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Resolving Common Pool Resource Dilemmas and Heterogeneities
Among Resource Users

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Introduction

Heterogeneities among resource users pose substantial barriers to cooperation and coordination in solving common-pool resource dilemmas.¹ For instance, a senior surface water user in Colorado may refuse to cooperate with junior surface water users in the same watershed knowing that his senior water rights are protected under the prior appropriation doctrine. Or, irrigators situated at the head end of a canal may fail to share in canal maintenance or limit excess water uses so that those at the tail end receive some water. Heterogeneities, whether they stem from physical, cultural, or institutional sources, position resource users differently in their access and use of a common-pool resource. Resource users may find that those differences present real challenges to gaining a common understanding of their shared problems, to communication, to devising fair rules of access and use, and to monitoring and enforcement of those rules.

It is generally accepted that heterogeneities among resource users can pose substantial challenges to gaining user participation and cooperation in addressing shared problems. Invariably, case studies of resource users failing to address shared problems point to some sort of heterogeneity as one of the root causes of failure. When substantial resource user heterogeneity exists within a common-pool resource situation, predictions are grim: resource users are unlikely, or substantially less likely, to address and resolve shared problems.

What is much less understood or accepted is how resource users overcome their differences and reach cooperative agreements for governing a shared resource.² Many common-pool resource situations in which dilemmas have been addressed were characterized, at some point, by resource user heterogeneity. In spite of heterogeneities, resource users confronted and attempted to resolve shared problems. The mechanisms that users utilized to simultaneously overcome their heterogeneities and address common-pool resource dilemmas are the focus of this paper. These mechanisms are diverse, ranging from institutional arrangements to substitutes for or complements to common pool resource flows. While diverse, these mechanisms share one characteristic; they attempt to minimize the differences among resource users while creating a common course of action for solving shared problems.

In examining and evaluating the mechanisms by which heterogeneities among resource users may be overcome, this paper will explore a number of issues. First, the sources and types of heterogeneities among resource users will be examined within the context of the Institutional

Analysis and Development framework. The framework permits a systematic examination of heterogeneities. Next, the obstacles and barriers to cooperation and coordination that heterogeneities create for resource users will be explored. Then the mechanisms by which heterogeneities may be overcome will be described and evaluated. Finally, how these mechanisms may be used in the design of institutional arrangements for solving common pool resource dilemmas will be discussed.

Resource User Heterogeneity and the IAD Framework

The Institutional Analysis and Development (IAD) framework provides a useful approach for organizing and carefully analyzing heterogeneities. The IAD framework builds on the concept of an action arena. An action arena consists of actors and an action situation. An action situation structures the setting in which individuals interact. “Action situations refer to the social space where individuals interact, exchange goods and services, engage in appropriation and provision activities, solve problems, or fight (among the many things that individuals do in action situations)” (Ostrom et al. 1994:28). The action situation consists of several elements – participants, positions, actions, potential outcomes, linkages between actions and outcomes, information, and the costs and benefits assigned to actions and outcomes (Ostrom et al. 1994:29). Actors, or participants in action situations, are characterized by preferences, information processing capabilities, selection criteria, and resources. “The actor is, thus, the animating force that allows the analyst to generate predictions about likely outcomes given the structure of the situation” (Ostrom et al. 1994:35).

Each of the characteristics of the actor and each of the elements of the action situation represents a potential heterogeneity. For instance, actors may differ substantially in the resources that they have to support their activity in the situation. One actor may have access to scientific and legal experts as well as generous funding sources that would allow it to take any action that it was physically and legally capable of. Another actor may have very limited funding sources and only her own time, placing tight constraints on the actions that she can undertake. Actors may differ in their preferences over actions and outcomes as well. One actor may prefer the maintenance of a relatively pristine river riparian corridor, while another may prefer the more manicured look of a golf course with a river running through it.

The elements of the action situation also present potential heterogeneities. Actors may differ in relation to the types of actions that they are required, permitted, or forbidden to take in a situation. One actor may have the authority to use a well-defined amount of surface water, whereas another actor may not have the authority to use surface water, but be permitted to pump as much groundwater as he can put to reasonable use, regardless if the groundwater pumping reduces the surface water flows. Actors may also differ on the types and amount of information that they possess about themselves and the situation, and the costs and the benefits that accrue to them from the actions and outcomes they collectively engage in and realize. Thus, the central conceptual unit of the IAD framework, the action arena, and its constituent parts, allows one to carefully analyze and pinpoint diverse types of heterogeneities.

The malleability of heterogeneities depends on their source. Again, the IAD framework provides the conceptual tools to address this issue. The action arena is itself defined and constrained by three sets of variables – attributes of the physical world, attributes of the community, and rules-in-use (Ostrom et al. 1994:37). “Implicit or explicit assumptions about rules, physical variables, and the nature of a community all influence the way the seven elements of an action situation are conceptualized” (Ibid.). Attributes of the physical world include such things as the type of resource used – whether it is a public good or a common pool resource; whether resource flows are mobile or stationary (Schlager, Blomquist, and Tang 1994); the distribution of resource flows across time and space as well as the predictability of such distributions; the location of a cpr relative to other cprs and population centers, and so forth. Attributes of the community include “generally accepted norms of behavior, the level of common understanding about action arenas, the extent to which the preferences are homogeneous, and distribution of resources among members” (Ostrom et al. 1994:45).

Rules-in-use is the final element that structures an action arena. Rules are “prescriptions that define what actions (or outcomes) are required, prohibited, or permitted, and the sanctions authorized if the rules are not followed” (Ostrom et al. 1994:38). Seven broad types of rules structure an action situation: position, boundary, authority, aggregation, scope, information, and payoff. These rule types correspond to and substantially define the elements that constitute an action situation. Boundary rules define the conditions that individuals must meet in order to participate in an action situation. Position rules define the positions that participants hold. Authority and scope rules define the actions that participants must, may, or must not take. Aggregation rules map actions into outcomes, and information rules specify the information available to each of the participants. Payoff rules specify the benefits and costs associated with particular actions and outcomes and how those benefits and costs are distributed among participants. Thus, heterogeneities among participants in an action situation may arise directly from the rules-in-use.

While the elements of an action arena allow one to identify and categorize heterogeneities, the factors that structure the action arena identify the sources of those heterogeneities. Whether heterogeneity among resource users can be neutralized depends on its source. For instance, resource users may possess different amounts and types of information about a cpr. If the information differences are due to an information rule that allows some resource users access to technical information that other resource users are forbidden, the differences may be directly resolved by changing the information rule. If the information heterogeneity among resource users is due to substantial distrust and a consequent reluctance to honestly reveal information, then the heterogeneity is not so directly or easily addressed. In other words, if the source of the heterogeneity lies in a single rule that structures the action situation, the heterogeneity may be resolved by changing the rule. If the source of the heterogeneity lies in deep-seated norms and perceptions, that is, in community attributes, then addressing the heterogeneity presents a much greater challenge.

The complexity and malleability of heterogeneities furthermore depends on the configural nature of their sources, which the IAD framework reveals. Heterogeneities often arise from multiple, overlapping, and interacting sources. Information heterogeneities among resource users may

result not from a single rule, or from a single community norm, but from a combination of factors. For instance, some resource users may possess more and better information about the relationship between actions and outcomes than other resource users in the same cpr situation because they possess the resources to hire experts to conduct studies of the physical characteristics of the resource, they are physically positioned in the resource to better track the resource flows, information rules require government officials to share information with them, and through years of working together they have developed norms of information sharing. This pronounced information disparity between the resource users is one that a rule change or providing additional resources is unlikely to effect.

When, Why, and How Heterogeneities Matter

The ubiquitous nature of heterogeneities among resource users begs the questions of when, why, and how they matter. There are at least two different answers to these questions. Non-cooperative game theory suggests that heterogeneities matter when they affect the payoffs actors receive from different outcomes. There may be a number of cooperative outcomes that resource users prefer that would allow them to resolve the cpr dilemmas that they experience. However, each of those outcomes may distribute benefits and costs differently across the resource users, causing conflict over determining a fair allocation.

Scharpf (1997) presents a non-cooperative game theory example using the Prisoners' Dilemma game. As Scharpf (1997:75) explains, the dominant strategy for both players is defection, which results in their second worst outcome. Furthermore, they cannot unilaterally escape from this outcome. If one player unilaterally chooses a cooperative strategy she runs the risk of being exploited, resulting in the worst outcome for her. If binding agreements are possible, as Scharpf (1997:77) points out, then achieving the cooperative outcome appears easy. Actors prefer the cooperative outcome to the defection outcome. This is only the case, however, if the cooperative outcome is symmetrical. As Scharpf (1997:77) argues,

“Real-world constellations will often allow for several “cooperative” solutions that may differ significantly in their distributive consequences...implying that the common aversion to the outcome associated with mutual defection is not sufficient to assure agreement on one of the competing cooperative solutions.”

Why might there be several cooperative solutions? There might be several cooperative solutions because of heterogeneities among resource users. For instance, some resource users may have invested more heavily in harvesting technologies than have others. When resource users come to understand that they must reduce overall harvesting effort in order to maintain the natural resource stock, those who invested more heavily in harvesting effort may want their additional investment recognized. Thus, they may support an outcome that does not allocate effort equally, but that allocates effort proportionate to historic investment in effort (Hackett, Schlager, and Walker 1994).

Don't all heterogeneities affect the cooperative outcomes that resource users may achieve? The answer is no, at least according to non-cooperative game theory. This is demonstrated in a series of experiments conducted by Ostrom, Gardner, and Walker (1994). In these experiments eight

subjects were given equal endowments which they could invest in Market One, which provided a constant return per unit invested and/or in Market Two, which was the cpr. The return a subject received from Market Two was a function of what the subject, plus all other subjects, invested. The subjects were not allowed to communicate and they made decisions independently of one another. As a group they achieved the Nash equilibrium, or the non-cooperative outcome. Ostrom, Gardner and Walker (1994) then changed the information rule and allowed subjects a few minutes of face-to-face communication. Since, the payoff structure remained unchanged so too did the prediction – subjects would achieve the Nash equilibrium outcome. Thus, according to non-cooperative game theory, heterogeneities only matter if they effect the payoff structure of the game.

The Ostrom, Gardner, and Walker (1994) experiments demonstrate another point. The non-cooperative game theory's answer to when heterogeneities matter is much too limited. The experiments suggest that heterogeneities that do not change the payoff structure of the game nevertheless effect the outcomes that are achieved. Once given the opportunity to communicate and commit themselves to courses of action that they believed would make themselves better off, subjects quickly discovered and achieved superior outcomes, even though their commitments were non-binding. What non-cooperative game theory provides is a sufficient condition for when heterogeneities matter, however, it is not a necessary condition.

Heterogeneities certainly matter in relation to outcomes, as non-cooperative game theory demonstrates, but heterogeneities also matter in relation to other things. What are some of those other things? Scharpf (1997) discusses the Negotiator's Dilemma. The dilemma involves searching for, perhaps even creating the possibility of optimal solutions while simultaneously resolving distributive conflicts over the solutions. Searching for, or creating, optimal solutions entail a distributive dimension. Some solutions will substantially benefit some while modestly benefiting others. Or, even more difficult is a solution that substantially benefits some, while making others worse off. Even if total welfare is maximized, this solution can only be reached if those made worse off are compensated. As Scharpf (1997:121) explains, "The creation of value will be impeded unless the acceptable sharing of value is assured." Thus, heterogeneities may effect the search for optimal solutions, or what Ostrom (1990) calls the problem of supply.³

For example, information asymmetries (or heterogeneities) can have a powerful and negative effect on both the search for optimal solutions and resolving distributive conflicts in relation to those solutions. As Scharpf (1997:124) explains:

The successful joint search for better overall solutions requires creativity, effective communication, and mutual trust, whereas success in the distributive battle depends on the strategic, and even opportunistic, communication and withholding of available information –and a good deal of distrust against potential misinformation. This means not only that the "cooperative" interaction orientation that is conducive to joint learning in the production dimension is psychologically incompatible with the "competitive" orientation that facilitates success in distribution but also that the party that contributes most to the search for better solutions lays itself open to exploitation by a party that concentrates its efforts on the distributive dimension.

Information asymmetries can contribute to creating an atmosphere of distrust and deception, discouraging individuals from working together to find outcomes superior to what they currently achieve.

Information asymmetries are not the only type of heterogeneity that confounds the search for institutional arrangements that create opportunities for achieving better outcomes. Any of the types and sources of heterogeneities identified using the IAD framework can create search barriers. For instance, individuals with different norms and values concerning the appropriate use of resources may find it very difficult to even identify a shared understanding of resources that would permit them to search for acceptable outcomes. Or, some resource users may possess well-defined, legally enforceable rights in the resource that are superior to those held by all other users. These well-positioned resource users may refuse to consider any alternative that may infringe on their property rights, even if that alternative was the one that made everyone better off.

In addition to the negotiator's dilemma, Scharpf (1997) notes that problems may also emerge in implementation. For superior outcomes to be achieved, agreements must be faithfully implemented. Ostrom (1990) breaks implementation into two parts – commitment and monitoring. Once an agreement has been reached, that is, once the supply problem has been resolved, individuals must still commit themselves to follow the rules and abide by the agreement. As Ostrom (1990:44) explains:

On many occasions after an initial agreement to a set of rules, each appropriator must make further choices. Minimally, the choice at each decision time subsequent to the agreement can be thought of as the choice between complying to a set of rules, C_t or breaking the rules in some fashion, B_t . On many occasions, B_t will generate a higher immediate return for the appropriator than will C_t , unless B_t is detected and a sanction, S , is imposed that makes $C_t > B_t - S$.

Heterogeneities can exacerbate the commitment problem in a number of ways. First, the commitment problem, at least in part, centers on trust. Individuals are more likely to remain committed to a set of rules if they know that others are also committed. Heterogeneities may affect the trust that individuals have in each other. For instance, cultural differences or resource differences may convince individuals that it is okay to break the rules because the only ones that would be hurt are those from a different group, or those who are wealthy.

Second, a closely related issue involves what Scharpf (1997:84) calls interaction orientations. As Scharpf (1997:85) explains, “a relationship may assume a character of its own that affects the valuation of “real” gains and losses and that distinguishes this particular relationship from “objectively” similar interactions with other parties or with the same party at another time”. Scharpf identifies four interaction orientations:

- individualism: only gains and losses to the individual are considered
- solidarity: a gain to an individual or to any one the individual is interacting with is equally valued. This “defines the precondition for unrestricted cooperation”(Scharpf 1997:85).

- competition: a gain to an individual or a loss to any one the individual is interacting with is valued equally. What counts, according to Scharpf (1997:86) is the difference between payoffs.
- altruism: an individual's payoffs are considered irrelevant, and a gain to another is considered positive
- hostility: a loss to another is considered a gain to the individual.

Interaction orientations strongly affect the commitment problem. Individuals who act from solidarity are more likely to remain committed to a set of rules than are individuals who act from competition. The orientation that individuals take, in turn, may be strongly affected by heterogeneities. For instance, differences in information about the resource and about other's uses of the resource may cause some individuals to cautiously support and abide by an agreement. They consider only their own gains and losses, that is, they adopt an individualism orientation, and once they find evidence of others breaking the rules, they too then break the rules.

Third, the way in which the set of rules resolved distributional issues may make it very tempting to break the rules. In other words, some individuals may substantially benefit from breaking the rules. For instance, a fisher may have been allocated an initial quota of fish, in part based on historic catch that is too small to sustain his operation. He may view his choice as breaking the rules or going out of business.

Commitment problems may be substantially resolved through monitoring. Monitoring individual behavior for rule breaking actions may provide resource users with the assurance they need to remain committed to a set of rules. Heterogeneities among resource users can affect monitoring of the agreement. For instance, some resource users, because of greater resources, or higher levels of investment in harvesting technologies may be able to land and sell harvested flows outside of the market network being monitored. This allows them to harvest more than what was allocated to them without easily being caught. Thus, monitoring is critical for commitment, and commitment is critical for the supply of rules that allow individuals to achieve better outcomes (Ostrom 1990:45). Each of these three activities, in turn, is strongly affected by heterogeneities among resource users.

When and why do heterogeneities matter? While specific predictions are impossible, heterogeneities matter in many more instances and many more settings than is recognized in non-cooperative game theory. Heterogeneities matter not only when they effect the payoff structure of outcomes, they also matter as resource users search for and implement institutional arrangements intended to allow them to resolve their cpr dilemmas and achieve better outcomes than they are currently achieving.

Mechanisms for Addressing Heterogeneities and Resolving Dilemmas

The institutional arrangements that resource users utilize to resolve cpr dilemmas are diverse. While markets and hierarchies are most commonly discussed in literatures ranging from public administration to biology, as Ostrom (1990) and many others have so forcefully argued and

demonstrated, there are numerous other types of arrangements, characterized by hundreds of different combinations of rules.

These diverse institutional arrangements that resource users utilize share at least one thing in common -- they attempt to address and resolve similar types of issues. They are devised to solve shared problems that resource users experience. In order to resolve common pool resource dilemmas, however, these institutional arrangements must address a number of other problems, specifically issues around distribution, commitment, and monitoring. The fact that these institutional arrangements address numerous issues in addition to cpr dilemmas is reflected in the criteria often used to evaluate them. Institutional arrangements are evaluated on the basis of effectiveness – how well the arrangements addressed dilemmas; fairness – how the arrangements addressed distributional issues; ease of monitoring and enforcement – how the arrangements addressed issues of commitment and monitoring; and efficiency.

The institutional arrangements are multi-dimensional. One dimension, however, that has not received much attention is how these institutional arrangements address the challenge of heterogeneous resource users. In general, most institutional arrangements use one or more of three approaches for addressing and neutralizing the obstacles presented by heterogeneities – separate, consolidate, or eliminate.

Separate

One general approach to addressing heterogeneities is to separate resource users from one another. Separation can take a variety of forms. An extreme form of separation is to allocate individual private property rights to portions of a resource. Individual private property rights substantially reduce the need for resource users to work together to collectively resolve shared problems. By allocating each user a “piece” of the resource, users first and foremost need to pay attention to their own actions. The outcomes an individual achieves under this institutional arrangement primarily depend on her actions, and not the actions of others. Individual private property rights address the challenge of heterogeneities by separating individuals from one another.

Individual private property rights may reduce the effects of heterogeneities once in place; however, the process of devising such arrangements highlights the differences among individual resource users. Resource users will differ on the basis of any single criterion used to allocate individual private property rights. If rights are allocated by auction, then differences among individuals in terms of resources to participate in an auction are highlighted. If rights are allocated by individual historic harvest levels, then differences in amounts of effort invested in the resource are emphasized. Heterogeneities play a significant role in the process of determining how to initially allocate individual private property rights.

A less extreme form of separation is to divide a resource among homogenous groups of resource users. Instead of separating individuals from one another, groups of users, who differ on a salient dimension, are separated from one another. Thus, homogenous groups can collectively decide how they will use their portion of a cpr without having to work with groups against whom they

compete. For instance, there are numerous examples of fishermen divided among types of gear, with each gear type allocated a portion of the fishing ground. Or, in Arizona, groundwater is allocated among the three major users of water – agriculture, municipalities, and mining and industry. Each group is allocated a portion of groundwater and each group has a set of rules and regulations that governs its use of groundwater. Just as is the case with individual private property rights, heterogeneities play a significant role in the initial allocation of portions of the resource to homogenous groups of users.

Finally, another form of separation is for users who are homogenous on a salient dimension to organize and address shared problems separately from other users who are heterogeneous on the salient dimension. This form of separation may downplay the role of heterogeneities in relation to the initial allocation of shares of the resource because the resource need not be portioned off. For this type of separation to work, the homogeneous groups of users must exercise sufficient control over their shared problems so that by collectively working together they can substantially address them. While this form of separation may have the desired effects of downplaying distributional issues among heterogeneous resource users, and allowing groups of resource users to address and resolve their own problems, it may have the unfortunate consequence of marginalizing resource users not part of the original homogenous group.

Consolidate

Another approach to addressing heterogeneities is to coerce or convince heterogeneous resource users to work together to solve shared problems. An extreme form of consolidation is to create a single hierarchical organization in which key decision-makers possess sufficient authority to impose rules and regulations on the organization's diverse members. This approach is intended to take care of the conflicts that erupt as a result of heterogeneities by "forcing" actors with diverse backgrounds, preferences, and needs and wants to work together within the context of a single, authoritative organization. Furthermore, once in an organization, the creation of organizational culture and mission can begin to align individuals' goals and preferences, promoting cooperation (Miller 1989).

While on paper, such an extreme form of consolidation appears to be an effective mechanism for resolving differences and dictating a common course of action, a number of authors have noted distinct shortcomings with such an approach. Actors will simply bring their differences within the organization and continue to compete, maneuver, and strategize among each other, making it difficult for organizational decisions to occur (Ostrom, Tiebout, and Warren 1961; Chisholm 1989). Or, as Scharpf (1997) points out, if one group of actors is given the authority to impose its desired solutions, it can easily exploit other groups of actors different from itself.

Another form of consolidation centers on tying together, or consolidating, the problems of heterogeneous actors rather than consolidating the actors themselves within a single organization. Scharpf (1997:128) calls this "issue linkage or package deals". Resource users who share a common-pool resource may experience distinct types of dilemmas. One group of resource users may experience one type of dilemma and another group of resource users may experience another type. If neither group can resolve the dilemma that they face without assistance from the other,

then it is possible to package these dilemmas and resolve them collectively. Issue linking often occurs in irrigation systems. Those situated towards the end of a canal depend upon those towards the head of the canal to act in ways that allow water to flow to the end of the canal. Those situated at the head of the canal may need the assistance of those towards the end of the canal in maintaining the headworks and canals of the system. By linking these two problems irrigators may collectively resolve them.

Issue linking, however, requires issues that can be linked and resolved in ways that make everyone better off. As Scharpf (1997:129-130) explains, “If package deals can be reached at all, they will typically have to involve two or more distinct policy areas with complementary asymmetries in their interest constellations.” Without such possibilities for linking issues, it is unlikely that heterogeneous groups will work together. For instance, while tailender irrigators are almost invariably dependent on the cooperation of headender irrigators, the reverse is not always the case. Headenders may not experience problems with which they need assistance from other groups. This leaves tailenders vulnerable to the actions of headenders.

Eliminate

Elimination brings us in a full circle back to separation. Elimination is similar to separation in that groups that are heterogeneous in relation to other groups, and who have veto power over any cooperative arrangement, are separated and removed from a common-pool resource situation. The most extreme form of elimination is extermination. Fortunately, there are other, less extreme forms of elimination. If individual private property rights are defined in a common-pool resource, and if they are made transferable, then some users' claims to the resource can be purchased and they can be removed from using the resource.

Another such form is to “purchase” any claims a group may have to the use of a common-pool resource by providing a substitute for the flows of the resource. The remaining, more homogenous, resource users then negotiate among themselves to resolve their shared problems. This form of elimination is relatively common in resolving and settling Native American water claims in the western United States. Water from projects built and operated by the federal government is provided to groups of Native Americans to settle their claims to surface waters governed by the states. Non-Indian state citizens then negotiate among themselves to address shared water problems.

The different types of separation, consolidation, and elimination mechanisms are well-known in the literatures on common-pool resources. They are well-known because they are embedded within institutional arrangements used to address common pool resource dilemmas.

Conclusion

Heterogeneities among resource users are commonly viewed as anathema to resolving common-pool resource dilemmas. Ostrom (1990:211) states that resource users are more likely to adopt a set of rules that improves joint welfare if “appropriators will be affected in similar ways by the proposed rule change”, which is only possible if appropriators are homogeneous in all important

respects. While heterogeneities may, in many cases, confound attempts to resolve common-pool resource dilemmas, they are ubiquitous. As the IAD framework demonstrates, there are numerous dimensions on which resource users may differ. Furthermore, most attention to heterogeneities has focused on attempting to reach agreements for solving shared problems. As both Ostrom (1990) and Scharpf (1997) argue, reaching an agreement is only one step in resolving shared problems, attention must be paid to implementation, including commitment and monitoring. Heterogeneities may effect resource users' willingness to follow as well as enforce rules.

Even though in many instances heterogeneities present substantial challenges to users of a shared resource, they nevertheless surmount such obstacles and devise and implement institutional arrangements. The issue then is how these arrangements address and overcome the obstacles presented by differences among resource users. In general, most institutional arrangements devised to address common-pool resource dilemmas also address heterogeneities by separating resource users into homogenous groups, forcing resource users to work together, or removing groups of users from the resource. Thus, in evaluating institutional arrangements for managing common-pool resources, attention must be paid not only to their efficiency, effectiveness, and fairness, but also to how they resolve resource user heterogeneity.

Endnotes

¹ Heterogeneities among resource users are different from heterogeneities among different types of cprs. Heterogeneities among users refer to differences in characteristics among individuals. Those differences may stem from cultural sources, such as gender roles or language, from physical sources, such as location within a cpr, or from institutional sources, such as differences in property rights (see Schlager and Blomquist 1998). Heterogeneities among different types of cprs refer to differences in physical characteristics of natural resources. For instance, some fish stocks are highly mobile, while other stocks are mostly sedentary. For a discussion of cpr heterogeneity and how those physical heterogeneities affect the types of institutional arrangements that resource users devise, see Schlager, Blomquist and Tang (1994).

² Another issue that needs further study is how some types of heterogeneities support cooperation among resource users. See Blomquist and Schlager (1997) and Schlager and Blomquist (1998) for theoretical explanations of the conditions under which heterogeneities support and inhibit the emergence of cooperation among resource users.

³ In fact, the problem of supply is a more nuanced and complete of a notion than is the search for optimal solutions. The problem of supply involves devising a set of rules, which if followed, create the possibility of adopting an optimal outcome. The problem of supply attends to how institutional arrangements structure an action situation, or a game, so that optimal solutions are possible outcomes. The search for optimal solutions does not attend to the institutional arrangements that are necessary for optimal solutions to be reached.

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