

Insights from the Field for Measuring and Analyzing Adaptation in Common-Pool Resource Management

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This paper will analyze how adaptation has been defined and measured in fieldwork studies of common-pool resource systems. Changing climate, land uses, demographics and markets all highlight how resource managers need to be capable of responding to and appropriately addressing change. In recent years, a growing body of literature on social-ecological systems has assessed adaptation and identified factors that determine a community's adaptive capacity. This is an exciting discussion, particularly given the dynamic conditions in many commons. Nonetheless, in order to fully understand how adaptation can be applied to common-pool resource management, it is imperative that we step back and examine how we identify and assess adaptation in the field.

This paper is an initial intent to examine how scholarly discussions of adaptation in social-ecological systems have been defined, applied, and measured in field studies of common-pool resource management. Our analysis is based upon a literature review of fieldwork studies conducted by geographers, anthropologists, political scientists and others that specifically look at community adaptation processes and outcomes in local common-pool resource systems. In the analysis we compare similarities and differences in how adaptation is defined and measured and discuss the empirical foundations for understanding adaptation. We hope that the findings will point to successful techniques for conducting empirical studies of adaptation, as well as suggest areas where our empirical understanding of adaptation and adaptive capacity might be improved.

Keywords: *Social-ecological systems, resilience, adaptation, institutional change, fieldwork studies, methods*

1. Introduction

Research on the commons has shown that communities that have been relatively autonomous and buffered from outside forces can, and have, successfully governed their commons for centuries. Nonetheless, their sustained success is uncertain when said communities are exposed to rapid change (Richards 1997; Agrawal 2001; Dietz, Ostrom et al. 2003). Change is, of course, inevitable. In our globalized world, however, change can be particularly challenging for local common-pool resource users as new markets, political systems, demographics, and ecological conditions present unexpected and pressing governance challenges. A vital question for the future of many common-pool resource systems is: How do local resource users adapt to increasing economic, demographic, and ecological change?

Understanding when, why and how resource dependent communities adapt to exogenous change is a critical question for two reasons. First, it is critical, from a theoretical standpoint so that we can better understand adaptation processes and improve our models of how resource-dependent communities respond to different types of exogenous threats. Second, it is critical from a practical standpoint,

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because, if we understand how resource-dependent communities adapt to a variety of exogenous changes and the types of challenges they face, we may be better able to create policies and programs that facilitate adaptation.

Studies of how resource-dependent communities respond to change are particularly challenging as they require an in-depth understanding of the communities, the resource and the changes that are occurring. As researchers interested in furthering our understanding of how common-pool resource communities adapt to exogenous changes (sociopolitical, ecological and economic), our intention in researching and writing this paper is to learn methods for identifying and evaluating adaptations in resource-dependent communities so that we can best contribute to this growing field and suggest lessons for future fieldwork.

Scholarship on adaptation has grown over the last decade as anthropologists, geographers, political scientists, and others have examined how individuals, communities, regions, and countries respond to a variety of social, economic, and environmental changes. For example, in the common-pool resource management context, some scholars have examined how individuals respond to new markets or policies (Coulthard 2006; Janssen, Anderies et al. 2007), while others examine how communities address natural disasters of changing climatic conditions (Berkes and Jolly 2002; Ford, Pearce et al. 2007).

In order to begin to answer our methodological questions for measuring adaptation, we draw on this rich body of research to look at how scholars have measured adaptations in fieldwork studies in common-pool resource contexts. The questions that guide our research are: (1) How is adaptation defined and measured in the field?; (2) Can we establish a causal link between a particular disturbance or set of disturbances and adaptation processes and outcomes?; and (3) How do we evaluate if an adaptation is “successful”?

In the following, we present the results from our literature analysis. We begin by discussing how adaptation is conceptualized and defined in the literature across fields of study and then explain our methods for conducting the survey and selecting fieldwork cases. In the survey of the fieldwork, we sought to identify how the authors define adaptation and the methods they use to measure said adaptation; the types of disturbances and adaptations studied and whether a direct causal link is established; and, the criteria (if any) used to assess adaptation. In the last sections of the paper we present our results based upon the above criteria and offer insights from the field studies.

2. Conceptualizations of Adaptation & Disturbance

The concept of adaptation originated in the natural sciences and is frequently defined as the development of genetic or behavioral characteristics which enable organisms or systems to cope with environmental changes in order to survive and reproduce (Smit and Wandel 2006). In the social sciences, various fields of study use adaptation to examine how different levels of human organizations respond to different disturbances that alter the status quo.

The study of adaptation is particularly prominent in the literatures on development, Human Dimensions of Global Environmental Change (HDGEC), and ecological resilience (Batterbury and Forsyth 1999; Janssen and Ostrom 2006). In our literature survey, we include studies from each of these fields. While it is not possible to draw clear lines between the fields (many of the authors publish and work with others across the three fields), we do wish to discuss some of the disciplinary tendencies in the conceptualization and use of adaptation and highlight how different

definitions may be particularly useful for providing a more precise understanding of adaptation and how to measure it.

Scholars in both the development field and the field of HDGEC, draw on traditions in cultural ecology in their definition and use of adaptation (Butzer 1989; Batterbury and Forsyth 1999; Smit and Wandel 2006). In the development literature, adaptation is considered to be the strategies that households and communities use in order to sustain their livelihoods while responding to environmental or social disturbances (Scoones 1998; Batterbury and Forsyth 1999; Bebbington 1999; Ellis 2000). Anthropologist and geographers in this tradition have generally conducted studies about how households and communities in poor rural areas of developing countries respond to social and environmental change (See for example: Steward 1963; Rappaport 1968; Denevan 1983; Netting 1993).

In analyzing adaptation, the development literature increasingly uses a political ecology approach. This approach emphasizes how the political and institutional context influences vulnerability and adaptation amongst different social groups (Batterbury and Forsyth 1999; Adger 2000; Robbins 2004). In the development literature, several authors distinguish between adaptive strategies and adaptive processes. The key distinction between adaptive strategies and processes is the length of time involved in implementing the adaptation. Adaptive strategies are those adaptations that can be implemented relatively quickly, whereas adaptive processes are decisions that take time, and often time considerable amount of organization, to implement. For example, crop diversification can be considered an adaptive strategy whereas constructing terraces for agriculture on steep lands is an adaptive process (Batterbury and Forsyth 1999; Berkes and Jolly 2002).

The concepts of vulnerability and adaptation are particularly important to climate change scholars that are concerned with the impact of climate change on human communities. The work of HDGEC scholars, many of whom are involved with the Intergovernmental Panel Climate Change (IPCC), focuses on the human causes and consequences of global environmental transformations, and the ways in which societies respond to these changes (Liverman 1999). Scholars in this field study how to assess and promote communities' capabilities to adapt, or successfully cope, with drought, flooding and other natural events associated with climate variability. Adaptive capacity is considered to be the set of preconditions that enables individuals or groups to respond to climate change (Tompkins and Adger 2004). A growing body of literature suggests that a community's adaptive capacity depends on a varied set of factors that operate at different spatial and jurisdictional scales. Such factors include: financial, political and social capital, information and technology, infrastructure, entitlements, and the ability to learn, self-organize, and make/change rules (Berkes, Colding et al. 2003; Anderies, Walker et al. 2006; Eakin and Lemos 2006; Smit and Wandel 2006). Nonetheless, although we are beginning to understand the conditions that promote adaptive capacity, the specific factors that spark adaptation and the process that ensues are not particularly well understood. As Smit and Wandel emphasize in their review of community adaptation to climate change, it is important to identify how a community experiences change and the processes that it evokes to accommodate these changing conditions (2006, p.285).

HDGEC scholars investigate adaptation at the household, community, sector, regional and country level (Smit and Wandel 2006). Like development scholars, those working in HDGEC draw on cultural ecology in addition to work on natural hazards to develop the concept of adaptation (Burton, Kates et al. 1978; Smit and Wandel 2006). In their work, HDGEC scholars clearly distinguish between

adaptation and mitigation. HDGEC scholars consider adaptation to be human responses to cope with environmental change, whereas mitigation refers to responses that reduce exposure to environmental changes (i.e. dealing with the source of the problems) (Smit and Pilifosova 2001; Nelson, Adger et al. 2007). HDGEC scholars define adaptation as a process, action or outcome in a system in order to better cope with, manage, or adjust to some changing condition, stress, hazard, risk or opportunity (Smit and Pilifosova 2001; Smit and Wandel 2006; Nelson, Adger et al. 2007). In the literature, adaptations have been classified in several ways, including: the timing relative to the disturbance (anticipatory, concurrent, reactive); intent (autonomous, planned); spatial scope (local, widespread); and, form (technological, behavioral, financial, institutional, informational) (Smit and Wandel 2006). The diverse classification systems illustrates the variety of factors that are important for improving our understanding of adaptations, and, some of the difficulties of coming to a common understanding of the concept.

In contrast to those working in development or on HDGEC, scholars working on resilience often draw on the ecological concept of adaptation to analyze dynamic social-ecological systems that occur at different scales across time and space (Berkes, Folke et al. 1998; Gunderson and Holling 2002; Folke 2006). A socio-ecological system is defined as an ecological system intricately linked with, and affected by, one or more social systems (Anderies, Janssen et al. 2004), and thus constitutes an integrated and dynamic system of people and environment (Berkes and Turner 2006).

In the study of the dynamics of SES, adaptation is considered a crucial component of a resilient system (Carpenter, Walker et al. 2001; Folke, Hahn et al. 2005; Folke 2006). Resilience is understood as i) the amount of disturbance a system can absorb and still remain with the same state or domain of attraction, ii) the degree to which the system is capable of self-organization (versus lack of organization, or organization forced by external factors), and iii) the degree to which the system can build and increase the capacity for learning and adaptation (Folke 2006). In the resilience literature, adaptation may be incremental adjustments to change or it may consist of complete transformation of the system when ecological, political, social or economic conditions make the current arrangement untenable (Folke 2006; Nelson, Adger et al. 2007).

In each of the three fields, scholars in the development, HDGEC, and ecological resilience traditions emphasize the importance of disturbances in the analysis of adaptation. Authors use a variety of terms to describe a disturbance (i.e. shock, stimuli, stress, and perturbation). Many also classify the disturbance based on: (1) the magnitude and timing of the variability (i.e. unexpected and spiked or slow and gradual) (Turner, Kasperson et al. 2003; Marschke and Berkes 2006; Janssen, Anderies et al. 2007); and (2) the proximate source of the disturbance (i.e. environmental or socioeconomic change) (Batterbury and Forsyth 1999; Janssen, Anderies et al. 2007; Nelson, Adger et al. 2007).

The different fields of research on both adaptation and the disturbance offer more nuanced ways of conceptualizing adaptation processes that may aid in the identification and specification of adaptation in the field. In each of the literatures there is an attempt to distinguish between the degree or extent of adaptation. For example, the development literature focuses on duration of the adaptation, whereas the SES literature examines the extent of change. The HDGEC offers one of the more complete definitions of adaptation in that scholars writing in this field distinguish between adaptation and mitigation and even further categorize responses based on

time, intent, spatial scope and form. In the following analysis, we look at studies of the commons across these fields in order to compare and learn from how the distinct conceptualizations and categorizations offered by each of the literatures have been measured and analyzed in the field.

3. Methods

3.1 Data

This article is based on a review of case studies retrieved from two databases: the Digital Library of the Commons (<http://dlc.dlib.indiana.edu/>) and the Institute of Scientific Information (ISI) online database on Web of Science (<http://apps.isiknowledge.com>). In each database we searched for papers published that included “adaptation” in their keywords, title or abstract. The searches were made on March 2008 and include papers published through December 2007.

For the Digital Library of the commons the searches with the word adaptation gave us 62 results. In ISI Web of Science – Social Science database the same search gave us 18,668 results. Due to the high number of results with the topic adaptation, we used 19 combinations of keyword searches (in all of them the word adapt was included). We used the following keywords: adapt*, common*, institution*, govern*, “ecological systems”, “resource management”, “environmental change”, learn* and collective*. The asterisks were used to include all possible word terminations (i.e. adapt* includes: adaptive, adaptation, adaptedness). The search combination in the ISI Web of Science database gave us 218 results.

From our initial search (total of 280 articles), we looked for papers that fulfilled two criteria: 1) the articles were direct results of case studies or meta-analysis of case studies and 2) the case studies refer to natural resources that comply the characteristics of a Common Pool Resource: low capability to control access and use of the resource affects the resource availability of others (Ostrom 1990). We identified 24 articles that met this criterion and that therefore included in the following analysis. Twenty are case studies and four are meta-analyses that consist of several case studies. Given the meta-analyses and individual case studies, we have a total of 30 case studies for our analysis.

A list of the 24 selected articles can be seen in table 1. Almost half of the selected articles were published between 2006 and 2007, which shows the growing attention and use of the adaptation concept in the environmental management literature. The common-pool resources included in our study are as follows: ten are of fisheries, eight examine water, wetlands and lakes, four focus on forests, four on communal rangelands, three examine wildlife/hunting, two examine collective farmland, and finally one study of livestock. As can be seen in table 1, most of the articles draw on the concepts developed in Ecological Resilience, although a number of articles also come from the development traditions. Some articles use theoretical frameworks from more than one tradition (for example, Tompkins and Adger 2004 use the resilience framework to understand a Caribbean island responses to climate change).

It is important to mention that we recognize that not all of the 24 articles have the explicit goal of explaining the adaptations processes, actions and outcomes. Some articles focus more on other theoretical discussions of particular components that are important factors in adaptation such as the importance of leadership, knowledge, scale, adaptive management, etc. Nonetheless, the 24 articles that were selected for the analysis use at least one of the theoretical traditions of adaptation and also explain to a certain degree the adaptations of socio-ecological systems.

3.2 Variable Analysis

In each article we searched for specific variables to explain the adaptation process. The variables we looked for included: academic tradition of the author(s); author supplied definition of adaptation; research methods, specifically to identify adaptation and causation; description of the disturbance; description of adaptations; and assessments of success or failure.

All of the data was gathered by both authors and put into an excel spreadsheet. In order to facilitate the analysis of the raw data, we coded the disturbances, adaptations, and causal mechanisms based upon categorization frameworks used in the climate change and socio-ecological systems literature, and a close examination of the research design and data gathering description. In order to provide some consistency to the categorization, the different variables were coded independently by each author. The following explains the principle criterion used to code these variables:

3.2.1 Disturbance.

Disturbances are coded based on variability and proximate source. Following Marschke and Berkes (2006), we use the terms “shock” for unexpected and discrete major spikes beyond normal variability and “stress” for regular, slow and continuous changes within normal variability. The classification of the proximate source of the disturbance is based upon work by Janssen, Anderies, et al. (2007). We categorize the sources of the disturbances as biophysical, institutional, and socioeconomic. Biophysical disturbances include events such as drought, flooding and climate change. Institutional disturbances are changes in the rules that regulate the common-pool resource system and include changes in governing policies or property rights. Socioeconomic disturbances include broad amorphous events like globalization and also more specific factors such as the introduction of new markets, new technology or new populations.

3.2.2 Adaptation

The list of adaptations is coded based upon (1) decision-making level; (2) form; and (3) intent.

The decision-making level of an adaptation serves to illustrate the degree of collective decision-making involved in the decision to adapt. All adaptations made at the individual or household level are coded as “individual”. In contrast, those adaptations that required some degree of collective decision-making between actors in the community or a government are coded as “collective”.

The classification for the form of the adaptation is based on work by Smit and Wandel (2006): behavioral, informational, technological, institutional, and financial. Behavioral adaptations consist in changes in the day-to-day use of a particular resource (ie livelihood diversification, changes in resource extraction), whereas informational adaptations include activities to gather or analyze information to adapt. Technological adaptations are actions that require a technological change, institutional adaptations include processes of organization and rule or policy making/changing, and finally, financial adaptations include monetary transfers and infrastructure.

Intent of the adaptation is used to distinguish between those adaptations that were self-generated by a community and when a government or external actor (non-governmental organization, researcher, etc) was instrumental in sparking adaptation activities. Drawing from the literature (Smit and Wandel 2006), we categorize

adaptations as “autonomous” when no external intervention was present and “external” when other actors promoted the adaptations.

3.2.3 Causal Mechanisms

Determining the causal mechanisms that produced an adaptation, particularly linking an adaptation to a particular disturbance, is one of the most challenging aspects of adaptation research. Nevertheless, if we want to understand when and how communities adapt, we need to be able to identify when and how they adapt to what. In order to assess whether the authors present a direct causal link between a disturbance and an adaptation process, action or outcomes, we examine the research design and the explanation given by the author. We ranked (from 1 to 4) each case study on the degree of clarity of the causal link. “4” refers cases where the authors do not mention the links and, furthermore, there is no evidence in the research to conclude that there is a direct causal link. “3” refers to cases where the causal link is implicit in the case study or merely stated by the authors without any evidence of causation. “2” refers to cases where the authors state that there is a link, but the authors do not provide sufficient evidence in the research so that others can testify the existence of the link. Finally, “1” refers to cases where the research design and the author provide a clear causal link between a particular disturbance and an adaptation.

3.2.4 Success or Failure

The last component of the analysis is whether the community is successful or not in adapting to a disturbance(s). Success is obviously a relative term that can be defined via a variety of factors. In our analysis we first attempted to examine whether an author stated that the adaptation was a success and the criteria used to define that success. Given the dearth of information in many cases on the success or failure of the adaptation(s), our final analysis only includes information on whether the author provides any assessment on the outcomes of the adaptation(s).

4. Results

In this section we present a general overview of the 24 articles analyzed and answer the following three questions: (1) How is adaptation defined and measured in the field?; (2) Can we establish a causal link between a particular disturbance and particular adaptation processes and outcomes?; and (3) How do we know if an adaptation is “successful”?

4.1 Definitions and measurements of adaptation

The definitions of adaptation varied amongst studies as did the types of methods researchers used to identify adaptation. Table 2 presents some of the definitions used in the case studies. Figure 1 presents an overview of the types of methods used in the articles.

Of the 24 articles, five provided explicit definitions of adaptation. Table 2 illustrates a brief comparison of the different definitions of adaptation used in the articles. In addition to the few articles that gave an explicit definition, eleven articles clearly implied how they define and use adaptation. The remaining eight articles did not offer a definition, nor was the definition easily presumed.

Table 2. Definitions of adaptation

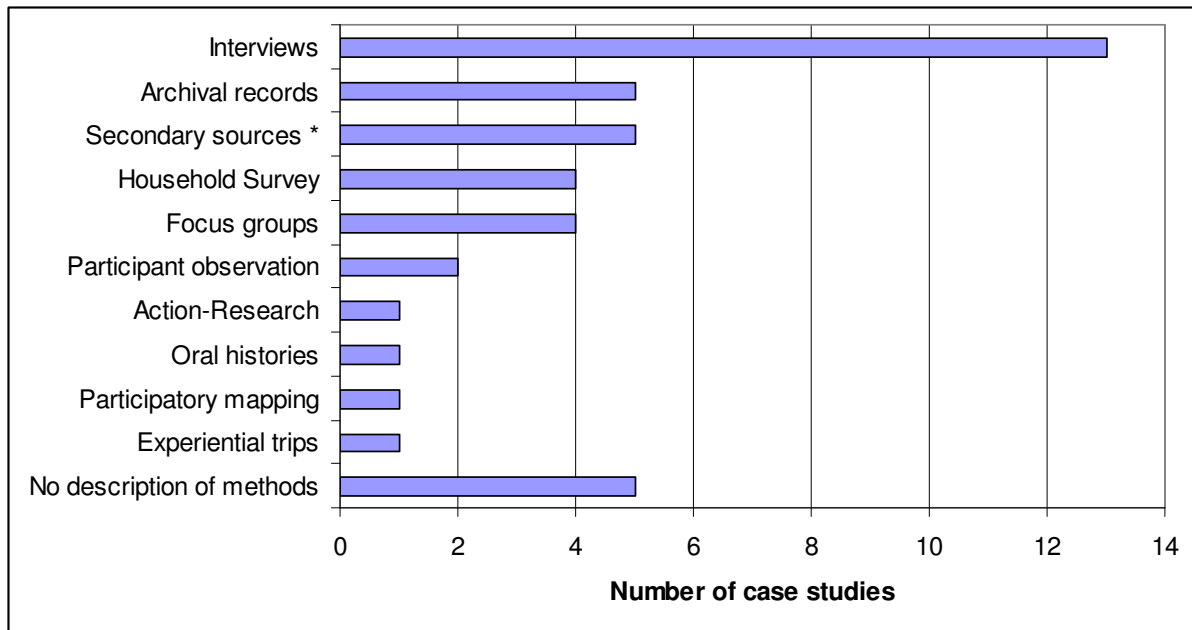
Field Tradition	Adaptation definition
Human Dimensions of	Adaptation refers to consciously planned adjustments in a system to reduce, moderate, or take advantage of the expected negative

Global Environmental Change (HDGEC)	impacts of climate change (Ford, Pearce et al. 2007)
	Adaptation refers to the actions that people take in response to, or in anticipation of, projected or actual changes in climate, to reduce adverse impacts or take advantage of the opportunities posed by climate change (Tompkins and Adger 2004).
	Adjustment[s] in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. To adapt to water shortages is to make changes that will maintain or improve the ability of a system to continue to serve its functions during periods of insufficient supply (Ivey, Smithers et al. 2004).
Ecological Resilience	Adaptation to variability may occur over many generations by experimentation and learning and, as a consequence, may lead to the development of specialized institutions. Such adaptations refer to highly optimized complex systems that are robust within a certain range and type of variability, but may be fragile to changes in these patterns of variability. (Janssen, Anderies et al. 2007).
Development / political ecology	Institutional adaptation is defined as the net outcome of the evolution of institutions within the wider social environment along with institutional inertia (Adger 2000).

In their research methods, all of the scholars used qualitative methods in their data collection and analysis. As can be seen in Figure 1, the method most used is semi-structured and non-structured interviews followed by archival records and secondary sources. Most of the authors used more than one method to gather the information required for their analysis. Five articles did not present the research methods.

It is important to note that in discussing the methods, none of the authors in the articles reviewed specifically described how adaptations were identified or coded. Although four articles cited the use household surveys in the methods section, none of the authors described how those surveys were used to identify adaptations. In only one study did the authors present summary tables of their surveys or offer quantitative results of their findings. Most often, authors described the adaptation processes, actions or outcomes, but failed to explain how they decided in the field what constitutes an adaptation and what not.

Figure 1. Methods used in articles



* As only source of information. Includes the 4 meta-analysis articles

The definitions in table 2 and the overview of the methods point to some possible sources of confusion in identifying and discussing adaptation. While a number of the articles did not offer specific definition of adaptation, from those mentioned in Table 1 we can see several differences in definition. Key differences include whether the adaptation process must be conscious or not, the implication of “success” in the definition of adaptation, and the different forms that adaptations might take (institutional, behavioral, etc).

The differences in how adaptation is conceptualized presents some challenges for comparing adaptation processes across sites and building a broader understanding of how communities adapt. These challenges are further compounded by the dearth of information on how a researcher identifies adaptation and measures it in the field. From the perspective of a field practitioner, it remains unclear how to measure adaptation. From an empirical standpoint, it is difficult to understand how to isolate researcher subjectivity in describing adaptation processes. While it is understandable that different fields or disciplines have different conceptualization of adaptation, greater description of the methods is needed in order to replicate studies in other contexts and compare notes with other researchers.

4.2 Causal link between disturbances and adaptations

A summary of the classification of disturbances and adaptation can be seen in table 3. The table presents the 30 case studies from the 24 articles we reviewed. We classify the disturbances presented in each case study by the variability (stress or shock) and proximate source (geophysical, socioeconomic or institutional).

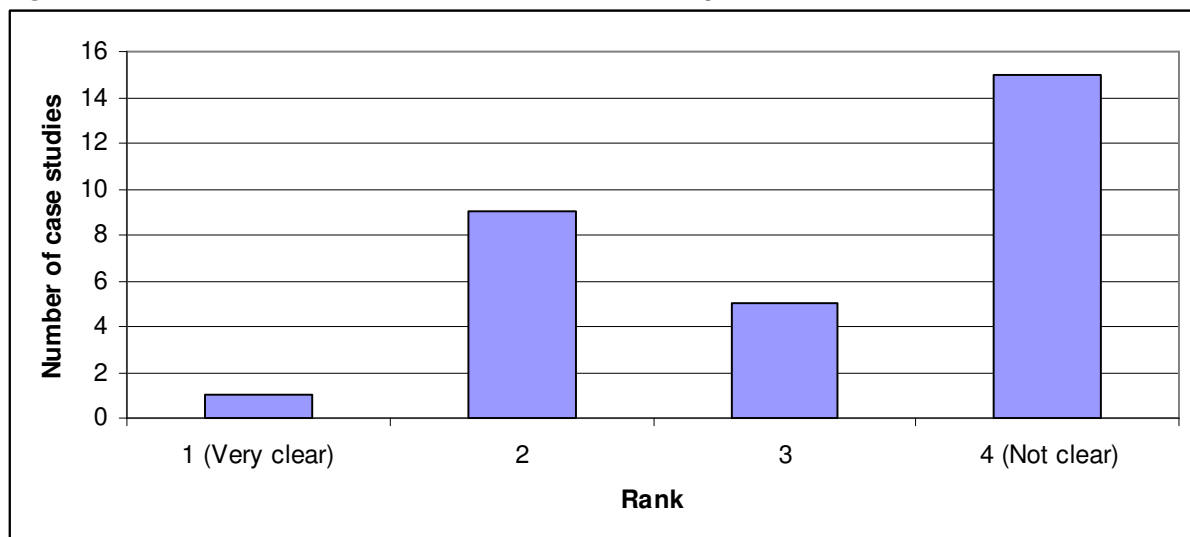
We classify the adaptation processes, actions and outcomes by (1) decision-making level, (2) form of adaptation and (3) intent of adaptation. The decision-making level is individual if no collective decision-making was done within the community or by the government. The form of adaptation may be behavioral, institutional, financial or technological. Finally, intent of adaptation refers to whether the community received external help or intervention in adapting, or whether the adaptations were community-driven. Our original intent was to classify the articles by categories

presented in the literature review. We were unable to do so, however, due to a lack of details in the articles. In cases where information is missing or unclear, it is noted in the table.

It is important to note that many case studies have multiple disturbances, adaptations and outcomes. For example, case #9 by Erni (2006) examines how peasant farmers in Minodoro Island, Philippines adapted to climatic changes (biophysical disturbances) and market pressures (socioeconomic disturbance). Irni finds that the farmers made changes in cropping patterns (behavioral adaptation) and also created new rules to regulate access and use of their forest lands (institutional adaptations). In this case the behavioral adaptations were autonomous, but the new land-use rules were encouraged by external government ministries.

The last two columns in table 2 present whether authors present a direct causal link between a disturbance and an adaptation process and if/how they assess the outcomes. As can be seen in figure 2, most of the case studies analyzed do not provide clear explanations of the causal links (rank 3 and 4). In nine of the thirty case studies, the authors explain the causal link, but in their methods and results they do not provide enough details so that the reader can verify the existence of the link. In some of these case studies, it is difficult to assess if the disturbance was the cause of adaptation or there were other reasons motivating these human changes.

Figure 2. Causal link between disturbance and adaptations



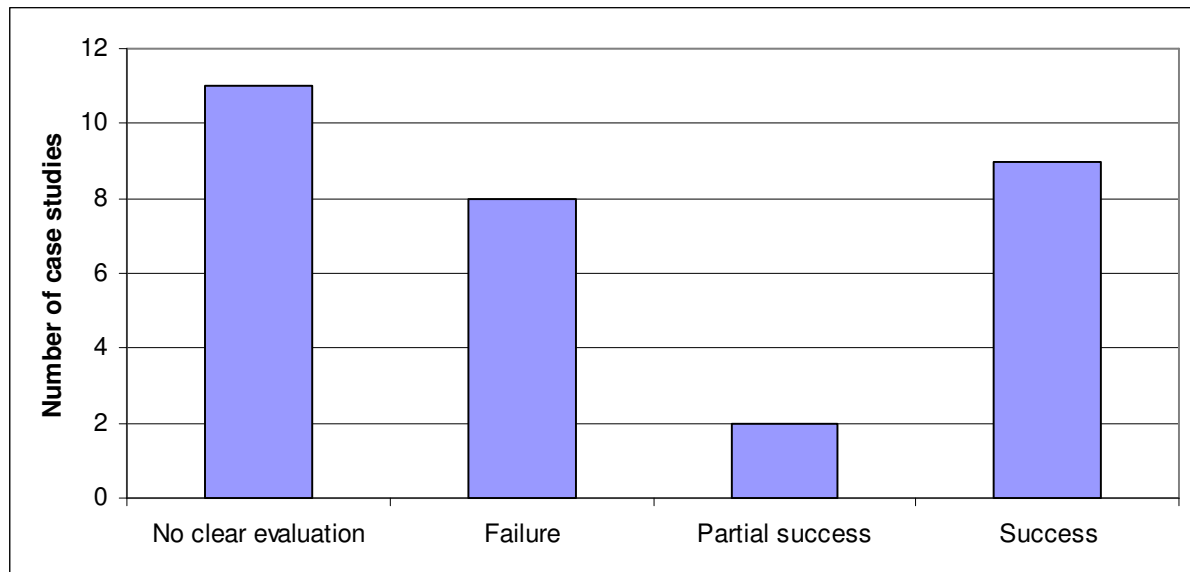
One case study takes a longitudinal approach to understanding the relationship between disturbance, adaptation and outcomes (Gautam and Shivakoti 2004). Gautam and Shivakoti present ecological and institutional data gathered between 1976 and 2000 to understand the impact of community-based forest management on the ecological and social systems in the hills of Nepal. The authors provide tables that detail both changes in forest condition and in the communities' access to forest products since the implementation of community-based forestry (ie the disturbance) in the region in a case study in Nepal. The study is exemplary in its use of biophysical and social data to illustrate the impact of a particular shock the system over time.

4.3 Criteria to assess success of adaptations

From the 30 case studies, eleven don't have an explicit or clear assessment of the success or failure of the adaptations outcomes. As can be seen in figure 3, from the 19 cases where authors discuss explicitly an evaluation of adaptation success, more than half of them are partial or fully successful.

Unfortunately, most of the authors don't provide measurement details or explain the criteria used to evaluate these adaptations successes or failures. This means that it is not clear whether the success or failure is in ecological or social terms (or both).

Figure 3. Evaluation of success of adaptations



Two case studies show how complicated can be to present an overall assessment of an adaptation success or failure. First, Ford and colleagues (2007) show how some groups of society can be better adapted than others, implying that for some groups, the adaptation is successful while it is not for others. They explain how adaptation inequalities in some Nunavut communities in Canada depend on economic advantages of some groups (Ford, Pearce et al. 2007). Second, Janssen and colleagues (2007) show how a society can be well adapted to some type of disturbance, while be highly vulnerable to other types. They explain how medieval peasants in England adapted very successfully to transportation changes, with a trade-off of unexpected increasing vulnerabilities to disease transmission (Janssen, Anderies et al. 2007).

5. Discussion: Lessons from the Field

The findings presented in the tables in the results show the diversity of studies on adaptation. The studies are impressive in the array of adaptation mechanisms that have been discovered and the variety of disturbances that have been investigated. Communities have responded using a variety of mechanisms to both gradual stressors and short-term shocks. From our survey of the fieldwork literature it is obvious the immense amount expertise on adaptations in common-pool resource communities that has been accumulated in recent years. This research provides an essential foundation for understanding adaptation and also sparks a number of possible future questions about disturbances and adaptations and the relations between the two. For example, do certain disturbances tend to spark particular types

of adaptations? Are there certain disturbances that are best addressed by external support for adaptation processes and others that tend to be autonomously driven?

Our original motivation for this case study analysis grew out of our own interests in conducting empirical analyses in the field that might provide answers to the above questions and contribute to a broader theoretical and practical understanding of how resource-based communities respond to changes. As field researchers we understand the importance of providing a clear and consistent methodology so that individual case studies can not only prove useful in understanding the particular human-environment interactions in a particular context, but may also contribute to a broader theory of human-environment relations. We also, however, understand that not all studies are necessarily comparable and recognize the importance of different approaches and research goals in examining adaptation. While some researchers may be interested in identifying the intricacies and contextual factors specific to a particular adaptation process, others may want to look for more generalizable models of adaptation. All of these approaches and goals are necessary for understanding how common-pool resource communities adapt to exogenous change.

In thinking of how we might conduct our own future fieldwork and possible directions for other researchers interested in empirically assessing adaptation, we believe that that review of the literature offers the following lessons. First, the review of case studies suggests that there are a variety of ways of conceptualizing adaptation. The various conceptualizations are important in that they enable each field to focus on particular aspect of the adaptation process. Nonetheless, these differences must be clearly pointed out and defined so as to avoid confusion and misunderstandings when talking across fields or disciplines.

For example, the definitions presented in table 2, point to four important areas in need of greater clarity. First, it is important to note the disagreement over whether an adaptation has to be conscious or not. Ford and colleagues (2007) define adaptation as a conscious adjustment. Some scholars, however, include unconscious (not planned) adjustments such as long term cultural adaptation (Berkes and Jolly 2002). Thus what one author might code as an adaptation, another would not. Second, does the action or decision have to be successful in order to be considered an “adaptation”? Several of the definitions from scholars working in HDGEC appear to presume that adaptation has a positive effect or success (reduces adverse impacts or takes advantage of the opportunities). However, this may not always be the case. For some scholars some adaptations can be actually “maladaptations”: when individuals or communities strategies unintentionally cause greater damage than good (Grothmann and Patt 2005). Third, it is important to note that usually the concept of adaptation is directly related to a disturbance as the stimuli or source of change to the system. This addresses the importance of measuring and analyzing adaptation processes and actions, not in isolation, but linked to a disturbance. Finally, the different definitions highlight the different forms that adaptations may take. For example, Adger (2000) emphasize that adaptation can be understood as institutional change. Others, however, look at behavioral and/or technological changes.

The differing conceptualizations and methods underscore the need for greater cross-disciplinary dialogue and a common set of criteria for identifying different elements of adaptation. This may be a long time in coming. Nonetheless, field researchers can begin to bridge these gaps and avoided unnecessary confusion or conflict by clearly specifying (1) how each defines adaptation in his/her particular

study and (2) describing how adaptation can be seen and measured in the field. For example, if a researcher considers institutional change to be an important adaptation, then the researcher could specify how the institutions are identified, what constitutes change and how this change is assessed. Adaptation is a commonplace word that has numerous connotations. Fieldwork can begin to uncover some of these connotations by empirically illustrating what these different conceptualizations look like on the ground.

The second lesson that the review of the fieldwork literature suggests, are the challenges of identifying causal links between disturbances and adaptations. Demonstrating a causal chain is obviously a very difficult task given all of the variability in the world. In many cases, there were several disturbances occurring and a multitude of adaptations, making the link difficult to identify. Understanding adaptation mechanisms and processes is a timely and difficult research challenge that is an essential component of our understanding of adaptation. Nonetheless, if we hope to learn from adaptation processes so that we might facilitate communities' abilities to adapt, we need to have a better understanding of when and how communities respond to particular types of disturbances. Are there thresholds or tipping points that we can identify? Can we predict when a community will adapt to certain disturbances and not to others? A particular disturbance may create a "window of opportunity" to respond to change or an impetus to adapt (Nelson, Adger et al. 2007).

One possible area of future research is in case studies with the specific goal of identifying causal links between a disturbance and an adaptation. Studies that use quasi-experimental designs that compare communities experiencing a particular disturbance to communities that share similar characteristics, but are not experiencing that disturbance are one way to start to understand the relationship between a particular disturbance and adaptive responses (Shadish, Cook et al. 2002). Other research designs may try and link change over time and explicitly document in the methods how that change is measured and how an adaptation clearly started after the disturbance. We understand that the range of possible case studies that fit these criteria may be very limited and that furthermore, such studies generally require extensive amounts of time and money. Such studies, however, would add an important component to our understanding of adaptation processes.

Finally, the third lesson that the study points to is the importance of establishing criteria by which to evaluate the outcomes adaptation studies. In adaptation studies there is a danger in looking at how a community currently survives and point to those factors as evidence of successful adaptations. We need to improve our understanding of the *process* by which a community adapted and the *outcomes* of those adaptations. How have adaptations impacted both the communities and their environments? Who benefits from the adaptations and who loses? As several scholars note, most adaptations do not necessarily reduce the vulnerability for those most at risk (Lebel, Anderies et al. 2006; Nelson, Adger et al. 2007). The impacts of different adaptations may differ by social group, scale or sector. For example, an adaptation to one particular disturbance may actually make the social-ecological system less resilient to other elements (Walker, Gunderson et al. 2006; Nelson, Adger et al. 2007). The need for greater understanding of the outcomes reemphasizes the need for longitudinal studies and comparative studies. Future research is needed to assess how different adaptations impact different actors, institutions, and ecosystems within a social-ecological system.

The studies in this paper highlight the dynamic growth of adaptation studies and our developing knowledge of when, why and how adaptation occurs. The studies highlight the excellent foundation that has been conducted with respect to common-pool resources and also the need for more studies that examine these critical questions. Areas for future research include working to identify common conceptualizations and criteria for adaptation so that we compare, contrast and learn from the rich diversity of studies of adaptation processes occurring in the commons all around the world.

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Table 1. Summary of analyzed articles.

Article	Case Study Location	Case ID	Resource	Academic tradition
Adger, WN (2000)	Vietnam	1	Water	Development & Political Ecology
Anderies, Ryan, and Walker (2006)	Goulburn Broken Catchment, Victoria, Australia	2	Water	Ecological Resilience
Bray, DB (2000)	Quintana Roo, Mexico	3	Forest	Ecological Resilience
Berkes and Jolly (2002).	Canadian Arctic	4	Hunting and fishery	Ecological Resilience
Berkes and Turner (2006)	Quebec-Ungava, Canada	5	Wildlife	Ecological Resilience
	Belcher Islands, Canada	6		
Coulthard, S (2006)	South India	7	Fishery	Ecological Resilience
Cousins, Hoffman, Allsopp, and Rohde, (2007)	Namaqualand, Southern Africa	8	Communal rangelands	Development
Erni, C (2006)	Mindoro Island, Philippines	9	Forest and Farmland	Commons
Evans and Mohieldeen (2002)	Lake Chad	10	Lake	Development
Ford, Pearce, Smit, Wandel, Allurut, Shappa, Ittusujurat, and Qrunnut (2007)	Artic Bay and Igloodik. Nunavut, Canada	11	Hunting and fishery	HDGEC
Galaz, V (2005)	Em River Watershed, Sweden	12	Water	Ecological Resilience
	Rönnea River Watershed, Sweden	13		
Gautam and Shivakoti (2004)	Nepal	14	Forest	Commons
Huitric, M (2004)	Belize & Main (his research is Belize)	15	Fishery	Ecological Resilience
Ivey, Smithers, De Loe, and Kreuzwiser (2004)	Credit River, Ontario, Canada	16	Water	HDGEC
Janssen, Anderies, and Ostrom (2007)	Medieval Peasants, England	17	Communal rangelands	Ecological Resilience & Commons
	Himachal Pradesh, India	18	Communal rangelands	
	Taiwan	19	Water	
Marschke and Berkes (2006)	Koh Sralao and Kompong Phluk, Cambodia	20	Fishery and Forests	Ecological Resilience & Development
Olsson, Gunderson, Carpenter, Ryan, Lebel, Folke, and Holling (2006)	Everglades, USA	21	Wetland	Ecological Resilience
	Northern Highlands Lake District, USA	22	Lake	
	Mae Nam Ping Basin, Thailand	23	Water	
Olsson, and Folke (2001)	Lake Racken Watershed, Sweden	24	Fishery	Ecological Resilience
Perry, and Sumaila (2007)	Ghana	25	Fishery	Development
Reed, Dougill, and Taylor (2007)	Kalahari, Botswana	26	Communal rangelands	Development
Sarch, MT (2001)	Lake Chad, Nigeria.	27	Farmland and fishery	Development & Commons
Sorbo, GM (2003)	Kenya & Sudan	28	Livestock	Development & Political Ecology
Tompkins and Adger (2004)	Trinidad & Tobago	29	Fishery	HDGEC & Ecological Resilience
Vanginkel, R (1995)	Texel, Netherlands	30	Fishery	Development. Cultural Ecology. Commons

Table 3. Summary of types of disturbances and adaptations

Case ID	Type of Disturbances		Type of Adaptations			Direct Causal link (rank) ³	Evaluation of Adaptations
	Variability	Source	Decision Level	Form	Intent		
1	Not clear	Biophysical	Collective	Financial & Institutional	Autonomous	4	None
2	Stress	Biophysical	Collective	Institutional	External	2	Failure
3	Stress	Biophysical & Institutional	Collective	Institutional	External	2	Not clear
4	Stress	Biophysical	Individual / Collective	Behavioral & Informational & Institutional	Not clear	2	None
5	Shock	Socioeconomic	Individual	Behavioral	Autonomous	2	Success
6	Stress	Biophysical	Individual	Behavioral	Autonomous	2	Success
7	Stress	Socioeconomic	Individual	Technological & behavioral & Institutional	External	4	None
8	Stress	Socioeconomic	Individual	Behavioral	Autonomous	4	Success
9	Stress	Biophysical & Socioeconomic	Individual / Collective	Behavioral & Institutional	Autonomous & External	4	Not clear
10	Stress	Biophysical	Individual	Behavioral	Autonomous	4	Success
11	Stress & Shock	Biophysical	Individual	Technological & behavioral & Informational	Autonomous	2	Partial Success
12	Stress & Shock	Biophysical	Collective	Financial & Informational	Autonomous	4	Failure
13	Stress & Shock	Biophysical	Collective	Financial & Informational	Autonomous	4	Success
14	Stress	Institutional	Individual	Behavioral	Not clear	1	Failure
15	Stress	Biophysical	Individual / Collective	Behavioral & Financial & Institutional	Not clear	2	Failure ⁴
16	Not clear	Biophysical	Collective	Financial & Informational	External	3	None
17	Stress	Socioeconomic	Collective	Institutional	Not clear	3	Partial success
18	Not clear	Institutional	Collective	Institutional	External	3	Failure
19	Shock	Institutional	Collective	Institutional	External	3	Failure
20	Stress & Shock	Socioeconomic Institutional & Biophysical	Individual / Collective	Behavioral & Informational & Institutional	Autonomous & External	4	None
21	Stress & Shock	Biophysical	Collective	Institutional	External	4	Success
22	Stress	Socioeconomic & Biophysical	No adaptation	No adaptation	No adaptation	4	Failure*
23	Stress	Biophysical	No adaptation	No adaptation	No adaptation	4	Failure*
24	Stress & Shock	Biophysical	Individual / Collective	Behavioral & Institutional & financial	Autonomous & External	2	Success
25	Stress	Biophysical	Individual	Behavioral	Not clear	2	None
26	Stress	Biophysical	Individual	Behavioral	Autonomous	4	None
27	Stress	Biophysical	Collective	Financial & Institutional	Not clear	4	Success
28	Stress	Biophysical & Institutional	Individual / Collective	Behavioral & Institutional	Not clear	4	Failure
29	Stress	Biophysical	Collective	Institutional	External	4	None
30	Stress & Shock	Biophysical & Socioeconomic	Individual / Collective	Behavioral & Institutional	Autonomous	3	Not clear

³ Rank from 1 (very clear causal link) to 4 (not clear causal link)

⁴ Here we analyze the Belize case study, which uses primary sources (Huitric, 2004)

* In these case studies Olsson et al. (2006) explain the reasons why communities didn't adapt to disturbances

