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The Reinvention of Social Capital for Socio-Technical Systems

Social capital has been defined by Ostrom and Ahn [1] as "an attribute of individuals that enhances their ability to solve collective action problems." They observed that social capital has multiple forms, including a notion of "trustworthiness," social networks including weak and strong ties, and institutions, i.e., those collections of conventional rules by which people mutually agree to regulate their behavior. They also suggested that trust was the "glue" that enabled these various forms of social capital to be leveraged for solving collective action problems, for example, the sustainability of a common-pool resource. However, we are concerned that trust is being undermined to the detriment of social capital, thereby adversely affecting our ability to address collective action problems. In developing socio-technical systems for successful collective action, for example in SmartGrids, we need to "reinvent" social capital, and discover a new "glue."

"Social Acetate"

The gradual erosion of trust (as the "glue" binding social capital to successful collective action) is being caused by three social, economic, and political forces. First, there is the creeping managerialism that is infecting many forms of public and professional life. There seems to be a wholesale adherence by the bureaucratic corps to the adage that "everything can be measured; and if it can be measured, then it can be managed." Consequently, for example, there is an increasing influence of h-index and journal impact factors in academia as criteria for appointments, tenure, promotions, and so on – diminishing actual scholarship in place of a metric in sharp defiance of both Goodhart's Law (that any metric which becomes a target ceases to carry any semantic value), and the fact these metrics can be, and are, manipulated.

Second, there is the increasing commodification of social relationships and the distortion of social concepts. Social networking sites that numerate the number of links diminish the human dimension of social relationships – friends used to be people to be counted on, not just people to be counted. Equally, "loyalty" programs tend to work one way, and incentivize shopping around rather than creating a mutual bond over time – existing customers, especially those who find themselves locked in, can find themselves subject to much worse terms and conditions than those who ephemerally flit from company to company. Similarly, the damage that has been done to the concept of privacy in recent years has been well documented [2] – not just by recent revelations about the NSA, but especially in the U.K., the infiltration of legitimate protest groups by undercover police officers.

Third, both bureaucracies and governing elites in whatever form of government – from dictatorships to (so-called) democracies – seem to have a growing distaste for those who are governed. In the U.K., public institutions are staffed by products of a private education system that was designed to produce cohorts to run an empire. The school system detached children from their families and reattached them to the institution – this was necessary to staff the institutions for colonial

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control like the army, clergy, and foreign office. Nowadays the U.K. no longer has an empire but it still has the old education system, and produces year after year people who are zealously devoted to the abstract notion of an institution but have zero empathy with its members.

This lack of empathy is manifested by a preference for behavioral economic solutions (popularly characterized by "nudge" [3]). For example, it is proposed to address public health problems like obesity by behavioral economics, rather than tackling the real source of the problem through regulation of the fast food and fizzy drink industries, supply chains that offer healthy food at competitive prices to junk food, and providing sufficient information for well-informed decision-making as citizens [4]. It is almost as though the ruling elite want the rest to eat poorly (it is, after all, extremely lucrative), but is irritated by the need to provide medical treatment when people subsequently develop health problems. It is redolent of the old Brecht quotation: "die Wahl eines anderen Volkes zu empfehlen" – they would like to recommend the election of another people. Furthermore, it is not just in the U.K. to which this analysis applies: it is a recurring theme in many countries.

The corollary of processes, such as creeping managerialism, commodification of social concepts, and nudge-style top-down behavioral conditioning, is to undermine trust, which in turn diminishes, to the point of obsolescence, all the various forms of social capital identified by Ostrom and Ahn [1]. For example, managerialism undermines the trustworthiness of a professional by implicitly suggesting that these individuals cannot be trusted to do their job well, or even at all, unless they are monitored, measured, and assessed (although science has been doing a pretty good job of self-assessment ever since the Enlightenment: the processes even have names – the scientific method, peer review, etc.). The commodification of social relationships creates networks emphasizing the number and not the nature of the links, instead of balanced networks with strong and weak ties [5]. Behavioral economics assumes that "the people" are unable to innovate solutions to collective action problems by themselves, i.e., by forming institutions of their own devising tailored to local contexts.

Moreover, the obsolescence of social capital diminishes the prospects for successful collective action. Without strategies and prospects for successful collective action, communities cannot properly address local or global issues, like climate change, youth unemployment, and sustainability.

In this article, we argue that emerging ICT should be used to fundamentally rethink – reinvent or rediscover – forms of social capital, as a precursor to restoring (and going beyond) trust and empowering people for collective action. With SmartGrids as a particular exemplar, we first review some illustrative systems that have represented (more or less explicitly), and reasoned with, social capital in computational form. We then propose a program of research intended to reinvent social capital in the context of online social networks, as the foundation for ICT-enabled socio-technical systems for collective action.

Social Capital in Computational Form

Four examples of systems that represent and reason with social capital in computational form are forgiveness in e-commerce, legitimate claims for "fair" resource allocation in open networks, demand-side self-organization in SmartGrids, and affective conditioning for self-regulation in open plan offices.

Forgiveness in e-Commerce

Trust is a concept that has been extensively studied with numerous formal representations as a basis for decision-making in open environments. Motivated by the basic definition of "trust" as the willingness to expose oneself to risk [6], the reasoning underlying such decisions has (at least) three dimensions: an economic dimension (reasoning based on utilities), a socio-cognitive dimension (reasoning based on social/cognitive indicators like recommendations, reputation and direct experience), and a normative dimension [7]. In the normative dimension, reasoning is informed by a belief component, in the form of a belief that there is a rule of some sort (norm, convention, law, etc.), and an expectation component, in the form of an expectation that someone else's behavior will conform to, or comply with, that rule.

Most of the formal (symbolic or numeric) representations of trust concentrate on narrowing the margin of error in the trust decision. However, eliminating the error altogether would not be a "trust" decision, so since there is a possibility of error, some attention has to paid to addressing the question implicitly posed by the normative dimension: what do you do when you get the trust decision wrong, in particular because of behavior that was "contrary to expectation," i.e., that did not conform to the rule? A common approach is to tarnish the reputation of the trustee, but reputation is part of the trust decision (in the socio-cognitive dimension) and not a complement to the trust decision. In other words, it is a punishment mechanism that might have an influence on future trust decisions, but it is not a reparation mechanism that helps to resolve the situation with the current trust decision.

In human society, there is a psychological mechanism used in such situations – forgiveness. This can be defined as the complement of trust, being the willingness to restore a system to a homeostatic equilibrium. Furthermore, it can reinforce trust: being able to repair a trust decision that goes wrong gives greater confidence for subsequent interactions. From the psychological literature, four positive motivations were identified [8], comprising twelve constituent signals

as the inputs to a forgiveness decision, and used fuzzy logic to implement this model. This system was then able to distinguish between intentional and unintentional violations, gradations of seriousness, and distinguish between "risk" trust (first encounter) and "reliance" trust (a shortcut based on prior experience).

The critical aspect of this forgiveness model is that some of the constituent signals, especially "prior beneficial relationship," are a form of social capital. They can be quantified but the reasoning with those quantities was entirely based on subjective assessments using fuzzy, context-sensitive reasoning.

Legitimate Claims

It is a commonplace occurrence, in open distributed computer systems and networks, for a set of autonomous components to have to pool their resources so that as a group they can achieve collective outcomes that they could not achieve acting individually. This mirrors the situation often facing a group of human actors: how to share and maintain a common-pool resource, e.g., water for irrigation, fisheries, forestry, grazing land, and so on.

Given a set of pooled resources and a set of actors (agents) requiring access to the resources, there are a number of "natural" solutions for determining who gets access: free-for-all, pecking order, "form an orderly queue," etc. Ostrom [9] studied how human societies formed self-governing institutions, formed by people willing to self-regulate the provision and appropriation of resources according to mutually-agreed, conventional rules. This study was particularly concerned with discriminating between those institutions that endured and sustained the resource over time (avoiding the so-called tragedy of the commons), and those that did not. Ostrom then specified eight institutional design principles that, from one perspective, are concerned with establishing the essential and determinate conditions for "forming an orderly queue."

However, while the design principles focused on the conditions for forming the queue, they necessarily made some assumptions about the properties of the queue itself, in particular whether the distribution of resources achieved by the queue was, in some sense, fair. This requirement for distributive justice has been studied in many fields, and Rescher [10] proposed a theory based on the idea of legitimate claims. Rescher held that all the various mechanisms for distributing resources could be categorized under one or other of seven different canons. His position was that each canon could be seen as representing a claim for access to resources; and that distributive justice consisted of determining, for any particular context, what the legitimate claims were, how to accommodate multiple claims in the case of plurality, and how to reconcile them in case of conflict.

In [11], Rescher's theory of distributive justice was formalized in the context of Ostrom's institutional design principles, specifically the principle of collective choice arrangements (those affected by provision and appropriation rules should participate in their selection and definition). Each of the canons was represented as a function that computed an ordering of the agents requesting resources. The functions were then used in a weighted Borda Count voting protocol that computed an overall order. To reconcile conflicts between claims, the agents themselves decided the weight to be associated with each function.

Experimental results showed that groups of agents implementing this allocation procedure achieved fairer distributions than alternative random, rationing, or queuing schemes. However, in the current context, the key point to note is that the representation of some of the claims – notably the claims according to efforts and sacrifices, and according to socially-useful services – provide a ranking based on a form of (earned) social capital.

Demand-Side Self-Organization in SmartGrids

The traditional model of electricity generation, as generally experienced by domestic consumers, has supply follow demand (with some minor variations, e.g., spot market, day-ahead market, and so on). The essence is the same: actual or predicted demand is determined and supply (generation) is scheduled and produced to satisfy that demand. The model has worked well enough until now, but there are various developments that are disrupting this model: over-provisioning of generation to accommodate peak demand is inconsistent with reduced carbon emissions, local generation by domestically-installed solar panels, and the proliferation of programmable "smart" devices (centrally scheduling the few devices of the early adopters is manageable; scheduling millions of devices as "smart" devices become mainstream is not).

This has led to an increasing focus on demand-side management for electricity markets [12], and mounting emphasis on the involvement of consumers through active participation or user engagement. In addition, domestic consumers have experienced increased deployment of so-called "SmartMeters," an ICT-enabled device installed "at the edge" of the electricity network. These devices are capable of monitoring and reporting electricity consumption from the meter to the central system, as well as accepting control signals in the other direction.

There has been (at least anecdotally) some resistance to the introduction of SmartMeters in domestic residences, as opposed to the enthusiastic adoption of SmartPhones. Arguably, the reason for this contrast is because the latter is (mostly) an opt-in technology owned by the end-user which facilitates generativity (the innovation of new tools from old ones, not perhaps imagined or intended by the innovator of the old tools). However, the SmartMeter is a "can't-opt-out" technology both

centrally imposed and controlled that prohibits generativity, and is not owned by the user whose behavior is being monitored – raising significant concerns for trust, privacy and security [13]. The "intelligence," such as it is, is definitely not "at the edge," nor is it operating on behalf of the end-user, i.e., the electricity consumer.

Instead, the SmartMeter's intelligence and interconnectedness could be leveraged on the consumer's behalf through self-organization. For example, in a local micro-grid, the meters can demand an amount of electricity for a certain period of time (e.g., for a programmable appliance). Once it is allocated, they can exchange these allocations among them to better satisfy their time preferences. During each exchange, meters check whether the received allocation is in their (or rather their consumer's) interest. If so, they count it as a "favor received" from the other meter. In the opposite direction, they count it as a "favor done" for the other. Since the calculation of favors is internal for each meter, an exchange where both meters get an allocation they prefer is perceived as a favor received by both of them [14]. The social capital created by such win-win situations can help to solve collective action problems.

Affective Conditioning for Shared Physical Spaces

The encouragement of pro-social behavior was also the aim of the "affective conditioning" system that has been design and implemented to self-regulate behavior in open-plan offices. It has been well-documented that the design of workplaces has a profound influence on work-related issues, such as productivity and efficiency [15]. However, even an ideal physical arrangement of machines and workstations can be undermined by the social and emotional intelligence (or lack thereof) of the people using them; personnel churn, i.e., fast-paced turnover in office occupancy provides little incentive for investing in reciprocal relationships; and interaction through high-tech, asynchronous communications. The result is uncivil behavior which displays scant regards for others, and is considered to be one of the most serious workplace problems that organizations have to address.

To address the growing problem of incivility in the workspace, we have designed and implemented an "affective conditioning" system, which provides a computer-mediated interaction between people in a workplace [16]. The interface supports collective choice arrangements with regard to the norms of office etiquette: the occupants of the office (i.e., those who are affected by the workplace norms) get to participate in the consensual selection of the office norms. These norms are mapped to a policy-based language and the violation of norms is reported by individuals anonymously, to avoid lack of participation caused by inhibition. However, interface mechanisms like avatars are used to promote self-awareness for compliant behavior, and to provide cues for pro-social behavior, for example reparative action like an apology (see Fig. 1).

In this system, the acquisition of non-market and non-marketable value, in the form of social capital as a reward for good "office citizenship," is the key to making the system work. The workplace itself is considered as a shared resource and the implementation of Ostrom's institutional design principles empowers the office workers and incentivizes their pro-social behavior.

Social Capital in Socio-Technical Systems

These examples of creating social capital in socio-technical systems highlight the attention that needs to be paid to considering psychological values (like forgiveness) and social concepts (like justice), the user-infrastructure interface, and the role of (and control of) conventional rules in self-regulating actions and interactions. A more systematic approach requires research in (at least) four directions: computational justice, design contractualism, collective awareness, and a new institution science. We consider each of these in turn, and then bind them together in the reinvention of social capital for socio-technical systems.

Computational Justice

Various experiments with Ostrom's institutional design principles have indicated a need for various forms of justice. For example, Ostrom's first principle of clearly defined boundaries and a third principle concerning participatory selection of collective choice arrangements indicate a need for a system of "natural" or "social" justice based on democratic engagement and empowerment. Similarly, Ostrom's second principle refers to appropriation and provision rules, and the need for a system of distributive justice which is "fair," "efficient," and "stable." Additionally, Ostrom's fourth, fifth, and sixth principles on monitoring, graduated sanctions, and access to conflict-resolution procedures indicate a need for a system of retributive justice. However, the institution members should also participate in the selection of the rules embodying these principles as well. Furthermore, fully ensuring the congruence of the appropriation and provision rules to the state of the prevailing environment indicates a requirement for a system of procedural justice underpinning the second principle.

These qualifiers of justice are deeply entangled and interdependent. Computational justice [17] is proposed as an interdisciplinary investigation at the interface of computer science and philosophy, economics, psychology, and jurisprudence. Its research program is to study and resolve this entanglement and interdependence through the formal representation of concepts of justice proposed in the social sciences. However, it is also concerned with transferring these formal representations back into socio-technical systems.

Fig. 1. Affective conditioning system: Interface for self-organization of workplace rules.

Design Contractualism

Design Contractualism [18] is the idea that the system designers should make moral, legal, ethical, or pro-social judgements and encode such judgements in the system. It can be seen, for example, as one of the seven foundational principles of Privacy by Design [19], whereby privacy is embedded in the design. In this way it becomes a default non-functional requirement of any IT systems architecture and design. However, for social networking platforms for socio-technical systems, the challenge is to raise this to "ethics by design," requiring that a whole range of ethical and pro-social judgements are designed into the system. Such judgements include Ostrom's institutional design principles.

An example of this design method is "Meet the Meter" [20], a serious game for SmartGrids, which attempts to ensure by design that the conceptual foundations of Ostrom's institutional design principles are perceptually prominent in the interface of a socio-technical system for infrastructure management. This game is concerned with trying to leverage active participation through demand-side self-organization using an innovative user-infrastructure interface. For example, one interface we have designed sets users (players) a number of tasks to perform using specific electrical appliances over a period of time. However, if everyone switches everything on at once then the system can be overloaded and cuts out. Players therefore have to use the social networking interface to arrange their individual actions to support synchronized effort, and to get positive feedback from their individual contribution to collective success through in-game achievements and rewards (see Fig. 2). Specifically, we are using social capital acquired through individual contributions to the community, in order to encourage pro-active, pro-social behavior. In particular, we want to feed back the idea that a user's (small, individual) action *X* contributed to a (large, collective) action *Y* that had a beneficial effect *Z* (e.g., avoiding a power cut).

Collective Awareness

Collective Awareness [21] is the common knowledge that is formed from within a community, as a consequence of social networking, meso-level structuration, and planned emergence in complex social ensembles, rather than as a reaction to external events. Meso-level structuration is concerned with the self-organized formation, interoperation, adaptation, innovation, and dissolution of institutions for conventional action and agreement of micro-level actors who are aiming to achieve planned emergence. Planned emergence entails the introspective use of meso-level structures to coordinate and influence micro-level beliefs, actions and interactions in the intentional pursuit of desired or desirable macro-level outcomes (or to avoid undesirable outcomes), for example in social innovation, community resilience, and sustainability. Planned emergence is a property of complex social ensembles, which are formed by groups of both ICT-enabled individuals and intelligent devices brought together for some collective purpose, whose underpinning principles are multi-functional micro-level components (the ability to perform different functions in different contexts) and their ability to form meso-level structures.

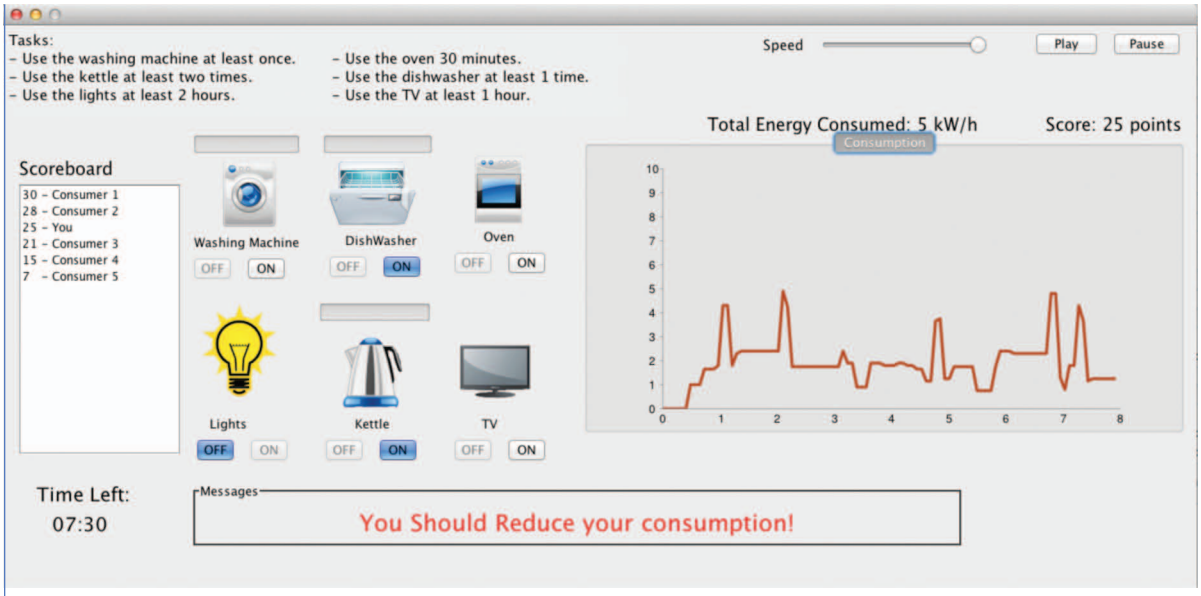

Fig. 2. Serious game interface for demand-side self-organization in a SmartGrid.

In particular, we refer to interoceptive collective awareness, i.e., it comes from within the community and is motivated towards a requirement for the well-being of that community. In this way it is an interoceptive sense like hunger or thirst, rather than an exteroceptive sense like sight or sound, which facilitates a reaction to an (external) environment in which the sensor is embedded. Collective awareness can develop synergy and symbiosis between networks of people and networks of devices and sensors, and is a critical link between Ostrom-style self-governing institutions and successful collective action.

Towards a New Institution Science

Building on interoceptive collective awareness, we propose a new approach to Institution Science, based on a convergence of first, a mathematical and computational representation of the structures, functions, and processes of self-organizing institutions implementing Ostrom's institutional design principles, and secondly, with tools and theories from Dynamic Social Psychology, i.e., the psychological study of complex systems.

There are many different representations offered by organization theory. However, for our purposes, to represent the structure, functions, and processes of institutions (i.e., the objects of study in "institution science"), we propose identifying the action situations (decision arenas) and the related "participation space" (as per Ostrom's first principle); the functional representation of Ostrom's tripartite analysis of rules into operational, collective, and constitutional choice rules; and a formal representation of institutional processes that identifies their procedural, temporal, and normative aspects, typically of concern in the study of social and organizational systems (cf., [11]).

However, to fully understand the entanglement of such institutions with *people*, so that they can fully support socio-technical systems for infrastructure management, say, then the simplistic homilies of behavioral economics and the abstract mathematical formulations of Game Theory are not, we contend, enough. Instead, formal models of theories of Dynamic Social Psychology are required. This includes: the Dynamic Theory of Social Impact [22], which specifies the processes by which a collection of private attitudes and beliefs becomes public opinion, common knowledge, or a form of culture; the Bubble Theory of Social Change [23], which specifies how a sustainable social change may be achieved, and concentrates on changing fragments of social networks (clusters or bubbles) rather than separate individuals; and the Dynamic Theory of Societal Transition [24], which investigates the processes and conditions under which meso-level social structures can be changed.

The Reinvention of Social Capital

These four research directions are essential for the reinvention of social capital in socio-technical systems. In particular, we advocate that (see Fig. 3):

- Social capital is an attribute of groups of individuals *and devices* that empowers their ability to solve collective action problems;
- Social capital has multiple forms: but more than trustworthiness of individuals, we need trustworthiness of social networking platforms and tools through design contractualism, and a new institution science founded on dynamic social networks and self-organization of institutions; and
- The link between (these new forms of) social capital and successful collective action is provided

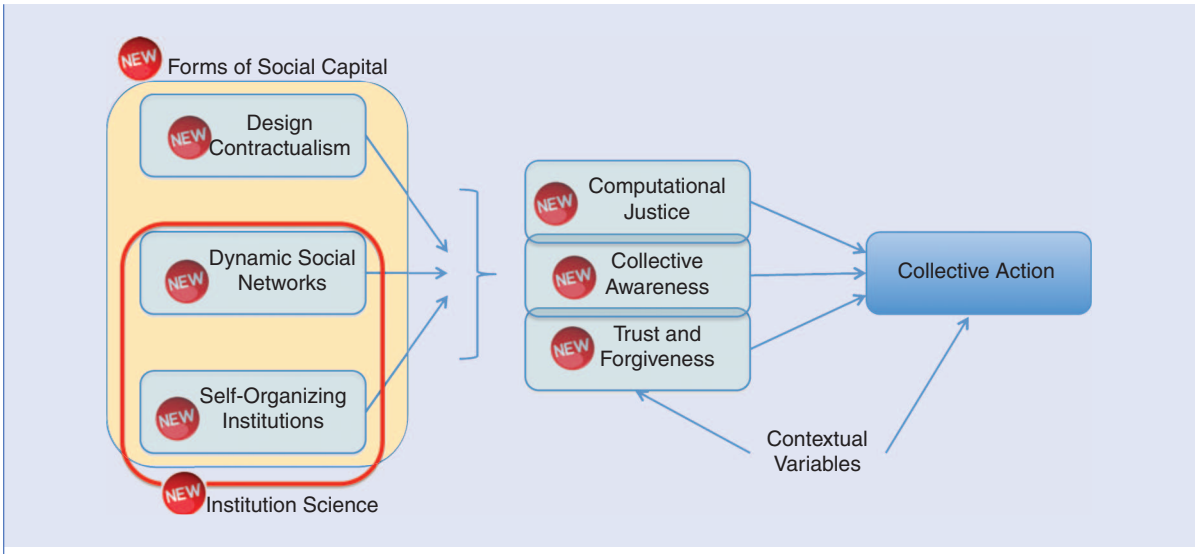

Fig. 3. The reinvention of social capital.

by trust and forgiveness, computational justice, and collective awareness.

In conclusion, we believe that the reinvention of social capital is crucial for the development of the next generation of socio-technical systems, not only to address systemic problems that threaten the sustainability of institutions and physical infrastructure, but also to understand and explain the processes through which socially resilient and sustainable institutions emerge and adapt. By providing the foundations for a new type of intrinsically beneficial adaptive institution, we believe the reinvention of social capital can enhance community resilience, social innovation, and sustainability properties of an institutions for socio-technical systems:

- *Community resilience* as the property of an institution whereby its structure, function, or processes can self-organize to react positively to change or adverse conditions to maintain social cohesion and protect community welfare;
- *Social innovation* as the property of an institution which facilitates, encourages, and empowers grassroots participation as a force for change in synthesizing or creating new structures, functions, and processes, having a specific social purpose and/or intended social benefit; and
- *Sustainability* as the property of an institution whereby its rule-set can self-adapt to ensure proactively that a common-pool resource is maintained (not depleted), and distributed fairly.

The reinvention of social capital is therefore fundamental to achieving successful collective action to meet pressing social challenges, and can have a significant transformative impact on society.

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