in terms of objectively verifiable indicators (OVIs). The outcomes (ultimate, intermediate, and immediate) are derived from the use of the outputs by the beneficiaries. The outputs are in turn produced by inputs (human and financial resources) and appropriate activities. While this is a significant improvement over inputs and activities monitoring, it works well in simple and even complicated situations as defined earlier, but not in complex situations.

In complex situations, system level outcomes are emergent from a wide range of people-to-people interactions, interconnections and interdependencies, information flows, interactions with the inputs, activities and outputs being introduced by the policy or project intervention. Indicators traditionally used under NPM were termed "SMART" indictors, indicating that their desirable characteristics should be: **S**pecific, **M**easurable, **A**ttainable, **R**ealistic, and **T**imely (OECD 2014). For complex adaptive systems it has been considered that so-called **SPICED** indicators might be better suited, having the following characteristics:

- ***S**ubjective*: using insights from informants (beneficiaries/stakeholders).
- ***P**articipatory*: indicators should be developed with stakeholders.
- ***I**nterpreted:* easily interpreted to different stakeholders.
- ***C**ross-checked*: comparing indicators and using different stakeholders, methods to ensure validity.
- ***E**mpowering*: the process should allow stakeholders to promote their own agency.
- ***D**iverse*: indicators should be different, from a range of groups and across genders.

We also need to consider a shift from evaluation for single loop learning (formative or summative) to evaluation for double loop learning. In single loop learning changes are made to improve immediate outcomes as the difference between actual and desired outcome is evaluated. Double loop learning involves questioning the assumptions, policies, practices, values, and system dynamics that led to the problem in the first place and making changes to the underlying system either to prevent the problem or embed the solution in a changed system.

The evaluation tools or techniques that are more suited to evaluations include:

- *Developmental evaluation*: uses evaluative questions and logic, to support program, product, staff and/or organizational development. The evaluator is part of a team whose members collaborate to conceptualize, design and test new approaches in a long-term, on-going process of continuous improvement, adaptation and intentional change.
- *Outcomes mapping*[6]: which assesses a programme's theory of change and changes in the behaviour of people, groups and organisations with which a programme works directly.

[6] See Better Evaluation, "Outcomes Mapping"

The results map traces outcomes from outputs to immediate, intermediate and ultimate levels both intended and unintended.

- *Outcomes harvesting*[7]: which collects ("harvests") evidence of what has changed (all outcomes) and, then, working backwards, determines whether and how an intervention has contributed to these changes (a kind of reverse mapping to outcomes-based mapping)

- *Contribution tracing*: A rigorous quali-quantitative method that is used in impact evaluations to test the validity of claims. It allows you to not only test a contribution claim (whether is it valid or not), but to also determine a quantifiable level of confidence in contribution claim. The developers of the method call it 'putting a number on it'

- *Most significant change* (MSC*)*: a qualitative method *that* collects and analyses personal accounts/stories of change among stakeholders and *qualitative impact assessment protocol* (QUIP)[8] an impact evaluation method that uses narrative causal statements that are taken directly from intended programme beneficiaries. This method provides an independent verification (or not!) of a programme's theory of change.

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9.0 Conclusion

In a world of rapid change, to address unprecedented and widely varying challenges to public policy, sense making tools such as the Cynefin Framework and the Stacy Matrix are useful to decide how to proceed. Generally, these situations can be ordered (simple or complicated) or unordered (complex or chaotic). Solutions to ordered situations are quite well known. Chaotic systems require special actions for stabilization before interventions. Complex adaptive systems on the other hand are of great interest because they are more common than is recognized, and are situations of emergent patterns, innovation, and self-organization and provide critical insights fro SDGs achievement. Many tools have been developed over the last 3 or 4 decades to work with these complex situations but these are not commonly known to public policy analysts and decision makers. This paper has surveyed public situations which demonstrate these complex adaptive systems characteristics, as well as the tools which are being applied for design or evaluation of policies or programs with these characteristics in the context of the SDGs. Many of these tools such as non-linear dynamic computational techniques, quantum-like social science models, agent-based simulations, and so forth are discussed the literature. However, as demonstrated here, and useful as they are, much good policy work can proceed even without these mathematical models.

[7] See Better Evaluation, "Outcomes Harvesting"
[8] See Better Evaluation, "Qualitative Impact Assessment Protocol"

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