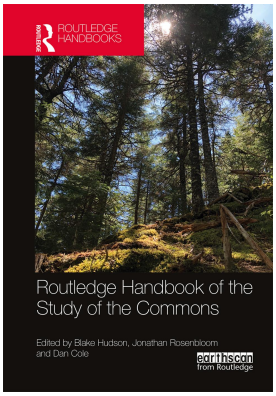

Routledge Handbook of the Study of the Commons

Blake Hudson, Jonathan Rosenbloom, Dan Cole

Using the Ostrom Workshop Frameworks to study the commons

Publication details
https://www.routledgehandbooks.com/doi/10.4324/9781315162782-3
Michael Cox
Published online on: 14 Jan 2019

3

USING THE OSTROM WORKSHOP FRAMEWORKS TO STUDY THE COMMONS

Michael Cox

The commons and institutional analysis at the Ostrom Workshop

In this chapter, I will discuss two well-known frameworks developed at the Workshop in Political Theory and Policy Analysis at Indiana University, now affectionately referred to as the Ostrom Workshop (https://ostromworkshop.indiana.edu/). These frameworks are known as the Institutional Analysis and Development (IAD) and Social-ecological systems (SES) frameworks. Each reflects one of the primary analytical approaches developed at the Ostrom Workshop: institutional analysis. This involves identifying the formal rules and more informal norms that influence the incentives that participants have in decision-making environments and to what effect for public outcomes.

That institutions are a key part of understanding human behavior in any social context has been reinforced by work that has demonstrated just how norm-driven humans are (Henrich 2015). Human psychology assumes a norm-driven world: in any social setting we look for the rules that guide our behavior. Rules are a universal feature of socially relevant human decision-making, and this is where much of the power of the Ostrom Workshop's institutional approach comes from. This approach has been applied to many areas of human activity (see McGinnis 1999), but its most famous application at the Ostrom Workshop has been to the study of environmental commons governance.

In studies of the commons the primary theoretical motivation is the presence of a social dilemma, or collective-action problem. The ideas of a commons and a collective-action problem are closely connected. A commons is a shared resource. When individuals have an incentive to use a commons such as a forest or a fishery for their own short-term benefit to the detriment of the longer-term group interest, interests at the two social levels diverge and we have a collective-action problem. In many cases individual decisions may lead to the deterioration of the commons, to the point where it is no longer able to support further use. This is commonly known as the "tragedy of the commons" as popularized by Hardin (1968). It is referred to as a tragedy because individual-level decisions lead to collective ruin, rather than having some winners and some losers.

Hardin (1998) subsequently clarified his point by stating that he would have preferred to call this the tragedy of the "unmanaged" commons. In more common terminology we could call this the "open access" commons. An open access regime is one without any

property rights that define who can and who cannot access and use a commons, and so does not involve any constraints on commons use. This clarification is made to emphasize that a commons can be used sustainably for the long-term benefit of the group. Much of the institutional work on the commons is based on the argument that collective-action is needed to maintain the commons and the interest of the group that relies on it. If resource users can co-provide public goods in the form of enforced institutional constraints on use, then they can mutually constrain each other's behavior towards their shared resource.

The most well-known work to come out of institutional analysis of the commons is Elinor Ostrom's (1990) *Governing the Commons*, in which she established the importance of a set of institutional design principles for sustainable community-based commons management. This work also helped establish the study of community-based natural resource management, and human communities generally, from an institutional perspective (see Wilson et al. 2013). Interestingly, while he is frequently criticized for advocating for only private or public ownership, Hardin (1968, 1247) includes language that sounds sympathetic to a communal solution as well, writing that "the only kind of coercion I recommend is mutual coercion, mutually agreed upon by the majority of the people affected." Ostrom's work also helped create an academic community now formally known as the International Association for the Study of the Commons, with a well-respected academic journal (www.thecommonsjournal.org/). Thanks in large part to the efforts of Ostrom Workshop scholars, the study of the commons is now a well-established field that engages with concepts and methods from multiple areas of research (Berge and van Laerhoven 2011).

Why develop frameworks to begin with?

The literatures on commons governance and social-ecological systems have a strong interest with frameworks as a scientific object (e.g. see Binder et al. 2013). This interest begs the question, why develop analytical frameworks in the first place? To answer this, we need to understand the role of frameworks in the scientific process. McGinnis and Ostrom (2014, 30) describe the role of frameworks here, along with two other concepts that are popular at the Ostrom Workshop, theories and models:

> A framework provides the basic vocabulary of concepts and terms that may be used to construct the kinds of causal explanations expected of a theory. Frameworks organize diagnostic, descriptive, and prescriptive inquiry. A theory posits specific causal relationships among core variables. In contrast, a model constitutes a more detailed manifestation of a general theoretical explanation in terms of the functional relationships among independent and dependent variables important in a particular setting.

Elsewhere, Ostrom (2011, 8), using the language of institutional analysis, has also related frameworks to the measurement of variables:

> Frameworks identify the elements and general relationships among these elements that one needs to consider for institutional analysis and they organize diagnostic and prescriptive inquiry. They provide a general set of variables that can be used to analyze all types of institutional arrangements.

In this account, frameworks provide the language that is used to express other important scientific objects: namely, variables and theories. A framework should help a scientist know

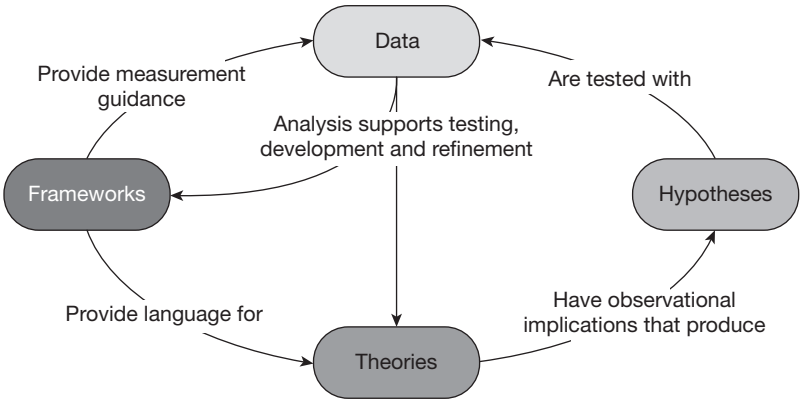

Figure 3.1 Model of the scientific process. Frameworks support the expression of theories and the measurement of variables. Data analysis tests theories and supports the generation of new ones and informs the utility of current frameworks.

(1) what they should be measuring, (2) how they might measure it as a variable, and (3) what theories they would or could be testing or developing by analyzing the relationships among their measured variables.

The distinction between frameworks and theories is fuzzy, particularly given Ostrom's (2011) use of the term "relationships" in the second quotation here. Both frameworks and theories express relationships. McGinnis and Ostrom (2014) are helpful here in clarifying that the primary difference is that theories specify causal relationships among a set of variables, whereas frameworks generally do not, or at least do so in less specific ways. Models then enter the picture primarily at the stage of data analysis to test the hypotheses derived from theories.

Figure 3.1 incorporates this understanding into an otherwise standard formulation of the hypothetico-deductive model of scientific practice. Here we see theories, hypotheses, and data that ideally interact in an iterative cycle to accumulate well-supported scientific theories, the primary goal of the scientific practice from this point of view. Here we see the role of frameworks displayed via its relationships with theories and the data used to test them. With this understanding in hand, we can proceed to discuss the two frameworks.

The IAD and SES frameworks

To discuss and compare the two frameworks, I present a combined depiction of them (Figure 3.2). In each framework, the primary analytical focus is the "action situation," which is a social arena in which interdependent actors make decisions. In the work on the commons the most prominent type of action situation involves a collective-action problem related to the use and management of a shared environmental commons. This underscores an important feature of action situations: while they can represent a unique meeting or discussion that a group of actors has at one point in time, as several examples from Ostrom (2005) illustrate, they also represent an ongoing set of interactions among a consistent set of interdependent actors. In the history of the IAD framework, action situations have played a similar role to that of games in game theory work, and the language used to describe the two also has historically overlapped (see Ostrom et al. 1994). For example, in making the distinction between more transitory and more ongoing action situations, we frequently talk about how many "rounds" will occur in a game.

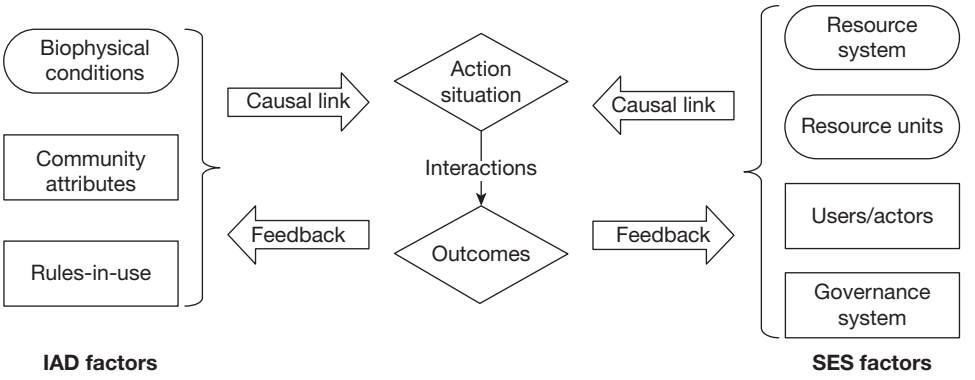

Figure 3.2 A combined representation of the two frameworks. Each contains a set of factors that affect social interactions in an action situation. The decisions in such settings produce outcomes that feed back into the original determining factors. Social factors are shown as rectangles and biophysical factors as rounded rectangles

An additional point to make about both frameworks is that they contain causal content: each contains factors that are assumed to affect human decision-making. While the precise nature of the relationships is not specified (this is left for theories), the frameworks here are not causally neutral. This is an example of the fuzzy distinction between frameworks and theories as I described earlier.

The IAD framework

There are three buckets of factors that are understood to affect decision-making in action situations in the IAD framework. Two of these are social: institutions, or rules-in-use, and the attributes of the communities who create them or are affected by them. The other is biophysical: in most cases this is understood to represent the relevant attributes of a commons. This way of breaking down the types of factors that influence decision-making in a social setting has carried over to much of the work on the commons (Agrawal 2003).

Of the three buckets, the literature associated with the IAD framework has developed the institutional factors most thoroughly. One of the unique aspects of the IAD is an accompanying typology of rules (Crawford and Ostrom 1995). This material reflects a point I made earlier, that human social settings (or now, action situations) are thickly institutional: it is a defining attribute of our species that we are so social and that our sociality is so strongly governed by rules and norms. Rules determine which actors hold which positions (such as a resource user, a religious leader, or a government agent), and they determine what actions are allowed or forbidden for those holding such positions. In the context of commons management, such rules determine who is a legitimate resource user and what types of property rights they have with respect to a shared commons (see Schlager and Ostrom 1992).

The actions that actors then take based on their positions are also affected by the information that they have available to them, which itself is a function of other rules. Moreover, how individual actions and decisions influence outcomes at the group level is influenced by aggregation rules (such as voting rules). Finally, there are rules that require or forbid certain outcomes (e.g. total allowable catches in fisheries governance or total maximum daily loads in

water governance), and rules that affect the costs and benefits obtained from achieving certain outcomes. This foundational institutional content has continued to be elaborated in subsequent work (Basurto et al. 2010).

In terms of the relationships represented in Figure 3.1, the IAD framework, and the associated literature[1] that Ostrom and colleagues have developed to articulate the contents of the "rules in use" box, provide important guidance in the measurement of institutional variables that affect outcomes in action situations. With respect to biophysical attributes, the two main developments most closely associated with the IAD framework are the typology of types of goods (private, public, tool, common-pool) and different production functions of such goods (Ostrom 2003). The community attributes that have been identified mostly come from commons work that has developed lists of important attributes of communities of natural resource users, such as resource dependence, group size, and the presence of leadership (Agrawal 2003).

Regarding the IAD framework's relationship to theory, Ostrom (2005, 817–818) makes the following statement: "Microeconomic theory, game theory, transaction cost theory, social choice theory, public choice, constitutional and covenantal theory, and theories of public goods and common-pool resources are all compatible with the IAD framework." Compatibility in this context means that the perspectives that Ostrom mentions make use of variables that can be expressed in terms of the components of the framework. Of these, CPR theory is the most well-known body of theory to have come out of work with the IAD framework, as most famously embodied in Ostrom's (1990) work on the institutional design principles.

This is a helpful statement, although it is difficult to interpret it in the context of the discussion of theories and frameworks earlier. Ostrom is referring to approaches to social science analysis here. Transaction cost theory and public choice theory are arguably not just about theories but also contain what we would call frameworks based on the earlier definition: they point us to concepts to pay attention to in the first place (e.g. transaction costs, bureaucracies, rent-seeking). Theories are then constructed that causally relate such concepts. This points to inconsistencies in the use of the word theory, to refer to causal narratives that generate hypotheses via their observational implications, as well as bodies of literature with at least implicitly stated frameworks, as well as a collection of theories in the first sense.

The SES framework

In Figure 3.2 we see several close similarities between the components of the SES framework and the IAD framework. To begin, we still have the action situation as the primary focus. This is again affected by several buckets of factors, associated with different components of the framework. We have actors, which in the original version were labeled as users, in a move that strongly reflected the historical focus commons settings at the Ostrom Workshop. The actors' bucket from the SES framework roughly corresponds to the community attributes bucket in the IAD framework. We then have governance systems which contain the institutional factors and roughly correspond to the rules-in-rules bucket from the IAD framework.

The most noticeable difference at this level of representation between the two frameworks is that the SES framework divides the biophysical world into two parts: resource systems and resource units. This distinction can be traced back to earlier work at the Ostrom Workshop (Ostrom et al. 1994). What is being imagined in this division is a prototypical situation in which commons users extract an exhaustible pool of resource units, which themselves are part of a larger resource system. In the paradigmatic example of an irrigation system, we have the irrigation infrastructure as the resource system, the provision of which as a public good ensures the availability of the resource unit, in this case water as a common-pool resource. For an in-depth

discussion of this distinction and the two associated components of the SES framework, see Hinkel et al. (2015). As these authors point out, the distinction between a resource system and a set of resource units associated with it is not always clear in an empirical setting.

An aspect of the SES framework that is not depicted in Figure 3.2 is Ostrom's (2007) decomposition of what she referred to as the tier 1 components of a SES, or what I am informally calling buckets here, into tier 2 variables. The use of this tiered language and the language of diagnosis that accompanied this hierarchical representation is a second place where the SES framework departs significantly from the IAD framework. Ostrom discussed the idea that the framework would eventually have multiple subsequent tiers, each with a version of objects at the previous tier that were somehow more specific to a smaller subset of cases. By "drilling down" into subsequent tiers, an analyst could diagnose the important factors of a system, or type of system, that they were focusing on.

Several additional points need to be made about the tier 2 objects, which I will also relate to the role of frameworks from Figure 3.1. First and foremost, their scientific identities are unclear. Several objects are readily interpretable as variables. For example, we have attributes of users/actors, such as the number of users (group size), their level of dependence on the resource, and their level of social capital. For the resource units we have their mobility, renewability, and economic value; and for the resource system, we have the clarity of its boundaries and its sector (e.g. water or forests).

Other factors listed by Ostrom (2007) and others are more difficult to interpret in this way, such as what she labels as "interaction among resource units," or the "history of use" of a group of users. These represent broad topics of interest, but additional work is needed to turn them into measurable factors in an empirical analysis. For an excellent example of work that does this for a particular type of system, see Leslie et al. (2015). Finally, we have factors such as human-constructed facilities, and governmental and non-governmental organizations. These are material and social objects in the world and, as such, are most easily thought of as actual subcomponents of an SES, rather than factors that we would measure about a subcomponent of an SES. The literature on the SES framework has mostly avoided this ambiguity, and so it remains unclear how to treat these objects.

Additionally, these objects strongly reflect the collective-action orientation of the Ostrom workshop. The majority of the factors listed are known to play important theoretical roles in the incentives that a set of users sharing a common-pool resource have to cooperate or defect. For example, dependence on a resource and local norms, as well as clarity of system boundaries and property rights systems are all strongly tied to the literature on common-pool resource management and collective-action. As such the main explanatory focus of the SES framework is in how external factors affect human decision-making, which in turn affect outcomes. Put another way, to the extent that the SES framework engages with theory, it is largely social theory that would explain how a set of factors affect human decision-making, rather than ecological theory that explains how ecological systems work to produce important outcomes. Ostrom (2007) herself uses the framework to express the "tragedy of the commons" theory (Hardin 1968). She ties key components of Hardin's argument to objects she labels as variables from her framework to formally express the theory that predicts ecological destruction from large numbers of users using a renewable resource.

To summarize, the SES framework does not provide as much guidance as many have assumed it would with respect to variable measurement, in large part due to the ambiguous identities of the tier 2 objects. Additionally, in spite of its name, I would argue that its theoretical orientation remains primarily social due to its direct inheritance of much of the components of the IAD framework, particularly the action situation as its focal point, and the collective-action perspective implied by the tier 2 objects.

Using the Frameworks

A question that has been often asked of the SES framework is, how exactly should it be used to diagnose a particular SES? Ostrom published two initial papers on the framework (Ostrom 2007, 2009) and subsequently published several articles with colleagues that make minor modifications to it (Ostrom and Cox 2010; McGinnis and Ostrom 2014). But an official manual for the framework has never appeared. I believe this has resulted in a high level of variability in how the framework is implemented. This argument is supported with empirical data presented by Schlager and Cox (2017), who demonstrate that, in terms of measurement protocols, there is little consistency across implementations of the SES framework. I believe this is a problem given the explicit goals of the framework, which includes supporting just this type of consistency, and the fact that a lack of comparability across cases is one of the primary challenges facing scholars of the commons (Poteete et al. 2010).

In order to produce comparable data across the analysis of SESs, several questions must be answered to augment the box-and-arrow representations that are commonly used in describing scientific figures. The first of these is, what is the unit of analysis implied by a framework for analyses that would use it? The unit of analysis is the entity about which a scientist is asking their research questions. It is tempting to say that the unit of analysis implied in the two frameworks is an action situation. But several applications of the frameworks have focused on a case containing multiple interdependent action situations (McGinnis 2011; Ostrom 2011; Cox 2014a), and it is these interactions that are used to understand case-level outcomes. So the role of action situations has often been to unpack a particular case, which is itself the unit of analysis.

This feature is in fact built into the IAD framework and SES framework in two ways. First, we have the distinction between different but interrelated institutional levels and associated action situations (from constitutional to collective-choice to operational) that have consistently been associated with the IAD framework. Second, we have the distinction between resource units and resource systems. Each of these is commonly associated with its own type of collective-action problem and action situation. Moreover, it has been commonly understood, at least in the prototypical irrigation system example, that the provision of the services required to maintain the resource system helps maintain the availability of the resource unit. Ostrom et al. (1994) labeled these provision vs. appropriation situations, respectively.

I believe this interdependence of action situations leads us to an important protocol for implementing either of these frameworks to understand a particular case: starting with a focal action situation, the analyst then considers what other decision-making arenas produce outcomes that affect the incentives faced by the actors in the focal situation. This focal situation is most commonly oriented around the collective use of a shared commons by a set of natural resource users, but it need not be: Fleischman (2016) relies in part on the IAD framework to examine the behavior of foresters in India, while Gibson et al. (2005) apply an institutional analysis to the Swedish development agency, SIDA.

Accompanying this protocol is an answer to the initial question: what is the unit of analysis here? For the SES framework, it is just this: a social-ecological system. For the IAD framework it is commonly a social system with multiple interacting action situations and their participants. I believe that this protocol also implies the need for mixed methods in the analysis of at least the social aspects of the cases examined with these frameworks. In my own work, which does start with a focal action situation oriented around resource use, this has commonly involved conducting formal interviews with a sample of natural resource users (fishers or farmers) and conducting quantitative analyses of the interview data to understand the behavior of these core actors. Then, more informal interviews are conducted with more peripheral

actors whose decisions affect the incentives that natural resource users face. Such actors are most often linked to the natural resource users through markets (see Ribot 1998) and formal governance (Andersson and Ostrom 2008). Case-level inference of these interactions is then both qualitative and quantitative.

Having explored the application of these frameworks to a particular case, an additional question we must ask is, how might we use the frameworks to compare across cases? In answering this question, we face the well understood trade-off between complexity and generalizability (Cox 2008): the more specific we are in our descriptions of a case, the harder it is to compare that case to others. In the case of these two frameworks, we can see how their box-and-arrow representations naturally lead us to unpack the complexity of a case. The component-subcomponent structure of the SES framework reinforces this, and I think this point is particularly easy to understand with this framework. For if we accept that the second-tier objects in this framework can be measured, then we see that we are measuring characteristics of components of SESs, not of SESs themselves. But comparison across systems, at least quantitative comparison (and I would argue that many so-called small-n qualitative comparisons are implicitly quantitative in nature), requires that we have SES-level measurements. So we face the challenge of aggregating component measurements to SES-level measurements in this case.

One way to meet this challenge is to provide instructions for how data associated with the use of a scientific framework can be stored, managed, and retrieved. Neither of the original frameworks discussed here originally came with such instructions, and this is the most common scenario with scientific frameworks in the social sciences. I believe that this is a critical problem for the study of the commons. Often the only data model that graduate students and scholars are aware of is a "flat model," or a simple spreadsheet. By data model I mean the specification of the structure of the database that will store data. I would go so far as to argue that a data model should be a required part of the specification of a framework, or at the very least that authors of scientific frameworks should specify how someone might collect empirical data on a set of comparable cases when using the framework. Such a process is far from intuitive based on the box-and-arrow representations that come with most frameworks.

There are two projects to highlight that have done just this for each of the two frameworks. For the IAD framework we have the International Forestry Institutions (IFRI) project, which originated at Indiana University and is now based at the University of Michigan (www.ifriresearch.net/). This project developed a relational database to store information about the interactions between forest user groups and the resources they use and manage (Wollenberg et al. 2007). The IFRI community has developed extensive coding protocols to help researchers reliably measure variables across sites. The unit of analysis in the majority of IFRI studies is the interaction between a user group and a forest. This is arguably the most successful empirical research project on the commons to date, producing many important studies on the forest commons (Chhatre and Agrawal 2009; Coleman and Steed 2009).

The project that has done the most to construct a data model for the SES framework is known as the Social-ecological Systems Meta-analysis Database (SESMAD) project (sesmad.dartmouth.edu) (Cox 2014b; Ban et al. 2017). This project has not had the large-scale empirical success of the IFRI project but nevertheless has produced some important findings and lessons. It is also based on a relational database model that enables a user to construct a model of an SES by adding components and coding information about their interactions. In order to address the two specific roles that frameworks have from Figure 3.1, the SESMAD database includes a table that explicitly describes the variables that can be measured in any system, and what types of components they are relevant for; it also contains a table describing the most important social-ecological theories that could be tested in such cases (Cox et al. 2016).

Conclusions

Frameworks determine what we attend to in our scientific analyses. Given the fuzzy boundary between frameworks and theories, they also enable what is commonly referred to as the "theory-ladenness of observation." As such, they represent the interpretive lens that scholars apply to their empirical cases. Given this importance, we must be self-aware about the ways in which any framework steers our attention and thus our conclusions. This awareness has been expressed in terms of each of these frameworks, particularly with respect to aspects that scholars have argued are under-developed in them. One primary concern has been that they do not capture power relationships and historical dynamics sufficiently (Clement 2010). This has been a concern of institutional analysis more broadly, and, according to a recent review conducted by Kramer et al. (2017), much of the scholarly community studying human-environment interactions does not strongly emphasize these themes. So, it is likely a valid critique, and it reflects a concern among many commons scholars over the temptation to offer technocratic solutions without an awareness of the power dynamics that will largely determine how such solutions are implemented and for whose benefit. Ostrom's own design principles have been criticized in this way (Cox et al. 2010).

I believe one response to this concern is that the language of institutions is an effective way of describing disparities of power and authority, since it is through institutions that such power is codified, most prominently in the language of property rights. At the same time, more work could be done to integrate the IAD framework and institutional analysis with concepts such as path dependence as most prominently developed by Arthur (1994), applied to institutional change by North (1990), and recently applied to commons analyses (Heinmiller 2009; Cody et al. 2015). This language is inherently historical and, because it also addresses issues of vested interests as an inherent obstacle to change, can incorporate power dynamics as well.

An additional concern has been the relatively small amount of ecological content in the frameworks. Arguably much of the motivation for the SES framework is to further develop the ecological content that is not formally captured in the IAD framework. Nevertheless, I believe it is fair to say that the SES framework does not extensively cover many important concepts commonly used by ecologists in their research. Rather, as I indicated earlier, much of the resource-oriented content in the SES framework is present because of its relevance to the collective-action/commons perspective that the SES framework inherited from the IAD framework. There have been efforts to explicitly add ecological content to the framework, or otherwise clarify how the resource-based components should be analyzed (Epstein et al. 2013; Hinkel et al. 2015). But these efforts have not led to formal changes to the framework. Moreover, as far as I know, no protocol exists for making formal updates to the framework in the way implied by the scientific process depicted in Figure 3.1. So, this remains a challenge for the commons community in its continued use of this framework. Frameworks are not tested in the way theories are, but arguably they should be amended and changed based on users' experiences with them.

To conclude, the promise of scientific frameworks is that they can provide a common, meta-theoretical language to enable scholars to engage with each other and produce comparable findings. However, having a framework does not guarantee that these goals are met, particularly if they do not come with protocols that guide their implementation and a literature that further develops them over time. As Poteete et al. (2010) eloquently describe in their final chapter of their excellent book *Working Together*, as a community of commons scholars we face our own collective-action problems in producing more highly comparable data and results with the frameworks that are currently available to us. We should consider applying our social theories to our research community to understand how this has been and should be done. Ostrom herself embodied one

of the most important theoretical arguments in work on collective-action when she served as a leader for the community, providing important public goods that the rest of us could benefit from and use to establish a common understanding and basis for mutual engagement. Another key factor is in-person communication that can enable interdisciplinary collaborations to develop organically over time based on a genuine understanding of the separate fields involved. Just like common understandings among resource users, this is a costly, time-consuming process that cannot be easily substituted with novel technologies. Producing more comparable results with highly integrated frameworks will require just as much change in social infrastructure as it will technological infrastructure. In the Ostrom Workshop we have a model for much of this, in the social capital and craft-oriented collective mentality embodied in its name.

Note

1 It is difficult to determine where the framework itself stops and literature loosely associated with it starts.

References

Agrawal, A. (2003). "Sustainable governance of common-pool resources: Context, methods, and politics" *Annual Review of Anthropology*, 32: 243–262.

Andersson, K.P., and Ostrom, E. (2008). "Analyzing decentralized resource regimes from a polycentric perspective" *Policy Sciences*, 41: 71–93.

Arthur, B. (1994). *Increasing Returns and Path Dependence in the Economy*. Ann Arbor, MI: University of Michigan Press.

Ban, N.C., Davies, T.E., Aguilera, S.E., Brooks, C., Cox, M., Epstein, G., . . . Nenadovic, M. (2017). "Social and ecological effectiveness of large marine protected areas" *Global Environmental Change*, 43: 82–91.

Basurto, X., Kingsley, G., McQueen, K., Smith, M., and Weible, C.M. (2010). "A systematic approach to institutional analysis: Applying Crawford and Ostrom's grammar" *Political Research Quarterly*, 63(3): 523–537.

Berge, E., and van Laerhoven, F. (2011). "Editorial: Governing the commons for two decades – A complex story" *International Journal of the Commons*, 5(2): 160–187.

Binder, C.R., Hinkel, J., Bots, P.W.G., and Pahl-Wostl, C. (2013). "Comparison of frameworks for analyzing social-ecological systems" *Ecology and Society*, 18(4): article 26.

Chhatre, A., and Agrawal, A. (2009). "Trade-offs and synergies between carbon storage and livelihood benefits from forest commons" *PNAS*, 106(42): 17667–17670.

Clement, F. (2010). "Analysing decentralised natural resource governance: Proposition for a 'politicised' institutional analysis and development framework" *Policy Sciences*, 43(2): 129–156.

Cody, K.C., Smith, S.M., Cox, M., and Andersson, K. (2015). "Emergence of collective action in a groundwater commons: Irrigators in the San Luis Valley of Colorado" *Society and Natural Resources*, 28(4): 405–422.

Coleman, E.A., and Steed, B.C. (2009). "Monitoring and sanctioning in the commons: An application to forestry" *Ecological Economics*, 68(7): 2106–2113.

Cox, M. (2008). "Balancing accuracy and meaning in common-pool resource theory" *Ecology and Society*, 13(2): n.p.

Cox, M. (2014a). "Applying a social-ecological system framework to the study of the Taos Valley irrigation system" *Human Ecology*, 42(2): 311–324.

Cox, M. (2014b). "Understanding large social-ecological systems: Introducing the SESMAD project" *International Journal of the Commons*, 8: 265–276.

Cox, M., Arnold, G., and Villamayor-Tomas, S. (2010). "A review of design principles for community-based natural resource management" *Ecology and Society*, 15(4): n.p.

Cox, M., Villamayor-Tomas, S., Epstein, G., Evans, L., Ban, N.C., Fleischman, F., . . . Garcia-Lopez, G. (2016). "Synthesizing theories of natural resource management and governance" *Global Environmental Change*, 39: 45–56.

Crawford, S., and Ostrom, E. (1995). "A grammar of institutions" *The American Political Science Review*, 89(3): 582–600.

Epstein, G., Vogt, J.M., Mincey, S.K., Cox, M., and Fischer, B. (2013). "Missing ecology: Integrating ecological perspectives with the social-ecological system framework" *International Journal of the Commons*, 7(2): 432–453.

Fleischman, F. (2016). "Understanding India's forest bureaucracy: A review" *Regional Environmental Change*, 16: 153–165.

Gibson, C., Andersson, K., Ostrom, E., and Shivakumar, S. (2005). *The Samaritan's Dilemma: The Political Economy of Development Aid*. New York: Oxford University Press.

Hardin, G. (1968). "The tragedy of the commons" *Science*, 162: 1243–1248.

Hardin, G. (1998). "Extensions of 'The tragedy of the commons'" *Science*, 280(5364): 682–683.

Heinmiller, B.T. (2009). "Path dependency and collective action in common pool governance" *International Journal of the Commons*, 3(1): 131–147.

Henrich, J. (2015). "The secret of our success: How culture is driving human evolution, domesticating our species, and making us smarter." Princeton, NJ: Princeton University Press.

Hinkel, J., Cox, M., Schlüter, M., Binder, C., and Falk, T. (2015). "A diagnostic procedure for applying the social-ecological systems framework in diverse cases" *Ecology and Society*, 20(1): article 32.

Kramer, D., Hartter, J., Boag, A., Jain, M., Stevens, K., Nicholas, K., . . . Liu, J. (2017). "Top 40 questions in coupled human and natural systems (CHANS) research" *Ecology and Society*, 22(2): n.p.

Leslie, H.M., Basurto, X., Nenadovic, M., Sievanen, L., Cavanaugh, K.C., Cota-Nieto, J.J., . . . Aburto-Oropeza, O. (2015). "Operationalizing the social-ecological systems framework to assess sustainability" *Proceedings of the National Academy of Sciences*, 112(19): 5979–5984.

McGinnis, M. (2011). "Networks of adjacent action situations in polycentric governance" *Policy Studies Journal*, 39(1): 51–78.

McGinnis, M.D. (1999). Polycentricity and Local Public Economies: Readings from the Workshop in Political Theory and Policy Analysis. Ann Arbor, MI: University of Michigan Press.

McGinnis, M.D., and Ostrom, E. (2014). "Social-ecological system framework: Initial changes and continuing challenges" *Ecology and Society*, 19(2): n.p.

North, D. (1990). Institutions, Institutional Change and Economic Performance. Cambridge University Press, Cambridge, MA.

Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge, MA: Cambridge University Press.

Ostrom, E. (2003). "How types of goods and property rights jointly affect collective action" *Journal of Theoretical Politics*, 15(3): 239–270.

Ostrom, E. (2005). *Understanding Institutional Diversity*. Princeton, NJ: Princeton University Press.

Ostrom, E. (2007). "A diagnostic approach for going beyond panaceas" *PNAS*, 104(39): 15181–15187.

Ostrom, E. (2009). "A general framework for analyzing sustainability of social-ecological systems" *Science*, 325: 419–422.

Ostrom, E. (2011). "Background on the institutional analysis and development framework" *Policy Studies Journal*, 39(1): 7–27.

Ostrom, E., and Cox, M. (2010). "Moving beyond panaceas: A multi-tiered diagnostic approach for social-ecological analysis" *Environmental Conservation*, 37(4): 451–463.

Ostrom, E., Gardner, R., and Walker, J. (1994). *Rules, Games, and Common-Pool Resources*. Ann Arbor, MI: University of Michigan Press.

Poteete, A.R., Janssen, M.A., and Ostrom, E. (2010). *Working Together: Collective Action, the Commons, and Multiple Methods in Practice*. Princeton, NJ: Princeton University Press.

Ribot, J.C. (1998). "Theorizing access: Forest profits along Senegal's charcoal commodity chain" *Development and Change*, 29(2): 307–341.

Schlager, E., and Cox, M. (2017). "The IAD Framework and the SES Framework: An introduction and assessment of the Ostrom Workshop frameworks" in Weible C and Sabatier P eds, *Theories of the Policy Process*. Boulder, CO: Westview Press.

Schlager, E., and Ostrom, E. (1992). "Property-rights regimes and natural resources: A conceptual analysis" *Land Economics*, 68(3): 249–262.

Wilson, D.S., Ostrom, E., and Cox, M.E. (2013). "Generalizing the core design principles for the efficacy of groups" *Journal of Economic Behavior and Organization*, 90: S21–S32.

Wollenberg, E., Merino, L., Agrawal, A., and Ostrom, E. (2007). "Fourteen years of monitoring community-managed forests: Learning from IFRI's experience" *International Forestry Review*, 9(2): 670–684.