**SES FRAMEWORK: INITIAL CHANGES AND CONTINUING CHALLENGES**

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**Abstract:** The Social-Ecological Systems (SES) framework investigated in this special issue enables researchers from diverse disciplinary backgrounds working on different resource sectors in disparate geographic areas, biophysical conditions, and temporal domains to share a common vocabulary for the construction and testing of alternative theories and models that determine which influences on processes and outcomes are especially critical in specific empirical settings. After justifying the need for such a general framework, this article summarizes changes that have already been made to this framework and discusses a few remaining ambiguities in its formulation. We expect that the SES framework will continue to change as more researchers apply it to additional contexts, but the main purpose of this article is to delineate the version that served as the basis for the theoretical innovations and empirical analyses detailed in other contributions to this special issue.

The SES framework was originally designed for application to a relatively well-defined domain of common-pool resource management situations in which *resource users* extract *resource units* from a *resource system*, and provide for the maintenance of that system, according to rules and procedures determined within an overarching *governance system*, and in the context of *related ecological systems* and *broader social-political-economic settings*. Processes of resource extraction and infrastructure maintenance were identified as among the most important forms of *interactions and outcomes* (or *action situations*) located in the very center of this framework. Since social-ecological systems also generate public goods and ecosystem services, we introduce incremental revisions to the SES framework in order to generalize its applications to complex multiresource systems. We replace the restrictive term “user” with a more generic category of “actor” and incorporate complex patterns of interaction among multiple actors and resource systems in the context of overlapping governance systems. We also develop the impact of evaluative criteria and other sources of dynamic change within this framework. Then we discuss potential directions for later development to incorporate complex technical systems, multiple layers of governance institutions, and diverse forms of learning and adaptation.

Each of these suggested modifications is developed in more detail in other contributions to this issue. As a whole, these articles demonstrate that the SES framework as currently constituted has already inspired high-quality research, and that it has the potential to further facilitate communication among scholars from a broad array of disciplines working on diverse resources in many different parts of the world.

**Key Words:** social-ecological systems; frameworks; institutional analysis; governance

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## INTRODUCTION

Most of the authors of articles in this special issue have been working together since the publication of "A Diagnostic Approach for Going beyond Panaceas" (Ostrom 2007) to build on and improve the Social-Ecological Systems (SES) framework initially proposed therein. After briefly summarizing the ambition that lay behind that effort, this article provides an overview of the initial changes that have been made to this framework as a consequence of continuing interactions among members of a still-growing network of collaborators. We also raise concerns related to potential changes in the representation of learning and governance systems that remain unresolved at this time. The final article in this volume revisits these issues, as well as other aspects of the diverse articles included in this volume.

Readers should be warned that the framework developed here is *complicated*, as an early commenter put it politely. However, we are convinced that it is essential to first establish a common conceptual language if we are to glean general lessons from a growing number of empirical investigations of the specific institutional arrangements devised by user groups (and other entities) in the management of diverse kinds of natural and technological resources in all regions of the world.

## INSPIRATION BEHIND THE SES FRAMEWORK

Now that increasing numbers of scholars are interested in sustainability of social-ecological systems (SES), the problem of how to provide a coherent analysis of complex, nested systems operating at multiple scales becomes ever more challenging. The disciplines at the forefront of SES research (ecology, political science, geography, economics) have evolved over time and each has developed its own technical languages. If one is addressing how multiple forms of governance influence sets of resource users of various scales and background and how they impact on resource systems that have diverse characteristics, one needs to draw on multiple scientific disciplines to address such questions. One cannot just pick up any single disciplinary language system and apply it to a new problem. Frequently, the definition of terms in one discipline's language differs from those of another discipline, such as the meaning of community in ecology as contrasted to sociology.

Since SESs are inherently complex, theory is needed to guide the selection of an effective analytical focus. Yet, no *one* theoretical perspective is sufficient to analyze all feasible situations. Hence, we need a common framework for analysis that can help begin the process of organizing our understanding of the factors that may be relevant to an explanation of a particular phenomenon.

Initial discussion of the SES framework identified several priorities guiding its development. The basic idea was to develop an organizing framework that would enable researchers from diverse disciplinary backgrounds working on different resource sectors to share a common vocabulary and a logical linguistic structure for classifying those factors deemed to be important influences on the types of SESs of most interest to them. This common language would enable productive comparisons to be drawn among different types of resource systems used in different ways by diverse communities living and working in disparate geographic areas, biophysical conditions, and temporal domains. It would also provide the basis for subsequent efforts to comparatively test theories focusing on different levels of aggregation.

This language framework was intended to remain “theory-neutral” so that competing hypotheses from alternative theoretical perspectives could be evaluated on a common basis. Finally, this exercise could serve the important purpose of identifying gaps in the existing literature, and especially gaps in existing data sets, and thereby provide compelling evidence that could be used to support applications for external funding.

The hope was that such a conceptual framework could, eventually, provide the foundation for establishing a diagnostic procedure through which institutional analysts could discern the most difficult problems facing stakeholders in a given set of circumstances. The remainder of this section explains what we mean by a framework as contrasted to theories and models, and why we think its establishment can be such an important advance on the current state of affairs.

## Frameworks, theories, and models

A puzzle for many scholars is the difference between frameworks, theories, and models. The three terms are causally used almost interchangeably by scholars coming from different backgrounds. Here we draw upon a well-established distinction among framework, theory, and model (Ostrom 2005). A “framework” provides the concepts and terms that may be used to construct the kinds of causal explanations expected of a “theory.” A “theory” posits specific causal relationships among core variables, while a “model” constitutes a more detailed manifestation of a general theoretic explanation in terms of the values of particular variables and functional relationships. Just as different models can be used to represent different aspects of a given theory, different theoretical explanations can be built upon a common conceptual framework.

Frameworks, theories, and models are nested concepts related to explaining interactions and outcomes in a SES. Analyses conducted at each level provide different degrees of specificity related to a particular problem. Colleagues contributing to this special issue have used all three concepts in their efforts to analyze SES processes and outcomes. In this section, we define the three types of analysis, how they relate to one another, and how they differ.

The development and use of a general framework helps to identify the working parts and relationships among these elements that one needs to consider when studying SESs. Frameworks organize diagnostic, descriptive, and prescriptive inquiry. They provide the most general list of relevant concepts that can be used to analyze all types of SESs ranging from Wisconsin lakes (Brock and Carpenter 2007) to the Planet Earth (Rockström et al. 2009). Frameworks provide a metatheoretical language that can be used to compare theories. They attempt to identify the universal elements that any theory relevant to the same kind of phenomena would need to include. Many differences result from the way these variables combine with or interact with one another (but one uses theory to predict outcomes of these relationships). Thus, the elements contained in a framework are the basic concepts that all scholars interested in the same general phenomena need, but if they come from diverse disciplines, how the concepts are defined and ontologically linked may differ substantially. Investment in updating and improving an interdisciplinary framework can provide an essential scientific dictionary for core concepts and their subconcepts so that scholars trained diversely can work effectively together.

The development and use of theories enable analysts to specify which elements of a framework are particularly relevant to certain kinds of questions and to make general working assumptions about these elements and their relationships. Theories select for further analysis a subset of variables in a framework and make specific assumptions that are necessary for an analyst to diagnose a phenomenon, explain processes, and predict outcomes. Several theories are usually compatible with any framework. Diverse ecological and evolutionary theories and multiple social theories (game theory, transaction cost theory, social choice theory, covenantal theory, and theories of public goods and common-pool resources) are all compatible with the SES framework discussed in this special issue.

The development and use of models make precise assumptions about a limited set of parameters and variables. Logic and mathematics, as well as simulation and lab experiments, are used to explore systematically the consequences of these assumptions on a limited set of outcomes. Multiple models are compatible with most theories. In an effort to understand the strategic structure of the games that irrigators play in differently organized irrigation systems, Weissing and Ostrom (1993) developed four families of models just to begin to explore the likely consequences of different institutional and physical combinations relevant to understanding how successful farmer organizations arranged for monitoring and sanctioning activities. This is one of the models we have developed for the precise analysis of a subpart of the theory of common-pool resources.

A number of scholars have asked why we need a framework. Isn't a theory enough? One response relates to the number of diverse processes occurring in SESs. If one is interested in understanding processes of use, maintenance, regeneration, and destruction of natural resources or humanly constructed infrastructures, then one is actually interested in a wide diversity of *different* processes going on either simultaneously or sequentially. One can have broad theories about the diversity of processes going on in such systems, but if scholars work independently on a theoretical explanation for each aspect of a phenomenon, those interested in related phenomena may not understand how work by one scholarly approach is related to theirs.

For policymakers and scholars interested in issues related to SESs, a framework helps to organize diagnostic, analytical, and prescriptive capabilities. It also aids in the accumulation of knowledge from empirical studies and in the assessment of past efforts at reforms. Markets and hierarchies are frequently presented as fundamentally different "pure types" of organization. Not only are these types of institutional arrangements perceived to be different but each is presumed to require its own explanatory theory. Scholars who attempt to explain behavior within markets use microeconomic theory, whereas scholars who attempt to explain behavior within hierarchies use political and sociological theory. Such a view precludes a more general explanatory framework and closely related theories that help analysts make cross-institutional comparisons and evaluations.

**Connecting the IAD and SES frameworks**

For a number of years, colleagues associated with the Workshop in Political Theory and Policy Analysis attempted to cope with the complexity inherent in policy analysis by the development of the Institutional Analysis and Development (IAD) framework (Figure 1). In the past three decades since the first publication of that framework (Kiser and Ostrom 1982), substantial progress has been made, particularly related to the governance of diverse systems and concepts of strategies, rules, norms, and other key institutional terms (see McGinnis 2000, 2011a, Ostrom 2005, 2011, Poteete et al. 2010).

<< INSERT FIGURE 1 ABOUT HERE >>

In extensive work on urban governance, on groundwater, on irrigation systems as well as on forestry resources, we have found that using the IAD framework for our microanalysis of the diverse, problematic situations that individuals find themselves in has been extraordinarily productive (Blomquist and deLeon 2011, Bushouse 2011, Heikkila et al. 2011, Oakerson and Parks 2011, Ostrom 2011). It is certainly possible to do a game-theoretic analysis of the harvesting decisions that individual appropriators from a common-pool resource may engage in when there are no property rights and no informal agreements. A core question of considerable interest is when will the participants cooperate and when will they invest in organizing themselves for longer-term governance and protection of a resource system? As soon as one gets into the wide diversity of puzzles and paradoxes related to governance, one no longer is coping with just a single theory of collective action (or collective inaction).

It is possible to do a formal theory of the costs and benefits of self-organization for the actors involved in a common-pool resource problem (see the SOM for Ostrom 2009). The number of variables that potentially affect the costs and benefits to diverse participants in a process is rather large, however, and it is difficult to get accurate measures of perceived benefits and costs for those involved. When people are in a market situation and they face market prices as benefits and costs, it is a lot easier to calculate net benefit cost ratios than when we are dealing with public goods or common-pool resources.

This is where a framework is particularly useful because one can slowly but surely identify a variety of factors about the resource system, the resource units, the actors involved, and the governance system that impact on initial self-organization. In a recent study of three communities in Mexico, Basurto and Ostrom (2009) were able to assign a three-level measure (low, medium, and high) to the variables posited in general to affect self-organization in an SES and to help explain why two of the communities did self-organize to manage their fishery and the third did not. That is an illustration of the framework and how it can be used. Our International Forestry Resources and Institutions (IFRI) research program and database also give us the chance of addressing multiple questions over time (Wollenberg et al. 2007). The SES framework grew out of our own efforts to identify relevant variables as well as those identified by many scholars in diverse fields. Thus, a framework is useful for identifying potentially relevant general knowledge and the general sweep. While a theory begins to identify how parts of that are linked, a model is a way of being very formal in the way you represent that.

At the heart of the IAD framework is the "action situation" in which individuals (acting on their own or as agents of formal organizations) interact with each other and thereby jointly affect outcomes that are differentially valued by those actors. The IAD framework highlights the social-cultural, institutional, and biophysical context within which all such decisions are made. Specifically, this framework helps organize the task confronting a scholar or policy analyst approaching a policy issue by directing their attention to (1) the rules-in-use, rather than only the rules on paper; (2) the underlying biological, chemical, and physical nature of the resource under consideration, as well as its characteristics in terms of being a private, public, or toll/club good or a common-pool resource (CPR); as well as (3) the most relevant attributes of the community, especially ambient levels of trust, and shared norms of reciprocity.

The IAD framework was based on a dynamic view of policy processes. Social, institutional, and biophysical factors were seen as inputs to a process of decisions made by individuals (with those decisions presumed to be influenced by their preexisting cognitive capabilities and cultural presuppositions). These decisions were aggregated to constitute policy outputs that would then interact with exogenous factors to produce some observable outcomes. Evaluations of these outcomes by these actors (or by other observers) would then feed back into all of the previous components of this never-ending process. In effect, the IAD framework was an extended elaboration on a basic systems model of policy processes.

Systems typically look very different depending on the level of aggregation being used, and that observation certainly applies to action situations. The IAD framework explicitly distinguishes three levels of analysis in which different types of choice processes take place. At the (1) operational level, actors (either as individuals or as representatives of collective entities) make practical choices among their available options, as determined by (2) collective-level choices involving the determination of which strategies, norms, and rules are, should be, or are not available to actors fulfilling the specific roles defined by that group (as well as specifying who is assigned to fill these roles); and (3) constitutional-level choices relating to who is or should be empowered to participate in the making of collective and operational-level decisions. Rules that define and constrain the operational activities of individual citizens and officials were established by collective-choice processes, and the rules by which these rules themselves are subject to modification are determined through a process of constitutional choice. The critical insight behind this framework is that the outcomes of interactions in different levels of analysis are explicitly connected to each other.

The actors in any action situation are presumed to be boundedly rational. They seek to achieve goals for themselves and for the communities to which they identify, but do so within the context of ubiquitous social dilemmas and biophysical constraints, as well as cognitive limitations and cultural predispositions. Within this broad framework, a range of theoretical perspectives may be employed to develop and analyze models of specific situations.

As Workshop scholars began to work more intensively with ecologists, we heard criticism of the IAD framework as not taking concepts of relevance to ecologists as seriously as we were taking diverse levels of concepts related to institutions. This criticism certainly had some merit. Since the IAD framework was designed for application to any type of policy situation, its applications focused on the process through which individuals and communities crafted new policies as partial solutions for changing policy problems. When applied to resource management issues, the natural tendency within the IAD framework was to treat the dynamics of a resource system as a mostly exogenous force, that is, as a driver of changing circumstances and not something directly under the control of the actors setting policy in those settings. This separation between natural processes as drivers and policy processes as the core concern made the IAD framework less directly relevant to the management of the complexly coupled human-natural dynamics of social-ecological systems.

Consequently, we began several years ago to expand the original IAD framework to explicitly encompass the broader set of ecological variables that are needed for the analysis of an SES. Since the publication of the first version of the SES framework (Ostrom 2007), there has been considerable interest by scholars across a wide diversity of disciplines in that approach. In 2009, a revision was published in *Science* (Ostrom 2009) and still more interest accumulated (see, for example, Gutiérrez et al. 2011). In this article, we examine how these reactions have already led to improvements in the SES framework. In later sections, we discuss some proposed future adjustments, specifically in the characterization of governance systems and the dynamic processes of learning and leadership. Other articles in this special issue point toward the establishment of a process that will guide additional future revisions of the SES framework, in hopes of facilitating collective learning from its applications to diverse empirical settings.

## INITIAL MODIFICATIONS

The SES framework was originally designed for application to a relatively well-defined domain of common-pool resource management situations in which *resource users* extract *resource units* from a *resource system*, and provide for the maintenance of that system, according to rules and procedures determined by an overarching *governance system*, and in the context of *related ecological systems* and *broader social-political-economic settings*. The processes of extraction and maintenance were identified as among the most important forms of *interactions and outcomes* that were located in the very center of this framework, as illustrated in slightly different forms in two articles by Elinor Ostrom (2007, 2009).

Previous researchers have identified several attributes of each of these components as being critical explanatory factors in some circumstances, and these factors have been included in the SES framework as second-tier variables or explanatory factors. In addition, allowance was made for the potential relevance of more detailed variables or empirical indicators located at lower tiers in this ontological framework.

To be clear, we use the term “tier” to denote different logical categories, with lower-level tiers constituting subdivisions within elements from the next higher tier. Thus, for example, Resource Systems denotes a top-tier category with second-tier subdivisions denoting such characteristics as its size, type of resource sector, clarity of resource boundaries, etc. In turn, entries in the second tier have characteristics that can be identified at the third tier. To continue this example, size may be denoted in terms of geographic expanse, number of species interacting within that system, etc. Our intention is that this framework could serve as a guide to researchers seeking to investigate questions concerning the initial establishment or sustainability of a particular configuration of patterns of interactions and outcomes experienced within a tightly coupled SES.

As others began to react to the initial statement of the SES framework, several argued that this framework was potentially broader in scope than was originally claimed. Several colleagues have questioned whether it made sense to restrict attention to common-pool resources. Social-ecological systems also generate public goods and services, most notably the ecological or ecosystem services upon which many markets depend for their continued operation. A related concern was this framework's potential relevance for social-technical systems, for which the outcome can range from private consumption goods to complex infrastructures shared by members of widely dispersed communities.

In this section, we specify a few minor modifications that emerged from a series of interactions among colleagues who have participated in a series of meetings to discuss and build on the foundation of the SES framework. We have called ourselves the SES Club (see E. Ostrom, this issue, for a brief history of the SES Club). Each of these modifications moves the framework in the direction of increased generality. Later sections in this article, as well as other articles in this issue, discuss more substantial modifications that are currently under consideration.

Figure 2 and Table 1 illustrate the updated SES framework as it was used by contributors to this special issue. (Specific changes in this figure and table are explained later in this article.) Rectangular boxes are used in Figure 2 to denote first-tier categories, and Table 1 is an updated list of the second-tier variables included within each of the top-tier categories. The rectangles used for Resource Systems, Resource Units, Governance Systems, and Actors are the highest-tier variables that contain multiple variables at the second tier as well as at lower tiers. Action Situations are where all the action takes place, as inputs are transformed by the actions of multiple actors within them into outcomes. The dotted-and-dashed line that surrounds the interior elements of the figure indicates that the focal SES can be considered as a logical whole, but that exogenous influences from related ecological systems or social-economic-political settings may impact any component of that SES. These exogenous influences may emerge from the dynamic operation of processes at either larger or smaller scales than that of the focal SES.

<< INSERT FIGURE 2 AND TABLE 1 ABOUT HERE >>

**Recognition of action situations**

The IAD framework attached prominence to the concept of an action situation – in which actors in positions made choices among available options in light of the information they had about the likely actions of other participants and the benefits and costs of potential outcomes. In the conceptual schema of the IAD framework, the structure of the action situation is defined by contextual variables, and the action situation generates patterns of interactions and outcomes that are later evaluated against various criteria. The initial versions of the SES diagnostic framework (Ostrom, 2007, 2009) implicitly incorporated the action situation within the box labeled as interactions and outcomes. Initial feedback on these versions of the SES framework suggested that the action situation needed to be explicitly incorporated.

Accordingly, Ostrom (2010) used the occasion of her Nobel Prize acceptance speech to change the label of the Interactions and Outcomes box to also include the broader term – Action

Situations. This simple step cemented a close connection between decades of work on the IAD framework and the newly established SES framework. In effect, the other components of the SES framework constitute a fuller elaboration of the relevant contextual factors that contribute toward a definition of the situation confronting actors located within a social-ecological system. The patterns of behavior they exhibit can then be characterized with reference to the second-tier and lower-tier variables included in the SES Action Situations category. In both the IAD and SES frameworks, feedback paths link outcomes of action situations back to the contextual variables, thus conveying an explicitly dynamic structure upon both frameworks.

All the factors listed in the SES framework are best interpreted as parameters or state variables in place at a given point in time. Outcomes of action situations at one point in time may influence the values of that same system in effect at later times. This form of feedback closely resembles the feedback paths that were explicitly included in the initial formulation of the IAD framework. Feedback paths were also included in the initial figures representing the SES framework, but we now realize that it is necessary to develop a clearer statement of the dynamic formulation implicit in this framework. In short, changes in any of the characteristics listed in the top-tier categories can be included as potential outcomes from action situations. We return to this question of dynamic representation in a later section.

**Generalizing users to actors**

The SES framework drew the attention of researchers investigating diverse types of resources, including several studying highly technical systems of infrastructure networks. For such applications, it is important to consider the behavior of third parties who are not direct users or consumers of the product or service in question. For example, the operators of a nuclear power plant are not "users" of the resource of electrical power generation, but their contributions to this system are critical and cannot be ignored. For this reason, the term "user" seemed inappropriately restrictive. In a meeting held in Delft in May 2010, participants agreed that the category "Actors" was more inclusive than "Users," and this change was recommended for any future application. As noted in the article by Hinkel et al. (this issue), the category Users is now treated as a subcategory of Actors.

Hinkel et al. also introduce a set of rules that should guide decisions about making changes in this framework. One of their suggestions is that after making a change in the terms used in any tier, it is critically important to reexamine each of its subcategories or attributes at lower tiers in order to make sure that these same terms are meaningful for the new label. In some cases, the changes required are simple, as in the change from U1 (number of users) to A1 (number of actors). Other changes required more thought. For example, U3 (history of use) was reworded to A3 (history or past experiences) to allow for the influences of past experiences in any kind of relevant activity. Similarly, U9 (technology used) is now written as A9 (technologies available).

By replacing Users with Actors, we greatly expanded the potential range of application of this framework, since we could now examine situations in which the set of direct participants in processes of resource extraction was not identical to the set of participants consuming the product of their labors. Allowing for the simultaneous operation of several action situations is useful for representing complex systems. McGinnis (2011b) defines action situations as adjacent to each other when outcomes generated in one action situation affect a structural attribute or affect the rules under which interactions occur within the other action situation. In that analysis, adjacent action situations are linked through changes in their internal structures as well as flows of material, financial, or informational resources.

McGinnis (2011b) uses examples from three distinct policy areas to illustrate the different kinds of adjacency networks that apply in different settings. For the case of Maine lobster fisheries, local user groups have sufficient autonomy to set and enforce their own rules (Acheson 2003), whereas beneficiaries in the cases of international development assistance or domestic welfare policy are unable to participate in such a wide range of relevant activities. If we restricted ourselves to cases where "users" can be easily identified, then it would not even be possible to consider applying the SES framework to the latter two policy sectors.

In the updated SES framework, groups of actors can be distinguished by the range of activities in which they are engaged. The list of relevant activities is, in turn, specified by the second-tier factors in the Interactions part of the Action Situations category. For different applications, it may be necessary to add additional processes to that list, but for now we leave these additions to subsequent research. We do wish to note, however, that in cases like that of the Maine lobster fisheries, analysts may interpret "user" as a particular type of actor, one that is simultaneously engaged in the processes of harvesting, producing, and consuming resource units.

**Multiple versions of top-tier components**

Initially, the SES framework was presented as if the focal action situation involved only one set of users, inhabiting one overarching governance system, who were dependent on a particular type of resource unit, which were in turn extracted from a particular resource system. The possibility of multiple governance settings or ecosystems was incorporated in the S and ECO categories located outside of the focal box. However, the initial figures made it appear as if the framework allowed only one instance of each of the first-tier components.

In practical examples, some researchers identified more than one resource system, or more than one relevant resource unit, as well as multiple user groups. For example, in his analysis of *acequias* in New Mexico, Cox (this issue) treats a network of irrigation canals and infrastructure and an underlying set of shallow aquifers as two separate subcomponents of the overall resource system.

We now prefer to use a representation that explicitly allows for the coexistence of multiple instances of each of the top-tier components. As shown in Figure 2, each of the top-tier components of the SES framework can exist in multiple manifestations in any particular application. Different sets of actors may be engaged in extracting or producing different types of resource units drawn from one or more resource systems, and their activities may be guided by rules drawn from overlapping governance systems. The analysis of focal systems involving irrigation systems, for example, requires specification of at least two action situations: one that focuses on how the physical system is maintained and a second that focuses on water distribution. Further, there may be two related resource systems: surface water and groundwater.

Allowing each of the first-tier components to exist in multiple versions is a major revision of the framework as it was originally presented. It also imposes an additional task on any analyst using this framework, namely, the specification of how different instances of first-tier components are related to each other. For example, actors engaged in extracting resource units from one resource system may not have rights to participate in rule-making activities for that same system. In other settings, exactly the same actors may be engaged in the full range of activities, from extraction to rule-making to sanctioning (McGinnis 2011b). Yet a single framework needs to be able to encompass both of these configurations.

After considering alternative formulations, we have decided to treat each instance of a single category as an element of the set of potential empirical referents of that conceptual category. To continue with the *acequias* example, each network of interconnected irrigation canals and each aquifer can be treated as an instance of the Resource Systems category. For some applications, it may be useful to aggregate all aquifers into a single resource system, but for other purposes it is useful to consider them separately. For some resource questions, it might be more appropriate to treat the entire irrigation-aquifer system as a single integrated water resources system or the watershed of the river as a whole. On the social side, it may also be desirable to treat the river valley as a single integrated community for some research questions, while other circumstances will require consideration of each tribal community or political jurisdiction as separate entities. In addition, each actor type must be associated with the range of activities or interactions in which that type of actor is involved.

In sum, the same set of second- and lower-tier factors are potentially relevant for application to resource or social entities located at different levels of aggregation. No matter what level of aggregation a researcher finds most appropriate for a given investigation, the SES framework provides what we hope can become an exhaustive ordering of all potentially relevant explanatory factors.

**Differentiating among diverse relationships**

Allowing for multiple instances of each of the top-tier concepts highlighted another issue. Some colleagues noted that the SES framework was effectively an ontology, in the sense that it defined a language of terms and specified a series of logical relationships among these terms. As we attempted to elaborate this underlying logical structure as a formal ontology, it became clear that these categories were linked together in more than one way. As a consequence, we need to be more explicit in the nature of the relationships we posit between components of the SES framework.

This topic is covered in detail in Hinkel et al. (this issue), so we can be brief here. Some relationships are compositional in form, such as the resource units that are contained within a resource system or the actors who are jointly influenced by the operation of a particular governance system. Alternatively, a resource system can be said to generate resource units that may be consumed in many forms. Other factors identified in the SES framework are attributes attached to instances of that class of entities, such as the number of actors involved in harvesting activities, or the physical extent of the resource system under consideration. Still other attributes must be associated to aggregations of units, or refer to properties that emerge at higher levels of aggregation. Finally, instances of different governance systems may interact with each other, and with other top-tier components, in a wide variety of ways. These interactions can be interpreted as instances of the action situation component, and may involve a large number of instances from one, two, three, or all four of the primary top-tier components (actors, governance systems, resource systems, and resource units).

## The updated framework

All of the modifications discussed above are incorporated into Figure 2. Multiple boxes are used for each subcomponent to illustrate the potential for concurrent operation of multiple instances of each of these first-tier components. Labels are added to the direct links denoted by solid lines in this figure. This was done to highlight the different logical nature of these connections. For example, resource systems that are characterized by a diversity of attributes include resource services and physical units that can be consumed or extracted for use by actors. Any given governance system will have authority over some defined set of actors, and its outcomes may effectively define the nature of those actors and the options available to them. Whereas actors participate in action situations, resource units are better interpreted as inputs into the processes that take place there. Both governance systems and resource systems set the conditions under which action situations take place. In terms used in the IAD framework, these categories specify the rules-in-use, attributes of the community, and the nature of the goods that serve as contextual or background conditions.

Labels in Table 1 were revised to reflect the specific changes detailed above. In addition, a few additional forms of interactions have been added to the original list of action situations. For example, the activities required for monitoring should be considered as forms of interaction (and thus within the Action Situations category) that are logically distinct from the monitoring rules included under the Governance Systems category. Evaluative processes have been included in the list of interactions, and O1, O2, and O3 have been designated as Outcome Criteria.

After reexamining the initial labels assigned to the second-tier factors under the initial RU category, we decided that RU6 (distinctive markings) should be replaced by RU6 (distinctive characteristics). Although markings make sense for application to such tangible resources as animals, that term does not seem appropriate for the case of electricity or a portion of the electromagnetic spectrum. Further, other characteristics of living entities identified by ecology – such as the breeding season and locations – frequently affect the outcomes of action situations.

To summarize, Figure 2 and Table 1 incorporate the following changes from the versions presented in Ostrom (2007, 2009):

1. Changes in labels for first-tier categories:
    a. Actors (A) replaces Users (U), and each Ux changed to Ax for second-tier attributes in that category.
    b. Action Situations added to label for Interactions and Outcomes (as in Ostrom 2010).
2. Multiple instances of first-tier categories may be included in applications.

3. Figure 2 includes labels summarizing the logical relationships between first-tier categories. Specifically, resource units are considered to be parts of (or drawn out of) broader resource systems and governance systems define and set rules for all actors.
4. Monitoring activities are included as a particular instance of the Action Situations category, with the rules under which monitoring takes place remaining under Governance Systems.
5. Evaluative activities are included as another action situation, and Outcome Criteria are specified as such.
6. Changes in the list of relevant social, political, or economic settings include the addition of Technology as a potential source of exogenous shocks, and generalization of market incentives to any factors relating to markets and government resource policies to other potentially relevant governance systems.
7. RU6 (distinctive characteristics) substituted for RU6 (distinctive markings), with the expectation that Distinctive Markings would be moved to the next lower tier.
8. “Levels” was deleted from Harvesting Levels (I1) to keep the focus on interactions rather than outcomes.

All these changes were made in the interests of generalizability, by extending the SES framework to apply to complex social-ecological systems in which multiple sets of actors consume diverse resource units extracted from multiple interacting resource systems in the context of overlapping governance systems. Figure 2 and Table 1 summarize the framework as it was understood by authors of the studies reported in this special issue. As our colleagues discuss elsewhere in this issue, we are certain that there will be further modifications as empirical and theoretical advancements are made in SES studies. Indeed, several of our colleagues report on significant advances in the concluding article. That version will be defined as the initial version of the electronic repository of the SES framework that the SES Club will collectively maintain. From this point forward, a wiki will be used to maintain records of any subsequent modifications to the SES framework.

## TOWARD FUTURE EXTENSIONS

In this section, we discuss a few aspects of the SES framework that continue to puzzle us. Given the ambitious reach of our goals, it should not be surprising that our effort to encompass so much within a single framework has generated conceptual issues that are not easy to resolve. Here we discuss three issues that we consider to be critically important for the future development of this mode of analysis, specifically potential expansion to cover all kinds of goods and services, the nature of governance institutions, and processes of individual and collective learning.

### Technical systems, goods, and services

Some colleagues have been eager to see us allow for a broader interpretation of the resource side of a social-ecological system. Specifically, some expressed a strong interest in being able to apply a similar mode of analysis to understand the governance of an artificially constructed technological system, such as a power grid or telecommunications system. Members of the SES Club continue to disagree over the extent to which a single analytical framework might be applied to both social-ecological systems (SES) and social-technical systems (STS).

Künneke and Finger (this issue) specify revisions to the SES framework that they argue are necessary to make a revised framework applicable to social-technical systems. The SES framework is designed to be applicable to a wide array of resource systems, and we are convinced that a few revisions to the SES framework could make it fully applicable to the study of social-technical systems. For example, human-constructed facilities were already included in the initial formulation as part of the Resource Systems category (RS4). However, Künneke and Finger have convinced us that it makes sense to add Technology (S7) as a separate component of the Social, Economic, and Political Settings located at the top of the revised SES figure. Technological changes in one area can have important spillover effects on other aspects of resource utilization, and there needs to be a place in the SES framework to allow for those types of exogenous shocks.

Künneke and Finger point out that appropriation per se is less critical to an STS than is typically the case for naturally occurring resource systems. But, as we argue above, appropriation is only one of the many action situations that comprise a given application of the SES framework. Applications to STS may emphasize different types of action situations, but no two resource systems are likely to have exactly the same set of critical action situations.

Künneke and Finger argue that a fundamental defining characteristic of a social-technical system is that the resources or services that it generates are not replenished by natural processes. Yet much the same could be said for any irrigation system, or fishing nets that need to be maintained or repaired, or crops that need to be replanted each year, or indeed for any process of resource extraction in which technology plays a critical role.

Also, there are important differences in the ways in which primary users experience their interaction with an SES or an STS. Fish drawn from a fishery can be identified as discrete entities, but those dependent on electric power tend to see its delivery more in terms of a continuous service rather than the purchase of discrete units. Another important difference is that there may be a clear separation between those with the technical expertise to understand the construction and maintenance of an STS and those who are merely concerned about continued access to this resource versus the more direct experience of ecological dynamics that users of natural resources may experience.

Frankly, we do not find it easy to specify exactly how a social-technical system differs from a social-ecological system. The social side seems the same in both instances, although the ultimate users of a technical resource may, in most cases, be further removed from those who actually construct the resource than is the case for fisheries. But the SES framework can incorporate many different kinds of actors, ranging from those who extract or build the resource to those whose only interest lies in consuming resource units or enjoying uninterrupted access to a resource service. There is an important distinction between the relatively natural dynamics found in ecological systems and the constructed dynamic process of complex technical systems, but the distinction between natural ecology and artificial technology is not as clear-cut as it may initially appear. In today’s world, it is virtually impossible to find any ecological system entirely free from human interference, nor is there any STS in which the continued operation of the relevant technology bears no dependence on naturally occurring phenomena.

Our discussions on the relationship between SES and STS have been especially useful in clarifying the potential power of this mode of analysis. This line of discussion helped clarify another aspect of social-ecological systems, namely their importance in the delivery of services that are difficult to conceive of as discrete units or products. For example, a forest can provide critical services in terms of water storage and purification, whether or not these ecosystem services are assigned an explicit economic value.

Our interpretation is that a resource unit need not be required to be as easily divisible as are most private goods. A public good is, by definition, consumed collectively, and cannot be divided into discrete subunits.  But if a resource unit is not divisible, then it may be possible to treat it as being a single unit. We admit, however, that such an interpretation may lead to confusion. Perhaps it would be better to add another second-tier characteristic to designate the Divisibility (or discreteness) of the resource services or units under question.

We considered changing the name of the Resource Units (RU) first-tier category to the more inclusive category of Resource Services and Units (RSU), but ultimately we were not able to obtain a sufficient level of consensus among the members of the SES Club. This change would have explicitly allowed consideration of services that cannot be broken into distinct units, and such services can be important in both social-ecological and social-technical systems.

Another, more radical, proposal would be to replace Resource Units with a category that would include any kind of Goods and Services that can be produced from inputs drawn from a Resource System. Doing so would move the resulting framework a long ways from its origins in questions of resource use, and would require a more explicit consideration of production, exchange, and other core concerns of the discipline of economics.

**Governance institutions and systems**

Of all the top-tier SES components, the initial list of factors for Governance Systems now seems to us to be the least compelling. The more we have worked with the SES framework, the more selection of those particular subcategories seems to have been guided by a different logic than the others. However, we also realize that others have used these categories to organize their own analysis of particular resource sectors. Furthermore, in this issue, Hinkel et al. have defined a procedure intended to guide future modifications to the SES framework. So, at this time, the most we can say is that we would expect the implementation of this procedure will most likely result in some significant changes in this particular category.

One difficult issue concerns the status of collective actors, including the organizations included as second-tier characteristics in the Governance Systems category. It is our understanding that actors in the SES framework may be collective entities, but that, in most instances, a specific individual can be identified as acting as an agent on behalf of that entity. The rules that define and govern the responsibilities of the role of agent should then be included as properties of the relevant governance system. In this way, a government organization, for example, would appear in two different top-tier categories of the SES framework. When an analyst is concerned about the actions taken by the agents of that organization, attention should be directed to the Actors category, but attention should be directed to the Governance Systems whenever it becomes necessary to explain the capabilities and responsibilities of that agent. By a similar logic, the norms that an actor considers relevant to his or her actions in a given setting can be treated as attributes of that actor, whereas the broader repertoire of norms available to individuals within the relevant social and cultural setting might best be interpreted as attributes of the governance system as a whole. We realize that not everyone will find this strict separation between structure and agency to be compelling, but it would be unreasonable to expect that any representation would be equally satisfying to the full range of social scientists and policy analysts. Instead, all we strive for is precision, to be perfectly clear about our intended meanings.

In hopes of triggering further investigation, we offer the following tentative list of potential second-tier (and selected third-tier) factors under the Governance Systems category (Table 2). Clearly, this list is significantly different from the list included in the original versions of the SES framework, as well as the updated version given above. Full implementation of this change would require a long and careful process of analysis focused on the implications of these changes. However, all of the factors included in the original list are still here, albeit in different locations.

<< INSERT TABLE 2 ABOUT HERE >>

We are proposing consideration of these changes in hopes of better clarifying how the logical underpinning of the second-tier factors in this category relates to the logic used in defining the other categories. (We use asterisks to remind the reader that these are only suggestions and not changes in the official structure of the SES framework.) Thus, we begin with GS1* as a specification of the relevant policy area (environment, trade, health, etc.), in a manner analogous to the resource sector variables that begin the list of Resource Systems characteristics.

For governance systems, there are two kinds of scale that need to be considered – its geographic range (GS2*) as well as the size of the population (GS3*) that participates in, or is subject to, that system of governance. In some instances, this population will be members of a jurisdiction defined in geographic terms, but in other instances the population may be defined on a functional basis, as in the Type II governance systems described by Hooghe and Marks (2003). Also, any single system of governance may encompass individual or organizational actors, or both.

Regime type (GS4*) moves to a more macro level by specifying the overall logic upon which the overarching governance system is organized. The term "regime" can be used in different ways, but for our purposes critical distinctions include between democratic and autocratic systems of governance, or between well-studied forms of "modern" governance and more traditional or indigenous systems. Another conceptual distinction is the one between monocentric and polycentric systems (Ostrom, Tiebout, and Warren 1961), based on the overarching logic of sovereignty, as understood by citizens within that system.

Within any governance system, different types of organizations may be responsible for crafting and/or implementing different kinds of rules. The next two factors specify the nature of these organizations (GS5*) and of the rules these organizations generate and/or implement (GS6*). The initial list of second-tier factors in Ostrom (2007, 2009) specified only governmental and nongovernmental organizations, but we have expanded this list to include private corporations, community-based organizations, and hybrid organizational forms that combine aspects of public, private, or voluntary organizations. Any of these rule-making organizations may operate at different scales, from local to regional to national to global. All of these types of organizations can play important roles in shaping the conditions under which rules-in-use are enacted in increasingly complex systems of governance.

Four of the second-tier factors listed in the original list are subsumed within our proposed new category of Rules-in-Use (GS6*). Drawing on the IAD framework, we distinguish among rules directed at operational decisions, those guiding collective choices, and those rules relating to constitutional-level questions. Although monitoring and sanctioning processes were initially included as a second-tier component of governance systems, we now prefer that characteristics related to these patterns of interaction are more appropriately located within the Action Situations category.

Given the importance attached to monitoring and sanctioning in sustainable systems of resource governance, it is worth distinguishing among relevant rules that are promulgated or otherwise established at the level of the governance system from their actual implementation in action situations. Rules concerning permissible forms of punishment are demarcated at the constitutional level, rules concerning the assignment of monitoring responsibilities and specification of the magnitudes of sanctions are defined at the collective-choice level, and rules governing implementation are realized at the operational-choice level.

More generally, any of the policy tools or policy instruments (Sterner 2003) that have been used by governmental or other policy agents can be decomposed into constitutional-, collective-, and operational-choice components. For example, a cap-and-trade scheme begins with the constitutional choice of what resources can legitimately be subject to this constructed market, followed by the collective choices of the allowable aggregate levels of extraction or use and the number and size of tradable units, and finally the operational-level trades among participants as well as the innovative technological responses that such a system is intended to inspire.

Rules that relate to ownership of property can also fall within each of these IAD categories. At the constitutional level, broad parameters are set concerning what can be considered to be someone's property, collective-choice decisions include what forms of property can be expropriated for the use of public purposes, and operational-level aspects distinguish among those actors with access, withdrawal, management, exclusion, and alienation. However, as emphasized by Schlager and Ostrom (1992), property rights are not rules. Instead, property rights define relations among people in relation to things, and specify both duties and obligations. Given the obvious importance of property-rights systems to the study of social-ecological systems, we include this factor as our proposed GS7*.

Although rules, norms, and shared strategies are included as alternative forms of institutional statements in the grammar of institutions (Crawford and Ostrom 1995), it is safe to say that norms per se have received less explicit attention by scholars working with either the IAD or SES frameworks. Still, we think it is important to include in our list of governance system characteristics (GS8*) a term encompassing the entire repertoire of norms or shared strategies that are available for the use of actors engaged in a particular setting. In effect, this term reflects the myriad ways in which culture affects decisions regarding social-ecological systems. As such, it needs considerably more attention and development to fill out the sociological and anthropological components of any application of this framework.

Network structure (GS9* in our proposed list) refers to the connections among the rule-making organizations and the population subject to these rules. Measures of network centrality or concentration would fit here.

The last item on our proposed list, Historical continuity (GS10*), is included to distinguish between those systems of governance that have been in place for long periods of time and those that are more recent in form. All forms of governance have deep roots in historical precedents, but some systems are more inclined toward stasis and others toward more flexible modes of response.

Although we can imagine other potentially relevant factors, we stop at this point, since this list is only meant to be suggestive and to inspire subsequent investigation. We do not presume that our proposed list is the final word on this matter. As with all other aspects of the SES framework, we encourage others to make additions or revisions, if these are needed to accomplish their research or policy objectives. This framework remains a work-in-progress, and we hope it will continue to change through use, but that future iterations will remain within the general structure detailed in this volume.

**Learning and other dynamic processes**

Words and pictures are often an incomplete representation of the full range of meaning intended to be included in a general concept, and we are concerned that our presentation of the SES framework may convey the mistaken impression that it is static in nature. That is far from our intention. The feedback paths incorporated in Figure 2 suggest that the consequences of action situations may spread to any of the other top-tier variables, but our experience is that this interpretation is not immediately obvious to all observers. Thus, to be precise, we interpret all of the factors included in the RS, RU, A, and GS categories to be, at least potentially, both inputs to and outputs from one or more action situations. Action situations take as inputs the values of the SES top-tier categories in time t and may generate changed values of those factors in time t+1.

It is the action situation where human activities directly impact natural processes, and vice versa. Yet each of these categories is itself in motion. Resource systems operate according to complex dynamic processes, many of which will occur with or without human intervention. Resource units, once extracted from a natural system and converted into some good or service, exhibit their own dynamic processes of change, including natural degradation over time. Individual actors are born and die, and systems of rules and norms exhibit changes over time that may be difficult to attribute to the actions of particular individuals. One way to convey this sense of the intrinsic dynamism of each of the top-tier variables would be to include circular arrows within each rectangle. However, most of the dynamic processes in the SES framework occur in the action situations where particular manifestations of the relevant resource systems, resource units, actors, and governance systems interact with each other and generate outcomes that can potentially change many, perhaps all, of these input factors.

The potential list of relevant action situations may turn out to be very long indeed, but learning is a process that we think is especially important to mention, and to which more explicit attention needs to be paid. Learning occurs within and across action situations. One of the puzzles regarding learning is whether it is an interaction or an outcome. Deliberative activities, included as a second-tier characteristic of action situations (I3), clearly constitute interactions – actors are engaged in discussions about what they are doing, the goals they should pursue, what strategies, etc. But learning is something more fundamental, since it plays such a critical role in the temporal connection between an SES at time t and its successor at t+1.

Our perplexity arises from continuing differences across disciplines. If you assume complete information (as in neoclassical economics), then learning is not considered a distinct process and as a consequence does not play any significant role in most economic analyses. Conversely, for scholars from psychology or cognitive science, learning is one of the core processes that they are trying to explain.

Another complication is that learning can occur on multiple time scales. Individuals learn during their lives, and language allows them to convey knowledge to contemporaries and to later generations. At the organizational level, new understandings can be incorporated within the set of decision procedures being implemented by members of that organization. Societies can also be said to learn, in the sense that traditions change over time, through a complex process of adaptation to new circumstances. In addition, information can be lost over time, and may have to be rediscovered by later generations.

Ecologists and others who study systems that exhibit complex dynamics are particularly sensitive to the concurrent operation of dynamic processes operating at different time scales. Direct feedback can be immediate, whereas other feedback paths are indirect and may be subject to time lags of varying duration. Complex systems can adapt over time, and can change dramatically when they cross thresholds that may not be apparent to observers at the time of transition. Given the complex dynamics of systems including multiple feedback paths, the researcher must carefully specify the time frame considered relevant for explaining outcomes.

Pahl-Wostl (2009, this issue) has articulated a similarly complex view of learning dynamics, specifically by differentiating among first, second, and third levels of learning loops. In the first loop, actors revise their strategies in light of the consequences they observe. Over a longer time frame, these mechanisms of observation and updating may be incorporated into the collective processes that guide selection of these strategies. In the third loop, organizational structures may be fundamentally transformed into learning organizations, optimized to make effective use of available information on a timely basis.

These three loops roughly correspond to the levels of analysis in the IAD framework. The first type of learning should be routine in operational-level interactions, whereas the second level of learning requires changes in the procedures through which collective policy decisions are made. The more fundamental changes identified in the third loop could be related, within the IAD framework, to either the constitutional or meta-constitutional level (Ostrom 2005, McGinnis 2011a).

Elsewhere, Pahl-Wostl (2009) posits explicit connections between generic stages of a policy process and specific action situations she identifies in her analysis of water management processes. In the dynamic models constructed on the basis of her Management and Transition Framework, action situations generate outputs in the form of flows of operational resources, knowledge, or institutional changes. This dynamic logic seems quite congruent with the intentions behind the SES framework, since the outcomes of many actions situations will change the values of several variables in the SES as measured at times t and t+1, thus serving as the analytical link between the static variables listed in the other first-tier headings. However, it is not apparent how this connection might best be formalized.

In a chapter entitled "Animating Institutional Analysis," Ostrom (2005) highlights the importance of a more careful specification of the processes through which actors learn new norms and decision heuristics. Poteete et al. (2010) summarize subsequent research demonstrating the critical importance of microsituational variables on the ability of groups to develop the levels of trust and capacities for learning required for sustainable collective action. But trust is not something that can be "created" on demand, as it takes time to be established and recognized as such.

Our problem is that we are not quite sure where these feedback paths and learning process should be located within the SES framework. When multiple action situations are relevant, they exhibit dynamic processes operating at different scales, with production feedback occurring more rapidly than feedback in terms of constitutional procedures, for example. Single or even double loop learning might be incorporated within a single action situation, but triple loop learning seems too long-term to be conceptualized as occurring within a single action situation. More generally, we are concerned that the SES framework as currently constituted may not fully incorporate the critical importance of multiple feedback paths. Other contributors to this volume raise related issues, including the final article's suggestions concerning some possible ways forward.

## CONCLUSION

In conclusion, we return to the original inspiration behind the SES framework, namely, to develop diagnostic tools for potential use by scholars studying sustainability in complex social-ecological systems. Diagnosis is a routine activity of medical professionals, and it plays an absolutely critical role in healthcare, but it is not immediately obvious what the appropriate analogy would be for the activities of social or ecological researchers.

Medical professionals ask questions about an individual's symptoms in order to ascertain the nature of the underlying health problem that individual faces. Medical textbooks include incredible amounts of detail, only some of which is relevant to particular diagnoses or treatments. Making the proper diagnosis is an essential step toward effective treatment. This process of diagnosis cannot be automated, but instead requires trained professionals to draw upon their organized understanding of the relevant fields of scientific study.

The SES framework offered here is intended to provide institutional analysts, ecologists, and others with the foundation for a similar form of organization for the knowledge relevant to the diagnosis of the properties of specific social-ecological systems. Ultimately, we hope a more fully elaborated framework can serve as a useful guide for analysts seeking to enhance the prospects of effective and sustainable outcomes. If nothing else, such a framework can contribute by prompting analysts to ask certain types of questions and to investigate certain aspects of any given situation.

Application of the SES framework to particular cases requires at least a three-step process, with each step corresponding to the framework, theory, and model distinctions identified above. In the first step, the analyst must select a focal level of analysis, by answering such questions as: What types of interactions and outcomes related to a particular resource system (or group of systems) and related resource units (or other relevant goods and services) are most relevant to my analytical or diagnostic concerns? What types of actors are involved? Which governance systems influence the behavior of these actors?

Answers to these questions will specify the actors, resource units and systems, and governance systems that the analyst will need to investigate in more detail. Examination of the framework will prompt the analyst to search for certain kinds of information, but without any additional guidance, any effort to fill in values of all of the possibly relevant variables identified at the second and lower tiers could turn out to be an endless undertaking.

For any practical results, analysts must also draw upon their theoretical understanding of the issue at hand. Theory, augmented by puzzles from past research that are not yet reconciled in a consistent theory, must guide the selection of which variables are likely to be most important in that particular setting. Of course, alternative theories may suggest the importance of different variables, but no reasonably small set of theories can exhaust all the potential entries in the framework. Even within a single theory, specific models will posit different functional relationships or causal pathways, and the analyst must choose which alternative explanations are most deserving of his or her attention. Here is where the critical concerns of research design become most important, as the analyst selects which cases and what kinds of observations of these cases can best provide the analytical leverage needed to be able to draw valid inferences from this particular research project.

In other words, application of the SES framework constitutes only the first step in the process of research. Much remains to be done to select which variables should be measured, and how these indicators can be defined and implemented, but the framework can help a research team feel confident that they have not overlooked some potentially critical factor.

After the analysis is completed, the framework can make still another critical contribution, by facilitating the communication of results across research communities focusing on different resource sectors in separate geographic regions, using the analytical lens of diverse disciplinary specializations. The specific meaning of each concept or the particular indicators used to measure them may differ considerably when moving from one empirical setting to another, but the first- and second-tier categories should remain equally relevant to all applications. Having this common base of shared terms increases the chances that cumulative progress can be made, making it easier for researchers trained in different disciplines and studying different resources in different places to compare their findings, and to engage in mutually beneficial exchanges of information.

We recognize that there are many challenges to be faced in the future as we try to make this a really useful tool helping scholars from multiple disciplines to use a common language for future theoretical and research efforts. A complete representation of dynamic linkages among concurrent action situations operating in complex SESs remains a distant goal, but the modifications discussed here point in promising directions for subsequent research. In addition, the empirical articles in this special issue demonstrate how much we can learn from efforts to apply this general framework to the analysis of particular cases. In each instance, new aspects take on increased importance, even as lessons are drawn from applications of similar concepts to quite different ecological settings. All this work is very exciting, and we can only hope that the SES framework continues to inspire such high-quality research, and especially that it can facilitate communication among scholars from a broad array of disciplines working on diverse resources in many different parts of the world.

At the Workshop, we are developing careful definitions for all major first- and second-tier concepts identified in the current version of the SES framework, which we will place on the SES website and encourage other scholars to help us improve these. We consider further refinement of the SES framework to be one of the major ongoing efforts at the Workshop.

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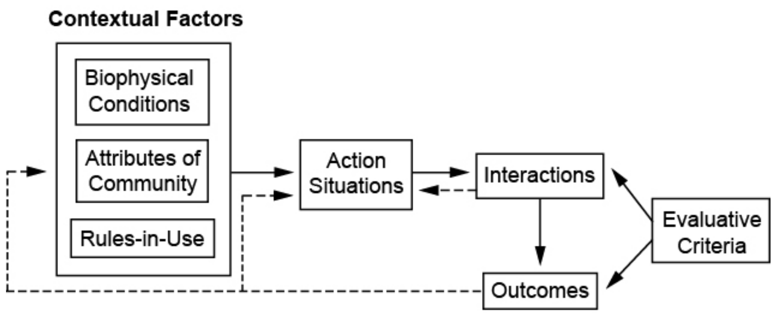


**Fig. 1.** Institutional Analysis and Development (IAD) framework.
*Source*: Adapted from Ostrom (2011: 10).

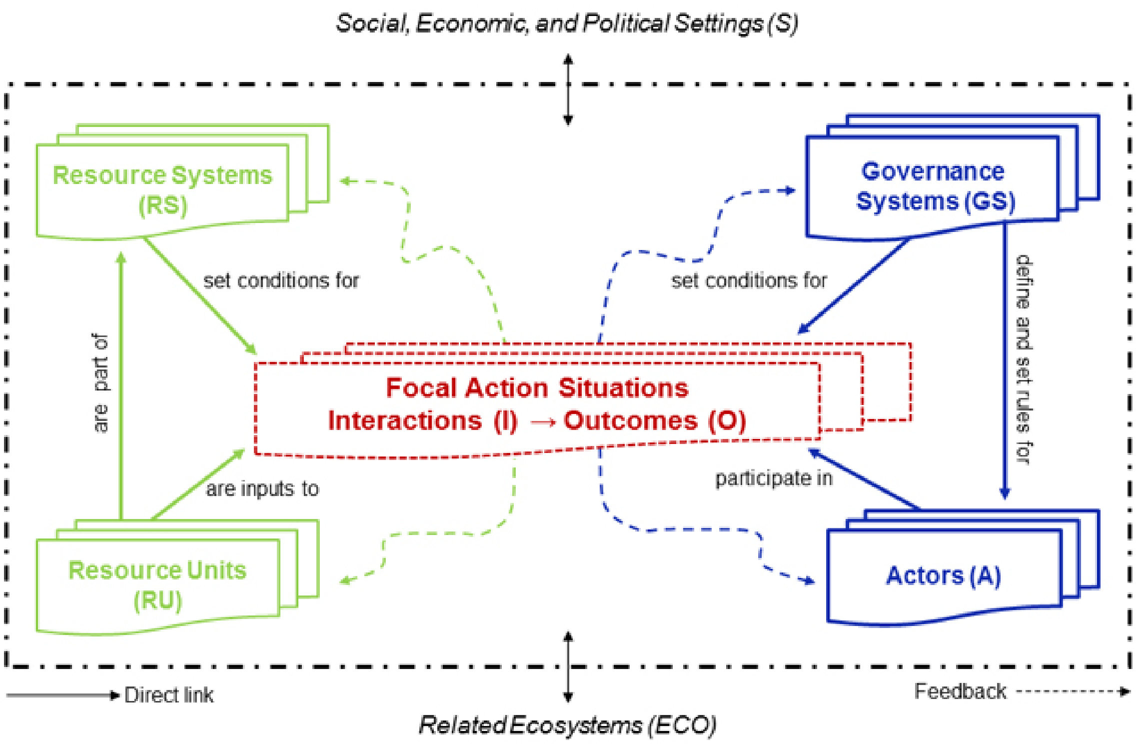


**Fig. 2.** Revised SES framework with multiple first-tier components.

**Social, Economic, and Political Settings (S)**
**S1– Economic development. S2– Demographic trends. S3– Political stability. S4– Other governance systems.**
**S5– Markets. S6– Media organizations. S7– Technology.**

**Resource Systems (RS)**

**RS1– Sector (e.g., water, forests, pasture, fish)**
**RS2– Clarity of system boundaries**
**RS3– Size of resource system**
**RS4– Human-constructed facilities**
**RS5– Productivity of system**
**RS6– Equilibrium properties**
**RS7– Predictability of system dynamics**
**RS8– Storage characteristics**
**RS9– Location**

**Governance Systems (GS)**

**GS1– Government organizations**
**GS2– Nongovernment organizations**
**GS3– Network structure**
**GS4– Property-rights systems**
**GS5– Operational-choice rules**
**GS6– Collective-choice rules**
**GS7– Constitutional-choice rules**
**GS8– Monitoring and sanctioning rules**

**Resource Units (RU)**

**RU1– Resource unit mobility**
**RU2– Growth or replacement rate**
**RU3– Interaction among resource units**
**RU4– Economic value**
**RU5– Number of units**
**RU6– Distinctive characteristics**
**RU7– Spatial and temporal distribution**

**Actors (A)**

**A1– Number of relevant actors**
**A2– Socioeconomic attributes**
**A3– History or past experiences**
**A4– Location**
**A5– Leadership/entrepreneurship**
**A6– Norms (trust-reciprocity)/social capital**
**A7– Knowledge of SES/mental models**
**A8– Importance of resource (dependence)**
**A9– Technologies available**

**Action Situations: Interactions (I) → Outcomes (O)**

**Activities and Processes:**

**I1– Harvesting**
**I2– Information sharing**
**I3– Deliberation processes**
**I4– Conflicts**
**I5– Investment activities**
**I6– Lobbying activities**
**I7– Self-organizing activities**
**I8– Networking activities**
**I9– Monitoring activities**
**I10– Evaluative activities**

**Outcome Criteria:**

**O1– Social performance measures (e.g., efficiency, equity, accountability, sustainability)**
**O2– Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)**
**O3– Externalities to other SESs**

**Related Ecosystems (ECO)**
**ECO1– Climate patterns. ECO2– Pollution patterns. ECO3– Flows into and out of focal SES.**

**Table 1.** Second-tier variables of an SES.
*Source*: Adapted from Ostrom (2009: 421).

**Governance Systems (GS*)**

**GS1*– Policy area**
**GS2*– Geographic scale of governance system**
**GS3*– Population**
**GS4*– Regime type**
**GS5*– Rule-making organizations**

- **Public sector organizations (government agencies, etc.)**
- **Private sector organizations (for-profit)**
- **Nongovernmental, nonprofit organizations**
- **Community-based organizations**
- **Hybrid organizations**

**GS6*– Rules-in-use**

- **Operational-choice rules**
- **Collective-choice rules**
- **Constitutional-choice rules**

**GS7*– Property-rights systems**
**GS8*– Repertoire of norms and strategies**
**GS9*– Network structure**
**GS10*– Historical continuity**

*Note*: * denotes the tentative nature of these suggestions.

**Table 2.** Alternative list of second-tier properties for governance systems GS*.