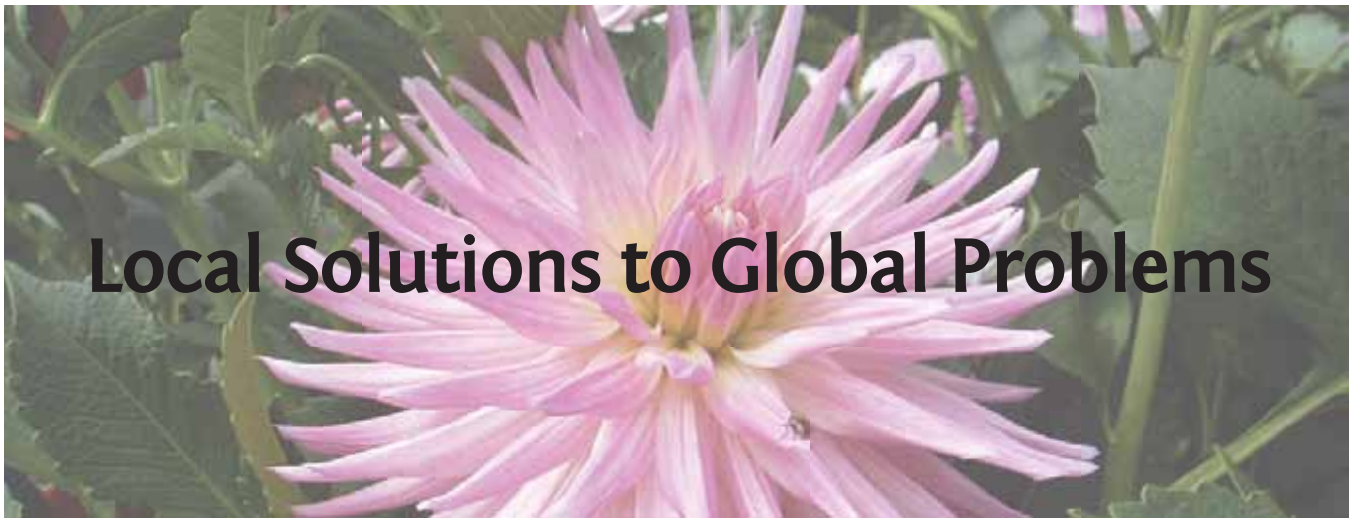


Local Solutions to Global Problems

A sustainable future requires human activities to change on a global scale, but global agreements have not been very effective. At the local level, however, there are many examples of successful efforts to solve problems within social-ecological systems. Studying these examples has led to an understanding of the principles of self-governance. Scaling up these insights by using social media tools can help address the challenges involved in global change.

Human societies have been affecting the environment for thousands of years. Initially their impacts were local, but these were still enough to leave traces in the geological record. During the twentieth century, the scale of human impacts became increasingly global; for example, the disruption of important biochemical cycles of phosphorus and carbon led to eutrophication (a process that causes the depletion of oxygen in water) of waterways around the world, as well as global climate change. Many people have come to fear that the scale of human impacts on the environment may exceed planetary capacity to sustain human societies (Rockström et al. 2009).

Countries commonly address the increasingly global challenges by defining policies that operate on a global scale. Some of these policies have been successful, such as the phasing out of several groups of halogenated hydrocarbons that were shown to deplete the ozone layer. The Montreal Protocol from 1987, for instance, led to a measurable reduction of halogenated hydrocarbons in the atmosphere, to the point where the ozone layer is expected to be fully recovered by 2050.

Despite such successes in global governance, many global sustainability challenges are difficult to address at that scale. For example, climate change has been a topic of international policy negotiations since the early 1990s. At that time, scientific studies showed that immediate stabilization and future reduction of worldwide greenhouse gas emissions (e.g., carbon dioxide [CO_2]) were needed in order to avoid an average global temperature increase of 2°C. Yet in spite of various global treaties, emissions of fossil-fuel-related CO_2 have increased by more than 40 percent. According to statistics provided by the US Energy Information Administration (EIA 2012), the global emissions from fossil fuels in 1990 were 21.6 trillion metric tons of CO_2, which increased to 30.3 trillion metric tons of CO_2 by 2009.

Addressing global-scale problems from the top down has not been effective. This might be because of the nature of the problem. In 1968, the US ecologist Garrett Hardin looked at the problem from a new angle in his essay published in *Science*, titled, "The Tragedy of the Commons," which concluded that overuse of common resources was inevitable because users would never self-organize. Hardin used the model of a pasture open to all, in which each herder received an individual benefit from adding sheep to graze on the common land and suffered costs from overgrazing only later (a cost shared with other herders). The only way to avoid overharvesting the commons, besides private property rights, would be an intervention such as taxing the use of common resources.

Climate change policy can be viewed as a commons problem. Each individual, firm, or nation must absorb the costs of changing lifestyle and production techniques as part of reducing emissions from the use of fossil fuels. The benefit will be a reduction in the level of climate change for future generations. But how do we overcome the tragedy of the climate commons?

According to insights from Hardin, the options are to either define carbon emission rights or impose a carbon tax. These are indeed the types of solutions discussed at international negotiations; however, so far, they have not

produced much change in the trend of rising greenhouse gas emissions.

Governing the Commons

If Hardin is right, why are so many common resources not overharvested? In the mid-1980s, a group of scholars from disciplines such as anthropology, sociology, political science, and biology started to compare case studies and discovered that the empirical evidence was not consistent with conventional theory as was advocated by Hardin. They became concerned about the theory's dominance and the consequences of privatization and nationalization policies, which were increasingly being adopted for natural resource management.

In order to understand the diversity of outcomes from individual case studies, there was a need for synthesis of these individual case studies. This happened through meetings of the National Research Council (NRC) starting in 1983. The NRC studied a large number of cases that showed both successes and failures in the self-organization of resource users. The resources included local fisheries, irrigation systems, pastures, and forests. Hundreds of case studies were analyzed and coded systematically with the aim of detecting patterns in the data to determine what the specific rules were that lead to successful governance of common resources.

Elinor Ostrom (1933–2012) was a leading scholar in the community studying these cases, and performed an influential meta-analysis of them, which was published in 1990. Ostrom, a political scientist, and her colleagues, had studied for decades the conditions that lead communities to solve collective action problems. In 2009, she was awarded a Nobel Prize in Economic Sciences for her contributions to the understanding of how people self-organize when they share common resources.

Ostrom had been unable to find a specific rule using statistical analysis; by considering many case studies, however, she discovered qualitative patterns that she called "design principles." Successful governance of common-pool resources, Ostrom determined, follows the same basic design principles:

1. *Well-defined boundaries*. Boundaries define who is allowed to harvest from a resource, as well as the limits of the resource system itself. Physical boundaries may be clearly marked by fences, rivers, specific tree species, or other markers. Social boundaries, such as permits, gender, kinship, or ethnicity, can be used to define who is allowed to have access.
2. *Proportional equivalence between benefits and costs*. The rules that participants use in practice should avoid unequal distribution of resources and revenues in order to avoid conflict.
3. *Collective-choice arrangements*. Having local resource users involved in creating and modifying rules leads to better acceptance of the rules by all. It also prevents elites from generating policies that benefit themselves disproportionally.
4. *Monitoring*. A cost-effective and transparent monitoring plan needs to be organized to ensure that the rules are followed and infractions enforced. Reliable monitoring can raise confidence among resource users.
5. *Graduated sanctions*. Mistakes can happen, and therefore there should be some tolerance of mistakes unless they become persistent violations of the rules, in which case more severe sanctions might be needed to guarantee compliance.
6. *Conflict-resolution mechanisms*. There should be low-cost ways to resolve conflicts among participants. Sometimes rules might be interpreted differently among participants, and easy ways to clarify such misunderstandings may reduce the number of conflicts that arise, and help maintain trust among participants.
7. *Minimum recognition of rights*. The rights of local users to craft their own rules should be recognized by higher levels of governance. If this is not the case, participants can be dissatisfied and challenge the authorities.
8. *Nested enterprises*. When resources are part of a larger system, different nested layers should be organized to match the activities of the local users and the biophysical conditions. Fitting the social and ecological scales to the problem at hand is crucial to a sustainable future.

These design principles have been tested in many publications since Ostrom, and they are well supported empirically. They show that a common feature of successful self-governance cases is that the rules people use in practice are understood and have been accepted by the participants. This is possible in small communities where the same common resource is shared over many years.

One of the questions that came out of the meta-analysis was whether the results can be generalized. Analysis of successful cases of self-governance is biased, since failing communities disappear and are therefore underrepresented in the data. Are the success cases historical artifacts? To study the principles of self-governance in greater depth, Ostrom and her colleagues used controlled experiments to test specific hypotheses. In the process, they made new discoveries.

Experiments

Controlled experiments are being used more frequently in the quest to derive an alternative theory of the governance of the commons. Since the late 1980s, laboratory and field experiments have been performed that confirm the basic insights gained from the field studies (Ostrom, Gardner, and Walker 1994). This is important for the

development of theory because observations in field studies might be disregarded by some scholars as anecdotal. Replicating field observations in controlled experiments with diverse populations around the world provides specific insights into what enhances the likelihood of successful self-governance of common-pool resources.

In a typical experiment, researchers create a situation where a number of human participants make decisions in a controlled situation in which the researcher controls aspects such as what decisions can be made, what information is available, and whether participants can communicate and how. The people voluntarily consent to take part in such an experiment. They receive instructions on the actions that can be taken and the consequences of those actions that result in monetary rewards. Decisions are made in private during a number of rounds. In each round, every participant receives an endowment that is used to invest in harvesting from a collective resource, or a risk-free return. The more participants who invest in the collective resource, the lower the reward per unit of investment. The best outcome for the group occurs when each participant harvests a moderate amount from the collective resource. Participants can gain more individually if they increase their share of the harvesting while other participants stay at the same level. If each participant uses this reasoning, however, overharvesting of the common resource can be expected.

Ostrom and colleagues performed a series of experiments, which showed that participants (in this case, undergraduate students of a US university) would overharvest the resource if they could not communicate or have any institutional arrangements to govern their common resources (Ostrom, Gardner, and Walker 1994). On average, participants harvest the level of earnings similar to the predicted outcome of selfish rational participants; if "cheap talk" or costly sanctioning is allowed, however, participants are able to derive much higher earnings as a group and avoid overharvesting.

In cheap talk, participants are allowed to communicate, face-to-face or in chat-rooms on the Internet, but they cannot enforce their agreements. In the conventional theory, cheap talk has been viewed as irrelevant; therefore, the findings on its effectiveness made by Ostrom and colleagues were considered remarkable.

In costly sanctioning, users pay a fee to reduce the earnings of someone else. The use of costly sanctioning was observed by Ostrom in field studies, but was not consistent with the theory of norm-free, completely rational, selfish behavior of the actors. Ostrom and her colleagues replicated the situation in the laboratory and they showed that participants did choose to use costly sanctioning, and that this led to a reduction of the harvesting rate. As a consequence, while the gross earnings are higher, the net earnings do not rise due to the cost of sanctioning. Therefore, the net benefits of costly sanctioning are not necessarily positive.

These findings have been replicated by many other studies, including experiments in the field involving traditional resource users with more complex resources, and experiments with public goods. For example, experiments were performed with forest resource users in rural Colombia wherein the researchers framed the experiment in terms of investing hours in collecting fuel wood from the common resource instead of talking about abstract resources and monetary payments. The participants received a payoff table that helped them decide how much time to spend for fuel wood extraction and how much time for alternative activities. These field experiments produced the same conclusions as were found for experiments using abstract instructions that were performed with undergraduate students in the United States.

In public goods experiments, every participant also receives an endowment in each round, but the question becomes how much to invest in a public fund and how much to keep. All the investments in the public fund are increased by the experimenter, and the resulting public good is equally shared among the participants. For example, in a group of five participants, the experimenter might double the investments in the public fund. All participants will see a doubling of their endowment by investing the whole endowment in the public fund. If, however, a participant keeps the endowment and receives a share of the public good, this participant is free-riding on the investments of others. The expected outcome of selfish rational participants is that nobody will invest in the public good.

Public good experiments show that participants invest initially about half of their endowment in the public good (Fehr and Gächter 2000). When communication and costly sanctioning are not possible, most groups will decline their investments in the subsequent rounds. But when communication or costly sanctioning is possible, we see an increase of investments into the public good up to 100 percent of the endowment.

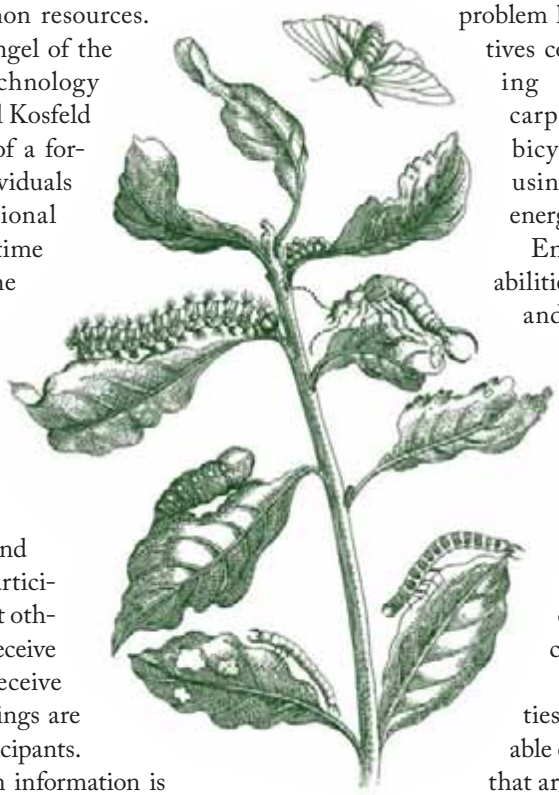
In sum, controlled experiments show that participants overcome the tragedy of the commons if they can communicate with each other and sanction free-riders. In line with the field studies, groups are able to self-govern their common resources under the right conditions. What are the underlying mechanisms that cause this? More in-depth analysis shows that a critical factor is that most participants are conditional cooperators.

Conditional Cooperation

Controlled experiments show that participants in experiments do not behave as selfish rational actors. There is increasing evidence that people value the earnings of others. But there is variation in people's preferences for the

earnings of others. Some individuals make decisions as if they are selfish and rational. Those participants never invest in the public good. Other participants are altruistic and invest a high amount, independent of what others are doing. Most participants will cooperate if others do the same, leading to the term "conditional cooperators"; in other words, those who cooperate in collective action situations if they expect others will do so as well (Fischbacher, Gächter, and Fehr 2001). In heterogeneous groups, conditional cooperators will reduce their level of contributions to the public good if they see that there are others who do not invest the same level as they do.

Field experiments show that the percentage of conditional cooperators in a community, as identified from participation in experiments, is a good predictor of the success of governance of common resources. Devesh Rustagi and Stefanie Engel of the Swiss Federal Institute of Technology together with economist Michael Kosfeld (2010) showed this in a study of a forestry program in Ethiopia. Individuals who were identified as conditional cooperators also invested more time in the actual monitoring of the rule-in-use of the villages and their common forests.



The observation that most participants are conditional cooperators explains why communication is so important. Communication enables participants to signal their intentions and trustworthiness. Not only do participants cooperate if they expect that others will, but they also value and receive emotional benefits if others receive good earnings too, and the earnings are fairly distributed among the participants.

Other studies show that when information is provided about the historical behavior of current participants in an experiment, the level of cooperation increases (e.g., Chaudhuri and Paichayontvijit 2006). If participants can choose with whom to participate, they will avoid free-riders (Ahn, Isaac, and Salmon 2008). Information on the characteristics of others in the group will thus affect the decisions of individuals. If a participant finds out that others in a group are not willing to cooperate, he or she will reduce their level of cooperation or leave the group if possible.

Critique and Challenges

The work of Ostrom focuses on small communities. There is a convincing amount of evidence that small communities are able to overcome the tragedy of the commons in the right context. They have the ability to develop and maintain trust relationships and monitor the behavior of the population. Larger groups make it more difficult for individuals to evaluate the trustworthiness of other participants while making it easier for anyone to free-ride on the actions of others. The information that a person can derive regarding the reputation of others can have an important influence on decision making.

Ostrom's advice for larger problems, such as global climate change, is to use a polycentric approach—meaning, use global- and national-level policies for certain aspects of the solution, and nurture and stimulate local initiatives to address other aspects of the solution. For a problem like climate change, local initiatives could focus on indicators appealing to the local level, such as carpooling to reduce air pollution, bicycling to improve health, and using solar energy to reduce the energy bill.

Empirical studies have shown the abilities of communities to self-govern, and their ability to develop and maintain trust relationships and monitor the behavior of the population. This does not mean that the local level is the only way to address collective action problems. The strengths of local bottom-up approaches can be employed to address the challenges of global-scale change.

Despite the ability of communities to self-organize there are profitable opportunities to reduce emissions that are not implemented. For example, research shows that the US national carbon emissions can be reduced by more than 7 percent without new regulation, technology, or infrastructure simply by taking advantage of existing opportunities (Dietz et al. 2009).

If there is proverbial low-hanging fruit, such as profitable ways to reduce carbon emissions, why don't individuals take advantage of it? To understand this, we have to look into the factors that influence individual decision making, since focusing on individuals themselves and providing factual information alone may not be effective. Research in social psychology shows the importance of social influence on individual motivation. Blending insights from social psychology on social influence with insights on collective action and the commons may lead

to concrete ideas on how to develop a bottom-up approach for global change.

As noted previously, in larger groups participants find it more difficult to evaluate each other's trustworthiness, and easier to free-ride on others' actions. One's reputation can have an important influence on other people's decisions. New information technologies reduce the costs of communicating with a larger number of people in different locations. What are the implications of this for collective action situations?

Since there has been limited focus on the potential impacts of information technology on the governance of shared resources, different areas of research need to be explored to identify those potential impacts. New technologies can monitor activities and deliver accurate information on the consequences of one's decisions as well as the decisions of others. Such real-time feedback may have an important effect on the decisions that people make.

Social Influence and Social Norms

Feedback provides information about someone or some group's performance so that people may understand the effect of their actions and adjust them to some desired level. In energy-use studies, for example, providing feedback could mean displaying current energy use to users, which enables them to make more-informed decisions about reducing energy use.

Feedback is more effective when it is specific, frequent, and related to goals that people set. For instance, one can install smart meters and monitor energy use in real time, and determine which appliances use the most energy. Such monitoring enables motivated users to reach their energy-saving goals.

But this might not be sufficient for broad-scale change; additional motivation may be required. Studies in social psychology have shown that providing feedback on how one's actions relate to the actions of others also influences behavior. An illustrative example of this is a study on energy use by Robert Cialdini, one of the key scholars of social influence. He and his colleagues studied the effect of providing social feedback on energy bills in a few hundred households in California (Schultz et al. 2007). When residents' energy bills showed that their households had a higher energy use than similar households in the neighborhood, the residents reduced their energy use in the weeks and months after receiving this social feedback. Residents who received feedback that their energy use was lower than similar neighboring households increased their energy use. So there was no net effect from providing factual information.

In the other half of the households followed in the study, information was added to the energy bill. Those with less energy use than average got a smiley face (☺) on their bills, and those with higher energy use than average got a frowny face (☹). With this treatment, the energy-efficient households continued to be efficient, and households that used more energy than average reduced their energy use. The net effect in this treatment was a positive effect of social influence.

The study was implemented by OPOWER, a customer engagement platform in the United States for the utility industry, which works with utility companies to send customers information on how they are doing compared to the neighborhood (Schultz et al. 2007). Another study analyzed about 600,000 households, of which half received the targeted feedback on their energy bills. The energy savings found of about 2 percent was modest but statistically significant (Allcott 2011).

Many similar experiments have been done related to recycling of towels in hotels, voter turnout, drinking behavior of college students, littering, donations to charity, and the like. All these studies show that providing information on what others do has an effect on the actions of individuals. In most cases there is an increase of contributions to the public good. But more understanding of the right social feedback in the right context is needed in order to develop concrete applications for enhancing collective action in diverse situations.

In the context of collective action and the commons literature, it appears that information about contributions of others stimulates conditional cooperators to cooperate. For instance, households that use more energy than their neighbors may be motivated by social pressure to comply with the social norm within their neighborhood. Households that get energy bills with information about others and see that they use less energy than others may feel discouraged in their contributions to the public good. Getting an additional smiley face may motivate the conditional cooperator to remain cooperative even though others don't meet the norm yet.

Studies from social psychology show that even small details in the feedback on social information can have an important impact on the effects. It is too simple to say that showing others' contributions to the public good will reinforce cooperation in every case. The results, however, provide hope for possible tools to stimulate cooperation in collective action situations like energy use, water use, and recycling.

Using Social Media to Catalyze Collective Action

As of 2011, about 5 billion of the world's 7 billion people had a mobile phone (Gartner 2011). In some regions in the world, there are fewer people with proper sanitation

than a mobile phone. Almost 1 billion people have an account on Facebook (Facebook 2012), and people are increasingly texting, tweeting, poking, finding their destinations based on GPS directions from their iPhones, taking pictures with their smartphones and sharing them with friends, and video chatting with people on the other side of the world. The world is becoming one big village exchanging an enormous amount of information.

As of 2010, the majority of the people in the world live in urban environments (UN 2012). The abilities of self-organization as found in small-scale rural environments do not directly apply to those urban environments where many unrelated people interact with each other. Although mobile devices and other computational devices are increasingly owned and used all over the world, not everybody has access to the same quality of services or equipment, or has the same level of expertise to use new technologies. The insights discussed in this section are mainly based on research in western societies and may not apply directly to other societies. This will be an area of research in the coming years.

Will it be possible to use the escalating amount of information that people produce and access to develop tools to catalyze collective action? While this is an open question to be addressed by scientific studies, there are a number of trends that suggest a positive answer.

The challenges involved in scaling up the findings on self-governance will be to capture the ability of people to develop and maintain trust relationships, know the reputations of others, and have the ability to contribute to the community. This may not be possible within an urbanized world where people often do not know their neighbors. By using social media, however, people can connect with their friends in a small community not limited by physical constraints. Even though people themselves experience a small community, social networks work on a global level.

Activities are increasingly monitored in real time. On a smartphone, people can check on traffic jams en route to their destinations. Smart meters enable people to monitor household energy use. Remote sensing provides information on the energy efficiency of homes. Smart water meters monitor the use of water. Supermarkets scan purchases and have accurate information on the stock and flows of consumer goods in people's households. Car insurance companies provide devices to monitor a person's driving style and provide discounts for safe driving.

All these activities allow researchers to provide rough estimates on carbon footprints, water footprints, and other sustainability indicators. Such numbers include a large degree of uncertainty, but it should be possible to provide an indication of degrees of impact. A particular activity, such as purchasing an organic local lunch, provides information for a number of sustainability indicators. Given that one of the challenges of collective action is monitoring, making use of crowd-sourcing techniques makes monitoring of self-reported activities a community activity.

If there is technology that combines this information, assuming that individuals provide consent, people could keep track of the impact of their activities compared to the common known statistics. Compare this with apps for smartphones, where people can keep track of the calories they burn and consume based on information they collect. An app like "The Eatery," for example, uses feedback from other users to rate the healthiness of meals and enables individuals to track their eating habits over time.

This information might be shared with others in a social network. Because an individual finds water footprints important, for example, he or she might use social media to share with others any information gathered. Doing so may affect individuals' reputations, enabling them to derive feedback and help from friends, and empowering them to reach their own goals.

Such a technology may seem utopian; to achieve it, many technical, cultural, ethical, and legal issues must be addressed. If such a technology were available, however, we could perform more systematic analyses on the incentives that motivate people to change their behavior for the common good. We must also work out functional questions, such as how to avoid an information overload, how to keep people involved, and what indicators are most useful.

Why might this technology be effective? As discussed above, most people are conditional cooperators and will contribute to the public good if others do the same. It has also been shown that people are influenced by information on what others like them are doing. Providing people with accurate, real-time feedback on various indicators of sustainability may stimulate behavioral change. While such behavioral change might affect only a small portion of the population, it may also provide opportunities for households to innovate and create sustainable lifestyles that will propagate to the broader population. In the past, this was achieved most effectively in small communities, since activities could be monitored by others. In an increasingly urbanized world, information technology may enable us to scale up the strength of the community governance to higher levels.

Developing tools to catalyze collective action introduces a number of ethical concerns. Some people may argue that this is social engineering, where people are manipulated to reach the goals of those who control the software. Other people may be concerned about potential privacy violation through software. These are valid concerns, but already

part of the debate in the common daily use of social media. The proposed tool would make use of existing trends in social media use, tools, and infrastructure. It is part of public debate to explore the changing social norms on privacy and use of information technology.

Conclusion

Rapid information technology development makes it possible to derive accurate, real-time information on the consequences of our decisions and the decisions of others. Increasingly, people participate in various online social networks that make it possible to share and compare information, and connect people with similar interests. This provides opportunities to apply the strengths of community self-governance to work on a global scale.

The opportunities to provide real-time feedback on resource use have been successfully implemented in various projects on energy use. Energy is a logical starting place owing to the availability of smart meters. Similar tools might be applied to water use, vaccinations, carbon footprints of people's groceries, recycling, and many more areas.

Connecting insights gained from collective action with social influence research shows that there are interesting opportunities for testing whether the power of small-group cooperation can be scaled up using modern information technology. This approach, however, presents several challenges. Although individuals share a lot of their private activities with the public through social media networks, the idea of having their behaviors tracked might be perceived as a frightening infringement on their privacy. Conversely, we face global challenges in an increasingly urbanized world that we share with strangers. Top-down nation- and state-based approaches seem to be ineffective in addressing global challenges such as climate change. Lessons from small-scale self-governance situations are inspirational, but cannot immediately scale up to an increasingly global-scope world.

Opportunities are emerging from low-cost monitoring devices that provide personalized feedback to others. Various initiatives are underway to implement such tools in practice, especially as related to energy use. Such applications are promising and need to be studied in detail to enhance our understanding of how to scale up the power of self-governance to address the challenges associated with global change.

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The author and editors are saddened by the loss of Elinor Ostrom during production of this volume.

See also Cities and the Biosphere; Collective Learning; Community; Economics, Steady State; Education, Higher; Progress; Property Rights; Values

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