Concept Paper

Science-Driven Societal Transformation, Part II: Motivation and Strategy

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Abstract: Climate change, biodiversity loss, and other social and environmental problems pose grave risks. Progress so far has been incremental and insufficient, and as a result scientists, global policy experts, and the general public increasingly conclude that bold change is required across all sectors of society. At least two kinds of bold change are conceivable: reform of existing societal systems (e.g., financial, economic, legal, and governance systems), including their institutions, policies, rules, and priorities; and transformation, understood as the de novo development of and migration to new, improved systems. This paper is the second in a series of three that together propose a novel science-driven research and development program aimed at societal transformation. Moreover, the series advances a conceptual framework and formal mechanics by which societal transformation might be approached. Two of the underlying hypotheses are that new societal systems can be developed in a science-driven process to be fit for purpose, and system fitness can be compared across designs. Societies are viewed as superorganisms, and systems are viewed as a societal cognitive architecture. The first paper in the series provides definitions, aims, hypotheses, and a worldview. This paper discusses motivations, the role of science in societal transformation, a theory of change, and fitness metrics. The proposed R&D program and theory of change are sound, viable, and affordable. The local-global-viral strategy invites the global science community to play a unique co-leadership role with local communities in the development, testing, and monitoring of new societal systems. Systems are implemented via a novel civic club model, where participation is voluntary. Clubs grow and replicate based on merit and aided by club networks, whose systems are also viewed as societal cognitive architectures. Benefits of the program and strategy are discussed.

Keywords: societal transformation; systems change; sustainability; societal cognition; climate change; biodiversity loss; active inference; cooperation; SAILS

JEL Classification: B50, I3, O1, O30, P20, P41, P50, Q01, Q54, Q57

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1. Introduction

Climate change, biodiversity loss, and other major unsolved problems pose serious social and ecological risks. Despite decades of warnings by the science community, nations, including the United States, have largely failed to take adequate steps to address root causes, reduce vulnerabilities, and mitigate risks [1,2]. The majority of past and current adaptation efforts have been incremental [3,4]. A growing body of scientific work and policy development suggests that incremental steps are insufficient to avoid catastrophe.

Frustrated with inadequate action, and aware that precious little time remains for a dramatic change in course, two complementary notions are gaining credence within the science, global policymaking, and public worlds. First, existing societal systems (e.g., economic, financial, and governance systems) are dysfunctional or maladaptive with regard to protecting human health and the environment (i.e., we face preventable catastrophe). Second, we are in need of bold change [4–19].

As one example, a 2018 special report from the UN Intergovernmental Panel on Climate Change (IPCC) warns that risks will rise sharply if global warming is allowed to exceed 1.5 °C [20]. The authors conclude that while limiting warming to 1.5 °C is not impossible, it would require unprecedented, far-reaching transitions in energy, land and urban, infrastructure, and industrial systems. These span geophysical, ecological, technological, economic, sociocultural, and institutional dimensions, including issues of governance, poverty, inequality, sustainable development, and social justice.

A second example is the 2019 Global Assessment from the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) [21]. It warns that about one million species currently face extinction and that without bold action the extinction rate will accelerate. The authors conclude that current national and global programs are insufficient and call for transformational change, which they define as "a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values."

Societal change can be classified as incremental, reformist, or transformational [16,22,23]. Using terms from the software development world, these are akin to updates (minor improvements), upgrades (major improvements or new versions), and migrations (the switch to new or different systems). Hereafter, I interchangeably use the terms transformation, systems change, and systems migration to refer to a process of transition to fundamentally new systems, including new institutions, rules, policies, and priorities. In particular, I focus on transition to new systems that are developed de novo in a science-driven (evidence-based) research and development process using modern tools and approaches.

To clarify, by societal systems I mean nearly all aspects of societal organization (beyond the family level) that involve collective learning, decision making, and adaptation. Thus, societal systems covers nearly every system of societal self-organization, including the six overarching ones, summarized as economic, governance, legal, health, analytical, and education systems [24]. Societal systems also includes their associated institutions, rules, and policies, and the coevolving social-cultural components (beliefs, values, norms, and worldviews) that shape and are shaped by systems. Existing systems (those in use by societies today) are called native systems.

Society refers here to any sizable scale of social organization, from local community up through city, region, nation, and world. Local community refers to a fraction of an urban or rural population, roughly 1,000 people or more.[1] A local community can be but is not necessarily (or usually) a formal political body, such as a city.

This paper is the second in a series of three that together propose a practical, affordable R&D program aimed at societal transformation. The first paper provides definitions, aims, core hypotheses, and a worldview [24]. This one builds on the first to discuss motivation, the role of science in transformation, a theory of change, and fitness metrics by which the quality of new system designs might be assessed. The last paper discusses design [25]. Aspects of the program have previously been discussed by the author in book, blog, and magazine formats [26–35]. The work here represents a maturation of ideas. A first simulation model has also been published [36] that illustrates how a novel local economic system might function.

While a limited number of academic, civic, and other programs already critique current systems, focus on the need for transformation, or study and support grassroots efforts aimed at transformation [37–42], to my knowledge this is the first proposal for a science-driven R&D program that tackles the research, development, quantitative assessment, implementation, monitoring, and improvement of new, integrated systems.

[1] Some types of communities are spatially distributed rather than being local to a geographic area. I focus here on local communities but recognize that distributed communities can play important roles in transformation and in the proposed R&D program.

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2. The Transformative Turn

The shift in focus from mitigation to transformation—the "transformative turn," as Dentoni calls it—is fairly new [43]. Up until the early to mid-2000s, adaptation to climate change, for example, was primarily seen as a technical and managerial challenge [3]. It's not surprising then that only limited, albeit expanding scientific work has been undertaken thus far to clarify the aims and definitions of transformation, or the proper role of science in facilitating or fostering it [44]. Example works include [4,5,7–9,11–15,18,45–47]. Almost no work has been published in academic journals identifying practical pathways through which transformation might be achieved.

Fazey et al. identify the "how to?" as arguably the most important question today for climate research [22]. They suggest that the answer must involve an expanded, explicitly normative, and reflexive *second-order* approach to science. A second-order science approach aims to effect change, and the scientist is understood as part of the experiment. The focus is on process, the effort is value driven, and the participants are scientists and stakeholders who learn, develop, and evaluate solutions together.

This is in contrast to a first-order science approach, where, for example, the aim is to produce knowledge, the scientist is viewed as an observer of the system, and the research is considered value-free. According to Fazey et al., the overwhelming majority of past and current research on climate change and sustainability is based on first-order science. The proposed R&D program articulates a second-order science approach.

Building on the worldview presented in [24], a society is viewed as a cognitive superorganism that, like every organism, expresses an intrinsic purpose of achieving and maintaining vitality. The set of systems used by a society are understood as its societal cognitive architecture. They are the structures through which sensing, learning, problem solving, memory storage and recall, anticipation, attention, and orchestration of action occur. For convenience, these processes are more succinctly referred to as learning, problem solving, and adaptation, or just cognition. Hereafter, reference to organisms implies also reference to superorganisms, including human societies.

Thus, with regard to developing new societal systems, second-order science can be understood as "learning to learn" and "adapting to adapt," or the "applied science of learning and adaptation." More specifically, it can be understood as a form of meta learning in which soft and hard technologies (societal systems and associated rules, norms, and cultural components) are learned that themselves allow a society to excel at learning, problem solving, and adaptation.

As the terms are used here, *learning*, *adapting*, *thriving*, *wisdom*, and *sustainability* all embody closely related concepts. One can phrase the intrinsic purpose of an organism—to achieve and maintain vitality—as the drive to express wisdom through action. Wise action, as understood here, tends to reduce uncertainty and secure vitality. A wise society adopts an extended view of self, reflecting its intimate connections with the local environment and ecology, as well as with the larger overlapping spheres of societies, environments, and ecologies to which it belongs and from which its actions reflect backward. Thus, the self that must be kept vital is, ultimately, the extended self.

The need to excel at learning, problem solving, and adaptation has never been greater. In the Anthropocene, humans are a massive and extremely powerful population that impacts all aspects of the biosphere and other Earth systems, including climate. With great power comes great danger and great need for wisdom. Unfortunately, indications are that native systems are ill-equipped to facilitate wise action (i.e., we face preventable catastrophe), and so may not be sufficiently capable of preventing severe damage and securing sustainable vitality. Nor are they designed to achieve the depth of cooperation that would be necessary to repair and regenerate that which has already been damaged.

Today, societies face a host of severe, interrelated, and thus far intractable problems, some of which act as drivers of climate change and/or biodiversity loss. These include loss and destruction of habitat; air, land, and water pollution by plastics, particulates, and toxins; topsoil erosion and degradation; natural resource depletion; financial instability; poverty and homelessness; income and wealth inequality; excessive debt; race and gender inequality; high rates of preventable disease; political violence and warfare; proliferation of nuclear, biological, and other weapons of mass destruction; and mass migrations of refugees due to social, economic, and/or environmental stress. New problems loom on the horizon, including the misuse of biotechnology and the militarization of robotics and artificial intelligence [48]. Scientists fear that a flare-up or crisis related to any single problem could initiate a cascade of events that sets off wider crises [50].

To give some idea of the size of just the migration problem, within 50 years, in a business-as-usual climate scenario and in the absence of migration, more than three billion people (about 30 percent of the projected global population) are expected to experience mean annual temperatures of greater than about 29 °C, currently found only in a few isolated locations like the Sahara desert. Given the inhospitable conditions of those areas, billions of people could become migrants in coming decades [49].

To successfully address or solve these entwined problems, and to achieve sufficient resilience and robustness, both system reform and transformation are needed. The former aims at reducing damage and improving native systems. Based on the literature, reform could be considered a 30-year project, with a goal of achieving major progress within the first decade. While transformation is often conceived of as being deep, rapid, and broad in scale, Termeer et al. caution that achieving all three at once is infeasible [4]. The proposed R&D program takes a prudent, measured approach to transformation in order to keep risks low, build support, create necessary infrastructure, conduct necessary studies, and allow for learning and adjustment at every step. As described here, transformation can be considered a 50-year project culminating in near-global-scale (i.e., widespread) change, with early adopter communities seeing benefits within the first decade.

System reform efforts are already underway by numerous groups. Transformation efforts, the focus of the proposed R&D program, have barely begun. Given looming dangers and a limited window of time for action, a focused transformation effort would ideally start immediately and run concurrently with reform efforts. If coordinated, the two approaches could be mutually beneficial, if not synergistic.

3. Reform and Transformation

System reform is needed to achieve rapid and dramatic reductions in greenhouse gas emissions and biodiversity loss, while also reaching United Nations Sustainable Development Goals (SDGs) [51]. Focused efforts by the UN, businesses, agencies, and groups have already begun. Examples outside the UN include versions of a Green New Deal, proposed in the United States and elsewhere [52–55], and the Global Deal for Nature, which addresses biodiversity loss [56].

Specific goals and targets are discussed in IPCC and IPBES reports [20,21]. For climate change, the 2050 targets include limiting warming to a threshold of 1.5 °C and achieving net-zero carbon emissions. For biodiversity loss, goals and targets are described in the Aichi Biodiversity Targets, the 2030 Agenda for Sustainable Development (which include SDGs), and the 2050 Vision for Biodiversity [51,57,58].

System reform efforts focus on and occur largely within native systems and institutions. Reform aims to limit damage, improve capacity for repair, reduce vulnerabilities, and improve conditions (for example, by eliminating the worst levels of poverty, an SDG). Systems transformation is intended to complete the journey to system-wide reorganization. Its aim is to enable societies and ecologies to flourish. Compared to reform, transformation involves deeper repair and regeneration, and in the case of societal systems, deeper reorganization.

The R&D program occurs over an approximate 50-year horizon (to about 2070), with the first 10 years focused on development and initial small-scale implementation and testing. It begins as soon as funding is secured and adjusts over time, as necessary, to the successes and failures of reform.

One might question whether transformation is necessary, given the bold goals of reform. For starters, reform goals might not be achieved. The social, political, and economic challenges are immense. Indeed, the IPBES report cautions that goals for 2030 and beyond might only be achieved through transformational change. Further, the lack of progress thus far in reform is frightening. The 2019 COP25 UN climate conference ended largely in disappointment [59]. Greenhouse gas emissions continue to set records [60]. Summary findings in the 2019 Emissions Gap Report are bleak [61]. As of March, 2020, we are still "way off track to meeting either the 1.5 or 2 °C targets that the [2016] Paris Agreement calls for," according to UN Secretary-General Antonio Guterres [62]. Likewise, of the 20 Aichi Biodiversity Targets originally defined for 2020, only four show good progress. The large majority remain un-met [63–65]. Further, the Aichi Biodiversity Target to protect 17 percent of terrestrial land and inland water by 2020 was set in a political, rather than scientific process, and is likely too low for safety [66]. A more scientifically justifiable target would be closer to 50 percent, within a range of 25–75 percent [56]. As of 2016, only about 15 percent of global land was protected.

In addition, some current climate goals are set too low. According to the IPCC report, "current nationally stated mitigation ambitions [for greenhouse gas emissions] as submitted under the Paris Agreement would not limit global warming to 1.5 °C, even if supplemented by very challenging increases in the scale and ambition of emissions reductions after 2030" [20]. Rather, ambitions are "broadly consistent with cost-effective pathways that result in a global warming of about 3 °C by 2100, with warming continuing afterwards." It should be noted that a warming of 3 °C would put societies and ecologies far into the danger zone [67] and could lead to severe, perhaps even crippling long-term damage.

Unfortunately, we might be on track for warming beyond 3 °C. Recent trends in greenhouse gas emissions most closely resemble worst case (RCP8.5) scenario models [68]. Further, as climate models become more sophisticated, they increasingly take into account larger sets of factors. As a result, the predictions of today's models span a wider range of outcomes compared to models of the past. Some new models predict a long-term warning of more than 5 °C, with the difference in predictions apparently due to how cloud feedbacks and aerosol interactions are modeled [69–71]. A warming of 5 °C would likely be catastrophic, with no guarantee that the human species would survive.

Finally, the political feasibility of taking sufficient action appears to be low. As Jewell and Cherp point out, "for key climate solutions that are already widely used, there is little evidence that they can be deployed world-wide at the scale and speed necessary for avoiding the 1.5 °C overshoot" [72]. For solutions that are still only "best practices" or demonstrations, the evidence for political feasibility is even more scant. The authors are not particularly hopeful that new public demands for action caused by increasing damage will be enough to overcome political infeasibilities and lack of capacities.

In short, societies have so far failed to stop growth in global greenhouse gas emissions and biodiversity loss, and worst-case scenarios are now looking plausible. The prospects for taking sufficient action look dim. The longer that targets are not met, even faster and deeper cuts in emissions would be required to to prevent major damage. As we wait, some scientists report that the Earth's sixth mass-extinction event, the human-caused Anthropocene extinction, has already begun and is accelerating [73,74].

If reform goals are not substantially achieved on time, it would mean, in effect, that native systems remain too dysfunctional to mount an adequate response to clear and present dangers. Such a failure would greatly increase the burden on transformation. A more intense effort would be needed to repair damage and avert greater catastrophe, which in turn would entail a more extensive and faster marshaling of resources.

Even if reform goals are fully achieved, substantial risk will remain. For example, the 1.5 °C threshold cannot be considered safe or damage-free [75], but rather a magnitude of warming that might limit damage to a manageable level for many, but not all, nations. Every nation, and especially poor ones, would still struggle with the impacts of climate change and perhaps also biodiversity loss in a 1.5 °C world. Today we are well below that threshold, yet already societies struggle with increased intensity and frequency of climate and weather extremes, including heat waves, heavy rains, drought, wildfires, and coastal flooding [20,62].

Further, tipping points might exist in Earth systems that, if crossed, could lead to unstoppable, runaway damage [67,76,77]. For example, if warming is high enough, ocean phytoplankton, the primary source of Earth's oxygen, might be driven toward mass death [78]. There are still many uncertainties, but writing in *Nature*, Lenton et al. argue that the intervention time left to prevent tipping might have already shrunk toward zero, meaning that we may have already lost control of whether tipping happens [79]. If tipping points exist but are not likely to be reached, cutting greenhouse gas emissions to net zero over the next 30 years might be sufficient, a goal of reform efforts. If tipping points have been reached or will be reached, we may need to pull additional greenhouse gases from the atmosphere over the long term to be below net zero, and act aggressively to repair and contain damage. Both are appropriate goals for transformation.

Planned reform efforts also do not adequately address certain structural problems, including extreme concentrations of wealth, financial instability, and the capture of governments by corporations. And they do not adequately address system-engendered motivations for selfish rather than cooperative behavior. Thus, even if successful, reform efforts are likely to leave societies hampered in their capacity to learn and adapt, and with unsolved problems to address.

Through transformation, societies will need to mount a massive, long-term repair and regeneration effort to test, clean, and restore polluted land, water, and air; reclaim deserts; plant forests and expand protected areas; stop erosion and build soil health; protect aquifers and watersheds; expand biodiversity; and otherwise heal damaged ecologies. A massive industrial retooling and reconfiguration effort will be needed to achieve effective pollution control and near-complete rates of recycling and reuse for most materials. A massive reformulation effort will be needed to remove or greatly reduce the presence of toxic chemicals in consumer and industrial products. A massive redesign effort will be needed to create products that have extended lifetimes (as opposed to planned obsolescence), and that are reusable, repairable, and recyclable. Wasteful consumerism will need to be severely curtailed. Medicine and medical research will need to shift some focus from the treatment of disease to disease prevention and promotion of health. Income and wealth disparities will have to markedly fall. Economic and governance systems will need to become far more transparent and responsive. Energy use will need to become more efficient, and energy sources dramatically decarbonized. Migrating individuals made homeless by social, economic, or environmental turmoil will need to be housed, fed, and integrated into new societies.

Above and beyond all this, wealthy societies will need to substantially reduce resource use per capita, even as poorer societies catch up, so that global thermodynamic and material budgets are not exceeded [23,80,81]. Among other things, this would mean adopting simpler (but not necessarily lower-quality) lifestyles for some nations. It also means ending continual economic growth as we know it (especially growth for growth's sake). Some argue that degrowth is necessary [17,18]. New and better indexes of societal health and wellbeing will need to be developed and implemented, replacing gross domestic product and related indexes as primary indicators.

In short, the need for repair, regeneration, retooling, reconfiguration, reformulation, and redesign, even reduction and simplification, across all sectors of business, civic life, and government amounts to a sea change in human endeavor. It is almost inconceivable that such a shift—much of it aimed directly at improving the common good, much of it highly disruptive to existing industries and business models, much of it incongruent with existing economic and financial systems—could occur without transformation.

Whatever the success of reform, we can expect that major problems, if not crises, will remain. Societies worldwide will continue to face enormous strain and challenges. Transformation is needed to empower societies, as much as possible, to rise to challenges, to expand opportunities, to learn and adapt, and to solve those problems that must be solved.

4. R&D Program

The aims of the R&D program are to research, develop, test, implement, monitor, improve, and advocate for new societal system designs that can best improve the common good. In [24] these are called *societal active inference and learning systems* (SAILS). Common good here means the degree of current and expected thriving (i.e., vitality), broadly defined to include factors of social and environmental wellbeing, uncertainty, sustainability, resilience, robustness, and problem-solving capacity. Thriving implies that a society recognizes its intimate connections with local and distant societies, environments, and ecologies (that is, it expresses an extended self-identity).

Ultimately, thriving is a functionality that has two aspects. Proximally, it is the capacity to sense, learn, decide, communicate, and orchestrate cooperative action. That is, it is a society's cognitive capacity, related to the design and mechanics of societal systems. The distal aspect is the conditions that arise from, or the effects of, societal cognition. Examples include the current and expected degree of security, uncertainty, public health, and environmental quality.

The distinction between proximal and distal aspects of thriving suggest different sets of fitness metrics by which system quality and operations might be assessed. The union set of these metrics, intended to capture the degree of thriving, can be used to score the *ex ante* and *ex post* fitness of a system design. As described in [24], the functional ordering considered in the R&D program is worldview $\rightarrow$ purpose $\rightarrow$ fitness metrics $\rightarrow$ system design. Thus, proximal and distal aspects of thriving, and the metrics they suggest, also inform the design of systems, and their operation.

The R&D program seeks to address a wide range of basic and applied science questions related to societal transformation, thriving, and system design and operation, using a variety of tools and approaches that include simulations, modeling, theory development, laboratory studies, population studies, and user testing. All iteratively culminate in field trials of new systems, monitoring, and system improvement. Each implemented system represents an experiment, and thus opportunities for learning. Over the course of the 50-year program, perhaps thousands of science papers will be published. The R&D program can conduct some of this work itself. If sufficiently funded, it could also disperse funds to high-quality proposed projects. And it can otherwise serve as an organizer of efforts and information, and as an advocate or channel for projects that seek funding from other sources.

Program efforts touch on numerous scientific fields and involve the public in a variety of ways. In particular, the program represents a partnership between the global science community and local communities. Field trials would occur in willing local communities, using systems and infrastructure co-developed by the science community and local communities, and in consultation with other interested groups. The program would also include cultural and education projects involving, for example, discourse, outreach, music, literature, media, and art. It could be centered within one or a few academic institutions, although much of the work could be distributed globally. Alternatively, the program could be centered within a new or existing civil society organization.

5. Role of the Science Community

The R&D program is envisioned as a broad interdisciplinary effort, inside and outside of academia and the science and the technology sectors. To give a flavor, its topics span agriculture, agroforestry, arts, climate and Earth systems science, cognitive science, complex systems science, computer science, ecology and environmental sciences, economics, education, ethics, evolutionary biology, information theory, law, linguistics, literature, materials science, media, medicine, philosophy, physics, political science, psychology, public health, sociology, statistics, zoology—literally an A–Z of academic fields, reflecting the broad goals of transformation and the high complexity of nature and society.

For convenience, I refer to the program as being science-driven and led by the science community. But obviously it involves many fields and topics beyond basic or applied science. Further, as a second-order science program, and consistent with the local-global-viral strategy discussed later, it involves a partnership between the science community and the interested public, especially local communities.

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There are several reasons why it is appropriate for the science community to adopt a leadership role in systems design and societal transformation:

1. Societal cognition, via societal systems understood as a cognitive architecture, is a timely and important subject that could advance scientific knowledge in multiple fields.
2. Systems are sophisticated and include social, economic, environmental, and technological aspects. They must reliably and securely operate under various kinds of stresses and shocks, even rare ones. The R&D effort will require simulations, field trials, and other types of studies, as well as innovations in communications, data science, and other fields. A large set of computational models will be needed both for system testing and in the daily operation of new systems. Metrics must be developed for assessing and monitoring system fitness. The science community is uniquely qualified to contribute to these efforts.
3. The goals of transformation are ambitious, yet the time available for action is short. Substantial progress must be achieved in just several decades. There is little room for casual trial and error. Mistakes, while unavoidable, must be minimized. Time and resources must be efficiently used. The science community can help keep the project focused, on track, and grounded in scientific methods.
4. The science community is trusted by the global public and is therefore in a position to help focus public attention on pressing problems, viable solutions, and possible positive futures. Further, the science community has fewer vested interests in the outcome of systems design compared to other institutions or groups of native systems. It is positioned to be a trusted authority on the development of new designs. As a side benefit of trust, an honest effort toward transformation could inspire hope in a population, and hope by itself could reduce the spread of violence and despair as (or if) conditions worsen.
5. The science community can offer a global perspective, and global coordination. As one example, Earth systems science necessarily looks at the big picture. A global perspective can help inform, unify, and guide local efforts, so that the end result is shared prosperity and thriving, across both human societies and ecosystems. Further, the science community can offer a consistent foundation that not only survives over time but that continues to learn, even if some individual projects at the local level are unsuccessful.
6. The science community can serve as a powerful ally to the public in promoting and securing transformation. Apart from technical skills, the science community can to some degree positively influence discussions and narratives within boardrooms, governments, media, and elsewhere.

By adopting a second-order science approach, the R&D program represents an expanded role for science in the public sphere and a new, more normative and participatory approach to scientific engagement [22]. While the program is consistent with the traditional goals of applied science and engineering—to create or improve materials, structures, and systems so as to practically benefit the public—the focus here is on achieving outcomes at the meta level of societal organization. Learning to learn, and adapting to adapt. By stepping across the second-order threshold, the science community gains the opportunity to play a more pronounced and profound role in guiding the intentional evolution of societies toward more optimal futures.

If the science community fails to adopt a leadership role, the prospect for humanity to achieve a bright collective future is less certain. In a leadership vacuum, and under growing social and environmental stress, who or what would take the place of science?

6. Theory of Change

Transformation could conceivably unfold through multiple paths. It could begin at the grassroots level and propagate upward to nation and world. Or it could be driven by national or global programs and propagate downward to local communities. The proposed R&D program employs a novel local-global hybrid strategy called *transform local, engage global, spread viral*, or local-global-viral, for short.

Local refers to a local community that implements a SAILS via a civic club model. A club constitutes a SAILS and consists of a group of people and local organizations that voluntarily choose to participate. Clubs act as a new layer of self-organization on top of native systems, complementing and competing with them. Club members remain engaged with the wider community and continue to participate in native systems. The local-global aspect refers to a partnership between clubs and the global science community, the latter of which develops the technology and infrastructure necessary for SAILS, conducts monitoring and assessment, and performs other tasks. The viral aspect refers to the growth of local clubs and the replication of clubs to new areas. The local-global-viral strategy allows even a small community to implement a full suite of quality systems.

While the initial focus of the R&D program is on club design, over time focus will expand to include the designs of club networks, which connect clubs, facilitate cooperation, and assist the viral replication of clubs. Clubs and networks share design motifs, with the big difference being that the members of networks are clubs rather than individuals and organizations. Networks represent a meta societal cognitive architecture, as they too facilitate learning, problem solving, and adaptation. The combination of clubs and networks allows for exponential growth in total membership, such that organic transformation on a near-global scale is possible within a reasonable span of time.

6.1. Clubs and Club Networks

Clubs and club networks represent a type of hybrid, soft and hard, innovative technology. Soft refers to elements like theories, social norms, goals, rules, procedures, programs, and stated purpose. Hard refers to technological elements like hardware, software, and methods for communications, data representations, data storage, and computation, including models for forecasting. Given that the strategy involves viral spread, the uptake of club technology in the general population is of central importance. In keeping with research on innovation diffusion [82,83], clubs are designed so that the barriers to participation are low and the benefits of participation are high. In overview, new systems are designed to outcompete native ones for the public's attention, engagement, trust, and respect. The theory of change is one of viral spread and voluntary shift to new systems.

A club represents the Goldilocks level for testing and implementing new system designs; it's neither too small nor too big. If clubs were smaller, say, representing one business, they would have too little impact on society and would be too fragile. Their vitality would heavily depend on native systems, like financial systems, which are outside of their control. If clubs were larger, say, representing a large city, they would be too costly to study and implement, and would be politically unviable. In the hierarchy of business, club, city, region, and nation, a club is the smallest level of organization that allows a SAILS to be viable, testable, self-replicating, and effective. A new club can be started by just a small number of interested people, businesses, and groups, on the order of 1,000 individuals. Further, in most locations a club can be started without legislative action, which greatly reduces or eliminates political obstacles.

By design, participation rates are expected to grow high over time, perhaps even to approach 100 percent in some local populations. Conceivably, a city could formally adopt a club model. But there is likely a size limit beyond which clubs become less effective and responsive. Research on this topic is needed, but as conjecture, perhaps the threshold is near one million participants. If so, it would mean that some large cities spawn multiple, interacting clubs. Related to this, designs could allow for individuals to participate in more than one club at a time.

Thus, the systems—economic, governance, legal, health, analytical, and education—of direct concern in the R&D program are the SAILS embodied by clubs and club networks, not native systems. In practice, however, participants naturally engage with native systems. As such, participants would naturally influence their operations and evolution. Further, the influence of clubs on native systems would likely grow as clubs grow and spread. For example, clubs might bring public attention to certain issues and causes.

While the focus of the R&D program is on SAILS, the endgame vision is that a high percentage of the global population uses societal systems that excel at serving the common good. This vision could be realized through a number of different scenarios. For example, clubs might grow successful and popular enough that, largely through example and leadership, they transform native systems from the inside out, much like a moth transforms into a butterfly. In this scenario, clubs demonstrate what is useful, desirable, and possible. Native systems adapt and evolve to incorporate the most beneficial and critical aspects of clubs.

Another scenario is that native systems do not adapt and improve enough to outcompete clubs for the public's attention, engagement, trust, and respect. Doing so would be a challenge for native systems, as clubs are specifically designed to attain these. Clubs offer something that individuals deeply desire: the power to collectively learn, decide, adapt, and cooperate in problem solving, and therefore also the ability to reduce uncertainty and improve vitality. In this scenario, participation rates grow very high over time, clubs spread widely, and power (and legitimacy) naturally shift toward clubs and club networks. Native systems, in turn, are rendered less relevant and potent.[2] The effect of group association on power is discussed further in [25].

In both scenarios, and in others that could be imagined, the program achieves its endgame vision.

6.2. Club Growth and Replication

As mentioned, clubs and club networks represent a type of technological innovation, and the uptake of innovation by the public is more likely if the barriers to participation are low and rewards are high. According to Rogers, five characteristics influence diffusion and uptake: relative advantage, compatibility, complexity, trialability, and observability [85,86]. Each can be considered in club design, as can other ideas from the diffusion literature.

Rogers also classifies individuals into five adopter categories: innovators, early adopters, early majority, late majority, and laggards. Considered as generic classes, innovators and early adopters would be the initial targets of the R&D program. The percentage of innovators and early adopters in a given location, or on average across locations, that might be interested in participating in a club is still unknown. It remains a topic for future research. However, given that a club can form with only a small number of people (roughly, 1,000), and given that only one club in one location in the world is necessary in order to hold the first field trial, it seems likely that recruiting enough people for that trial will not present a major obstacle. If the first field trial indicates that clubs offer substantial benefits for members, then recruiting individuals and organizations for subsequent field trials should be easier. Over time, educational materials developed by the R&D program, outreach efforts, and published results (on laboratory and population studies, field trials, etc.), will likely affect the level of interest that individuals have in club participation.

Design work and preliminary studies could occur over several years or longer before the first field trial is ready to start. At the start of the first trial, participants should have a very good idea of how the new system functions, how conditions are likely to change from year to year, and the benefits, costs, and risks that participation might bring. Predictions would be available from simulation and other types of models. If the preliminary work is thorough, there should be very few surprises in the outcomes of a trial. This is not to imply that a system is deterministic. Rather, it is driven by the daily choices of participants. While the general trajectory is a part of system design (a system is designed to achieve requirements), participants can steer their system as they see fit, altering course as necessary in response to local conditions.

[2] Due to legislative gridlock and other signs of dysfunction at the national level, a shift in power from national to local levels may already be occurring in the United States [84].

A field trial is likely to occur in a phased fashion. Conceptually, the first two years would be most intense with regards to data collection, assessment, and interactions between the community and the R&D program. It should be possible to limit the financial risk of participants during this period via a bond or other mechanism that allows for recovery of financial loss if a trial goes badly. At the end of the first phase, a community could decide if it wishes to continue using the system. If the answer is affirmative, then several more two-year phases could occur, with the R&D program playing a reduced role in each.

Once the initial phases of the first few field trials are completed, and assuming that systems perform as designed, a growing set of communities will likely show interest in the next round of trials. At some point, even while trials continue, other communities will begin to implement systems outside of the field trial format. Aided by the R&D program, networks will form to connect clubs and promote cooperation. At that point, the conditions for exponential growth will be achieved—clubs and networks will be capable of "going viral." This is consistent with the way self-organization occurs within biological systems. Local interactions lead to global effects, and exponential growth is a common occurrence in nature. Of course, no population grows or spreads exponentially fast forever. Clubs and networks will reach a saturation point, and growth and replication will eventually slow down. But at that point, networks may have spread through much of the globe. Further, as clubs replicate and networks form, networks themselves might organize to form networks, which could organize to form larger networks still, and so on, with each new layer representing a more global perspective. This is not unlike the way the human brain and other natural systems have organized over time, as discussed in [24].

What one club does affects others. As size and capability expand, so too do the potential impacts of one club on another, and of one club on local and distant environments. At the same time, club computational and cognitive capacity will also expand, and thus too capacity to anticipate the results of actions and choices. Eventually, clubs and networks could query sophisticated "What if?" models to better understand potential impacts and trajectories. But even in early years relatively simple but useful models can be developed to anticipate outcomes. For example, technologies available today allow for forecasting natural resource use and greenhouse gas emissions, and aggregating such forecasts at the global level.

Clubs do not act without restriction. Internally, and externally due to networks, each club is motivated to act responsibly, according to common goals and values. If it does not, its vitality would suffer and it would risk alienation from other clubs. The result could be loss of support and cooperation, and perhaps other collective actions as allowed by network rules and under existing laws. Clubs and networks can be designed to encourage responsible action, as well as cooperation in such matters as trade, business formation, club replication, education, healthcare, cultural exchange, training, and environmental restoration.

Finally, the R&D program does not aim to create a one-size-fits-all solution for local communities, or to tell communities what designs to implement. Rather, it aims to develop a rich choice of solutions, in partnership with communities. Each design or design element could be flexible and adaptable to local needs and conditions.

6.3. Strategic Advantages

Consistent with low barriers to participation and high rewards, there are several advantages to the local-global-viral strategy compared with other possibilities. First, it achieves change via a nonviolent, constructive process, which means it does not harm others or exist as an anti-movement. Rather, it acts to secure elevated wellbeing for participants and also for the wider society and environment. Further, it measures status and progress through scientific, rational, and verifiable means.

Second, the strategy minimizes political opposition. In most democratic nations, individuals can start or join a civic club without any preauthorization or legislative action. Thus, there are few if any voting hurdles that must be crossed in order to start a club, which means that there is no need to convince a larger public body that transformation is necessary or that the club approach is useful. Moreover, the presence of a successful club in a city is likely to produce beneficial spillover effects for the city as a whole. As such, a club might be welcomed and valued by both participants and nonparticipants alike. Benefits could include a stronger and more stable local economy; higher tax revenues for local governments; improvements to parks, roads, and other public infrastructure paid for in whole or in part by clubs; a stronger manufacturing base; increased tourism; and increased social, education, cultural, and professional opportunities. Such benefits could breathe new life into some rural areas and cities that have been aging and losing population for decades, or that struggle to maintain quality of life.

Third, the local-global-viral strategy is less costly, less risky, and more flexible than other options. Implementing a local club would be far less expensive, easier, and safer than implementing a new societal system at the regional, national, or global scale. The strategy allows clubs and networks to start small and grow organically over time. Further, it allows for parallel testing of different system designs and design components in a wide range of environments and conditions. By starting small and growing organically, improvements can be made and bugs can be worked out without undue risk to large populations.

None of this is to suggest, however, that the growth and replication of clubs would be unacceptably slow. While the viral strategy starts slow and clubs start small, exponential growth allows total participation to reach a near-global scale within several decades (recall the 50-year horizon). Benefits to local populations, and global society and global environment, expand exponentially fast. Early adopters see benefits relatively quickly.

Finally, the cost of the program is small both in absolute terms and as compared to potential benefits. Costs are certainly far lower than other bold scientific endeavors, such as space exploration or the Large Hadron Collider. Yet potential benefits are similarly massive. Adequate progress could be made at a level of funding typical for a large technology startup. Roughly, annual costs in the first year or two might be less than $10 million. Annual costs in subsequent years, still within the first decade, might be on the order of tens of millions of dollars. Eventually, the program could become partially or wholly self-funding, especially if a consulting/service arm is involved. Further, as clubs mature, they could support individuals to work on and coordinate with the larger R&D effort.

6.4. Opportunities

Beyond the advantages mentioned, the program offers opportunities for some forward-thinking businesses to play an important role in the larger transformative turn. The task of developing and testing the software, hardware, and other technological infrastructure for a SAILS falls on the global science community. Core components would be available to the public via open source or similar license. Some portion of the R&D effort could occur through one or more businesses that operate similar to RedHat Inc., which provides consulting, training, and other forms of assistance to groups that use the Linux open-source operating system. Like RedHat, companies could support R&D; offer services and products that sit on top of and improve the open-source stack; and provide training, consulting, and other services to clubs. Given the strong need for transformation, and the common desire for increased security and greater thriving, companies acting in this space could potentially grow to a size that rivals RedHat, now a billion-dollar publicly traded entity.

Future conditions could expand the market even further. For example, mass migrations of environmental refugees are expected as conditions worsen, as noted. Patterns of population density are likely to shift [87], and whole new communities and cities could spring up. All present opportunities for the club model. Further, patterns of population density could shift if smaller thriving communities using the club model become established beyond what are now large metropolitan areas. The decades-long trend toward urban growth could slow or even reverse if equal or better opportunities and a higher quality of life exist elsewhere. To some degree, this might already be happening in response to Covid-19; as employers shift to offering remote and flexible work options, employees have new flexibility in choosing where they will live [88].

Clubs sit midway between the family and business levels of societal organization, on the one hand, and the city level, on the other. Markets for family/business and city are currently massive, but the middle ground is not yet organized. When it does organize, it could rival the others in size. One might expect that it will organize because this is the ideal level for empowering a community. It is also in keeping with how complex systems naturally self-organize. Power is distributed in successful systems, hierarchies form across levels, and the smaller, local organizations tend to be more informed about and responsive to local needs.

There are hints that the middle ground is already starting to solidify. For example, community groups are starting to act as their own generators and brokers of electric power [89]. NextDoor, a private social network tailored to the neighborhood level, has grown popular and is now valued at more than $2 billion [90,91]. Further, numerous groups in the United States, United Kingdom, and elsewhere have started community currency programs [92,93]. Eventually, clubs themselves could cooperate in spawning service companies to act in the club/middle-ground market.

Two other opportunities are worth noting. First, local governments might greatly benefit from the presence of a club. In particular, tax revenues could substantially increase. A simulation of a prototype club model (discussed in [25]) illustrates how average family income of members rises (more than doubles) over a period of years, in concert with a fall in the local unemployment rate. The simulation is for a modest size club of about 100,000 members at maturity. Even at this size, its members and member businesses generate more than $1 billion in tax revenues, more than double initial tax revenues. A club is also likely to improve quality of life for the surrounding community, as it seeks to improve its own quality of life. For example, a club might help fund parks and other community projects. Thus, it is not unreasonable that a consortium of city and county governments could form to participate in and assist with the R&D project.

The second opportunity is for institutional and other large investors. Assets held by the 300 largest pension funds fell by $81 billion (0.4 percent) globally in 2018 [94]. Losses could mount in the future, as the trend is toward greater social, economic, and environmental strain due to climate change, biodiversity loss, and other unsolved problems. In December, 2019, Bank of England governor Mark Carney warned that pension funds are at risk due to climate change [95]. He cautioned that some assets could become worthless. If conditions worsen over coming years through a collection of social and environmental strains, clubs could come to represent a safe haven for long-term social investments.

The idea here is that large investors might be interested in reasonably safe but low- or zero-yield long-term social investments. Retaining assets over time might be viewed as more favorable than substantial loss. Moreover, public pressure is growing on large investors to shift funds in order to address climate change and other pressing problems [96].

7. Related Work

Over the last several decades a substantial effort has been made by some government agencies, nonprofits, corporations, universities, industry groups, policy makers, and others to address climate change, biodiversity loss, and other social, economic, and environmental problems. Some were mentioned in the first section of this paper, categorized as reform efforts. Transformation, the subject of the R&D program, is not a competitor or alternative to reform, but rather a necessary extension. It does not focus on native systems, but on developing and testing new system designs. As part of that, it uses new institutions, as much as possible, as vehicles to accelerate change.

Nevertheless, some aspects of what might be considered reform efforts relate to the R&D program. One example is smart cities programs, which typically seek to increase the energy efficiency and reduce the ecological footprints of cities. Some also address quality of life for city residents. Most are commercially driven. A variety of ideas explored in smart cities programs, such as energy efficiency,

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energy generation, and communication of resource and information flows, could be incorporated into club design and operations. However, I am not aware of any smart cities program aimed at societal transformation, as defined here.

Relative to the proposed R&D program, there are numerous smaller and/or more narrowly focused projects that seek to improve wellbeing and/or deepen democracy. Examples include programs that encourage ranked voting in elections [97], and programs like Evergreen Cooperatives that fund and support local cooperative businesses [98]. Proposals like Liquid Democracy (and the software tool LiquidFeedback) represent new approaches to democratic voting, including online and delegated voting [99,100]. Tools like Loomio facilitate online collaboration and decision making [101].

Basic income programs aim at increasing income security by providing a stipend to all citizens of a region, regardless of need [102]. In these, the typical stipend is about $1,000 per month per adult. In comparison, the club model could offer a much higher income for members, regardless of work status. A simulation model of a prototype club system (see [25]) illustrates how incomes are intended to rise and equalize over time, eventually reaching the equivalent of about $110,000 for all families who join the club [36]. This is roughly 4.5 times higher than a typical basic income stipend.

Finally, numerous community currency programs exist, and in some cases are backed by cities. An example in the UK is the Bristol Pound [103]. Cyclos is the advanced open-source payment software behind the Bristol Pound and many other community currency programs [109]. Community Inclusion Currencies (CICs) are related. One in Kenya is sponsored in part by the Red Cross with modeling work done by Grassroots Economics [104–106]. The *International Journal of Community Currency Research* publishes reports and developments in the community currency field [107]. Socially responsible global digital currency systems are also starting up, an example being SEEDS [108].

The proposed R&D program is wider in scope and ambition compared to these projects. Its aim is science-driven societal transformation, including development, testing, implementation, monitoring, and refinement of new, integrated societal systems that span all six overarching categories (economic, governance, legal, health, analytical, and education). Further, it aims to assess alternative club and network designs, and operations, via a set of metrics that capture pertinent information about societal cognition, social and environmental conditions, and expected vitality. It seeks to create systems that operate as cognitive architectures, and as part of this, systems that excel at anticipating future conditions and reducing expected uncertainty. As such, it necessarily involves a more integrated and advanced set of tools and technologies, and addresses a wider sphere of societal activity. Finally, its tools and technologies must scale to use by perhaps a million or more people in large clubs.

New tools and communications technologies will be needed, and these can be developed by building upon existing ones. A wide range of simulation and predictive models, including associated data infrastructures (see discussion below about data repositories), will also need to be developed.

Nevertheless, it is reasonable to ask if existing smaller or more narrowly focused programs might be sufficient to reach the goal of transformation as defined here. If so, perhaps the R&D program is not necessary. It seems unlikely that smaller or more narrowly focused programs could achieve transformation within any reasonable length of time. First, most do not hold as their goal or define system-wide transformation.

Second, even for the proposed program—hopefully a focused, well-funded R&D effort that engages the global science community—transformation at a near-global scale is cast as a 50-year project. It stands to reason that smaller or more narrowly focused efforts would take much longer. Without involvement of the science community, new systems might be less effective, robust, or resilient. Even when grassroots-grown systems dramatically boom, they can also dramatically bust, as happened in the early 2000s with the Trueque, a community currency system in Argentina [110]. Better design and more thorough testing might have helped to prevent its fall.

Third, an integrated approach is necessary in that the six overarching kinds of systems are deeply entwined. It would be difficult to make progress in one without making progress in others, and having their support. A financial system is needed for job creation, for example, and a governance system is needed to steer job creation, as well as to steer the operation of financial and economic systems. System components developed and implemented as separate, standalone entities would be at a real disadvantage. For example, a community currency system that does not also have an adequate governance system to manage it, or an associated market and economic system to foster the circulation of new currency, or a financial system to focus currency flows toward useful projects, is unlikely to expand to its full potential. Likewise, cooperative businesses are unlikely to reach their full potential if they do not operate within economic and financial systems designed to support cooperatives.

A number of groups and programs deserve special mention as working on themes that are complementary to the R&D program. These include Transition Towns [39], New Economy Coalition [111], Peer2Peer Foundation [38], Economy for the Common Good [112], Next System Project [113], Sustainable Economies Law Center [114], and Wellbeing Economy Alliance [115]. Also of note is Participatory Economics, which proposes a model for a new economy [116]. Unlike the current proposal, its focus is limited to economic systems and it is not described as a science-driven (evidence-based) R&D program.

On the academic/research/institute side are Center for the Understanding of Sustainable Prosperity (CUSP) [37]; Stockholm Resilience Centre [117]; Great Transition Initiative [118]; Research & Degrowth [119]; Sustainability Transitions Research Network [120], with a focus on the meso-level of societal organization (and which tends to view capitalism as a landscape factor beyond the meso-level [46]); and the Santa Fe Institute [121] and New England Complex Systems Institute [122], with a focus on complex adaptive systems. See also the work cited in [47].

The R&D program would seek to engage these and other groups. To my knowledge, none have proposed a comprehensive science-driven R&D program aimed at societal transformation, as discussed here.

8. Fitness Metrics and Indexes

As discussed in [24], fitness metrics are positioned as a precursor to system design to suggest a kind of reverse engineering process. We might wish for certain target levels of social and environmental wellbeing, for example. What kinds of designs would help us reach those targets within a reasonable length of time? In preparation for the third paper in the series, which is focused on design, this one ends with a brief discussion on what fitness metrics are and how they might be used.

An organism (or superorganism) senses, learns, and acts in order to achieve and maintain vitality. To do this, it must monitor its own status, including the status of its cognitive facilities. Recall from [24] that an organism is fundamentally anticipatory, and prediction requires information. A club must monitor its current status in order to determine its level of vitality and to anticipate the trajectory of that vitality. Also as discussed in [24], the objectively important variables that deserve monitoring are those that reflect the physiological and psychological needs of members. As per extended self-identity, they also reflect the needs of environments and ecologies. Together, these variables are called *essential variables*.

The true essential variables, which completely and accurately capture the status of a club with respect to vitality and its trajectory, are unknown and unknowable. They are hidden, in the mathematical sense. As discussed with reference to active inference in [24], the cognitive actions of a club largely revolve around reducing expected uncertainty about essential variables.

Although hidden, essential variables can be estimated. For example, any large set of real-world variables is likely to exhibit internal correlations (air quality can be related to disease rates), which suggests that they reflect a smaller set or data space of hidden variables. Essential variables could be estimated as a condensed linear or nonlinear combination (via dimension reduction) of a larger set of measured variables. For example, a maximum entropy network approach has been used to to assess the inter-relatedness among a large set of health-related variables for cities [123]. The result, in this case, is a single (one-dimensional) integrated health indicator.

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Hereafter, the term fitness metric refers to a measured variable that contributes to the estimation of essential variables (metrics are variables measured in a standardized way). Some metrics will be measures of subjective characteristics or conditions; many others will be measures of objective characteristics or conditions. Fitness indexes are estimated essential variables, or intermediate approximations of them, derived from a larger set of fitness metrics.

8.1. Purpose of Fitness Metrics and Indexes

Fitness metrics and indexes serve several purposes in the R&D program and in club design and operation:

Assessing status. Fitness metrics are the information that a community has about itself. Indexes are a summary of that information. They span a wide range of topics that could include health, trade, economics, education, skills, ecosystem diversity, pollution, recycling, soil quality, water quality and flows, property use and ownership, demographics, leisure time, parks, traffic, funding, employment, food production, waste production, manufacturing, supply chain use, currency flows, energy use, income, and wealth. A community should have enough information about its needs, actions, desires, conditions, concerns, and impacts, both past and present, to understand itself. Monitoring and reporting are a part of assessing status. Clubs and networks are highly transparent, which not only serves to build trust, but also informs clubs and networks about opportunities, risks, problems, and potential solutions.

Forecasting. Prediction is a core aspect of cognition. Fitness metrics and indexes are the data on which forecasts of future conditions are based. Predictive accuracy itself, in its various forms, could constitute a set of fitness metrics. Predictive accuracy can pertain to formal mathematical models, as well as to semi-formal predictions made by individuals and groups. Some people and groups are particularly good at foresight, and their capability can be recognized.

Problem solving. Humans, and increasingly, machines (e.g., artificial intelligence) can excel at problem solving. For example, they can identify a path of actions that reduces risk and achieves a goal (clean water, for example). Problem-solving for humans and machines depends on conceptions, or models, of the world. These in turn depend on information/data, which metrics and indexes can provide. Particularly promising are hybrid approaches to problem solving and expanded societal cognition that involve humans and machines (also known as human-in-the loop systems), where human reasoning is integrated with artificial intelligence [124]. As mentioned, the fundamental problem to be solved is how to reduce expected uncertainty about essential variables. In short, will current and future conditions support thriving?

Assessing system design. Fitness metrics are used to assess the *ex ante* and *ex post* fitness of system designs. To some degree, this occurs at the club level, where a community might continuously monitor its own system to identify weaknesses, strengths, risks, and opportunities for improvement. It also occurs at the network and especially R&D program levels. Two of the program's central tasks are to assess and compare designs.

Informing members. Fitness metrics and indexes represent rich information that club members could use in their day to day activities. For example, a business might desire timely information about supply chains, product or materials demand, or community conditions. A person might desire timely information about pollution, food quality, or educational opportunities. Thus, a club not only collects and processes information, creating indexes and forecasts, it also presents and disseminates the results in a way that is useful to individuals. To these ends, a club will likely operate a secure, intelligent data repository.

Basic and applied science. The rich information that clubs collect would be a boon to medicine, public health, sociology, environmental sciences, complex system science, and numerous other science fields. For example, a club might collect information about product safety and disposal, leading to improved, longer-lasting, and safer products. From a science standpoint, a large repository that contains longitudinal records of individuals on diverse topics would be a gold mine. It could accelerate the rate of scientific discovery.

If a society is a cognitive, anticipatory organism, then information plays a central role. Yet it must be handled with care. If constructed, a data repository could allow each club member full control over his or her information. An individual could grant permissions to others, allowing them to access specific information, over a specific time period, for a specific use. For example, a member might grant access to a research group to assist in a study on heart disease or cancer.

After anonymizing data, a club might use the information in a repository to create a kind of digital twin (an executable replica of itself in computer programs), in order to summarize status and facilitate the asking of "What if?" questions. The concept of a digital twin is gaining traction in industry [125]. As computational capacity and data volume increase, their use and benefits are likely to increase. Even without a digital twin, however, the repository could still incorporate different kinds of models that allow for asking and answering questions.

Generally speaking, predictive models can be used in two ways (or two different kinds of predictive models can be created). In the forward direction, the input is a set of past and current conditions and the output is a forecast of future conditions. In the backward direction, the input is a set of targets that a club would like to achieve. The output is a path or policy that leads from current conditions to the desired future, as just discussed for problem solving. Such models could be applied to club design itself. Computational power will increase in coming decades, and as it does clubs will increasingly be able to choose desired social and environmental goals and then let models work backward to suggest not just optimal paths of action, but optimal system designs and adjustments that can best achieve those goals.

8.2. Relation to Census Data and SDGs

Two existing programs that also focus on data collection are national census programs and the UN Sustainable Development Goals [51]. These share only limited similarity with the information systems and fitness metrics proposed for clubs. The similarity is that information collected for census, SDGs, and clubs spans a wide range of social and environmental topics [126]. The differences are that a larger and more detailed set of information is collected by clubs; information is collected and managed at the community level (rather than national levels); information is about local conditions (rather than national conditions); the data repository, fitness metrics, and information processing system for clubs is designed to serve a different set of purposes, related to club cognition; and forecasting and other kinds of models are integrated into the information system of a club.

Lastly, a club collects information on a far more frequent basis. Nations submit SDG reports annually, as do some census programs. Other census programs collect information at two, five, or ten-year intervals. In contrast, some information for clubs would be collected almost continuously, while other information might be collected on an hourly, daily, weekly, or different schedule. Connected sensors and other Internet of Things devices can play a role here. A community makes decisions every hour of every day and needs timely and accurate information with which to do so. At every point in time, a community should have a good understanding of how it is doing, where it is headed, where it came from, and what is likely to happen next.

9. Conclusions

The idea that societies must undergo bold change is gaining ground. Two complementary, if not synergistic pathways to bold change are reform and transformation. I argue that both are necessary if humanity is to sustainably thrive. Transformation is slower than reform, but the results are deeper and longer lasting. There appears to be public interest in transformation, as evidenced by groups such as Transition Towns, New Economy Coalition, Peer2Peer Foundation, Economy for the Common Good, Next System Project, and Wellbeing Economy Alliance. Even Pope Francis is adopting the language of transformation [127]. Thus, there is reason to believe that enough public support is or would be available to initiate the R&D program and, eventually, to conduct the first field trial. Likewise, as evidenced by tens of thousands of signatories to the warning letters of Ripple et al. [1,2], and by groups such as Great Transition Initiative [118] and Sustainability Transitions Research Network [120], there is reason to believe that enough interest in transformation exists within the global science community that, with adequate funding, work on the R&D program could move forward.

Securing funding for the program is a challenge, but one that should not be insurmountable. Program costs are moderate in absolute terms, not unlike costs for larger technology startups, and tiny compared to potential massive benefits. Once funding is secured, the program can move forward. As it picks up steam, and especially as field trials begin, successes should lead to greater public interest and easier access to funding. The program could also become partially self-funding in time. Further, it could spawn new business opportunities in the potentially large but still nascent club/middle-ground market, which is waiting for the right company or companies to step into.

If I'm correct that the barriers to transformation are not too large, it suggests, perhaps counter intuitively, that transformation might be easier to achieve than major reforms. After all, climate change and our other big problems have been well known for decades. Governments and other organizations and institutions within native systems have had plenty of time to act. Yet even at this late date, sitting on the precipice of catastrophe, we are still far away from successful mitigation and adaptation.

Compared to reform, transformation via the local-global-viral strategy does not necessarily involve native systems and institutions, and so does not require them to vote, act, or approve. Electoral victories are not required. Transformation doesn't require native systems or institutions to change their behavior. It builds new ones that act as desired. Nor does it require mobilization of trillions of dollars within native systems, as does reform. Once new systems are established, however, raising large sums within clubs and networks for worthwhile projects should be relatively straightforward. Thus, other than securing initial funding, the hurdles to transformation might be modest.

The program should be attractive to and generate excitement within the global science community. Indeed, it could act as a spearhead for discovery and research, somewhat like NASA has done for the space program. Only here the exploration is cognitive space, of societies and of life in the biosphere. Local communities too might feel excitement, especially once it becomes clear that new systems could help them reduce uncertainty and stress and achieve a higher quality of life.

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