

# On the Same Page: Providing Theoretical Context for the Critical List of Variables for Sustaining the Commons

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## Abstract

Elinor Ostrom pioneered common pool resource management theory. Her work was advanced by other contemporaries in the field. The result was a list of enabling variables for sustaining common pool resource systems. However, the interpretation of the qualifiers for the variables has been somewhat inconsistent among researchers, rendering meta-analysis and cross-case comparisons less robust. As the basis for CPR system theory, the importance of context for consistency becomes more significant with the pressures for effective analyses and subsequent policy— increasing with the impacts of climate change on the world's CPR systems. This variable context must be preserved in the operationalizing process to ensure more robust comparability in data collection and, ultimately, a more effective evolution of theory. This review paper presents a reference where each variable is discussed in the context of its nascence and application in CPR theory by the researcher who flagged its importance. The goal of providing a reference for the theoretical context for the critical list of variables is to maintain the variables' theoretical integrity. The goal is to enable more informative and robust results in singular and comparative CPR analyses. Additional variables are defined and recommended for inclusion.

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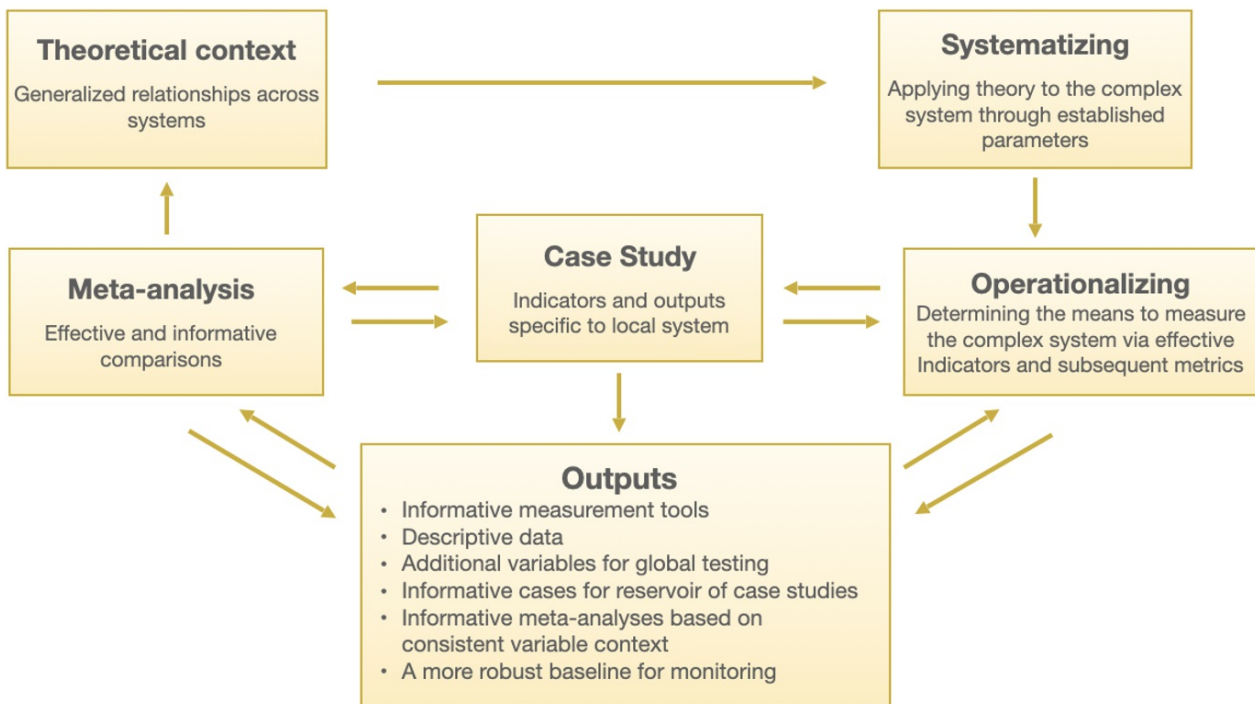
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## Introduction

Elinor Ostrom provided over 30 years of critical insight into common pool resource (CPR) management. She demonstrated, using case studies, how local managers and management institutions make decisions with regard to management— including sustainability, use, and allocation. The results of her work are the foundation of current CPR theory. In her initial discussion on CPR parameters, Ostrom (1990) named eight design principles (DPs) necessary for successful CPR management. Her research has advanced our understanding of how sustainable and equitable management can be achieved in common pool resource (CPR) systems (Damon et al. 2019, Anderies et al. 2007, Ostrom & Nagendra 2006). Over time, however, the DPs have been argued as insufficient for explaining total CPR system success/failure (Fleischman et al. 2014, Quinn et al. 2007, Agrawal 2001). Apropos, the DPs are not the final outcome of Ostrom's seminal work.

Ostrom (2002) recognized that with time and application, theory evolved as the fruits of contemporaries in the field like Wade (1994) and Baland & Plateau (1996) added to the discourse and her theory. In 2001, Agrawal published a synthesis list developed by these preeminent CPR researchers— Ostrom (1990), Wade (1994), Baland and Plateau (1996)— and added his own contributions, calling it the “enabling conditions for the sustainability of the commons.” However, the explicit theoretical context of each variable was not present, as that was not the compilation's purpose. In 2003, Agrawal again presented the compilation, referring to it as the “critical list of variables for sustaining the commons,” as it will be referred to here.



**Figure 1.** Visual representation of the relationship of theoretical context with the evolution of theory and systematization enabling informative comparisons and outputs in research and practice. A lack of systematizing breaks the feedback loop. Robust outputs result in streamlined evolution of cases and theory, where systematizing is present.

The goal of the CPR pioneers was to provide a basis for operationalizing to both add to the breadth of case studies and facilitate comparability (Ostrom 2009). Operationalizing is a requisite for data collection/analysis, and context can be a complicated element in the determination of variable indicators (Schlager 2016). The theoretical context is essential in guiding this process since it provides a direct and consonant basis for determining indicators and subsequent metrics (Figure 1). In other words, in applying the theoretical context, a comparable pool of indicators is easier to produce. It is particularly relevant since the interpretation of the variables is the basis for all conclusions drawn once the data is processed in both case studies and meta-analyses. Parenthetically, in CPR research, there is a history of inconsistency in interpretation of variable context (Gari et al. 2017, Barnett et al. 2016, Agrawal 2003). Congruency is possible and advantageous. The consistent application of theoretical context not only enables faster refinement of theory but also its evolution. It should be noted that the descriptive value provides circumstantial context and transparency, along with the statistical value, for all of the variables.

Agrawal (2003) focused on some of the complications in assessing and analyzing the critical list and clear approaches to improve their analysis as a comprehensive collection of variables. However, the theoretical criteria for the variables were beyond the scope of that paper. Villamayor-Thomas et al. (2018) also discussed the difficulty in comparing case studies due to the varying ways the variables can be measured, along with the subsequent approaches to causal inference. The theoretical context pertinent to each variable is fundamental to the systematic defining of them. This theoretical basis provides the consistency and comparability considered by the CPR pioneers and subsequent peers. Comparability results in more robust comparisons (Warren & Cohen 2012). Consistency and comparability through context also facilitate the direct evolution of theory (Shi et al. 2014). This also lays a solid foundation for replication and interpretation at different scales. This robustness and evolution are rooted in the definition of the variables, in which theoretical context is essential. The importance of this foundational context becomes more significant with the pressures for effective analyses (and subsequent policy) ramping up with the impacts of climate change on the world's CPR systems and the increasing need to determine the most efficient research foci rapidly. It should be noted that the descriptive case study context, in terms of how the theoretical context is applied to the variables, is pertinent in informing management interventions and theory development as well (Figure 1). Transparency is key here and is touched on in the variables' discussion.

By virtue of the above, the purpose of this paper is to provide a reference for theoretical variable context based on the original, documented work in CPR theory development. Each variable is discussed in the context of its nascence in CPR system studies by the researcher who flagged its

importance (Table 1). Additionally, I discuss the addition of several modifications to the list, with four additional variables, based on current CPR research in the body of the review for each category.

**Table 1.** The critical list of variables for sustaining the commons is adapted from Agrawal (2003) and based on Elinor Ostrom's (1990) design principles. Originally (Ostrom 1990), there were eight; Wade (1994) added eight; Baland and Plateau (1996) added twelve; Agrawal (2003) added nine; and Mishkin (2021) added three. The initials of the researcher who suggested their inclusion in critical CPR studies are in parentheses after the variable, following Agrawal's (2003) presentation of the list: EO= E. Ostrom, RW = Wade, B&P= Baland and Plateau, AA= A. Agrawal, and MM= M. Mishkin.

Variable Category	Variable	
<b>1. Resource system characteristics</b>	Small size (RW)	
	Well defined boundaries (RW, EO)	
	Low levels of mobility (AA)	
	Possibilities of storage from benefits from the resource (AA)	
	Predictability (AA)	
<i>Additional variable</i>	<i>Geographical location (MM)</i>	
<b>2. Group Characteristics</b>	Small size (RW, B&P)	
	Well defined boundaries (RW, EO)	
	Shared norms (B&P)	
	Past successful experiences—social capital (RW, B&P)	
	<i>*Modified to local perception</i>	<i>Appropriate leadership—young, familiar with changing external env, connected to local traditional elite (B&amp;P)</i>
	Interdependence among group members (RW, B&P)	
	Heterogeneity of endowments, homogeneity of identities interests (B&P)	
	Low levels of poverty (AA)	
<b>3. Extent of human pressure on the resource</b>	Overlap between user-group residential location and resource location (RW, B&P)	
	High levels of dependence by group members on the resource system (RW)	
	Fairness in allocation of benefits from common resources (B&P)	
	Low levels of user demand (AA)	
	Gradual change in levels of demand (AA)	
<b>4. Institutional arrangements</b>	Rules are simple and easy to understand (B&P)	
	Locally devised access and management rules (RW, EO, B&P)	
	Ease in enforcement of rules (RW, EO, B&P)	
	Graduated sanctions (RW, EO)	
	Availability of accessible adjudication for conflict resolution (EO)	
	Accountability of monitors and other officials to users (EO, B&P)	
<i>Additional variable</i>	<i>Collective monitoring determined by local managers (MM)</i>	
<i>Additional variable</i>	<i>Institutional continuity (MM)</i>	
<b>5. Extent to which rules take into account ecosystem potential</b>	Match restrictions on harvest to regeneration of resource (RW, EO)	
<b>6. External Environment</b>	Technology: Low cost exclusionary technology (RW)	
	Technology: Time for adaptation to new technologies related to the commons (AA)	
<i>Additional variable</i>	<i>Information access (MM)</i>	
<i>Additional variable</i>	<i>Monitoring is determined and supported by local and central government (MM)</i>	
	Low levels of articulation with external markets (AA)	
	Gradual change in articulation with external markets (AA)	
	State: Central governments should not undermine local authority (RW, EO)	
	State: Supportive external sanctioning institutions (B&P)	
	Appropriate levels of external aid to compensate local users for conservation activities (B&P)	
	Nested levels of appropriation, provision, enforcement, governance (EO)	

## Resource system characteristics

This category refers to the physical resources and the variables that speak directly to the resource area. Physical resources are the foundation of a CPR system. The corresponding variables that pertain to the physical resource are described in their theoretical context below.

Ostrom (1990) presented *small size* of the resource system as necessary in efficient management in the original design principles (DPs). Further, according to Ostrom (2000), the size of the use or management group is sometimes inextricable from the size of the resource, which is addressed in the inclusion of the group size variable in the group system category. After a review of various case studies, Wade (1994) found that when resources for monitoring and enforcement are limited, smaller areas of human settlement are easier to manage successfully. This was later supported by a meta-analysis of a body of CPR research (Baggio et al. 2016). Agrawal (2003) also presents the importance of a manageable resource area—implying a small, parsimonious management area relative to the number of managers and users. However, no specific definition of small size is provided. Because ‘size’, by its nature, is a relative comparison, the best unit for comparison is often inherent in the study area unit or units. This context does provide a general element of relative size for the geographical area occupied by the resource base, whose importance was signaled by Gari et al. (2017).

The *well-defined boundaries* variable in this category refers to land boundaries. This was first included in the DPs by Ostrom (1990) due to the necessity for political boundaries (centralized and/or locally determined) to provide clarity and focus for management analysis and actions. This is one of the more complicated variables due to the array of proxies possible. Agrawal (2003) makes the point that if the flow of benefits is predictable and the user group is stationary (ex., forests, and some water resources), then well-defined stationary boundaries are useful. However, when those are not the case, it may be beneficial to have flexibility in the definition of fluid or flexible boundaries (ex., rivers, air). So, this is about established boundary definitions, whatever they may be, that refer to the use and allocation of the CPR. It is then important to determine whether the focus needs to be on one or more of the following: settlement boundaries, protected area boundaries, ecological boundaries, or all of the above-- taking into account ethnic, legal, or political boundaries pertinent to the CPR system management in each case.

The *Low levels of mobility* variable aggregated by Agrawal (2003) in the comprehensive list is an important aspect of resource management. Schlager et al. (1994) discuss the elements of resource mobility in detail. The researchers focused on fisheries and water CPR systems, which are physically mobile in varying units and rely to a significant degree on resource storage (storage will be discussed in the next paragraph). The authors argue that this variable is based on the physical characteristics of mobility of the resource that necessarily impact the problems that CPR managers face and heavily influence the solutions/strategies they choose. This physical context is applicable to all mobile CPRs with the possibility of storage (see also Naughton 1995) and is extremely complicated to specify as a general variable since the units vary considerably from individual units to liquid quantities or flow— and even vary on a spatial scale (for example, upstream vs. downstream).

For the *possibilities of storage of benefits* variable, Agrawal (2003) distills the overarching finding by Schlager et al. (1994) to “Greater mobility of resources and difficulties of storage make management more difficult for users because of problems associated with reliability and costs of information.” The focus of Schlager et al. (1994) was the physical nature of the resource and how that translated to storability, having a direct impact on management strategies. Storage is actually referred to as the storage capacity of a CPR system. They argue that the possibility of storage enables more variety in quantity assignments, reducing any “first capture” incentives and subsequently reducing the possibility of over-exploitation. Schlager et al. (1994) define storage capacity as the ability to “capture and contain flow units, at least temporarily.”

As a pertinent aside, according to Schlager (1994), a limiting factor in management was the level of information access around the resource that influences and even restricts the number and kinds of strategies that CPR managers can consider. Later, Hess and Ostrom (2001) discuss information as a CPR of its very own. Additionally, information access was ultimately included as the Sustainable Development Goal (SDG) indicator 16.10.2 in the SDG framework published in 2017 (UNESCO 2023). Abundant work on the topic calls for equity in information access and appropriation (e.g., technology, intellectual property) if sustainability is the goal. Thus, it would be wise to consider *information access* as a critical variable, particularly given its impact on management and management decisions (Feng et al., 2020). The context for *information access* would probably need to be limited to information access around the possible strategic elements pertinent to the management of a given CPR. In other words, similar to the variables for new technology and time to adapt to it, information access would refer to the information pool of possible management options accessible at the level of utility in a given CPR system to managers. In terms of the current applicability of this variable, we must also consider that it will score low when

taking global information into account, particularly in many cases of rural management (Seretse et al., 2018). This is quite a complicated variable because of the many moving parts around information access. For example, in this digital age, we must also include technology (and this variable could be included in that category) and literacy as indicators and possibly drivers. This variable fits into the *external influences category* as information access is external to a local group and/or physical area and relies on the cooperation of external institutions for the degree of access.

*Predictability* refers to the consistency in resource flows that influence the strategies and dependence on the resource base. This variable was included in the critical list by Agrawal (2003), and he based the context on mobile and seasonal resources, which aligns with the conclusions of Blomquist (1994) and Schlager et al. (1994). Naughton and Trevers (1995) further develop their discussion of predictability, arguing that unpredictability limits managers in resource allocation and augmentation of supply, as inconsistency necessarily limits predictability. Predictability, then, is time- or period-dependent (frequently seasonal or based on climate) in terms of historical/present availability based on biotic and abiotic conditions for resource presence and quantity. For example, forests are predictable in part due to their fixedness, at least while their functional structure is maintained, while water resources can be seasonal and contingent on a diverse array of actors and managers moving from upstream to downstream.

## Group characteristics

For the group *small size* variable, it was Wade (1994) and Baland and Platteau (1996) who noted that the smaller the user group, the more probable it would be for management to be efficient. However, Ostrom (1990) also talked about small size in relation to the portion of the population that has the right to make decisions with regard to resources and have a collective influence on the enforcement and possible development of rules (1990). So, size can refer to the total user group (settlement or community with CPR management) or the portion of the user group members with authority to make decisions. This distinction could be particularly informative in assessments of the impact of land tenure. The choice would reflect a dependence on the situational indicators and nature of the case or cases regarding what aspect of small group size is being measured and should be transparent when taken into account in meta-analyses.

In the case of *well-defined boundaries*, the variable being measured is essentially the clarity of the social and institutional rules for participation in forest management. The context and indicators should be adapted from Ostrom (1990), where clear social boundaries provide greater control for users/managers over the resource by providing a structure for rules around appropriation and provision. Wade (1994) echoed Ostrom (1990). In many cases, particularly in protected areas, the overarching rules are established by the nature of the land tenure unit and are regulated by Federal law, resulting in authority provided for certain members who are afforded land rights by the central or local government. In this way, the group boundary is defined by the governing institutions and upheld by local managers. It is possible that there is incongruence between the levels of governance, which would impact the clear definition of boundaries, having a negative effect on management. Ostrom (1990) also noted that both authorized and unauthorized members use the resources. The relationship/boundaries between the rule-making group and the conservation group (which are frequently overlapping) established by the former can inform strategy and policy on their own, thus justifying the inclusion of this variable.

The context of *shared norms* is based on Crawford and Ostrom (1992), who define norms as “shared understandings about actions that are obligatory, permitted, or forbidden.” Kang and Haab (2005) provided an analysis of DPs with a discussion of the primary role social norms play in governing CPRs. In CPR systems, gender is a notable factor. In all cases, women should be given some focus for two main reasons: 1) because of the clear normative element of female participation, and 2) because of Ostrom’s (1997) discussion of the critical role women play in the management of CPR resources. This was also brought up by Agrawal (2003) in terms of the importance of the use and management of CPR resources by women and has been the general consensus since Ostrom’s (1997) work. Thus, gender is an important indicator of shared norms in many CPR cases. As well, resource system care and harvesting/use norms are pertinent to this area of inquiry, as indicators. Of course, there are numerous others. Each CPR will have norms associated with it that impact the system management. Exploration of those norms provides an important dimension to understanding management strategies and their “success” or “failure.”

A similar process can be used for *past successful experience* or PSE. PSE is a clear manifestation of collective action and gives an indication of how well the collective has worked together in the past. Wade (1994) considers that PSE provides a basis for future cooperation, and Baland and Platteau (1996) argue that past successful experiences provide a precedent for rule-abiding behavior, making enforcement easier and compliance more likely in

the future. Gari et al. (2017) suggest that considering the age of a human/CPR system relative to the robustness of a CPR system makes the timescale a potentially useful indicator. The idea is that the greater the frequency and quantity of PSE, the more it indicates the length and quality of time a CPR has been under collaborative management. Here, transparency in the indicators for success is key, as is a scale for success over time. Particularly in successful cases, though, it is important to note the indicators of PSE for young CPRs or enduring CPRs that are showing success after a period of uncoordinated efforts. Young CPRs have important implications for informing CPR management in less successful cases. However, the overall context of PSE is fundamentally based on the collective experience that CPR managers have had over time, in which outcomes have been favorable for both the resource base and the local managers.

The indicators for the *appropriate leader* variable were considered based on Agrawal's (2003) and Ostrom's (1990) discussion of leadership. Agrawal (2003) and Baland and Plateau (1996) suggest that leaders should be young, familiar with changing environments, and connected to the traditional local elite. While these traits are certainly backed up by some research, this is not always the case (Mishkin 2021). Assuming that a researcher's assessment of "appropriate" is more correct than the decisions made by local managers (again, particularly in cases of efficient management) would create a large blind spot in understanding how local leaders are chosen and how to connect with local managers and their chosen leaders. If management of a CPR is effective in sustaining the resource base, it is useful to look at local perceptions of "appropriate." Because appropriate leadership is a subjective question of local perception, it is this author's experience that "appropriate" is best qualified by local managers. The local assessment of appropriate leadership has implications for strategic interventions, as well, since leadership is key to rule-following (Ostrom et al. 1994). For this and other reasons, it is more informative to determine what the local managers consider appropriate leadership, particularly if local managers vote on their leadership and the CPR is efficiently and successfully managed. Thus, to encourage deeper comprehension of local leadership, inform future interventions, and honor local perceptions/needs, it is incumbent on researchers to investigate local perceptions of appropriate leadership based on leadership indicators (van Norren & Beehner 2021).

The context for the *interdependence of group members* variable is taken from Ostrom (1990). The theoretical context here is the understanding that the choices made by the individual not only affect the collective but also must take into account the collective to be sustainable. She bases her determination on the theories of 'the firm' and of 'the state'. The main focus of Ostrom's (1990) context for the interdependence of group members is the process that they follow to encourage coordinated strategies for use and appropriation that rely on contingent strategies (often showing contrary behavior and results to Hardin's (1968) "tragedy of the commons") that are based on repetitive actions around the resource. This can be reflected in local resource-use rules and the impact and perception of participation. Ostrom (1990) identified evidence of this in actions where "individuals forego immediate returns in order to gain larger joint benefits when they observe others following the same strategy." It is useful for both statistical and descriptive purposes to explore the perception of participation and actual participation across community activities and services and how these are manifested in management actions.

The context for *homogeneity of identities and heterogeneity of interests* is based on the criteria outlined by Baland and Plateau (1996) and Agrawal (2003) regarding class and ethnicity, though they also discuss livelihoods as a manifestation of identity and interests. Baland and Plateau (1996) outlined the empirical basis for this in their work that discusses several of the DPs they considered most pertinent to the efficient management of CPR systems and the importance of this variable in successful cases. The inclusion of this variable is based on the theory proposed by Sugden (1984) that homogeneity of identity encouraged greater cooperation and the provision of useful resources. Ostrom (2002) noted the importance of cultural background, interests, and endowments on successful CPR management because of the influence of this variable on collective trust. Klinger (2020) added that economic heterogeneity aided in promoting trust, while cultural homogeneity was present since economic needs could be met with less competition (speaking to heterogeneity in interests). Additionally, taking into account the diverse nature of CPR systems, livelihood is not always informative since some CPR systems have more to do with daily life or subsistence and not necessarily income-generating activities, which can involve resources or markets outside the CPR. Weber et al. (2007) did a multiple-case analysis of ethnicity and migration in Indonesia. Their results supported the hypothesis that ethnicity is fundamental to decision-making based on cultural practice. Therefore, it is informative to look more closely at class and ethnicity, particularly where livelihoods are less of a factor in resource use and allocation. It is important to consider subsistence practices based on the "heterogeneity in interests" element of this variable, even where livelihood is not a gauge. As always, local context is key since geographic location frequently comes with its own array of different identifiers in terms of identity and activities, which speaks to the suggestion by Gari et al. (2017) that this element be considered in CPR studies, whether it be its own variable, indicator, or category. This is also a variable that lends itself to the indexes that Agrawal (2003) and others have suggested for variables with multiple sub-categories (ethnicity, history of identity and

available interests, participation in them, etc.), like this one.

Agrawal (2003) added the variable *low levels of poverty* to the list. The qualifier “low” is more perception-based, which is dependent on the scale of perception. In many studies, the context for poverty has been based on global measures. For descriptive and comparative purposes, local and global poverty measures should be considered and differentiated, especially in the case of efficiently managed and successful CPR systems. Perceptions of poverty can be addressed as a reference and socio-economic context, as local perceptions can differ significantly from global measures. This is particularly true in collective and subsistence CPR systems in which global poverty measures may not align with local perceptions because of cultural differences in defining fundamental needs and wealth. Additionally, it is imperative to consider how poverty is influenced by the management system and how its current state acts reciprocally as an influence beyond the basic consideration of poverty as a critical variable. Conventional theory hypothesizes that poverty has a negative effect on some CPR systems, although there is some variability in research that disputes this in some cases (Busch & Ferretti-Gallon 2017, Mishkin & Kiker 2021). This can be explained by the fact that neo-liberal policies have been identified as a driver in creating a reciprocal relationship between poverty and dependence (Feldman 2019). Adams et al. (2001) discuss poverty as both a variable and a result of management policy and practice and provide a framework from which to contextualize poverty in the CPR system and CPR regime. These distinctions are extremely important to consider, as is their discussion of poverty in the global management context. They demonstrated that poverty is often a result of management caused by policies at the level of centralized government. This additional consideration is important, as the causes of poverty impact CPR systems, and the addition of this nuance in the definition and causality of poverty has significant implications in informing CPR management assessment and subsequent policy.

## Extent of human pressure on the resource

It should be noted that the category title in Agrawal’s (2003) compilation of the critical list refers to this category as the Relationship between 1 (Resource system characteristics) and 2 (Group Characteristics). Because the wording can be confusing in presenting the results of the critical list to reference them not only as numbers but also as a relationship, this category was renamed “Extent of human pressure on the resource.”

*Overlap between user group and resource location* was a general criterion named by Wade (1994) and Baland and Plateau (1996). It is one of the more straightforward variables. They both referred to the physical proximity of user groups and settlements to the CPR. Baland and Plateau (1996) determined that greater overlap between the user group and resource location resulted in greater consideration for the resource in its management. Thus, theoretically, greater resource and user group area overlap is considered ideal in cases of collective CPR management. Looking at this physical proximity and comparing cases is useful in determining whether their hypothesis is supported across cases and why or why not. The outcomes provide important implications for management policy and strategic foci.

Wade (1994) considered that *high levels of dependence by group members on the resource* for services, subsistence, and products were important for conservation, which provides a focus on the resource as a system and speaks to the previous variable. Essentially, this refers to how much the managers depend on the ecosystem services that the resource base provides by its existence in a balanced, natural state. So, this variable has two possible components, which pertain to the physical resource system and the social dependence component. Again, the local perceptions of dependence are informative, albeit for the local context. It is important to keep in mind that since the answers to perception questions can be consistently positive, contrary behaviors might not be represented unless the perception and behavior are separated. The reason is that one can have positive perceptions and contrary behaviors (Ostrom 1990), and this should be considered in the development of measurement instruments and indicators to ensure the representation of both.

*Fairness in allocation of benefits* revolves around ascertaining how benefits are allocated and perceptions of fairness in that allocation (Baland and Plateau 1996, Agrawal 2003, Richie and Lewis 2003). In fact, a universal formula for fairness has still not been determined. Thus, this exploration is useful for that purpose and for case comparisons. The reasons for this are discussed by Agrawal (2003), who mentions the influence of socio-political factors, which can result in the sustainability of “asymmetric” distribution due to established dynamics. There is also the issue of how benefits are defined, which can also be influenced by local perception and should be considered on a case-by-case basis. Local perceptions of fairness are informative and can sometimes tell us more than external perceptions of fairness and/or whether or not a given group adheres to a particular strategy. The dialogue around fairness has the additional benefit of being useful in giving context for future incentive development and strategies to enhance

local management success. It can be empowering for local managers to voice their perceptions, particularly where relationships are problematic between levels of managers.

The *Low levels of user demand* variable is based on the use of resources as evidenced by the demand by activities and households for resources, as interpreted by the criteria established by Agrawal (2003), who added it to the list. Agrawal expresses concern that the demographics of demand have historically been overlooked in the determination and expression of levels of user demand. So it is useful to consider them directly, which also provides useful details to inform current and future interventions. Certainly, how demand manifests will depend on the kind of CPR, which can vary considerably from case to case but can be measured by indicators that scale up either as comparative indicators or as a combined measure of demand.

As a notable aside, a significant impact factor on levels of user demand is population pressure, and there is still a need to determine how much that pressure exerts influence on CPR systems. It can be argued that it is considered in the demand-oriented variables in this category. However, with exponential population growth globally, this is a variable that may require direct attention (which was also mentioned by Agrawal (2003) and others). This is particularly relevant since there has been limited research on user demand and its drivers, specifically in CPR systems, with the majority being from the 1990s. For example, Low and Heinen (1993) looked at behavior around resource management, Pimental and Dodds (1994) looked at population and destruction of resources, and Leach et al. (1996) focused on population and community-based natural resource management (CBNRM)—and there are various others during that decade with limited publications since. Giving specific attention to *population pressure* with regard to user demand on the resource over time may help inform future strategies and bring resource managers and decision-makers closer to understanding just how much impact population has on demand in current CPR systems. Given the appropriate treatment, this aspect of pressure could be taken into consideration in the Extent of human pressure on the environment category (Table 1), but it is not suggested as a variable at this time so much as a specific consideration. It is an investigative angle on its own (Ostrom 2008) and one easily observed in conjunction with the critical list (particularly in light of the group size variable).

*Gradual changes in levels of demand* were added by Agrawal (2003) based on the research that shows that if there is a sudden jump in demand (Colchester 1994, Young 1994), particularly if there are market pressures involved (Oates 1999), then the pressure on the resource is likely to increase beyond the ability of the resource base to maintain healthy levels over time. Of course, “gradual” as a qualification also needs to be defined. For this, it may be helpful to use that premise as the definition of gradual, as incremental changes that occur in such a way as not to result in a negative impact on the reproductive and maintenance needs of the system over either the short-term or the long-term. If demand changes are more gradual, it is more viable to adapt management strategies to consider and enable the reproductive and maintenance needs of the system (Villa et al. 2014, Erickson and Gowdy 2007). This would mean ensuring that the demand for the resource unit that is removed from the system does not exceed the amount necessary in the natural system to maintain a healthy state, similar to the *match restriction on harvest to regeneration* variable discussed in the *Extent to which rules take into account ecosystem potential* category.

## Institutional arrangements

*Rules are simple and easy to understand* is an important factor in rule adherence and thus in successful conservation. This variable was suggested for the critical list by Baland and Plateau (1996), and they focus largely on whether rules have some bearing on the socio-cultural and socio-economic needs and constraints of the local users. The premise for this variable is quite literal. The simpler and easier to understand the rules are, the greater the likelihood they will be followed (Baland and Plateau 1996). Again, perception rears its head. The local perception of rules is key to informing future strategy and to determining strong and weak points in the rule structure in the descriptive element of research and reporting, aside from its statistical value.

The *locally devised access and management rules* variable was developed by Ostrom (1990) primarily and was supported by Wade (1994), Baland and Plateau (1996), and Agrawal (2003) for inclusion in the critical list. Ostrom (1990) explains that an external framework of rules can be helpful in maintaining the commons as long as local managers are involved in modifying them. This is due to local needs and situational nuances as CPR systems change over time, a sentiment echoed by the others. They also agree that rule compliance is more likely if local users and managers have had a part in making the rules. There is a lot of nuance here since the use and management of common pool resources can impact users differently



depending on proximity, area designation, land tenure, and type of CPR (water, forest, air, etc.). In other words, the definition of “locally devised” can be different depending on the previously mentioned factors, among others. However, based on the theoretical context, we can discern that it refers to the local managers feeling they had a significant hand in the rule designation or, at the very least, understand and agree that the rules are necessary. The social context here is also useful for informing strategy adaptation to changing conditions and/or development apart from analytical value.

*Monitoring* is not nested in locally defined access and management rules, as there is a diverse array of other rules typical in CPR management systems. For that reason, monitoring is presented as a stand-alone variable for addition to the critical list. Monitoring has been determined as a key feature of successful resource management systems and adaptive management (Coenen et al. 2008).

The context for *ease of enforcement of rules* was taken from Ostrom (1990). This is a straightforward variable that would appear perception and outcome-based. Ostrom noted that social pressure is a significant factor in enforcement. She discusses the importance of the normative element of rule-following, having observed in her own work (and that of other CPR researchers) that a rule-following majority encouraged more widespread and long-term compliance with rules by others. Baland and Plateau (1996) also discussed the normative aspect of rules and how social pressure has an impact on ease of enforcement. So, the foundation of this variable is a question of local managers' perception of ease of enforcement as well as proxies to enforcement. Ideally, the rule context and outcomes can provide an educated approximation of how easy the rules are to enforce. It should be noted that the dialogue around the indicators for this variable is as useful as the direct measurement data to give context and perceptions around rule enforcement, and suggestions may arise that are important for interventions.

The context for *graduated sanctions* was also taken from Ostrom (1990), who based her conclusions largely on the work of Margaret Levi (1988). Levi (1988) talks about the contingent element of participation inherent in compliance with rules in a cooperative system. She found that “strategic actors” were compliant with a set of rules when two conditions were met: 1) There is a general perception that the collective objective is achieved, and 2) there is a general perception that compliance is common in the group. Levi found that enforcement enhanced the perception of legitimacy as well as compliance. Graduated sanctions act as an incentive to comply in what Levi (1988) termed quasi-voluntary because it is the decision of the individual to comply based on whether they believe they will be caught. This could also provide some context for *ease of enforcement of rules*. However, it seems foundational to the concept of graduated sanctions to take into account the circumstances and frequency involved in rule-breaking behavior and utilize the potential to strengthen rule adherence. If enforcement does not take into account circumstances (poverty, need) and the same punishment holds for singular as well as repeated rule-breaking, the legitimacy of the rules is called into question, and compliance is less likely (Ostrom 1990). This may also be a useful element in future interventions, as instances of non-compliance and incentives can be informative. Ostrom (2009) further suggests that these instances be compiled and shared with local leadership in a final report to provide empirical and analytical support for rule enforcement in a manner empowering to local managers.

The *availability of low-cost adjudication* was based on the definitions of the variable by Agrawal (2003) and Ostrom (1990). In simple terms, this variable covers whether there is a system in place to help those who need formal conflict resolution that is either free or otherwise not cost-prohibitive. Both argue that this is a variable that enables enduring institutions and efficient management structures. This is a question whose background (as with the majority of the variables) is as useful as the direct question itself. In other words, the line of inquiry regarding how conflicts are resolved officially is informative to provide insight into conflict resolution and institutional mechanisms. It is important to gain some background on adjudication in order to determine whether availability is equivalent to accessibility, though this is implicit in “availability”— in the context of Ostrom and Agrawal's discussion of it. Again, beyond the presence or absence of availability of low-cost adjudication, the descriptive value for determining what the mechanisms are (if any) is useful to inform conflict resolution and accountability. A form of accountability is a variable of its own focused on the authorities outside of the local managers and is discussed in the next paragraph.

*Accountability of monitors and other officials to users* was added by Ostrom (1990) and Baland and Plateau (1996). They all discuss the importance of an accountability structure to enhance compliance with rules and to ensure rules are fair. In the case of this variable, the context is the accountability of authorities beyond the local managers to provide a sense of legitimacy to the process and the governance structure acting on local managers. Again, we see the importance of perception. Perceptions of accountability, along with mechanisms, are an important factor as perception impacts legitimacy (Ostrom 1990). The exploration of perceptions serves to inform future strategy and give context to current relations between levels of managers and governance and should be considered.

## Extent to which rules take into account ecosystem potential

As with the Extent of human pressure on the resource category, the category title in Agrawal's (2003) compilation of the critical list refers to this category as Relationship between (1) Resource system characteristics and (3) Institutional arrangements. For the same goal of providing better clarity and depiction, the category was retitled "Extent to which rules take into account ecosystem potential."

The *match restrictions on harvest to regeneration* variable is discussed by Ostrom (1990), Wade (1994), and Ostrom et al. (1994). In the latter, they devote an entire chapter to the different kinds of restrictions that are possible in the rules governing CPR systems, with a focus on irrigation, though other systems are discussed throughout the book. This represents a necessarily limiting variable to sustainability based on the reproductive and regenerative specifications inherent in any CPR. This is an intuitive and fundamental element of sustainability, as over-harvesting or over-use consequently ensures no resource base to depend on (Erickson 2015). The operationalizing is straightforward and based on the requirements of a given CPR and its ecological components to function at full, self-perpetuating capacity over the long term.

## External environment

### *Technology:*

- a. *Low-cost exclusionary technology* was highlighted in its importance to CPR success by Wade (1994). This refers to any technology that aids in the enforcement of rules of harvest and protects the resource base over time. This can be represented by fences, specialized fishing nets, water catchments, or any number of other protective technologies that can be simple or complex but that have a low cost to users/managers and directly aid in the protection of the resource. It should be noted that maintenance costs (in terms of time, material, and money) can be prohibitive to the integrity and effectiveness of the technology. The details regarding upkeep, maintenance, and efficiency should be considered when applicable.
- b. *Time for adaptation to new technologies related to the commons* was included by Agrawal (2003). The implication is that managers and users of the resource(s) have sufficient opportunity to adjust their concepts and practices to efficiently incorporate new technologies related to the CPR system in a beneficial way that does not result in prohibitive cost, waste, or over-exploitation. Agrawal (2003) references a body of work on the impacts that new technologies have on commons management, changing the cost-benefit ratios for managers (Oates 1999). This, in turn, impacts the sustainability and structure of management, often benefiting the participants with greater means (Agrawal 2001). It may be important (even if considered as a part of the measure of the fairness variable discussed earlier) to consider whether access to new technologies is equal. However, this is tangential to the fundamental essence of this variable. It would seem to be more along the lines of the discussion in Ostrom et al. (2012) regarding the "adaptive capacity" of firms to technological change and the formational periods that influence the robustness of the routines that lead to adaptability. This adaptive capacity will be contingent on the kind of technology, the level of complexity, and the working knowledge present among local managers. It is subsequently tempting to change the name of this variable to "adaptive capacity of users to new technologies."

There are two variables that are related and can be discussed in concert: *low levels of articulation with external markets* and *gradual change in articulation with external markets*. These are two variables that were included by Agrawal (2003) and follow a similar vein as the *gradual changes in levels of demand* variable in the way that they are all heavily influenced by pressure and demand. The theoretical context for *low levels of articulation with external markets* lies in the ways that products resulting from the CPR system are used, developed, and exploited with regard to the external markets. Based on Agrawal's discussion of the variable, we can discern that he appears to have adopted a concept of articulation like that discussed by Robertson (1992). Robertson references the Standing Commission on the Scottish Economy and defines articulation as "the strong network of (formal and informal) linkages which in successful economies 'harness market forces, negotiate around market failures and in other ways serve many of the functions necessary for a complex economy to work.'" These low levels of articulation refer to the local managers' limits on linkages to the local and other external markets for the use of materials and value-added products that come out of the exploitation of the CPR. There is a general consensus that greater market involvement in products resulting from the CPR has an adverse effect on the system (Colchester 1994, Agrawal 2003, Ostrom et al. 2012).

For the variable *gradual changes in articulation with external markets*, Agrawal (2003) presents the essence of the variable as determining whether the market linkages formed happen in such a way as to enable sustainable market involvement, i.e., fine increments vs. sudden large changes. In terms of

the qualifier, it is helpful to return to the premise in the definition of gradual that was used in the *gradual changes in levels of demand* variable: incremental changes that occur in such a way so as not to result in a negative impact on reproductive and maintenance needs of the system. Thus, the context is that the changes in market linkages occur in such an incremental way that demand for the products does not result in damage to the CPR system and a lack of sustainability.

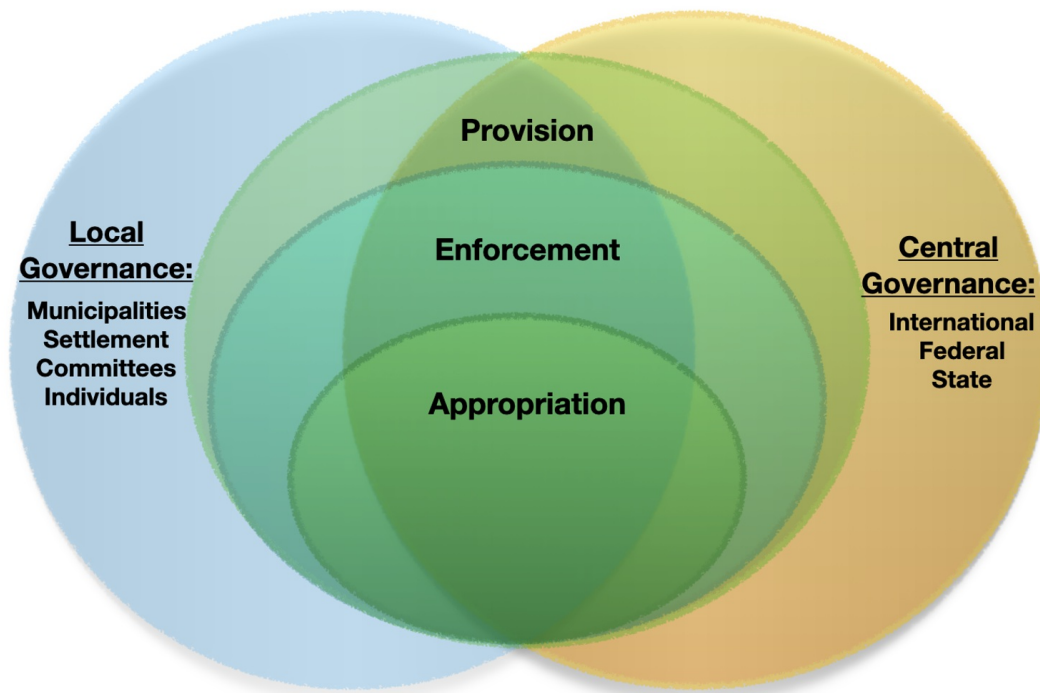
#### *State:*

The context for the *supportive external sanctioning agencies* variable is based on the external agencies that provided financial, enforcement, and monitoring support, as described by Baland and Plateau (1996). The authors demonstrate that external sanctioning agencies can provide further pressure to induce cooperation by local managers and other local actors. Exploration of whether there are supportive external sanctioning agencies and how their support manifests also provides useful information regarding the perception of external agencies for current and future interventions. It should be noted that Slough et al. (2021) found that community monitoring was a significant enabling factor in sustaining the commons, particularly when monitoring was part of local managers' collective action. Both points must be considered when external agencies develop and refine management strategies. Moreover, *monitoring* should be considered a critical variable in the list as Ostrom (1990) and others documented the importance of monitoring in the long-term success of CPR systems, and their research supports the efficiency of collective action. Monitoring would ultimately need to be broken into two parts- 1) the group characteristic of self-determined monitoring, and 2) support of monitoring efforts by external agencies overseeing local CPR management.

*Central government should not undermine local authority* was first a DP (Ostrom 1990), and was supported for inclusion in the list by Wade (1994). Ostrom (1990) discusses the importance of legitimizing local authority in rule-making and enforcement by central governance institutions as an important element of the long-term sustainability of management practices while aiding in enforcement. Wade (1994) echoes this argument. Along with the sources of authority-generated guidelines, this is another variable that involves the local authorities' and practitioners' perceptions. As to whether the central governing institutions undermine local rules, practices, and enforcement, the supporting experiential evidence and local perceptions are crucial.

Associated with central and local governance is *institutional continuity*, defined as the consistent accumulation and sharing of knowledge and protocol from one governing cohort to the next. This additional variable in this category should be considered for inclusion in the critical list as institutional continuity often has a marked impact on efficiency (Mishkin 2024, Mishkin and Kiker 2021). It can also influence the ways in which governance reciprocally impacts local perceptions with regime changes (Agrawal 2005) and influences the support of local managers by governing institutions over time and could impact additional variables in this category.

*Appropriate levels of external aid*, integrated by Baland and Plateau (1996), speak to compensation where opportunity costs impact the willingness and ability of local managers to participate in conservation activities, particularly where external institutions require conservation interventions. This means that the variable has several layers. Local manager perception is, again, an important factor since "appropriate" is, in essence, a subjective measure. Local managers carry the full weight of conservation responsibility, often having to offset that time and effort with livelihood and subsistence activities. As follows, the contributions by external organizations are pertinent here. The opportunity cost of conservation measures can be complicated as valuation is still imperfect, though some strategies have been developed (Costanza et al. 2020, Capmourteres & Anand 2016). There are also various forms of compensation that are provided in different CPR scenarios, and it would be important to determine what kinds of compensation are present, e.g., monetary, additional resource access, status, etc. Because of the responsibility placed on the local managers, it is important to put heavy consideration on their perception of "appropriate levels," as this has a documented impact on participation (Ostrom 1990), and with reflection on their unique position between the global need for the resource base and their local needs. It also has implications for fairness and equity (Baland & Plateau 1996). As a pertinent aside, Shapiro Garza (2010) notes that there are areas where payments for ecosystem services have been understudied so that the investigation of this variable could be taken advantage of to inform PES studies and policy, as well.



**Figure 2.** A visual representation of Elinor Ostrom's (1990) 8th design principle: Nested levels of appropriation, provision, enforcement, and governance. Provision, enforcement, and appropriation occur at the nexus of local and central government, where there must be balance for sustainable management, as demonstrated by the variables that precede it in the critical list.

The *nested levels of appropriation, provision, enforcement, and governance* variable is one of Ostrom's (1990) original eight DPs, and she considered it one of the most fundamental. Her very simple breakdown of the context for this variable is that “establishing rules at one level, without rules at the other levels, will produce an incomplete system that may not endure over the long run.”

Ostrom (1990) provides a certain amount of focus on the rules at each level as context for this variable. Thus, the different layers of rules are evidence of the nested layers in accordance with the various nested authorities. It is important to note that this variable speaks to the importance of congruence and feedback in the levels and rules governing the nested levels. The institutions responsible for rule-making have been noted and documented in the data for previous variables: *Central government should not undermine local authority* (since one must determine where the central government's institutional authority lies as well as what the local authorities are), *supportive external agencies* (as these would be researched and listed and are pertinent to this variable), *appropriate levels of external aide* (as some of these agencies may be involved in enforcement and support but may be different from the previous two variables), *availability of low-cost adjudication* (some of the institutions or actors involved may influence any or all of appropriation, provision, and governance but not be found in the previous variables), and *accountability of monitors and other authorities to users*. This also applies to the suggested variable of *institutional continuity*. We can then infer that when observing and informing strategies, it is important to gain insight into those perceptions of the nested levels since the level can exist, but if it is not present in the decision-making system (management perception), the influence is limited or nominal. The subsequent dialogue can inform perception and awareness of the rules' origin and purpose for non-statistical purposes while being useful in providing context and informing policy where there are weak linkages between and among levels-- and pointing out where those lie. This is key in encouraging the success of CPR system intervention and ensuring the relationship between and among levels is maximized for greater efficiency at all levels.

## Discussion

A full review paper could be written on each variable of the critical variables (Table 1). However, the goal of this paper is only to provide an elemental reference to the theoretical context for the critical list of variables for sustaining the commons to reduce interpretational variation. The idea is simply to provide reinforcement of the theoretical context of each variable for the further evolution of theory and its applications so that the outputs of CPR work

are continuously more robust and informative. In agreement with Schlager (2016), we are in the very midst of this process. As Ostrom's (1990) DPs evolved into the critical list, the critical list of variables for sustaining the commons is evolving. They evolved into the SESF framework, which was designed to make analysis and understanding of complex CPR systems systematic and suitable for scaling up into meta-analyses, which is beyond the scope of this paper but bears mentioning. This and other frameworks that seek to aid in the assessment and comprehension of CPR systems rely on theoretical integrity to guide the components and facilitate the evolution of theory. Clearly, the most direct route to evolve theory (and methods) is to apply it, and this reference provides an essential overview of theoretical context to enable more systematic operationalizing along with more elucidative comparisons.

The issue of 'one size fits all' metrics or even indicators has never been applicable to CPR systems due to their diversity, and for this reason, researchers must determine the appropriate metrics on a case-by-case basis (Frey 2016), even while the variables remain the same. Unfortunately, suggestions for particular metrics for all variables and CPR categories are a different animal and beyond the scope of the context discussed in this work, which also contends with limitations in paper length. Suffice it to say, the kind of CPR system weighs heavily since they all behave differently (e.g., mobile versus immobile systems, protected areas vs. public lands, etc.). Villamayor-Thomas et al. (2018) also discuss the importance of proper metrics and methods to compare them, as does Cox et al. (2020). Happily, in spite of the variation in indicators, the variables themselves do apply to all CPR systems, at least in their vast majority— so providing the theoretical context creates a level playing field for measuring variables in individual cases as well as scaling them up. Bernstein et al. (2019) suggest the need for contextualizing the basis for critical variables and a systematic means for tailoring frameworks (and subsequent coding) to address evolving commons dilemmas due to climate change and other factors that result in greater external pressure on CPR systems. Villamayor-Thomas et al. (2018) and Cox (2020) demonstrate the application of Agrawal's (2014) discussion of the importance of starting from a theoretically stable foundation so that scaling up is robust and methodological evolution is supported. Opportunely, there are many experts in particular CPR systems who have developed novel approaches with publications on the same.

It should be mentioned that Agrawal (2003) makes some very practical suggestions on how to create indices for variables in order to reduce analytical limitations for multivariate data sets. In terms of operationalizing, the UN has a number of resources pertinent to the Sustainable Development Goals that could be useful in CPR studies, like the UN Ecosystem Assessment, Multidimensional Poverty Index, and others that could aid in the determination of effective indicators. The Organization for Economic Co-operation and Development (OECD 2008) provides "consistency indicators" reflecting the intensity of the use of natural resources by relating harvested or extracted amounts to sustainable yield levels or the annual growth of the resource. They discuss material flows that take into account the amount of resources available in a given time period (often measured seasonally) without impacting the resource base necessary to ensure sustainability, which requires a baseline. These resources, among others, are helpful in providing additional consistency in applying indicators and developing metrics.

Having a solid theoretical foundation results in a much more robust and efficient case analysis as well as scaled-up comparisons, even to the meta-analytical level. Understanding how the variables influence CPR systems and how they interact is imperative in understanding CPR system dynamics. In fact, Agrawal (2003) noted the importance of determining the conditionality of influence as well as interaction effects among variables, which is complicated because of the number of variables and the limitations of linear statistics. Agrawal (2014) later highlighted the importance of establishing the theoretical context in the evolution of more sophisticated analytical methods and robust results as climate change puts greater pressure on CPR and CPR managers. Having a consistent theoretical basis for operationalizing the variables allows for efficient experimentation with multivariate models and higher-level variance (Mishkin & Kiker 2021). Thus, this reference paper provides an essential reference for systematizing the operationalization of variables and maintaining the integrity of the theoretical context of their qualifiers, resulting in a foundational "equalizer" in the determination of indicators.

## Conclusion

The critical list of variables, as a set of general parameters provided here, enhances global systematizing while remaining flexible in the assignment of metrics based on CPR type and situational nuances (Mishkin & Kiker 2021, Agrawal 2003). In practice, agreement on the theoretical context of the variables ensures the integrity of the criteria is maintained, laying a solid foundation to build on for operationalizing and comparisons. This paper is a central resource providing the theoretical context of the critical list of variables for sustaining the commons as an accessible reference for CPR researchers.

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