No goal is an island: the implications of systems theory for the Sustainable Development Goals

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Abstract

The Sustainable Development Goals (SDGs) have now been in place for 4 years, as the center-piece of the sustainable development program of the United Nations. This paper argues that the Earth system fundamentally represents the organizational framework of the planet and, therefore, any attempt at avoiding the existential threat to humanity that our activities are creating must be integrated within this system. We examine how complex systems function in order to identify the key characteristics that any sustainability policy must possess in order to deliver successful, long-term coexistence of humanity within the biosphere. We then examine what this means in terms of the SDGs, currently the dominant policy document on global sustainability and lying at the heart of Agenda 30. The paper explores what a sustainable program of actions, aimed at properly integrating within the Earth system, should look like, and what changes are needed if humanity is to address the multiple challenges facing us, based on systems theory. Central to this is the acknowledgement of shortcomings in current policy and the urgent need to address these in practice.

Introduction

The journey toward the Sustainable Development Goals (SDGs) in many

ways approximates to the journey of humankind over the last 70 years. Following the First World War, Woodrow Wilson, then president of the USA, led the charge to establish a body to pursue peace among the nations of the world, rather than the terrible cost of war. The League of Nations was established but fell apart in the years leading up to the Second World War.

As the Second World War came to an end, a renewed ambition for global unification led to the creation of a number of global organizations. The World Bank (1944), the International Monetary Fund (1944), The United Nations (1945), the General Agreement on Tariffs and Trade (1947), the World Health Organization (1948), and the Organization for Economic Cooperation and Development (1961) all worked toward achieving a better planet through the mantra of development, targeted at reducing poverty through economic growth and improving health and education. It was to be the realization of the Enlightenment dream. This brave new world would reduce war and globalize the success of the Western, Northern economies. With empires collapsing, this post-colonial world would need a different form of governorship, that of economics.

Development has been a central pillar in the work of the UN since its inception (Kumar et al. 2016). In January 2016, as part of Agenda 30, the United Nations Development Programme (UNDP) unveiled 17 Sustainable Development Goals (SDGs) (Skene and Malcolm 2019). This program was "a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity" (UNDP 2018).

The SDGs themselves followed on from the Millennium Development Goals (MDGs), which ran from 2000 to 2015, with the stated intent of sparing "no effort to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty" (UN 2015). The MDGs found their foundations within the International Development Goals, launched by the Organisation for Economic Co-operation and Development (OECD) in 1996.

Millennium development goals

The MDGs have been widely seen as well meaning, but encompassing serious failings. Some of these failings were consequential upon their design (Clemens 2002). This design process relied on a small group of non-representative experts, with very little contribution from post-development thinkers, indigenous representatives nor grassroots movements (Amin 2006; Richard et al. 2011). Civil society organizations had no role to play (Waage et al. 2010). Instead, the program was designed and put together by a group aligned with the neoliberal agenda, based on private-sector donor-centric solutions and globalization (Saith 2007).

There was little meaningful emphasis on environmental protection (McMichael and Butler 2004). The MDGs were seen as focusing solely on the developing world, while ignoring significant issues within the developed world, such as obesity and related health problems, huge waste production, pollution associated with industrialized agriculture, vast energy use, and the growth of extremist political ideologies (Saith 2007). It was further expressed that even within the developing world, issues such as the existential threat to indigenous people, values and ethics, urbanization and the geo-political context were all ignored (Breidlid 2009).

There was no significant reference to democracy, security, peace nor disarmament, despite these areas representing essential foundation stones for any functional society, a pre-requisite for sustainable development (Hill et al. 2010). Key areas such as human rights, empowerment and social justice were hardly mentioned (Fukuda-Parr 2010; Langford 2010).

Gender targets were viewed as not going anywhere near far enough and were limited to an aim toward parity in education (Abu-Ghaida and Klasen 2004; Eyben 2006; Hulme 2010). There was no interconnectivity between goals (Van Norren 2012). Finally, significant inaccuracies in terms of the

data analysis underpinning indications of progress were highlighted (Attaran 2005; Hickel 2016).

Sustainable development goals

In 2010, Paulo Caballero became Director of Economic, Social and Environmental Affairs in the Ministry of Foreign Affairs in Columbia. She was tasked with preparing a presentation for the upcoming Rio + 20 Summit in 2012. Caballero realized that the MDGs would come to an end in 2015, and so the summit in Brazil represented an opportune moment to consider what should replace them. She emphasised three aspects: the environment, economics and society. Over the next 5 years, with a gradually growing group of people from across the world, the SDGs took shape, resulting in 17 goals, 169 targets and 304 indicators by 2016 (Caballero 2019).

Awareness of the previously identified weaknesses in the MDGs led to significant changes in the SDGs (Maurice 2015; Fukuda-Parr 2016; Schmidt-Traub et al. 2017). All 193 member nations of the UN were involved, in addition to grassroots movements and civil society (Skene and Malcolm 2019). Furthermore, the emphasis (and, therefore, the perceived blame for the sustainability crisis) no longer rested upon the developing world alone, but now included developed countries. Processes now accompanied targets, as evidenced by an entire goal being dedicated to the process of change and implementation (Goal 17) with interconnectedness being identified as important, at least in principle. Private funding is still important (Rashed and Shah 2020).

But issues remain relating to the detail and the underpinning philosophy. This paper seeks to explore how fit-for-purpose these goals are in terms of addressing the existential crisis facing humanity and delivering a sustainable future.

Aims and objectives

This paper aims to dissect the characteristics of the Earth system given

that this system represents the organizational framework of the planet, and therefore any attempt at avoiding the existential threat to humanity that our activities are creating must be integrated within this system. The paper explores the implications of systems theory in terms of human behavior and practice. It further aims to critically analyze the current dominant sustainability policy, Agenda 30, with particular emphasis on the Sustainable Development Goals, and how such sustainability policy might be refocused in order to deliver a sustainable future for humankind through re-integration with the Earth system.

Methodology

This paper focuses on examining the implications that the Earth system is the basis for the survival, functioning and continuance of every species on the planet, including ourselves. It combines a critical review with an exploration of systems theory, before exploring the implications for policy. As such, it approaches the challenge of what policy would best provide a sustainable future for ourselves by exploring the literature related to the current dominant policy, Agenda 30, exploring its roots and current direction, while critiquing the policy itself in terms of the Sustainable Development Goals.

Issues with the meaning of the sustainable development goals

Sustainability

The word 'sustainability' is a highly contested one. Literally meaning 'to keep going continuously', it has taken on the meaning of maintaining some form of status quo. Furthermore, it tends to be human-centric in its focus, in terms of our management of the environment in such a way that we can continue to exist and where ecosystems can continue to service our needs, and those of our children and grandchildren. Everything is couched within the context of our survival. Thus, sustainability has come to describe the process by which we ensure that we can continue

enjoying our experience here on Earth. The outline for Agenda 30 was entitled "The future we want" while the influential Brundtland report discussed sustainability as meeting our own needs while ensuring that the needs of future generations were able to be met. Chertow and Ehrenfeld (2012) discuss sustainability as a normative concept, referring to an ideal state of being in which humans are able to flourish within the ecological thresholds of the planet alongside other living entities for perpetuity.

Development

Development theory originally arose as a means of being seen to take responsibility for the Third World, reframed as the Developing World. The operation to lead this world toward a progressive utopia, that of the Enlightenment philosophers, was to be called development. Development and economic growth were seen as complimentary concepts, wherein the generation of wealth would help deliver wellbeing in terms of education and health, thus building an equitable society.

The United Nations developed a unit of measurement for development called the Human Development Index (HDI), which combined health, earnings (measured as national income per capita) and education (UNDP 1990). Each year, the world's nations are compared. In 2019, Norway was assessed as being the world's most developed nation, while Niger was the least developed, according to the HDI. Hamilton (2003, p. 184) describes this tight relationship between economic growth and development as follows: "The development mentality is the daily manifestation of growth fetishism".

There are concerns that the relationship between economics and development is based on questionable foundations, namely the Kuznets curve, where increasing economic growth is seen to initially led to an increase in social inequality, but then a decrease, as shown in the classic inverted U-shaped curve (Kuznets 1955; Skene and Murray 2017). Kuznets argued that a nation could grow its way out of inequality and that economic success would lead to social sustainability and improved

wellbeing. His ideas were extended to the environmental arena by several economists such as Shafik and Bandyopadhyay (1992), Panayotou (1993) and Grossman and Krueger (1995), who suggested that with economic growth environmental damage would initially increase before decreasing, again in an inverted U-shaped trajectory, in what became known as the environmental Kuznets curve (EKC).

These two curves lie at the heart of ecological modernization theory (Dryzek 1987; Spaargaren and Mol 1992). Mol (1995, p. 42) has argued that the only "possible way out of the ecological crisis is by going further into the process of modernization". Indeed, according to the EKC, a decrease in economic growth could well deliver increased environmental damage, depending on where on the curve you find yourself. Thus, these curves provide strong foundations for a growth-led, globalized development policy, one embraced by the Western world and applied, unilaterally, to the developing world.

However, both the Kuznets Curve and the Environmental Kuznets Curve (EKC) have been challenged more recently (Perman and Stern 2003; Gill et al. 2018). Stern (2003) states that "The evidence …shows that the statistical analysis on which the environmental Kuznets' curve is based is not robust. There is little evidence for a common inverted U-shaped pathway that countries follow as their income rises". Kuznets (1955, p. 26) himself declared that his research involved "perhaps 5% empirical information and 95% speculation, some of it possibly tainted by wishful thinking".

Milanovic (2007) demonstrated that there was no increase in inequality from the Roman Empire to the 1880s, contradicting Kuznets. Caviglia-Harris et al. (2009) found no significant EKC relationship between economic growth and development. More recent research by Dietz et al. (2012) has pointed to a U-shaped relationship between environmental damage and economic growth, not an inverted U. Following an initial decline in pollution, higher levels of growth lead to higher levels of ecological damage. Poudel et al. (2009) and Fujii and Managi (2013)

revealed an N shaped curve for CO_2 emissions while the same relationship was uncovered for sulfur oxide emissions (Torras and Boyce [1998]) and deforestation (Bhattarai and Hammig [2001]), again reflecting an overall trend toward increased ecological damage with increased economic growth.

The treadmill of production theory, established by Allan Schnaiberg ([1980]), contradicts the ecological modernization theory, and clearly states that even with increased efficiencies in production, savings are outstripped by increases in the scale of production (see also Jevons [2001]; Ewing [2017]).

In a detailed study, Jorgenson and Clark ([2011]) demonstrated a clear and increasingly strong coupling between environmental damage and economic growth (as measured by GDP) over the last 50 years, in both developing and developed nations. This again undermines the ecological modernization theory and supports the treadmill of production theory.

The importance of these findings cannot be overstressed, as they undermine the foundations of a central pillar of current development policy: that economic growth delivers better societies and environment.

The globalization of this development mantra, with a single political and economic philosophy being enforced upon all, has been seen by many post-development thinkers as a form of neo-colonialism (Kumi et al. [2014]). Esteva ([1992], p. 9) argues that: "The metaphor of development gave global hegemony to a purely Western genealogy of history, robbing peoples of different cultures of the opportunity to define the forms of their social life."

Sustainable development

Yet despite the contribution of economic growth to environmental degradation, the fact that development is underpinned by a necessity for economic growth and the contested conception of what sustainability actually is, one of the great ironies is that the most significant global

movement for sustainability is called 'sustainable development'. The Brundtland Commission defined sustainable development as "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 147), adding that "Conservation of living natural resources is… crucial for development." What is clear from these definitions and statements is that this concept of sustainability is human-centric, and Nature is still seen as a resource, serving the goals of human progress, as prescribed by Enlightenment philosophy, while the total focus is on meeting the needs of humanity.

Griggs et al. (2013, p. 306) redefine sustainable development as "development that meets the needs of the present while safeguarding Earth's life-support system, on which the welfare of current and future generations depend." However, we would prefer to rephrase this as follows: "tailoring the consumption of the present to meet the needs of a fully functional Earth system". The key differences in emphasis are: tailoring—the need to prioritize and recognize the Earth System as the only priority, thus requiring us to cut our cloth to fit this system and not ourselves; fully functional—placing emphasis on emergence and self-organization, wherein our activities facilitate and restore the sovereignty of nature and the functionality of the Earth system. A status quo is not enough, given the damage, we have already wreaked upon the planet.

Escobar (1996, pp. 51–52) argues that sustainable development emerged through the "problematization of global survival, a process which induces a re-working of the relationship between nature and society. This problematization appeared as a response to the destructive character of development, on the one hand, and the rise of environmental movements in both the North and the South, on the other… the eco-developmentalist vision expressed in mainstream versions of sustainable development reproduces central aspects of economism and developmentalism". This has led to some authors referring to sustainable development as an Orwellian doublethink (e.g. Wals and Jickling 2002).

Thus, when the UN announced that their new set of goals would be entitled the Sustainable Development Goals, there were immediate concerns as to the appropriateness of this title. Problems also arose relating to the details of these goals. We shall now highlight some of the main concerns.

Concerns relating to the content of the SDGs

It was felt that the narrow conceptualization of poverty and the overly ambitious aims for poverty eradication within the SDGs did little to directly target global structural inequities, while the failure to consider systematic implementation of the SDGs as a whole had the potential to lead to unintended consequences that could undermine The Earth system (Stafford-Smith et al. 2017). Hickel (2017) argues that to eradicate poverty, global GDP would need to increase to 175 times its present value if we take earnings of $5/day as adequate. In other words, if we want to eradicate poverty with our current model of economic development, we need to extract, produce, and consume 175 times more commodities than we presently do.

Sustained growth was identified as a clear objective (8.4) despite Herman Daly, a former World Bank economist and proponent of steady state economics, observing that the term sustainable growth should be rejected as a bad oxymoron (Daly 1990). Goal 8.1 aims to sustain *per capita* economic growth in accordance with national circumstances and, in particular, to achieve at least seven percent gross domestic product growth per annum in the least developed countries. Goal 10.1 aims to progressively achieve and sustain income growth of the bottom 40 percent of the population at a rate higher than the national average.

There is a perceived failure to acknowledge the inevitable environmental and potential social impacts of transforming agrarian economies to those based on manufacturing.

Although Target 9.4 promotes green technologies, the focus on increased industrialization and production remains. Ward et al. (2016) use historical

data and modeled projections to demonstrate how difficult it is to decouple GDP growth from increases in material and energy and argue that it "is therefore misleading to develop growth-oriented policy around the expectation that decoupling is possible". There have been further concerns over the haphazard inclusion of international law, while many people feel that intergenerational equity and population concerns ought to have received greater attention.

Issues with SDGs highlighted by Greijdanus et al. (2015) include compartmentalization (see goal 8.4, where the suggestion is made to decouple goals), specialization (where the sub-goals mostly focus on what needs to happen or be done for developing countries in order for them to participate in global partnerships, e.g. 1a, 8.1, 9.2, 9a, 17) and the dominance of linear, unidirectional paths (developing nations transitioning to developed nations).

Some of the challenges of implementing such broad and sweeping goals at national and local levels are explored in a paper by Galli et al. (2018) in Montenegro. Challenges include existent government structures and laws, regional laws (EU), shorter-term government cycles (much less than the 15 years of Agenda 30) and the dynamic nature of many issues. More generally, Gao and Bryan (2017) observe that trying to achieve these goals simultaneously is impractical, while any pursuit of each goal separately is nonsensical.

Much emphasis has focused on issues in terms of the interconnectivity of the goals (e.g. Le Blanc 2015; Hall et al. 2016; Nilsson et al. 2016; Spangenberg 2016; McGowan et al. 2018). While these concerns are very probably problematic and challenging, this paper emphases much more fundamental issues relating to systems theory, and focuses on key properties of systems, which, it suggests, must be addressed if the SDGs are to contribute to the restoration of the Earth system and our own survival within it. If we are to move toward improving the likelihood of our survival on the planet, we must grasp how the Earth system functions, and the primary objective must surely be to re-integrate within this system in

order to persist within it. Only by grasping how this vast and complicated system works can we hope to identify what needs to be done. We argue that by failing to address this, the SDGs cannot lead to a future that allows both humanity and Nature to mutually flourish.

Ison and Shelley (2016, p. 589) note that: "what is missing … are the contexts for a systemic sensibility to flourish, to be recovered and/or fostered. Investment in systems literacy and then systems thinking in practice capability is missing in education as well as organizational life." So, what are the key characteristics of a system, and, more specifically, the Earth system in particular?

Key characteristics of systems

Nonlinearity

Simple systems are linear and aggregative, meaning that they are simply an outcome of the parts and are predictable (Wimsatt 2007). An example is a car, made up of a number of parts, each of which acts in a teleological manner, doing what it is designed and purposed to do and nothing else. Complex systems are nonlinear, meaning that they are asymmetrical, failing to exhibit clear cause and effect. The human driver of a car is an example. A commonly cited example of nonlinearity is the butterfly effect, where even the smallest change in initial conditions can lead to huge changes at the level of the system (for an interesting deconstruction of the history of the butterfly effect, see Hilborn 2004). Strogatz (2003, p. 182) observed that "every major unsolved problem in science—from consciousness to cancer to the collective craziness of the economy, is nonlinear".

Folke et al. (2016) commented: "Causation is often non-linear in complex adaptive systems with the potential for chaotic dynamics, multiple basins of attraction, and shifts between pathways or regimes, some of which may be irreversible." As a consequence of this, systems can undergo dramatic change, or bifurcations, with little or no warning, transitioning into a new

state (Arnold [1994](); Scheffer et al. [2009](); Rocha et al. [2015]()). The direction and rate of transformation are unpredictable and rapid in Nature and unintended consequences can result, often referred to as tipping points (Milkoreit et al. [2018]()). This also applies to societal change. Aoi et al. ([2007]()) argue that those responsible for the planning, management and evaluation of social interventions need to recognize that unintended consequences are normal outcomes of the dynamic nature of complex systems.

Interesting consequences of nonlinearity include self-assembly and self-organization at the system level. Bishop ([2012](), p. 6) observes that: "The interplay between parts and wholes in complex systems and their environments typically leads to the self-organization observed in such systems". It is this ability to re-assemble differently than before that creates huge interest and concern in terms of the Earth system. Ultimately, we cannot determine how the Earth system will respond to escalating stress placed upon it by human activities, as that response is a consequence of myriad interactions within the system itself. And this brings us to the second important characteristic of systems: emergence.

Emergence

Emergent systems display characteristics and responses that belong to the whole, rather than the parts (Bedau and Humphreys [2008]()). If we have a collection of particles, A, that combine to make up a larger particle, B, and if B can be understood as nothing above or beyond a collection of A particles, then B reduces to the A particles. However, if B is dependent on A for its existence, but does not reduce to A, then it can be said that B emerges from A. This means that B cannot be understood using empirical thinking (Mill [1843]()).

Emergent characteristics are both autonomous from the underlying components, and consequent upon them (Bedau [1997]()). Of necessity, the entire system is not unrelated to its constitutive parts, but the entirety represents the interaction of these parts, adding complexity to the whole.

The whole can also be less than the sum of its parts because a certain number of qualities and properties present in the parts can be inhibited by the organisation of the whole (Morin 2005). The resulting structural hierarchy of a complex system is emergent and self-organized and thus should be expected to change with the system as it adapts and evolves in response to its environment (Cilliers 2001).

This is challenging as humans prefer to have fairly rigid, empirical organizational structures. However, in true systems thinking, everything is dynamic. Complexity also brings resilience, as the interconnected networks provide functional integrity and drive self-organization and assembly. Hollnagel et al. (2006, p. 16) note that "Resilience cannot be created—and it does not have to be, as it is already present as an inherent, emerging, property of all natural as well as engineered complex adaptive systems". Thus, we do not need to re-invent resilience, but, rather, embrace the Earth system which is inherently resilient when functioning properly.

Likewise, fragility can be understood as a complexity deficit, wherein a system that has undergone simplification (for example as a result of habitat destruction or perturbation) will have a decreased capacity to self-organize. Within a social context, a lapse into violent conflict can be thought of as a social system collapsing due to a loss of complexity (Tainter 1988). Clemens (2002) notes that cultures long devoted to universal literacy and to independent thinking have a far greater capacity for self-organization and resilience than those that resisted universal literacy and free thinking.

Emergence in sociology brings with it the concept of society as more than the sum of the individuals. This stands in opposition to the currently dominant position of individualism. Individualism has become a driving force behind much of the social policy of Western governments, whether it be through personalization (Needham 2014), neoliberal philosophy (Rose 1999; Clements 2008), individual empowerment (Staples 1990) or individual actualization (Rogers 1959). Lord and Hutchison (2009) define

empowerment as "processes whereby individuals achieve increasing control of various aspects of their lives and participate in the community with dignity". This reductionist approach, wherein society is constructed through empowered and progressive individualism is far removed from any concept of systems thinking.

However, this position of the individual as the unit of social currency is a contested concept. In addition to the work of Adam Smith, who espoused the functioning society as essential to progress, Husband (1995, p. 95) writes: "In non-European cultures, the self-evident primacy of the individual in relation to the collective cannot be assumed." Ubuntu, a sub-Saharan African philosophy, can be summarized as the concept that no one can be self-sufficient and that interdependence is a reality for all (Nussbaum 2003). Ubuntu is an example of social holism, built around the concept that the individual can only have meaning in the context of its embeddedness in a specific social system and in their relationship to others (Gibson 2002, p. 543).

The Andean philosophy of buen vivir stresses that wellbeing can only exist within a community, where the conceptualization of community includes Nature (Gudynas 2011). As such, the individual is not an entity as such but part of the Earth system. MacIntyre (1999) concluded that we do not have individual rights at our foundations, but that we are irreducibly social animals with acknowledged dependence being seen as a virtue, in terms of recognizing our place as part of the greater whole. Wilks (2005, p. 1251) asserts that "feminist ethicists have argued that our moral identities are located in and constructed through our caring relations with others." Ecological ethicists, such as Curry (2011), would argue that this duty of care extends to nature.

Sub-optimality

Perhaps the most difficult feature for humans to grasp in relation to complex systems is sub-optimality. We are so used to reading about eco-efficiency, the circular economy and zero waste, and, consequently, the

impression is given that Nature is completely optimized and efficient. Yet this is far from the case (Skene 2018). Nature is extremely wasteful, as demonstrated by food pyramids. At each trophic level, only around 10% of the available energy is transferred to the next trophic level (Pauly and Christensen 1995).

Further evidence of extreme wastefulness comes from the KT mass extinction. The impact winter, caused by dust in the atmosphere from the impact of the comet and concomitant volcanic activity in the Deccan Plains, reduced the incoming radiation dramatically and the Biosphere underwent a huge collapse. This is because Nature is reliant on vast amounts of incoming solar energy every day. And this points to the fact that every day, Nature wastes most of the energy that it assimilates from our neighboring star. This waste is in line with the second law of thermodynamics and should be expected. Furthermore, increased complexity requires increased dissipation of energy (Fenchel 1974). Thus, the more complex a system is, the greater the sub-optimality.

Sub-optimality, in the form of trade-offs, is universal throughout the Biosphere (Parrish and Edelstein-Keshet 1999; Rodríguez et al. 2006; Shoval et al. 2012; Tendler et al. 2015). Interspecific trade-offs are typically thought to be a requirement for species coexistence in communities at small spatial scales (MacArthur 1972). DNA repairs itself, but sub-optimally, allowing genetic variation to be produced. Squirrels forget where they hide some of their nuts, hence leaving some to grow into trees or to feed other animals such as bears (Crawley and Long 1995). Optimizing at any one level is damaging at the system level, as it prevents essential trade-offs, preventing functionality at other levels.

Farnsworth and Niklas (1995) concluded that as the number of challenges increase upon a process, only solutions that are increasingly sub-optimal for each challenge will work. This is a reality in natural and human-driven design. Trade-offs exist everywhere. For example, a car with large storage capacity, such as a family saloon, will not have the aerodynamic properties of a Lamborghini sports car, but will have much greater space

for offspring and a pram. Orchid seeds are so small that they have insufficient food stores to allow germination, but, because of their lightweight, can spread huge distances. Some weigh only one-millionth of a gram (Arditti 1967). However, they require specific fungi to scavenge food for them immediately upon germination due to a lack of food reserves, and this places limitations upon where they can germinate successfully (Bernard 1906; Batty et al. 2001).

Stearns (1989) observes that "If there were no trade-offs, then selection would drive all traits correlated with fitness to limits imposed by history and design. However, we find that many life-history traits are maintained well within those limits. Therefore, trade-offs must exist."

Much Enlightenment thinking is shrouded in optimization for the human condition. Yet trade-offs and sub-optimality are not a sign of failure but are indicative of a properly functioning system. Thus, in the SDGs, a silo mentality must be avoided, where specialists focus on optimizing the outcomes of each goal. Rather, we should be looking for inefficiencies and designing them into our solutions, in order to have a fully integrated, functioning system. Sub-optimality lies at the heart of a sustainable approach, we argue, rather than being viewed as a problem. If we build trade-offs into our efforts, rather than optimizing them out of the system, then we will be truly managing a successful re-integration into the Earth system.

An important question relates to how sub-optimal our activities should be. In ecological thinking the intermediate disturbance hypothesis offers solution space. In ecology, the intermediate disturbance hypothesis (Connell 1978; Huston 1979) suggests that the highest species diversity is maintained at intermediate levels and intensities of disturbance. At low frequencies and intensities of disturbance, the most competitive species will dominate, either by most efficiently exploiting resources or by interfering with other species most effectively, establishing themselves and filling any empty space that becomes available. Diversity will decline over time.

At high disturbance frequencies and intensity, only a very few, rapidly reproducing species can survive, such as ruderals, because the disturbance is of such a level as to prevent more slowly growing species from surviving. It is at intermediate levels of disturbance where the maximum level of diversity can be attained. Thus, sub-optimality delivers greatest benefits, in terms of diversity and resilience, at intermediate levels. Many examples of this have been studied, but perhaps the most interesting has been that of the impact of elephants on diversity in Amboseli National Park in southern Kenya (Western 1989), where the greatest species diversity occurred just outside the park boundaries. It is only be tuning into the feedback from the system as a whole that we can ascertain what level of sub-optimality at any given level of organization is most appropriate.

Real-time feedback

Systems rely on real-time feedback, an essential element in self-organization (Jervis 1997). Feedback lies at the heart of a system, conveying information between different levels of organization and within any single level. Feedback leads to dynamism, wherein change is constantly occurring, impacting on functionality. It is like an electric current that runs through the system, gluing the entirety together. The Earth system is continuously providing feedback, but humans have so distanced themselves from their environment that we do not hear it. By ignoring it, humans have become isolated. Yet re-integration into the Earth system, the only path to meaningful sustainability, depends on listening and responding to the multitude of messaging that occurs in the Earth system.

With an understanding of feedback processes, the consequences of decisions are evident and system behavior can be understood (Sterman 2001). When the consequences of feedbacks are not fully understood by managers, unpredictable system behavior can emerge with potentially devastating impacts (Allenby 2009). Furthermore, we have the technology available to access this feedback. Remote sensing provides an

insight into the physiology of the Earth system (McGowan et al. [2018]; Andries et al. [2019]), allowing us to follow the impacts of changes in our behavior in real time, while artificial intelligence provides the analytical power to interrogate the data from the billions of smart devices available to us.

An ocean of data is available. All we have to do is tap into it. This can allow us to understand the impacts of our actions, and act as an indicator of our progress or otherwise toward a sustainable future. This feedback must be the basis for our appropriate re-integration into the Earth system, and will also allow us to realize our roles and to understand how much disturbance we can make. Allen et al. ([2019]) note that there is a lack of monitoring data for some of the sustainable development indicators, which needs to be addressed, because of the centrality of feedback to any functioning system.

It is not as if we are new additions to the system. We spent some 95% of our existence on the planet as an integrated part of the whole. Indigenous First Nation people are still part of the system. The concept of a social-ecological system as an integrated system of ecosystems and human society with reciprocal feedbacks and interdependence has become a recent approach to understanding this embeddedness. Folke et al. ([2016], p. 41) write that "In essence, the social-ecological systems approach emphasizes that people, communities, economies, societies and cultures are embedded parts of the Biosphere and shape it, from local to global scales". Young et al. ([2006]) raise concerns that cultural and economic globalization are leading to a decoupling of social and ecological systems.

Discussion

Consequences of system theory for SDGs

Any complex system, such as the Earth system, is composed of multiple parts which are connected to and interdependent upon each other and their environment (Nicolis and Prigogine [1989]). Systems are self-

organizing and self-assembling. The Earth system has self-assembled, self-organized, re-assembled and re-organized on many occasions during the 3.4 billion years of its existence, recovering from mass extinctions along the way. Nature has no need for the wisdom of humankind and has no requirement for the formation of an organizing committee of experts nor an action plan to repair itself.

Yet, as we face the environmental crisis of our own making that poses the most significant existential threat that our kind has encountered in its brief sojourn on the planet, we turn to human-centered solutions, rather than recognizing that it is re-integration within the Earth system itself that holds the only hope for our persistence.

We suggest that humanity embraces four misconceptions that hold us back from taking the right path. Firstly, we suffer under the illusion that human wellbeing is defined at the level of the individual. Secondly, we indulge in the Kuznets illusion, that economic growth can deliver social and environmental sustainability. Thirdly we persist in the empirical illusion that the Earth system is a linear construct, best understood through empirical philosophy and dominated by silo thinking, in ignorance of trade-offs and the importance of interconnections. We proselytize an approach centered around the substitution of natural capital with economic capital. Fourthly, we continue to optimize for ourselves rather than for the Earth system. And our sustainability policies, dominated by the dogma of growth-based sustainable development, only build on these misconceptions.

In terms of the SDGs, the very idea of setting goals comes under significant scrutiny within systems theory. Nonlinearity and emergence speak to a path created by the system itself, not to a set of goals toward which the system is forced to travel. Furthermore, the reliance of development upon economic growth is highly questionable, given the recent undermining of the Kuznets curve and the environmental Kuznets curve. Also, the globalized approach runs against the pluriverse that we see within the Earth system. Ecosystems are not seeking to convert each

other into some global identity, wherein some are judged as developing and others as developed. Rather, each ecosystem is tuned to its physical environment, where the 'culture' of the communities is in harmony with the landscape. Indigenous human cultures are similarly resonant with their landscapes, and demanding different paths of travel (Agusdinata et al. 2020). Finally, any concept of sustainability must be at the level of the Earth system, and must center around the dynamic functioning of that system, rather than some 'sustainable' status quo. Sustainability of process is not sustainability of form. Rather a sustainable process will continue to deliver change, underpinning the dynamic nature of the problem set and of the solution space.

Limitations and future work

While systems theory points the way to re-integration, and thus a sustainable future, applying it to current policy has its difficulties. Firstly, it needs a completely different approach, requiring sacrifice, significant change and political will in terms of selling it to an electorate. Secondly, it requires global agreement, something that has proved challenging, given the withdrawal of the USA from many of the current climate policies. In addition to these issues, lies the subtle nature of the environmental crisis, in that it is a slow and almost imperceptible manifestation to the naked eye. Yet the changes are occurring and need urgent action before we reach tipping points that promise to further accelerate the declining ecological functionality that supports our existence (Dakos et al. 2019). These challenges exist, but they must be overcome. Future work requires not only understanding the barriers to change and how to overcome them (Gifford 2011), but also political will and the ability to recognize the dangers of silo thinking in terms of focusing on the entirety of the problem rather than separated efforts to solve single issues, and avoiding any form of hierarchical arrangement (Kumar et al. 2018). Trade-offs are par for the course in any complex system, and so should be the expectation rather than a downside. From this point, policy makers need to focus on systems theory in terms of any implementation of thinking, and must concentrate upon feedback in order to carefully monitor the emergent

outcomes of their actions. Only integrated thinking across all fields can deliver the appropriate practical elements for a meaningful sustainable outcome.

In terms of Agenda 30, the goals themselves are, fundamentally, reasonable, but represent consequences rather than targets, in that only by prioritizing an appropriate set of cohesive policies that are in resonance with the Earth system can we hope to create the space, in terms of atmospheric and water quality, soil quality, climate and food supply, all of which are outcomes of a properly functioning planet. Thus, the emphasis must be on reducing our impacts and allowing the Earth system to self-organize and regroup, which it always has done. It is therefore essential to revisit the SDGs and prioritize releasing the pressure that we have placed on the planetary system, while embracing the key characteristics of emergence, nonlinearity, sub-optimality and feedback. By releasing this pressure, as we temporarily were forced to do during the COVID-19 lockdown, we then allow the Earth system to set about repairing itself. Only prospective (future) cost should be acknowledged, and therefore in order to improve the chances of our ongoing survival, this paper argues that urgent change is needed in terms of prioritizing systems thinking in any functional approach to sustainability, and revisiting Agenda 30 urgently, whatever the cost.

Conclusions

Given that we are part of the Earth system, and that our own sustained existence on the planet relies on our integration and engagement with this system, then systems theory would suggest that in order to promote sustainability the following core principles must take center stage.

Nonlinearity brings with it the risk of regime change, as noted earlier. Systems can flip into alternative states at any time, due to apparently trivial changes, as can be seen by ecotones, where whole ecosystems can transform into completely different functional and structural states across a few centimeters (Williams et al. 2011; Jiang et al. 2016). In terms of any

plan for a sustainable future, we must prepare not only for gradual change but for dramatic transformation. Such contingency planning is essential if we are to survive dramatic system regime change. Furthermore, urgent research is required into ecotones and the underlying processes that determine their transition. Only by doing this can we gain insight into the mechanics of nonlinear change. Furthermore, a greater focus on societal tipping points is also essential (Bentley et al. 2014; Kull et al. 2018). There is a lack of consideration of the importance of nonlinearity within the current SDGs.

While SDG 17 pays homage to the importance of interconnectivity in principle, any plan for a sustainable future must place emergence at the center of its strategy. Mikulecky (2005, p. 98) observed that: "The nature of the world out there is such that the idea that much is lost by trying to reduce it to parts is paramount. The whole is more than, and often different from, the sum of its parts".

Only by recognizing that the Earth system is above and beyond everything else, can we begin to understand our place within the Biosphere, and the essentiality of re-integration. Here, processes, rather than structures, dominate. We must embrace an emergent Earth system that can self-assemble and self-organize as it always has done. Furthermore, individualism and the silo mentality must be replaced with socio-ecological philosophy, where landscape and humanity can interact at local levels, ensuring appropriate cultural diversity within local environmental contexts. A pluriverse of ecosystems demands a pluriverse of societal organization. There is no end point, but rather our destination is a journey, based around proper functioning of the natural world, where embeddedness and resonance are the foci.

Only by recognizing that sub-optimality and trade-offs are properties of a successful, functioning system can we fully re-integrate into the Earth system. It has been our continuous drive toward optimizing conditions for our own success that has laid waste to the very foundations of our own existence. While we have temporarily stabled the three Malthusian

horsemen of the apocalypse (famine, disease and war), we have instead unleashed other horsemen, such as climate destabilization, habitat fragmentation, soil erosion and atmospheric and aquatic pollution. Ironically, these new horsemen will in turn liberate the original ones, as agriculture, environmental change and diversity collapse re-acquaint us with the familiar foes of starvation, disease and conflict. Optimization at any one level of a complex system leads to the collapse of the system, because without trade-offs, functionality across the entirety is lost. Our drive toward re-shaping the natural world as our source and sink has been the greatest contributor to the existential crisis facing us. Sub-optimality must be a key target, not an inconvenience that we attempt to ignore or avoid.

Our increasing isolation from the Earth system has led to us disconnecting from the conversations that are the very life-blood of any system. We need to re-join these conversations. Accountability can only come from feedback. Yet today, we have a greater opportunity to do this than ever before. Billions of smart devices are now embedded around the world and in satellites orbiting the planet. Many of these provide a vast array of remotely sensed data on the health of our planet and on human activities. By harnessing this rich source of data, we can once again begin a conversation with the Earth system. It was James Hutton ([1788](#)) who stated that the Earth was a superorganism and that its proper study should be physiology. And physiology, fundamentally, is reliant on feedback processes for its dynamic responsiveness. Thus, if we are to understand our place within the Earth system, then we need to reconnect to the constant flow of feedback that diffuses through the rest of Nature. This must be a priority in any sustainability planning, yet is missing completely in the SDGs.

The damage that we are unleashing upon the Earth system is jeopardising its ability to regenerate and re-organize, impacting upon its resilience and its connectivity. Be it light pollution in the atmosphere, sound pollution in the oceans, raised estrogen levels in the oceans or nutrient pollution in our rivers, all of this is impacting the feedback processes upon which the

natural world depends. By damaging the very life-blood of the Earth system, we damage our chances of continuing on the planet.

Ongoing changes make regime shift more likely, and regime shift may deliver a very different system that no longer has room for such a vulnerable species as ourselves, whose niche space is extremely narrow at the best of times. Being a multicellular, sexually reproducing, large, warm-blooded mammal creates problems in terms of requiring very specific environmental conditions within which we can survive. Bacteria can tolerate a much wider range of conditions, and can swap genetic material between species and even kingdoms through horizontal gene transfer, allowing access to a vast array of solutions. We cannot do this.

Of the seventeen SDGs, only four specifically address the Biosphere (goals 6, 13, 14 and 15). If we are to take a systems approach, fundamentally all of our efforts should be focused on the Earth system, with those pertaining to society centering around our re-integration with this system. Morgan ([1986](#)) emphasizes that the role of grand designer should be avoided in favor of the roles of facilitation, orchestration and creating the enabling environment that allows the system to find its own form. And societal sustainability is also only possible by such re-integration. Chambers ([1997](#), p. 200) suggests that "the key is to minimise central controls, and to pick just those few rules which promote or permit complex, diverse and locally fitting behaviour". This element of 'locally fitting' is key, while socioeconomic connectivity is central to any truly resonant relationship between humanity and the Earth system.

We have seen that the Earth system displays key characteristics throughout all of its levels of organization that offer guidance for our journey toward re-integration. As the fundamental basis of life on Earth, with its inbuilt, complex interactivity and resilience, the path to sustainability is within its domain, not ours. If we are to continue to thrive on the planet, we can only do so if our activities resonate with and are part of the Earth system.

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