A Theory of Sustained Cooperation with Evidence from Irrigation Institutions in Nepal

by

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ABSTRACT

Why do some locally based institutions for using and managing shared resources survive, adapt and continue to perform well in the face of changing circumstances while others decline and disappear? To answer this, I revisited 233 irrigation canals in Nepal, originally used to illustrate the Common Pool Resource Framework, between 16 and 37 years later. The resulting longitudinal dataset with 509 variables, plus 39 randomly selected cases called for a different explanation of why only some of these paradigmatic institutions sustained cooperation over decades of rapid and multidimensional changes to keep their canals functional.

Analyzing 827 interviews with canal users revealed a difference between the reasons of one considering committing to an institution, and one considering whe-ther to change their existing commitment. Focusing on the latter revealed two variables relating to institutional performance over time: how fair the users perceive the institution to be, and how flexibly the rules are applied. Furthermore, the relevance of perceived fairness relates to government assistance; flexibility is bounded by the resource's technical needs; and the relationship of flexibility to institutional performance depends on perceived fairness. These patterns appear in the original data, the newly collected data, and in the changes between the two.

The resulting theory of sustained cooperation is consistent with these empirical findings. It predicts that the adaptability of institutions for using and managing shared resources depends on the qualities of cooperation or non-cooperation with the rules. These are characterized by perceived fairness and bounded flexibility.

Overall, I find that institutional performance over time depends on how the rules fit the users' sense of fairness as well as the specific features of the resource and its environment. This differs from current explanations in three ways. First, it broadens the analytical focus beyond interpersonal cooperation to include cooperation between users and the institution over time. Second, it recognizes that perceived fairness of an institution's rules is a determinant of its adaptability and performance over time. And third, it identifies the conditions under which flexibility or rigidity of rule application can contribute to institutional adaptability in changing circumstances.

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There are many people who have contributed to the research presented in this dissertation, but every word that I have written has been influenced by those farmers, government employees, researchers and political activists who shared their lives with me. For the four years that they sat, walked and waited with me, all the while patiently explaining the obvious, all I could promise was that they might contribute to an understanding of an important question.

I could not have pursued this question without my advisors: Bish Sanyal, Amartya Sen, and Richard Locke. The three of them together have been consistently involved in this research from the beginning, and over half a decade. Their intellectual guidance and practical support is the warp and woof of this work. My debt to them is profound.

Judith Tendler helped me find the question by urging me to compare my experiences in Nepal to the literature on its irrigation canals. I am also indebted to Elinor Ostrom, who granted access to the NIIS dataset and questionnaires. Her willingness to throw open a core work helped me to begin by trying to convince myself of her team's results. Yet, the process of replication is uncertain and fraught with dangers. Not the least of which is that one might not find anything "new" at the end of it. During this very uncertain expedition, I also acknowledge the persistent and subtle encouragement of John F. Nash Jr., who has been a mentor, guide and close friend.

This dissertation owes much to the fact that it was written in the vibrant environment at the Department of Urban Studies and Planning at MIT. Seemingly immune to arbitrary assumptions, DUSP has remained a rare place where insights and approaches from many disciplines can be brought together to understand, and change, the world. I hope that I have been able to practice its core discipline of sincerely asking and rigorously pursuing bold questions. This dissertation would probably not have been possible in any other academic community.

And what to say of my wife, Sritika, to whom this dissertation is dedicated. She fearlessly accompanied me into blind alleys, wrong turns, fruitless searches and aimless wandering. Despite being subject to the ups and downs of research, she remained my constant support throughout. But for her steadfastness, it would have been very difficult to makes steady progress.

There are many others who have made important contributions, only some of whom I can list here. Ajaya Budathoki, Prashidha Kharel, Sujana Dhital, Nitesh Shrestha, Bambam Mandal, Simpson Lamichhane, Aakash Maharjan, Prapti Giri and Meera Shrestha assisted me throughout the fielwork while Udaya Ale, Sagar Shiwakoti, Bhim Pr. Ghimire, Pradip Sharma and Sanjiv Subedi were a great help at particular stages. My travels with Rajendra Uprety were eye opening, and regular discussions with Norman Uphoff, Ganesh Shivakoti, Robert Yoder and Prachanda Pradhan helped me immensely to understand irrigation in Nepal. I am also grateful to my colleagues and the inimitable staff at DUSP.

In the end, any remaining errors are all that I can claim to be originally my own.

Contents

1 Sustained Cooperation as a Puzzle

There are many outcomes in society that cannot be achieved without sustained cooperation[1] between individuals. Working together is particularly necessary when people share a resource upon which they all depend. In these shared-resource situations, each user has a connection to the others through the resource because their actions in relation to it affect the others as well, as does their lack of action. The fact that all rely on the same resource establishes an interdependence between the individuals. This interdependence is something that, for example, roommates sharing a bathroom know well. There are many familiar examples of interdependence that in turn call for cooperation.

A common example of an interdependent situation that appears throughout human history is a shared irrigation canal. Indeed, irrigation canals still exist in many countries and they continue to play an important role in our food systems.[2] It is easy to see how the interrelationship between farmers that share a canal comes about, even in a highly simplified account of their situation. All farmers require water from the canal in order to grow their crops. However, these canals are usually long enough that one farmer cannot both maintain the canal and tend to his crops. Furthermore, without regular inspection, cleaning and repair the physical structure of the canal deteriorates and it is able to transport less and less water. So he must depend on the cooperation of other farmers who use the canal. At the same time, the amount of water that the downstream farmers receive depends on how much the upstream farmers

[1] "*cooperation:* The act of co-operating, *i.e.* of working together towards the same end, purpose, or effect; joint operation." OED-Online (2014) This is different from a much later word, co-ordination, which has the sense of arranging or placing of actions in relation to another.

[2] See for instance IWMI & FAO (2009) for a policy-oriented discussion of the role of irrigation canals in "food security".

use. Overall, without cooperation there is no other way for the farmers to continue to receive water from the canal.[3]

The actual situations faced by farmers are always much more complex than this stylized account. Farmers that use the same canal have many more relationships to each other and the canals exist in far more complex environments. For example, the farmers might have social relationships to each other through custom, or family relationships. They may also depend on each other in other ways such as for the harvesting of crops, or for maintaining the safety of their village. Furthermore, the particular technology used in the canal, such as a concrete weir, might require even more maintenance than the users can contribute themselves. In this case, their interdependence may extend to others who do not use the canal, but are able to help maintain it. It is a common experience that individuals living in society are far more interconnected than the example above admits. And so it is possible that cooperation is more important to human society than we are able to recognize.

Nevertheless, my purpose in this dissertation is not to examine how important cooperation is to society. Instead, I seek to understand what is required for people to sustain cooperation even in the face of difficult circumstances. So I begin with the premise that there are situations in which cooperation is essential to achieve desirable outcomes. From the discussion above, and with minimal reflection on one's own experiences, it should be clear to the reader that this is not an unusual or unreasonable assertion: such situations are common. With this in mind, I now turn to some examples that have been studied thoroughly in prior efforts to understand cooperation.

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[3]See Chambers (1988, fig. 2.4) for a schematic illustration of the different flows and leakages in irrigation systems, and the many points at which cooperation becomes necessary.

1.1 Examples of Sustained Cooperation

In the literature, there are many examples of sustained cooperation between users for the maintenance of a shared resource. A prominent early effort to collect and analyze such cases came from a team lead by Elinor Ostrom, who used them to refine and illustrate a theory of "Commons Pool Resources" or The Commons for short. And of these examples, a subset of 233 irrigation canals in Nepal were particularly well studied (Pradhan, 1989; Shivakoti, 2002), scrutinized (Tang, 1992; Lam, 1998) and modeled (Gardner et al., 1994). They came to be regarded as paradigmatic examples (Ostrom, 2010) of successful self-organization of resource users for sustained cooperation.[4] Among the hundreds of cases that they collected, there were numerous examples of well-managed irrigation canals in various parts of the world, in addition to fisheries, forests, and other resources. There is now a library of documented cases in which users of various shared resources in many countries have been able, for long periods, to overcome challenges to cooperation and the collective action problems[5] associated with their situation.[6]

When researchers turned to these examples of well-maintained shared resources in the mid-1980's, the variety of cases that they found helped them to establish the

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[4]A reference to these canals is merely an endnote in the famous Governing the Commons (Ostrom, 1990, p.229 n.33). However, 4 years later they would come to feature prominently as an example of irrigation in "Rules, Games and Common Pool Resources", a follow-up book meant to give a theoretical foundation to the program outlined in the first.(Gardner et al., 1994) Between 1991 and 1994, at least three doctoral students used these Nepalese irrigation cases for their research. By the time of Ostrom's Nobel Prize lecture in December 2009, these cases had gained enough significance to receive mention in the second slide as a representative empirical study illustrating the Institutional Analysis and Development Framework - the successor to the Common Pool Resource framework.

[5]I use 'collective action problems' in the sense of Olson (1965).

[6]A large collection of cases can be found at the Digital Library of the Commons here: http://dlc.dlib.indiana.edu/dlc/

possibility of sustained cooperation between individuals even in unlikely situations. However, this same data proved to have important limitations for understanding how the cooperation came about. First, to identify these cases they had to rely on existing studies which had been conducted for other purposes, such as for inclusion in doctoral dissertations, books or evaluation reports for aid organizations such as the United States Agency for International Development (USAID).[7] Thus it was likely that the documents did not contain information that could be relevant to understanding the question. Nevertheless, this was overcome by revisiting some of the cases to collect the missing data. Second, the researchers had little control over the sampling of cases and were restricted to those that were already documented.[8]

However, the data was far more limited for understanding sustained cooperation over time. This limitation was also insurmountable. Each case study had been conducted over a year or two, thereby resulting in a snapshot of each example. Even when all of the cases were compiled and subject to a meta-analysis, the data could not take researchers beyond the patterns that existed when they were studied. Since there was no information on these same cases at multiple points in time, it was only possible to conjecture that the patterns existing in common to all cases were responsible for sustained cooperation.[9] Since there were no cases of failed cooperation in the dataset, it was not possible to check whether failed cases didn't have these features. Recently, there have been sporadic attempts to revisit old cases in order to examine

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[7]See for example Benjamin et al. (1994) for an account of this process of collecting and coding these cases.

[8]In the early studies based on this data, such as Lam (1998) and Tang (1992), the non-random sampling was not a concern. It became a point of focus only decades later. (Poteete et al., 2010)

[9]In essence, the strongest argument that could be made based on the data was of the form: "These patterns appear in successful cases, and therefore, they are likely to be responsible for success."

failures but they have not been as systematic or as comprehensive as the first studies that documented the patterns associated with success.[10]

Hence, even though the framework that emerged from these pioneering cases was thorough (Ostrom, 2005), the explanations that it generated about why and how cooperation is sustained could not be examined directly from this same data. Nevertheless, the main contribution of this body of work to an understanding of cooperation was to empirically establish two facts. First, institutions as rules can play an important role in sustaining cooperation between individuals. And second, users of a resource have the ability- and sometimes a superior ability- to devise the appropriate institutions for sustained cooperation themselves. The Common Pool Resource (CPR) framework, later generalized into the Institutional Analysis and Development (IAD) framework, also contributed important conjectures about the requirements for sustained cooperation between individuals that have stayed remarkably similar to the original formulation over the last three decades. (Ostrom et al., 2009) Users of this framework also refer to these requirements as "design principles" of robust institutions.

The Commons approach is not the only literature to address cooperation, however. As I elaborate in Chapter 2, there are multiple approaches to the question of how cooperation can be sustained between individuals in various situations - not just around a shared resource.

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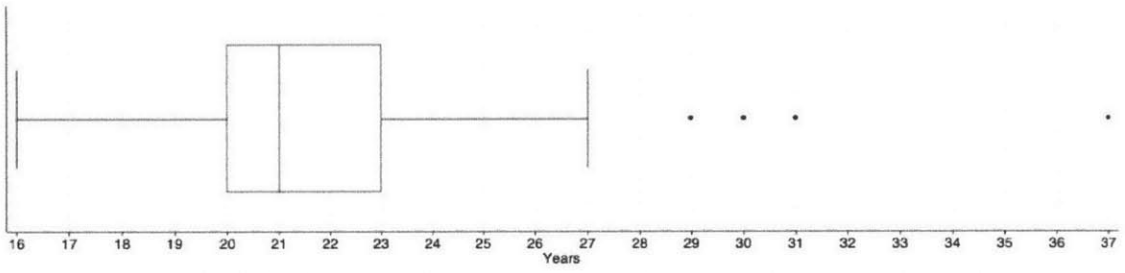
[10]In Ostrom et al. (2011) the authors revisit 19 Irrigation canals that are part of my sample, but do not administer the survey again. In Chhatre & Agrawal (2008) the authors describe the results of a cross-sectional multi-country study of 152 examples of shared forests, in 9 countries over 15 years.

1.2 The Research Question

Motivated by the question of what it takes to sustain cooperation over long and difficult periods, I revisited all 233 of the paradigmatic cases of irrigation canals in Nepal between 16 and 37 years after they were first studied as shown in Figure 1. During this period, Nepal experienced unusually complex changes as I describe Section 1.4.1. This history provided a unique opportunity to study sustained cooperation using these cases. Faced with these changing circumstances, 202 of the 233 cases continue to function and 31 have stopped. There is also variation in the performance of the surviving canals. In the case of a shared canal, performance of the canal is directly related to the performance of the institutions for managing them.[11] This is because

Figure 1: Years between the first and second observations for each case in the sample: The box and whiskers plot shows that between 16 and 37 years have passed between the first and second observations. The median is 21 years.



cooperation in these cases is directly related to the characteristics of the institution among other factors.

Aside from providing a way to empirically address the various theories of cooperation, including Ostrom's, this revisit also allowed me to attempt to reproduce very

[11] Performance is described in Section 1.5.3 below as consisting of the physical condition of the structure, and also user assessments of its ability to deliver water. The argument that institutional performance is indicated by canal performance in these cases is elaborated in Chapter 3.

influential prior findings before embarking on my own search.[12]

I observed that the reasons for survival, decline and varied performance of these institutions are not primarily those that the original framework emphasizes, as section 1.5 of this chapter shows. Thus, the motivating question in this dissertation is *why some of these locally based institutions for sustained cooperation continued to perform well in the face of changing circumstances, while others declined and disappeared.* This question is concerned with the institutional foundations and mechanisms for eliciting cooperation, and therefore speaks to three different literatures that are described in Chapter 2: the literature on cooperation, the literature on institutional change, and the literature on institutions for collective action.

In order to trace the similarities and differences with earlier approaches, I describe how I conducted this research in the following sections. After that, I present my unexpected findings after replicating the original study in order to motivate the remainder of the dissertation.

1.3 The Cases in Context

Beginning a study by replicating a prior one, especially in the social sciences, requires understanding how and why the first study was done. This includes its methodology as well as its history. Both of these considerations are likely to have influenced the

[12]The criteria of reproducibility is an important part of the scientific method, possibly more so than any particular research design. In my study, the investment in replication is justified because of the significance of prior findings on my question about sustained cooperation. I also reasoned that without formal training in the IAD framework, and with the opportunity to interview respondents myself, I might regard different observations as salient, or ask different questions. It is standard practice to assess earlier results using a smaller random sampling of the original cases. A small sample assessment is often the most efficient balance between effort and rigor. However, this approach is less useful here since the original case selection was neither random, nor representative of a larger population as explained in Section 1.4.3.

decisions that the original research team made about the questions to ask, the sample to select, and the types of analysis to perform. These decisions also affect any follow up study such as this one because changes can only be examined in those cases that were previously sampled, and only with respect to those questions that were asked. Overall, even the most rigorously designed social studies are very often influenced by the realities of implementation.

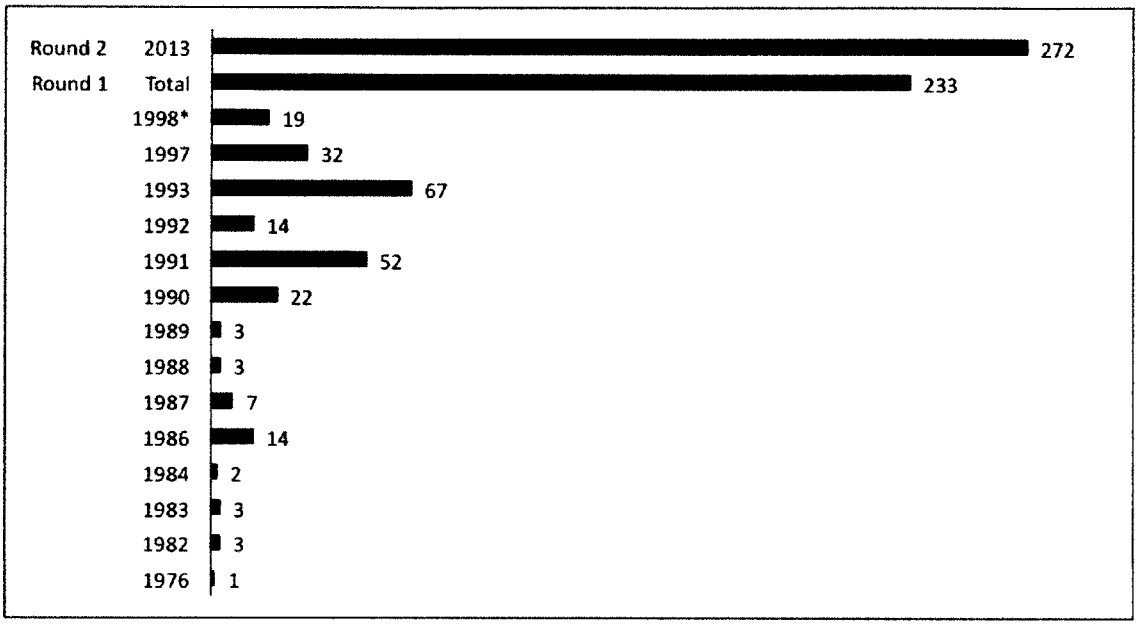
In the current cases, as I show, the researchers chose their questions, their sample and their mode of analysis for theoretical and methodological reasons just as much as other reasons, such as feasibility and political necessity. Because of this, the context of their study provides essential information to appropriately view the design of this study and results of my analysis. So before presenting the results of revisiting, I will describe in detail the historical context of these cases and how it affected the design of this study.

The analysis in this dissertation is based on revisiting the 233 canonical canal irrigation systems in Nepal with an additional 39 selected randomly as shown in Figure 2. The original research team had collected all of the cases from about 75 studies that were already available at the time, making their study a meta-analysis of documented cases. Their goal was to identify how assistance to irrigation systems in developing countries could be made more effective[13] and so they collected information about these canals based on what was known to impact irrigation performance at the time. As such, their enquiry was informed by the literature on collective action and irrigation management, and it was also an attempt to contribute to that literature.

The literature on how irrigation systems can be managed well grew rapidly in

[13]Here it is instructive to see the series of studies that were published using this data. The prominent ones are Tang (1992); Lam (1998); Shivakoti (2002).

Figure 2: Sampling by years of fieldwork and round: The black bars indicate how many cases were studied in each year listed. The elements of the 'Spilled Panel' consist of two rounds of data collection, and 39 additional cases in the second round. The data collected in 2013 is Round 2, and the Round 1 refers to that collected between 16 and 37 years ago. The cases from 1998 are revisits to 19 in the first round. They are treated as part of the first round.



the 1980's. By that time, many of the irrigation projects that donor agencies had paid for in developing countries to be run by government agencies had clearly begun to underperform. (Chambers, 1988, p. 19-27) True, their huge investments in infrastructure had increased irrigated land, particularly in South Asia, and led to increased agricultural production. But, the overall costs of operation and maintenance appeared to be far outstripping any benefits. This led to efforts in the early 1980's by governments, USAID and the World Bank, among other donors, to hire scholars as consultants tasked with assessing irrigation projects worldwide. The main theme of the evaluation reports was that irrigation projects were too focused on building physical structures, and ignored management and operation.(Ostrom, 1992, p. 1-5)

Recommendations for improving the performance of these systems addressed

three aspects of irrigation management that had previously been neglected: (1) community involvement; (2) bureaucratic performance; and (3) efficient and equitable allocation of water. Some argued that the central problem was that farmers were not themselves involved in the design and operation of the system and therefore building community capacity to participate was essential. (Chambers, 1988) Others focused on bureaucrats who were insensitive to farmer involvement, as well as their wrongly structured agencies. Therefore, they emphasized reorganizing irrigation agencies and training bureaucrats differently. (Uphoff, 1991) Those who followed a stricter rational choice approach stressed that the problem was systemic corruption caused by misaligned economic incentives at all levels of bureaucracy. The proposed solution was to change the structure of the situation so that corruption was no longer optimal. (Wade, 1982) One proposed way to do this was to enable users as a community to discipline bureaucrats, which was a prelude to later arguments for "local accountability". Finally, there were two distinct approaches for recouping costs. One used a "rent-seeking" analysis to advocate the introduction of accurate water pricing. The other argued for ways to make service providers' employees more accountable. [14] The studies during this period reflect close attention to management of these canals, in addition to the costs of operation.

A distinct approach also emerged towards the end of the 1980's when it became clear, upon reflection, that scholars had seen many examples of self-governed systems during their travels. [15] This possibility of self-governance was not revealed by theory - on the contrary, the popular model of rational self-interested farmers trying to maintain an irrigation system was a Prisoner's Dilemma game. A widely accepted

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[14]See Moore (1989) for a comparison of these approaches.

[15]See Wade (1988a) for a summary paper that articulated this realization.

prediction was that because of inevitable and numerous collective action problems such as shirking and free-riding, self-governance in the absence of an outside authority was not possible. The two prevalent policy prescriptions that followed from this characterization were either that the state needed to better manage the irrigation system, or that it had to be managed by a private profit making utility. In contrast, the newer studies of this period focused on finding alternatives to this duality.

In answer to the question of whether people could get themselves out of these inevitable dilemmas, the work done by a team led by Elinor Ostrom (Ostrom, 1990) emerged as an influential alternative approach that synthesized alternative approaches and emphasized local self-governance. After this, formalizing shared systems, not just irrigation canals, as cases of Common Pool Resources (CPR) that were embedded in a web of nested rules crafted to match their conditions became common in the literature.[16] The current set of irrigation canals in Nepal were part of this argument, and they came to be coded and studied using the Common Pool Resource (CPR) framework.[17]

This framework aimed to draw attention to the reasons why farmers might or might not cooperate with each other to maintain the shared canal. Working under the assumption that farmers were reliably rational and self-serving, the framework enumerated the variables that affected their comparison of the costs and benefits of

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[16]See Ostrom (1993) and Ostrom (1992) for detailed applications of the CPR model to irrigation infrastructure. The framework is called the Institutional Analysis and Development (IAD) framework, and also sometimes referred to as the Common Pool Resource (CPR) Framework. A thorough exposition can be found in Ostrom (2005). A retrospective assessment of the viability of the framework in light of accumulated evidence is in Ostrom et al. (2009) In sum, this framework allows one to develop an argument for how rational, self interested actors can overcome collective action problems in certain situations, on their own. It also helps to identify the key variables that might affect the possibility of self-organization.

[17]A concise description of the conceptual elements of this framework as applied to empirical cases such as those here is given in Ostrom (1990, p.182-216).

alternative actions. The CPR framework was not an attempt to capture the reasons that farmers acted in the way that they did, as much as it was an attempt to account for the multiple variables that affected this unidimensional internal assessment that was assumed to guide action.

Consistent with the understanding of "all institutional arrangements as games in extensive form" (Ostrom, 1990, p.23), the 509 questions asked of each of the Nepali canals focused more on "external" variables that "structured" each farmer's "action situation" by altering their "incentives". (Lam, 1998) Since farmers knew more precisely about the incentives that they were facing than government agencies, this approach was used to argue that farmer input would improve irrigation interventions.

This data was coded into database form and called the Nepal Irrigation Institutions and Systems Database (NIIS) in order to facilitate analysis of many variables at once.[18] The number of cases (233) and the number of questions (509) made the NIIS the largest and most detailed such effort ever undertaken, even though the sampling of cases was not systematic. Nevertheless, the cases ranged from small systems shared by 25 households to those used by over 5000 households. Similarly, it included systems in which rules were primarily made by farmers (farmer managed) to those in which the rules for using the canals were made, fully or partly, by government agencies such as the Department of Irrigation of the Government of Nepal (agency, or jointly managed).

In general, the NIIS data supported the basic claims about the features of successful institutions, and the conditions under which groups of private individuals could

[18]See Poteete et al. (2010, p.102) for a detailed account of how this database was constructed. It also interfaced with another collection of data, the CPR Database.

overcome collective action problems.[19] Three main claims stand out. First, farmers can govern and manage their own irrigation systems regardless of size (small, medium and large). Second, government intervention - usually in the form of building physical infrastructure- can be effective, and less destructive to the local institutions, if it incorporates farmers input. Third, farmers and officials have to cultivate mutual trust and work together in order for interventions to succeed.[20]

This third wave of analysis thereby drew attention to the role of farmers in irrigation management generally. However, it differed from simple participation by its emphasis on allowing the farmers themselves to make the rules for accessing, allocating and maintaining the resource. The prediction was that rational farmers would have good reason to devise and commit to rules that made cooperation beneficial in the long run. If the state did anything on its own, it was to provide legal ways, such as through national legislation, to recognize the validity of this process of local rule making. Policy advice that emerged from this analysis called for the formation of, or at least the recognition of, local administrative bodies organized around irrigation canals and other shared resources such as forests.[21] In Nepal's case, the third wave of ideas about irrigation management led, among other things, to the introduction of

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[19] A stark question remained unapproachable despite this effort however. The data was a cross section of examples that existed, and so it did not include any systems that had stopped functioning. Thus, the reasons for survival and decline could only be examined by finding the common features of these systems. To complete the argument, researchers had to claim that these institutions survived because of these features, while those that did not survive lacked them. There was no evidence of this claim, however.

[20] Although not explicitly tested, there was an underlying claim that the role of government agencies should be passive - it is to act only when local users make demands of them.

[21] Proponents of this approach sought the establishment of "polycentric systems" of governance. In such systems, the units of local government are set up around shared resources and services. These units of governance may or may not be contained within the same administrative unit of decentralized central government. See Wagner (2005) for a retrospective summary of this school of thought.

the Water Resources Act in 1992, which gave formal recognition to local-governance of water resources, including irrigation, by registered User's Associations.

There were two main reasons for emphasizing the role of the farmer. First, farmers were claimed to have better information about how water was to be allocated locally, and to have a greater ability to construct more appropriate rules for that purpose. And second, farmers were claimed to be more likely to not irrigate too much land whereas government officials would be more likely to do so (in order to show a greater return on investment). That is, farmers would set more appropriate boundaries of the resource.[22] These and other reasons led to the central motivating claim for the third wave - that farmer managed systems were superior compared to government managed ones. (Ostrom, 1992; Lam, 1998; Joshi et al., 2000; Shivakoti, 2002; Ostrom, 2005, 2010; Ostrom & Cole, 2010)

More recent work in this vein has begun to document the market pressures that local irrigation institutions are facing and to suggest a role for these locally based institutions in effectively helping farmers to cope.[23] All recent studies of sustained cooperation using the CPR framework[24], such as Bastakoti & Shivakoti (2012) and Chhatre & Agrawal (2008), have supported the initial prediction that the creation of appropriate rules and their robust enforcement by users are the keys to sustained cooperation. Larger efforts using this formulation of canals as socio-technical systems

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[22] A less generous interpretation could be that local groups would be better able to exclude some users whereas government agencies may be less able to do so.

[23] See Bastakoti et al. (2010), who argue that these local institutions mediate external market pressures effectively. They document changes in rules that resulted from both a change in national policy and outside market pressures. The statistical model that they use does not allow them to trace the mechanisms of change, and by default they use the CPR framework to attribute this association to a greater ability of local systems to adjust to changes as needed.

[24] The CPR framework has achieved a degree of maturity and is now called the Institutional Analysis and Development (IAD) framework as described in Ostrom (2005).

are also underway. They continue to emphasizes the rules and their characteristics in order to explain adaptability.[25]

Thus, these historical and theoretical influences shaped earlier studies, guided the data contained in the NIIS, and continue to motivate current research into sustained cooperation around a shared resource. The data was constrained by the availability of documented cases, which in turn limited the types of claims that could be made. Similarly, the types of questions that were coded were intended to challenge the policy recommendations of two main theories i.e. government or privately led management, by uncovering variables that might affect the costs and benefits of individual farmers. And finally, all of these studies ended with conjectures about how cooperation is sustained over time because time series data was not available. Since this study builds directly on these earlier efforts, the following design addresses each of these influences in turn.

It should be noted here that the approach of this study is not to test the accuracy of the IAD framework. By definition, a framework cannot be tested and must be either rejected or accepted. Theories based on this framework can be tested, but they inherit the assumptions of the framework. For example, theories based on the IAD framework inherit the assumption that the myriad dimensions of human reasoning can be understood completely in terms of their effects on an internal cost-benefit assessment at the time of making a decision. In contrast, I drop the assumption that human reasoning is unidimensional, and begin with interviews to understand what variables should be emphasized in order to explain the findings. As a second example, the IAD framework posits that once users can make their own rules, as is the case with nearly all the canals in the sample, multidimensional and rapid "external" shocks are

[25]See Poteete et al. (2010) for a program of sorts for this school of thought.

the main challenges to survival as described in Ostrom (2005). I do not assume this to be the case, and explicitly examine the relationship to external shocks below.

1.4 The Study Design

Overall, this study had several iterative stages of data collection and analysis. They resulted in two observations each for 233 irrigation systems separated by between 16 and 37 years, one observation each for 39 systems, recorded interviews with 827 respondents, and detailed case studies of two canals.[26] The survey portion of this study is in the form of a longitudinal data set of 509 variables per case at two time periods. During this time, the canals experienced multiple changes due to the changes that occurred in Nepal at that time.

The research began with a set of field visits to irrigation systems in Nepal, without knowledge of whether they had been studied before nor not. During this preliminary stage, I visited twelve villages in six districts: Morang, Sindhupalchok, Kathmandu, Chitwan, Kailali and Rolpa. On the visits to Sindhupalchok, I accompanied individuals who had conducted the studies on which the NIIS was based.[27] On the visits to Kailali, I was accompanied by the secretary of an NGO which had worked in the district for several years. In Morang, I made the visits with an Agricultural Extension Officer of the Department of Agriculture, Government of Nepal. In Chitwan, I was guided by a professor who knew of the NIIS, but hadn't taken direct part in its creation or maintenance. And in Rolpa, I was guided by members of the Maoist

[26] I use "canals," "systems" and "cases" interchangeably.

[27] In the districts of Sindhupalchok, these were Dr. Prachanda Pradhan, who had first initiated the compilation of cases of successful farmer management, and Dr. Robert Yoder who had led several of the engineering studies of irrigation canals in Nepal in the late 1970's. A third gentleman, Mr. Bhattarai had coordinated the fieldwork to survey these systems in greater detail at the time.

Party who lived and worked in the area where the People's War originated. Through these preliminary field visits, I found that the canals were facing complex situations, in consonance with the changes the country as a whole had experienced.

After sharing the initial observations with Elinor Ostrom, I was granted access to the NIIS database.[28] I proceeded to reconstruct the history of the database as described above and began a re-analysis of the original NIIS data. This stage consisted of phone and in-person interviews with many of those involved in creating the NIIS, and those who had authored the papers and reports from which the cases were drawn.

Based on the preliminary visits, initial analysis of the NIIS data, and a reconstruction of the history of the NIIS project, I designed a survey instrument. My survey contained all of the questions from the first survey, with additional questions based on the data collected during my preliminary field visits. The additional questions were primarily about the effects of the decade-long conflict, and contained several open ended questions particularly about the effects of the conflict.

The second stage consisted of revisiting each of the 233 cases and administering the new survey instrument while simultaneously recording all of the interviews with willing respondents. Using this data, I was able to observe patterns that needed further investigation. The primary reason for additional fieldwork was that I could not rule out that these patterns were due to the way these cases were initially selected, as I describe in greater detail below. To do this, I then added an additional sample of 39 cases that were selected randomly in order to check the patterns that had begun to appear in the analysis of the two visits.[29] I also added an additional set of questions

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[28]Professor Ostrom passed away two months after this.

[29]The original goal was to reach all the remaining 45 administrative districts that had not made it

Figure 3: Locations of sampled irrigation systems The non-zero numbers indicate the original sampling in the NIIS. The zeros indicate the five districts of Baglung, Myagdi, Mustang, Manang and Humla that could not be visited due to bad weather. One random canal was chosen from each of the remaining 39 unmarked districts. This resulted in a sample of 272 canals, with two observations for each canal in the original sample. *Modified map based on original from The National Planning Commission, Government of Nepal.*

to the survey at this stage because I wanted to probe further certain patterns that had already started to emerge. The geographical distribution of the resulting sample is shown in Figure 3.

The third stage consisted of another round of survey work for the added random sample, again to collect data and record interviews. After cross checking the initial

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into the NIIS. However, the summer of 2013 saw an extremely heavy monsoon leading to unusually severe floods and landslides. Because of these conditions, canals in these 5 districts could not be visited.

findings with this added set of cases, I selected two cases to examine in greater depth based on geographical variation and how accessible they were to me. One was located in the district of Tanahun, and the other in the district of Dang. The final stage consisted of ethnographic-type fieldwork of these two cases over two months in order to gain insight into the day to day functioning of the canals over an extended period of time. When I lived in each of these locations, I focused on observing user discussions, their relationships with government agencies, political parties, and each other.

The overall design allowed for systematic observation of why some institutions for sustained cooperation survived, and continued to perform well while others declined in the face of myriad changes that they experienced between the first and second visits. The changes during this period were a result of larger trends in Nepal, which I turn to next before describing further the details of sampling, fieldwork and methodology.

1.4.1 Nepal's Changing Context

Officially classified as a 'hard core' Least Developed Country by the United Nations in November of 1971 and never having graduated, Nepal remains a permanent representative of "the poorest and weakest segment of the international community."[30] According to the United Nations, Nepal is one of the countries countries that have received special attention from the International Community since the late 1960's because of their special needs. The criteria for "graduation" has changed slightly

[30]Like another 14 of the 47 other countries that make up this list, Nepal is also landlocked. The list was formulated by the United Nations Committee for Development Planning, and it was recognized by the General Assembly on November 18, 1971 in resolution 2768 titled "Identification of the least developed among the developing countries."

over the years to keep up with development thinking[31], but they refer in general to low levels of economic growth, low per capita income and a generally low level of "socio-economic development". This underdeveloped condition is "characterized by weak human and institutional capacities, low and unequally distributed income and scarcity of domestic financial resources." (UN, 2014)

This classification has resulted in the country becoming a cauldron of development activity over the years.[32] These activities have rarely been government led, instead being guided by a large donor community.[33] Nepal's government has been characterized as relatively weak and the country is said to suffer from "governance crisis, political instability and internal and external conflicts." (UN, 2014) The list of problems with government is long, but also appears typical of other countries in its LDC group. In short, the responsibility for development has always been seen to rest on the government itself. However, it has been one persistent participant among many in Nepal's development process.[34]

The economy of the country has remained dependent on agriculture which makes up approximately 38% of GDP. Agricultural production is subject to large seasonal fluctuations depending on the weather. It is usually of the smallholder type with 95% of all holdings below 2 ha (4.9 acres) and 54% below 0.5ha (1.2 acres). The main mode of irrigation is gravity-flow systems (33%) in which machinery is not required. (?)

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[31]For instance, the notion of weak "human and institutional capacities" is a recent formulation.

[32]For example, even a cursory examination of Nepal's National Plans from 1956 onwards shows the variety of projects and programs that were proposed.

[33]See Library of Congress (1993) for a study which gives an account of foreign aid in Nepal at the time of the first study. See Khadka (1997) for a discussion of donor motivations in Nepal in the post-cold war period. The Ministry of Finance, Government of Nepal maintains a database of Foreign Aid projects in Nepal at portal.mof.gov.np.

[34]See Wildavsky (1972) for a discussion predating the first study on why planning "fails" in Nepal.

The current sample of canals reflects these characteristics. Most (51%) of the canals in this sample have a temporary intake, made of stones and twine rather than concrete. This normally needs to be rebuilt every year, and is more easily damaged by natural conditions than more permanent concrete headworks. Similarly, 23% of the channels are made entirely of earth without any cement linings. The sources of water also continue to be predominantly rivers (88%), with only a small number relying on rainfall, springs and groundwater. These characteristics are summarized in Table 1.1.

Table 1.1: General technical characteristics of the sampled canals: This table summarizes the important physical aspects of the canals in this sample. This does not include those that are no longer in use, but includes the random sample of 39. (N=233, 8 missing)

	Yes	No
Does the canal have a permanent intake?	115	118
Do the walls of the canal have any lining?	179	54
Is a river the main source of water for irrigation?	206	27

There are several relevant particularities that are likely to set Nepal apart from other countries in the extent to which the state is weak, and the country diverse. It has also, surprisingly, exceeded India's progress in certain indicators of development although it is surrounded by India on all but the Northern side. (Dreze & Sen, 2013) Most prominently, Nepal recently saw the end of a decade long civil war between armed Maoist rebels and the State in 2006. The war resulted in large swaths of the countryside being cut off from central government while it raged. In 2006, the country turned to writing a new constitution as part of the peace agreement that ended the war. The constitution has not yet been written. This process continues and as a consequence, local government bodies have not had elected representatives for 16 years as of April 2014.[35]

[35]See Whelpton (2005) for an accessible general history of Nepal. See also Hutt (2004) for an account

The conflict had an effect on 44.5% of the canal management institutions in the sample, as shown in Table 1.2. Users reported difficulties in meeting with each other, in gathering to maintain the canal and in communicating with local government offices when they faced problems or needed assistance. Without the ability to meet, they also reported adopting a range of other strategies for keeping the canal functional such as gathering in smaller groups and coordinating their actions without general meetings but by visiting each other's homes. For some users, the conflict seems to have made canal maintenance easier: they reported that without government assistance, users did not have to worry about misusing funds and had greater flexibility in using the money that they collected from each other for canal maintenance.

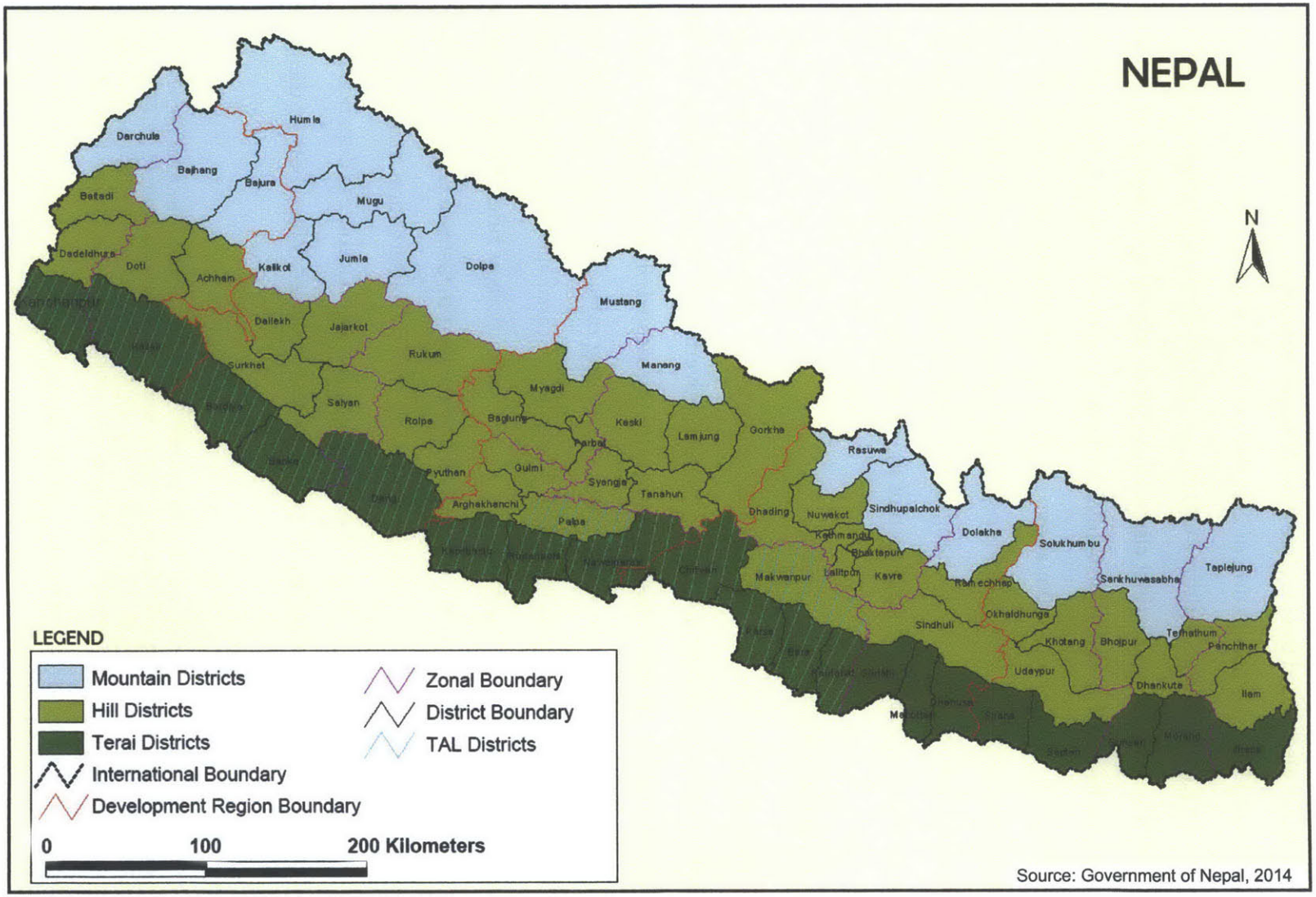
Table 1.2: Was the operation of the canal affected by the conflict? This table shows the number of cases in which respondents reported difficulties in the normal operation of the canal management institutions because of the conditions created by the conflict. (N=229, showing only those that are still in use. 4 missing.)

	Frequency	Percentage
Yes	102	44.5
No	127	55.5
Total	229	100

Table 1.3: Distribution of cases by geographical region: This tables shows the locations of the canals in the sample. The Terai are plains in the South of the country. Hills refer to the middle third, and Mountains to the northern third of the country. (N=272)

	Frequency	Percentage
Mountain	52	19.1
Hills	119	43.8
Terai	101	37.1
Total	272	100

of the People's War.


NEPAL
N
Darchula
Baitadi
Bajhang
Bajura
Humla
Mugu
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Mustang
Manang
Dailekh
Jajarkot
Rukum
Surkhet
Salyan
Rolpa
Myagdi
Baglung
Keski
Parbat
Lamjung
Gorkha
Rasuwa
Pyuthan
Gulmi
Syangja
Tanahun
Arghakhanchi
Palpa
Dhading
Nuwakot
Sindhupalchok
Dolakha
Solukhumbu
Kathmandu
Bhaktapur
Lalitpur
Kavre
Makwanpur
Ramechhap
Sankhuwasabha
Taplejung
Sindhuli
Okhaldhunga
Khotang
Bhojpur
Tehrathum
Panchthar
Udaypur
Dhankuta
Ilam
LEGEND
Mountain Districts
Hill Districts
Terai Districts
International Boundary
Development Region Boundary
Zonal Boundary
District Boundary
TAL Districts
0
100
200 Kilometers
Source: Government of Nepal, 2014

Nepal is also varied in language with 11 major languages (of 123 reported) spoken by at least 1% of the population of 26.5 million.[36] Castes and ethnicities show a similar variety (125), and its cultural variation is related to a wide range of variation in geography. It has three distinct climactic regions ranging from Alpine in the North, through temperate in the middle hills, to Tropical in the Southern Terai, and ranges in altitude from less than 100m above sea level to the highest point on earth.[37] Thus, the country has a wide variation inside the country along several dimensions and has also experienced complex changes in the last 37 years, which is the period of this study. The geographical distribution of the cases is shown in Table 1.3.

1.4.2 A Definition of Institutions

As I noted above, the NIIS dataset was compiled to study how users can create institutions to govern themselves and thereby govern their irrigation canal. Because my study builds on this dataset, I begin with the same definition of institutions that was used in the first study: a collection of working rules that is known to all users. These working rules pertain to actions related to the canal such as cleaning, monitoring, penalties, withdrawing water, and so on. "Institutions as rules" is one commonly used definition of many other definitions as described in Ostrom (2005). The reason that this definition was used initially had to do with the observation that it simplifies the analysis significantly. As a set of rules, an institution's success depends on two conditions: getting the rules "right" and enforcing the rules. When both of these con-

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[36]See CBS (2013) for the report of the 2011 Nepal Population Census. The total population was reported to be 26,494,504. The major mother-tongues were: Nepali (44.6%), Maithili (11.7%), Bhojpuri (6.0%), Tharu (5.8%), Tamang (5.1%), Newar (3.2%), Bajjika (3.0%), Magar (3.0%), Doteli (3.0%) and Urdu (2.6%). In total, approximately 79% are Indo-Aryan languages, while 18% are Tibeto-Burman.

[37]See Sharma (2008) for a visual account of this spatial variation.

ditions are met, it is argued that somewhat selfish and suspicious users can then make longer term commitments such as refraining from overexploiting a resource. (Ostrom, 1990)

Using this narrow a definition to examine such a rich dataset may seem to be an unnecessary restriction. While equating institutions with rules and rule-like statements does limit the initial breadth of this study, it makes patterns of institutional changes more stark by focusing on a single aspect of institutions. Using the same definition also allows me to compare the rules as they are now with what they were in the past. While I do not examine how the specific content of the rules have changed in the current analysis, it is something that can now be easily done using this same dataset. I also do not make the same assumptions about human behavior and motivations, taking them instead as something to be understood through interviews with users. Thus, while I use the "institutions as rules" definition in this analysis in order to compare results with the earlier study, I am not automatically bound to the conclusions of the prior study.

In the remainder of this dissertation, 'institutions' and 'working rules' will be used interchangeably. The reason for not using only the latter is that in these cases institutions are a set of rules that have a certain structure: they not only contain rules pertaining to actions related to the canal, but they also contain rules for changing other rules. The relationship between rules and institutions is described in greater detail in Section 2.4. I use "system" or "irrigation system" to denote the canal along with its associated institutions. It is also important to note that the institutions may contain rules for establishing organizations such as Water User's Associations with a membership structure, leadership positions, as well as other formal positions. One of the sources of the institution's rules might be this sort of organization, but it is not so in every case. Institutions and organizations are different but related entities in this

analysis.

1.4.3 Sampling

The sampling in the original study is a more significant influence on the scope of this study because it was neither random nor representative of a larger population.(Poteete et al., 2010, p. 102-107) Instead, it was most likely a convenience sample that was itself influenced by several political processes. Because of this, I am more cautious in my interpretation of the numerical methods used to analyze the data than would have been necessary if the current sampling was not largely bound to the prior one.

Nevertheless, in order to observe institutional changes over decades it is necessary to build on a sample of cases whose selection I could not have controlled.[38] In the original sample, cases were drawn from studies existing at the time. In turn, the authors of those studies chose the canals to suit particular purposes. For example, the Engineering Assessments sought to identify suitable canals for development assistance. This in turn appears to have been influenced by those who were in government at the time and sought to draw investment to their constituencies.[39]

Some of the original cases appear to have been chosen simply for ease for access.[40] In general, because of Nepal's rudimentary road network only a small proportion of rural locations in the country were accessible. And so this sample was concentrated along highways and near towns as shown in Figure 3. There are also gaps in the

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[38]The oldest of the cases in the sample was studied before I was born.

[39]For instance, according to a member of the team that conducted one set of appraisals, the Minister of Water Resources at the time had influence over which districts received assistance because his approval was ultimately needed for the project to proceed. His district is one of the most heavily sampled.

[40]In particular, the cluster in Chitwan appears to have been influenced by the proximity of the agricultural university which was a partner in developing the NIIS database.

original sampling in the North East and North West of the country, which are some of the poorest and most inaccessible regions.

Although I made a concerted effort to ascertain the pressures on selection at the time by interviewing those who conducted these early studies, the myriad influences on case selection are even less discernible now than they had been then.[41] What did become clear, however, was that these studies could not have been done without political accommodations between those who did the original studies and those in government.

However, even with a reasonably complete model of the influences on the original sampling, a second problem remains. There is no way to know what the universe is of canals from which the sample was taken because there is no known list of all irrigation systems in Nepal. Thus, no sampling of canals can convincingly claim to be representative until the universe of canals has been convincingly characterized. These two reasons make probabilistic generalizations of this study irresponsible: such arguments can neither lean on randomized sampling to make general claims, nor can they lean on a model of the sampling bias and correct for its implications.

Thus, past realities of implementation affect the claims that my study can make in two ways. First, they severely weaken stochastic arguments about the relative effects of particular factors on the survival and decline of institutions over time.[42]

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[41] In the early stages of this research, I interviewed those who were involved in the initial sampling and data collection. This led to a rough account of how the canals had been chosen. To make up for this sampling, to an extent, I added an additional random sample.

[42] For an elaboration of this argument, with sketches of proofs based on combinatorial interpretations see Freeman & Lane (1982). See Tversky & Kahneman (1971) for a classic discussion of the role of randomness and its interpretation, emphasizing repetition. Freeman & Lane (1982) gives an overview of non-stochastic interpretations. Pitman (1937, 1938) provide useful overviews of tests that can be used in different population types. Hoeffding (1951) and Ho & Chen (1978) give a thorough treatment of the underlying combinatorial results.

The best that such a study can do with this sample is to compare the values of test statistics against a null hypothesis that is admitted to be an incredible description of reality. Without greater confidence regarding the influences on the original sampling, it becomes prudent to stay away from probabilistic arguments.

Second, the interpretations of basic statistical tests- *p-values* in particular- will need to rely on combinatorial commonality of the observed patterns.[43] Thus, the numerical arguments in this study are all observational rather than confirmatory. The general approach of this study is to trace multiple lines of evidence and highlight empirical observations that are difficult to explain using old theories, but that are easily explained from the view of the new theory that is proposed. It is left to future researchers to confirm or reject the findings.

Overall, the patterns inferred from an unknown sampling and an unknown population can also be corroborated using an additional sample which is more random, and for which the influences on selection are known. In order to partially make up for the unknown nature of the biases in the original sample, the sample of canals has an additional 39 canals chosen randomly, one from 39 of the districts left out of the original sample. There was no pattern to this selection, although there were a few likely influences. First, the enumerators were bound, just as in the original study (henceforth the *first round*), to survey systems that they could reach and study in a reasonable amount of time, which was approximately two days from the nearest town by foot. This pulled the sample towards those systems that were closer to towns.[44]

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[43]In effect, p-values indicate how likely the observed pattern is over all possible randomizations of responses. Unlikely patterns cannot be passed off as mere coincidence.

[44]This bias is common to the first round as well. The sample is taken from the set of systems that are feasible to access given certain fixed constraint. With improvements in transportation, this frontier has expanded since the first study. There are also a handful of cases that made their way into the sample by accident: they were surveyed and only later found not to have been in the original sample.

Furthermore, because there was no master list of canals, the were randomly selected by visiting the district headquarters and asking people that the enumerators met, or walking around to look for canals. An alternative approach for obtaining a random sample was to randomly select geographical coordinates within the country's boundaries and look for corresponding canals. However, this would have been too time consuming because there wasn't a way to determine whether a particular location was served by a canal or not without visiting it. Furthermore, since only about 27% of arable land in the country is irrigated, the chance of finding a canal randomly through this method was not practical.

Thus, this random sample is also restricted to canals that are known to local residents near urban settlements. Overall however, this added sample does not suffer from unknown influences as much as the first. So, I use it to provide a useful check on the numerical patterns found in the original sample.

The overall design of the study was shown in Figure 2 and Figure 1. The second round refers to the 2013 survey. The first round refers to the data collected for the original study. The sampling in the two rounds resembles a 'spilled panel' because the second round sample covers the first and extends beyond it.

1.4.4 The Questionnaire

The new questionnaire contained almost all of the questions from the first round[45] along with new questions. The most important set of new questions asked about the perceived effect of the armed conflict that took place in Nepal between 1996 and 2006. There was also a supplemental questionnaire for the 39 additional cases be-

[45]Some questions did not apply in the context of the new study because the earlier study had assessed documented cases for use in a meta-analysis. Questions such as "Does the author mention..." were omitted in the new questionnaire.

cause they were added after completing most of the panel. This included further questions about patterns that had appeared through a preliminary comparison of the two rounds which were not asked in the first round.

The questionnaires were in English, but they were translated into Nepali in the field by trained enumerators. Nepali is the most widely spoken language in the country, even by those who do not consider it their mother tongue. The questionnaires were designed to structure the interviews with respondents, although respondents were allowed to take the interview where they wanted. Since these interviews were recorded in most cases, this provided a new source of data for the second round that was not there for the first.

1.4.5 Locating the Same Cases

The location descriptions from the first survey guided the search for the canals to be revisited. After reaching the general area described, it was necessary to ask those we met where to find a canal that matched the specific details- length, size, history, direction of flow, villages irrigated- of the earlier one. [46]

In cases where this procedure did not lead to the same canal, or in cases where the canal had stopped being used, older residents who might remember it were sought out and interviewed. If it had stopped functioning, follow up questions attempted to glean why it declined. A typical canal serves more than one village and each village might be located at different points along the canal. Depending on how long the canal is, areas along it may be dramatically different in terms of geography, water availability, proximity to regional centers, accessibility, crops and sensitivity to water

[46]No single detail, such as the name or administrative division in which it was located, was always accurate. The same name could be used for many canals and due to political changes over the years, administrative divisions had also changed. Thus the search was unusually involved in some cases.

availability among other factors. In general, those closest to the headworks have the most water available whereas those closest to the tail have the least available. [47]

In those cases where the village name was mentioned in the location information, interviewers visited the same village. In those cases where this was not mentioned or multiple villages were mentioned, the team visited the one closest to the headworks because it was the most likely to still be using the canal. This introduces a bias towards the inclusion of institutions that were more likely to survive - thereby making decline even more surprising. This resulted in the following breakdown of the locations of the villages along the canal in the second round.

Table 1.4: Location of respondents along the canals: The table shows the location of villages from which users were interviewed. The position along the canal significantly affects water availability and other characteristics because water flows from head to tail. (N=233, includes only the original sample)

Location	Number	Percentage of total
Head	97	41.63
Middle	87	37.33
Tail	49	21.03

1.4.6 Finding Respondents

A potential problem was finding the same, or comparable, respondents after such a long period of time. As the length of time between observations stretches over decades, finding the same person can be impossible. A further difficulty with finding the same person was that the original survey did not mention who the respondent was.[48]

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[47] In some cases where the canal collects runoff from another water source or is fed by other sources downstream, the tail-enders have more abundant water than those at the head.

[48] This did not prevent finding the same people though, and in some cases the original respondents were also interviewed.

There are two main reasons why finding the same respondent is less of a concern for this study. First, the unit of analysis in this study is the institution and not an individual. There are aspects of this study that rely on the perception of individuals. However, since more than one individual was interviewed, a slightly more "collective" perception is understood in these responses. All that is required of the respondents is that the they be knowledgeable about the rules that they use.

Second, in all existing analyses of commons type resources, there is an explicit assumption that the rules are known to most users. More specifically, the original study was based on the assumption that institutional rules are "common knowledge" to all the users, and therefore it does not matter who is asked about them.[49] This assumption is common in game theoretic explanations of user decisions, and it helps to construct a model of coordination between individuals. Overall, in this part of the study it is more important that the same canal be identified than the same respondents. Chapter 4 is devoted to an examination of this assumption. There, I examine the implications for this study of variations in the knowledge and understanding of the rules across users of the same canal.

Thus, after locating the original canal, several people were interviewed. A single person was unlikely to know all of the details asked about in the questionnaire. Officials with the Department of Irrigation and local government bodies were also interviewed for more information where possible. The main source of information on the canals was farmers who currently used the canal. Enumerators walked along the

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[49]Here, common knowledge is used in the sense of Aumann (1976), but in a slightly weaker form. The CPR framework does not require that everyone know the rules, nor that everyone know that everyone else knows the rules - but only that the "majority" do in both conditions. (Ostrom, 1990, p. 51) More generally, the role of "common knowledge" in the original framework is similar to that which allows Hume's farmers to coordinate - they each know what the other expects in transactions where giving and receiving are not instantaneous. (Hume, 1896, p. 520)

length of the canal to the headworks and spoke to those met along the way. All interviews were recorded for later analysis except when such permission was not granted by the respondent. On average, there were three respondents per questionnaire. This resulted in 827 interviews which I later analyzed in addition to the data from the surveys. Thus, although the questionnaires were filled out in the field, I was able to check their accuracy by listening to the interviews myself.

The interviews were sometimes conducted in groups, sometimes one on one, or at times in the presence of officials of the Water User's Association, which is the local administrative body for a canal. The physical condition of each canal was examined directly by walking from the village along the length to the headworks. Some questions were asked during this walk to respondents along the canal who may have been in their fields. This allowed enumerators to get a sense of the variation in apparent economic condition of users.

Poorer looking households, based on materials used in their homes and size of land being irrigated[50], were not interviewed in the presence of other users in order that they could speak more freely. In general, interviews were conducted without an official present because it might affect the respondents. In every case, the enumerators introduced themselves as students who had come to study the canal. This reduced to some extent the slant of responses that is common when the respondents expect the questioner to provide assistance.[51]

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[50]These two indicators can be misleading if users have savings or assets elsewhere but have not changed their visible living conditions. This was the case in several instances where family members were abroad and sending money home. There was a danger to visibly changing ones lifestyle - others might ask for money, or they might be targets for thieves. This complication does not significantly affect this study as the distinction is made between "poor" and "poorer looking" - the latter being a relative assessment between users of the canal.

[51]Some canals, particularly in Chitwan, had been visited so often that the members of the user's association charged a fee for answering survey questions. When they were convinced that the enumer-

Recall that the questionnaires were in English and translated into Nepali in the field as they were administered.[52] These questions gave a structure to the interview, although the respondents were allowed to direct the interview in directions that they wanted to take it. These interviews were examined later to identify concepts that tended to connect to one another within and across responses. The recordings were also used during the data entry phase to cross-check some survey entries.

In some cases, the timing of the survey can also become significant. Questions that depend on the season in which they are asked introduce a further consideration for repeating a prior study. For instance the quality or quantity of water in a canal often varies with season. During the rainy season, both tend to be better overall. Questions about the maintenance of the canal are also sensitive to when it was last cleaned. For example, it is common for canals to be dirty and clogged when unused in the dry season. These additional considerations are part of subsequent analyses, where possible, particularly when the condition and functioning of the canal is assessed. In particular, since the months during which fieldwork was completed in the first round was not always available, I have not used enumerator assessments of canal functioning as far as possible. Instead, I rely on user assessments of functioning, and enumerator assessments of the physical condition as I describe in Section 1.5.3.

In sum, this section has described the political elements of the initial sampling that shape this study as well as the considerations for a study that begins by repeating an earlier one. In particular, there are considerations of sampling, finding respondents and overall reproducibility. In this case, the inherited selection was augmented with

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ators were students by examining student identification cards, they agreed to answer our questions free of cost.

[52] I trained all enumerators for three weeks beforehand in order to come to a uniform set of translations and explanations for each question. This limited the variation in the asking of the questions.

a random sample. Although institutional changes can only be studied directly in the non-random sample, the random sample provides a "sanity check" on the findings. Finding the same respondents was not necessary as long as the same canal and same village were located. Overall, the conclusions of this study are non-stochastic, observational and corroborated with a random cross-sectional sample. In light of these considerations, I now present some motivating results from revisiting the canals.

1.5 Upon Revisiting

Recall that of the original sample of 233 canals, 202 were still in use when I revisited them. Thus, 86% of the institutions for managing these canals were still in existence thirty years later.[53] The IAD framework identifies five main threats to the success of these particular institutions (Ostrom, 2005, p.272), of which the most basic and significant are external and internal changes. The faster these changes occur, and the more that occur, the greater the challenge is predicted to be. This is especially the case for institutions whose rules have been made locally for many years, and which have managed to survive.

However, as this section shows, this relationship between external changes and survival or decline did not appear in a significant way when these cases were revisited. Nor does there appear to be a significant relationship between changes in performance of the canals over time and the number of changes. The results below neither match the predictions for performance nor the predictions for decline. Thus, there is a double mismatch with what was predicted. First, a significant number of

[53]I assume that when the canal stops being used, the institution for managing the canal also becomes dysfunctional. However, it is possible that the specific rules might come to be used in other situations, or the organizations that were set up previously turn towards other objectives such as managing forests, or providing small loans.

canals that experienced many changes performed well. And second, a significant number that experienced very few changes declined. This does not imply that the original theory is wrong, but it does suggest that there may be other reasons behind these variations. Overall, these initial findings emphasize the need to explain both decline and survival as opposed to only one or the other. They further suggest re-examining the specific characteristics of the institutions in these cases, rather than focusing on the external changes.

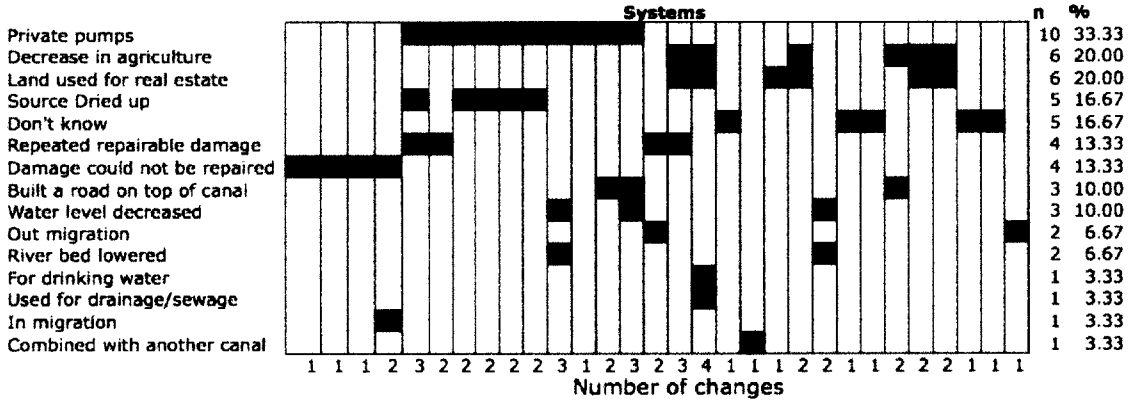
In what follows, I begin by describing the causes of decline according to interviews with former users of now defunct canals. I then examine the presence of these causes in the canals that are still in use. After that, I move to looking at performance of the canals rather than just survival and decline, under the assumption that the performance of the canal is a consequence of the institution for managing it. I then examine the relationship of canal performance to the number of external shocks. Finally, I extend this analysis to changes in performance over time. In all of these instances, external changes alone do not appear to significantly relate to changes in institutional performance. The approach that I take in this section is to examine the perceived and theorized reasons for decline and compare them to the data.

1.5.1 Apparent Reasons for Decline

In those cases where the canals were no longer in use, former users[54] gave various accounts of why. As shown in Figure 4, users were more likely to cite multiple reasons (80%) as being responsible for the decline of their canal than a single one. The most common reason was that agriculture had become less important. In many cases,

[54]These former users identified themselves. There was no way for enumerators to verify if indeed they were past users, although older respondents who had lived continuously in the area were more likely to have been users in the past.

Figure 4: Reported reasons why canals perished: In the figure, each row of the table represents a reason that former users cited for decline. Each column represents a canal that declined. A cell in the table corresponds to a canal and a reason. It is darkened when the former users of that canal cited that reason as responsible for decline. The numbers below the table are the total reasons cited for each canal. The numbers (n) at the end of each row represent the total number of times the reason was cited across canals, followed by the percentage (%) of the defunct canals in which it was cited. (N=31)



the land had been used for other purposes such as housing, or the soil for brick production. In these cases, the canal provided convenient[55] public land over which to build a road. In other instances, the water had been used for urban drinking water. And in yet others, the canal had been damaged by a natural disaster or the source had dried up, but the users had lacked the resources or the willingness to repair it. A few were also reported to have declined because there were not enough people to maintain and repair them. And at the same time, those who continued to need water for agriculture had dug private bore wells. Consequently, the canal had fallen into further disuse and disrepair. It is also interesting to note that none of the reasons

[55] According to an engineer at the department of roads, it was convenient for two reasons. First, the land was already public, and second the canal's path followed a gradual gradient in hilly terrain that roads also require.

concerned conflict.

On their own, these reasons sound convincing as reasons for decline. After all, it is reasonable to expect institutional adaptability to have its limits. With enough external changes, or shocks, of sufficient effect or sequence, any institution would become dysfunctional. For example, it is conceivable that a flood could damage the canal to such an extent users do not have the ability to make it operational again it with their resources. These responses from former users appear to support the prediction that the canals that are already user managed are likely to decline because to changes beyond their control. However, these reasons alone look less convincing when I examine the conditions experiences by surviving canals.

1.5.2 Uncertain Surprises

Table 1.5 shows how many canals had experienced each of the changes cited as reasons for decline, and also shows how many of them survived or declined. The table shows that these changes were faced even by canals that did not decline.[56] Furthermore, of those that experienced each change, many more systems survived the "shock" than declined. Take for instance those that were reported to have experienced decreased agricultural production. Only 12.7% of them stopped functioning. There is a similarly small proportion of decline for those that experienced physical damage, out migration,the opening up of roads or a combination of these.

Thus, based on user responses it appears unlikely that facing these changed conditions alone would cause decline. The reasons that former users associated with the demise of their canals still leaves open the question of why it was that in the face of

[56]This is based on user responses to questions that asked whether they had experienced each of these changes.

similar types of changes some institutions declined while others did not. But it does begin to turn attention away from external conditions, which appear similar across the cases in this sample, towards the effects of the internal characteristics of the institutions over time.

Table 1.5: Survival proportions by type of shock experienced: Each row in this table represents one of the reasons that users of now defunct canals cited as a cause of decline. The final column shows the total number of canals that had faced similar types of changes, based on user responses. This total is broken down by the number that survived and did not survive in the remaining two columns. (N=233)

Type of shock	Survived	Did not survive	Total
Decreased agricultural activity	41	6	47
Land used for other purposes	154	6	160
Physical damage	104	8	112
Use of private pumps	-	10	-
Out-migration	163	2	165
New roads	152	3	155
Water to urban areas	27	1	28

A further examination of the reported reasons for decline in those cases that have survived questions the initial predictions further. Every institution in the sample experienced at least one of these changing conditions as shown in Table 1.6. The surviving systems experienced an average of 4 of the changes which had been cited as reasons for some to have declined. Thus, the changes in external conditions that were given as reasons for decline were pervasive across all canals, surviving and not.[57]

In prior studies such as Lam (1998) and Joshi et al. (2000), the performance of these self-governed canals was compared to the performance of canals managed by

[57]There could be several other reasons for decline that cannot be examined here because there is limited data about the ones that have declined. For instance, there is no information on the intensity of the changes or the sequence in which the changes occurred.

Table 1.6: The number of changes experienced by surviving canals. The table shows then number of canals (n) that experienced a certain number of external changes (x). It is apparent that most of the canals faced multiple changes in their external conditions. ($N = 194$, $\mu_x = 4.4$, $\tilde{x} = 4$, $\sigma_x = 0.96$)

Number of changes *(x)*	Number of canals *(n)*	Percentage of canals *(%)*
1	1	0.5
2	3	1.5
3	28	14.5
4	69	35.6
5	74	38.1
6	17	8.8
7	2	1.0

government agencies.[58] This resulted in conclusions that Farmer Managed Systems were superior to Agency Managed ones.[59] The distinction between these three types relied on the extent to which farmers or a government agency decided who could use the canal, how the water was allocated, and how it was to be managed in general.

It is no longer possible to make this comparison between Agency and Farmer managed systems using this dataset since most of the canals in the sample have been handed over to local institutions.[60] Yet a closer look at the resilience of those that were government managed then versus those that were completely self-governed shows that nearly all of those that have stopped functioning were of the "Farmer

[58]The canals were classified as either completely government managed and called Agency Managed Irrigation Systems (AMIS), or jointly managed with government agencies called Jointly Managed Irrigation Systems (JMIS). The third possibility was farmer managed (FMIS). "Managed" refers to who makes the institution's rules - farmers, a government agency, or both.

[59]See Cole (2012) for a reiteration and re-emphasis of these claims.

[60]This raises a point worthy of considering regarding the extent to which policy-relevant studies change that which they study. To the extent that they do, the study itself must be considered part of the eventual intervention. This places limits on direct reproducibility of findings. In the cases here, the predictions of earlier studies were used to make policies to "hand over" canals to user management. These policies changed the management of canals in such a way that the original prediction can no longer be tested using the same sample at a later time.

Managed" type in the first study. In contrast, only one of those that were managed in cooperation with government agencies has stopped functioning.[61] This is shown in Table 1.7. Taken at face value, this seems to go against the basic claim that decreased government involvement improves resilience. Indeed, Farmer Managed systems had a higher failure rate (17%) than the sample as a whole. This suggests that the more the government was involved then, the greater the chance of survival now despite being handed over to local users in the meantime.

Table 1.7: Survival by how the canal was managed in Round 1. This table shows how many canals survived by how they were managed when first studied. (N=221, 3 missing. Fisher's exact=0.016)

Type of management	Survived	Perished	Total
Farmer Managed	139	29	168
Jointly Managed	29	1	30
Agency Managed	20	0	20

In 12 cases, the type of management was unclear.

Thus, in these cases, external changes alone do not appear to identify those that are likely to decline. This suggests examining the institutions themselves in addition to the external conditions that the canals face. This in turn requires a finer measure of an institutions ability to evoke the necessary cooperation to maintain the canal. Next, I turn to an examination of the institutions that manage these canals based on the performance of the canals that they govern. Another reason to move beyond survival and decline when assessing these institutions is more practical: all of the canals that stopped functioning did so before I surveyed them a second time. Therefore, without reconstructing this history through sources other than this dataset, it is not possible to systematically examine changes to most of the variables that were documented in the

[61] It should be noted that 18 of the 20 Agency Managed Systems in the original sample were subsequently "turned over" to farmers under policies seeking greater local resource management.

first study. However, looking at canal performance allows me to view survival and decline as two ends of a continuum. While time series data for those that are no longer in use is not in this dataset, detailed data for those which are declining but have not yet stopped is. This allows for a finer examination of what affects institutional performance.

1.5.3 From Survival to Performance

Unless the canal comes to an abrupt stop such as through a comprehensive disaster, there are two features of the canal that would likely exhibit decline before the canal itself stops being used. These are the physical condition of the canal (including the intake or headworks) and its ability to distribute water. Both of these aspects are also closely tied to the institution for governing the canal, for the institution is responsible for enabling individual users to work together on maintenance and upkeep. I assume, based on earlier studies, that without these institutions, cooperation between users would be irrational and therefore unlikely in these cases. (Ostrom, 1990) I also assume that, in the absence of outside assistance, the only reason a user-managed canal continues to function well is if the users cooperate to use and maintain it and the only reason for decline is if they fail to do so.[62] Based on these assumptions, I take institutional performance to mean the extent to which it can elicit the required cooperation. I further take institutional performance to be indicated by canal performance.

Overall, the surviving canals show variation in physical condition and performance. As Table 1.8 shows, the surviving canals have varying physical conditions.

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[62] I examine the detailed implications and justifications of these assumptions in Section 1.6 and further in Section 3.1.

Indeed, 90% of the canals show some sort of physical deterioration. There are four causes that users cited for this deterioration: difficult conditions created by the war, natural disasters, neglect, and normal wear and tear that has yet to be repaired. Of particular interest is the large number that have deteriorated due to neglect or that have remained unrepaired after a disaster (about 41%). These are directly suggestive of a lack of maintenance by users. The deterioration that is attributed to normal wear and tear does not indicate whether the users actually will repair it, although they say they will.[63]

Table 1.8: Causes of physical deterioration in the canal: The second last column of this table shows the number of canals that showed physical deterioration in the water channels (canal) and the intake (headworks). In the columns preceding it, this total is broken down by the reasons that users gave for the deterioration. The final column gives the percentage of total canals. (N=182, 20 missing)

	Conflict	Disaster	Natural*	Neglect	Total	Percentage (%)
Headworks	1	37	66	13	117	64.2
Canal	0	43	88	16	147	80.7

No deterioration=18; Only headworks=17; Only canal=47.

* Natural refers to normal wear and tear which has not been repaired, but users say they will.

In order to include an assessment of how likely the users are to repair the deterioration, I use two different variables. The first is the physical condition of the canal as assessed by the enumerator by walking along it and after discussions with users to evaluate how likely they are to repair it. The second is a similar variable for the physical condition of the headworks. Looking at the canal in this way is more appropriate because the canal and headworks affect different users. These variables are tabulated in Appendix A.

[63]It is more likely that users will not repair it because the canals were visited between the end of February through June. Repairs are usually done in the dry months preceding February. Thus, this table likely overstates how many will be repaired.

The physical condition of the headworks affects every user because it determines how much water is available to all. The canal, however, only affects those downstream of it. Thus, while the stretch of canal between the headworks and the first user affects everyone, the parts downstream do not affect the water received by those upstream. The canal usually takes more physical work to maintain, as well as much more cooperation between users, than the headworks does. On the other hand, depending on the technology used in the headworks, it might be more expensive to maintain than other parts of the canal. Because of this, the physical condition of the headworks is likely to be much better than the canal.

One of the possibilities that could not be examined by looking only at survival can now be examined using performance: that some canals may have experienced more challenging conditions than others. Table 1.9 shows the condition of the canal by the number of external changes. Similarly, Table 1.10 shows the condition of the headworks by the changes that users reported having experienced. Thus an examination of the physical condition of the canal with the number of changes that the canals experienced does not show any relationships that demand an explanation. Furthermore, the frequency of changes, defined as the number of changes divided by the years between first and second observations, also does not show a relationship to the physical condition of the headworks or the canal.[64]

A second dimension of canal functioning is its ability to distribute water according to the needs of users, irrespective of its physical condition. For example, although the physical condition of a canal might appear poor to an observer, users might assess that it's ability to deliver water is adequate. Thus, in order to examine user assessments, I use variables that encode how the users perceived three aspects of the canal

[64]See Section A.3 in Appendix A for the detailed tables.

Table 1.9: Number of shocks by physical condition of the canal. This crosstabulation shows the relationship between the physical condition of the canal and the number of external changes. It does not include the random sample.(N=202)

	The physical condition of the canal			
Number of shocks	POOR	FAIR	GOOD	Total
0	0	0	2	2
1	1	0	0	1
2	1	1	1	3
3	7	17	4	28
4	21	35	13	69
5	14	44	16	74
6	7	9	1	17
7	0	1	1	2
Total	51	107	38	196

Fisher's exact= 0.165

Table 1.10: Number of shocks by physical condition of the canal. This crosstabulation shows the relationship between the physical condition of the headworks (intake) and the number of external changes. It does not include the random sample.(N=202)

	The physical condition of the headworks			
Number of shocks	POOR	FAIR	GOOD	Total
0	0	0	2	2
1	0	1	0	1
2	1	1	1	3
3	9	12	7	28
4	24	26	19	69
5	22	27	25	74
6	7	5	5	17
7	0	1	1	2
Total	63	73	60	196

Fisher's exact= 0.940

functioning: timeliness, adequacy and reliability. Timeliness refers to the availability of water when it is needed, depending on the crops that the user has planted. Adequacy refers to whether the amount of water that users receive from the canal is adequate for their needs. Reliability refers to how confident the users are that the water will be available on time and in the amount that they need. Overall, there is significant variation in these characteristics of water availability across the surviving canals in as shown in Table 1.11.

Table 1.11: Perceptions of of water availability This table shows how users perceived the functioning of their canal according to three criteria: Adequacy, Timeliness and Reliability. Each of these had three possible values: Good, Satisfactory and Poor. (N=182)

	Good	Satisfactory	Poor	Total
Timeliness	84	56	36	176
Adequacy	63	78	35	176
Reliability	68	63	44	175

Using these indicators of water delivery, I now examine whether user perceived functioning of the canal bears a significant relationship to the complexity of external changes that the canal faced. Specifically, the table that follow show its relationship to the number of shocks and the frequency of shocks. Table 1.12 shows that there is no relationship between the user perceived timeliness, adequacy or reliability of canal functioning and the number of external changes. Similarly, there is no significant relationship between how users perceive canal functioning of the canal and the frequency of changes as shown in Section A.3 in Appendix A.

1.5.4 Changes in Performance

The analysis so far has been static because I have only examined the relationships between performance and other variables in the second round. Moving ahead by combining the first and second datasets allows me to examine these relationships

Table 1.12: User perceived performance by number of external shocks. This table shows the relationship between the three aspects of canal performance (Timeliness, Adequacy and Reliability of water delivery) and the number of external shocks that the canal was reported to have experienced since the first observation. p-values are computed using Fisher's exact test. (N=201)

		Number of external shocks								
		0	2	3	4	5	6	7	Total	
Timeliness	Not good	6	0	4	12	11	3	0	36	
	Passable	9	0	8	16	20	3	0	56	$p = 0.083$
	Good	13	3	8	24	28	6	2	84	
	Total	28	3	20	54	63	12	2	182	
Adequacy	Not good	5	0	3	9	14	4	0	35	
	Passable	14	1	9	25	23	5	1	78	$p = 0.108$
	Good	9	2	7	18	23	3	1	63	
	Total	28	3	20	54	63	12	2	182	
Reliability	Not good	7	0	5	12	17	3	0	44	
	Passable	12	0	5	19	20	6	1	63	$p = 0.114$
	Good	8	3	10	21	23	2	1	68	
	Total	28	3	20	54	63	12	2	182	

over time. In particular, it is necessary to examine whether *changes* in performance are related to the number of shocks or other variables. Table 1.13 shows that there is variation in how performance with respect to each of these aspects has changed since the canals were first visited. 15% have improved the physical condition and 24% have improved their headworks. It is important to note here that for adequacy and reliability, I have only looked at the perceptions of users who are closer to the tail. This is because tail users tend to feel the effects of even small problems upstream, and so the condition at the tail is more sensitive than the canal as a whole. This prevents the possibility that I will compare village that are located at different points along the canal. Also, timeliness was not assessed in the first round and so it does not appear in the change related tables.

Keeping this in mind, and looking only at those canals whose tail-end performance was assessed (comprising about a fifth of the sample as shown in Table 1.4), 50% of them were perceived to be more adequate, and 14.5% were perceived to be

more reliable. In contrast, a much larger percentage of canals appeared to be in a worse physical condition. When I look at the relationship of these changes in performance to the complexity of external changes in Table A.17, there are no significant relationships.

Another possibility is that those which were visited further in the past are now performing worse than those that were surveyed more recently. Related to this is the possibility that those which experienced many shocks in a given period performed worse than those that experienced fewer in the same time. However, further examinations of the relationship between performance and the duration of time between the first and second visits, as well as the frequency of changes shows a similar lack of association. These tables are in Section A.4.

Thus, there appears to be another factor that is working against the normal tendency of canals to decline. Two immediate possibilities are that some have received assistance from outside the group of users, and another is that the institution itself has been able to cope with the changes. As to the first possibility, there is no significant relationship between changes in canal performance and whether or not they received government assistance. These tables are also included in Section A.4 of Appendix A.

Table 1.13: Changes in canal performance. This table shows how the aspects of canal performance have changed across cases between the first and second visit. User perceptions are restricted to users at the tail end.

	Better	Same	Worse	Total
Physical condition of the canal	28	95	62	185
Physical condition of the headworks	45	63	77	185
User perceived adequacy at tail	24	23	1	48
User perceived reliability at tail	7	35	6	48

Therefore, revisiting these canals reveals that there are a significant number that have experienced multiple external changes yet continue to function well, while there are many others which have not faced challenging circumstances but have declined. Further examining this variation in performance shows that the obvious variables of

Table 1.14: Changes in canal performance and number of external changes. The table shows the relationship between changes in performance between the two visits and the number of external shocks. User perceived functioning is restricted to tail users. Every case at the tail end of the canal experienced at least two shocks. p-values are from Fisher's exact test.

		Number of shocks								
		1	2	3	4	5	6	7	Total	
Physical condition of the canal	Worse	1	1	6	26	20	8	0	62	
	Same	0	2	16	32	37	7	1	95	$p = 0.519$
	Better	0	0	3	9	14	1	1	28	
	Total	1	3	25	67	71	16	2	185	
Physical condition of the head	Worse	0	2	9	30	26	9	1	77	
	Same	1	1	13	24	22	2	0	63	$p = 0.242$
	Better	0	0	4	13	22	5	1	45	
	Total	1	3	26	67	70	16	2	185	
User perceived tail adequacy	Worse	0	0	0	1	0	0	0	1	
	Same	0	1	2	13	7	0	0	23	$p = 0.339$
	Better	0	1	5	7	7	3	1	24	
	Total	0	2	7	21	14	3	1	48	
User perceived tail reliability	Worse	0	0	0	4	2	0	0	6	
	Same	0	2	4	15	11	2	1	35	$p = 0.594$
	Better	0	0	3	2	1	1	0	7	
	Total	0	2	7	21	14	3	1	48	

time, external assistance, and complexity of external changes do not exhibit a significant relationship to the functioning of the institution over time or at a point in time.

Overall, two facts have emerged prominently: one, being locally governed alone does not appear to lead to uniformly good performance; and two, nor does focusing on the complexity of external changes explain decline. This emphasizes the question of what does, and at the same time refocuses attention on the "internals" of an institution. Thus, upon revisiting the same canals, I have found that the central reason predicted to lead to decline or survival of long-enduring local institutions for managing shared resources - the rapidity and the number of changes in the external environment- appears to have been overemphasized in the original formulation.

This original emphasis on external changes as the causes of decline was a logical consequence of a framework that was built to highlight that users of the canals

themselves could devise appropriate rules. The evidence presented here does not overthrow the IAD framework. However, to the extent that the emphasis on external changes as the primary challenge for local institutions to overcome derives from the foundational assumptions of that formulation, the evidence presented here fundamentally contradicts it. For this dissertation, these results of revisiting the old cases sharpens the question that is being asked, which I take up shortly. Next, I examine two counterexamples to the assumptions that I have made about institutional performance in order to be able to do the analysis above.

1.6 Institutional Performance

As I noted above, the definition of an institution as the set of working rules has its advantages and limitations. One of the main advantages is that the definition appears to provide a way to assess whether an institution is present or not. To do this, one needs only to ask users whether they have working rules for using the canal. However, this definition alone does not allow one to assess performance. For this, it is necessary to know what the institution is intended to do.

In all of the cases in this study, it is reasonable to assume that the institution is intended to assist in the maintenance of the canal unless there is compelling evidence otherwise. Since the canal begins to show deterioration unless it is actively maintained, the physical condition is a good measure of how effective the institution is at evoking cooperation and the required patterns of behavior in its users. Since the physical condition need not be perfect in order to satisfy users, I have added three assessments of the canal's performance by the users themselves.

But, there are a few cases that I encountered where this assumption is not applicable. In one type of case, physical deterioration and an expressed lack of performance is intentional. In the other, deterioration indicates that the canal has performed very

well. In both, the assumption that the institution is intended to assist in canal maintenance is wrong.

In the first type of case, the purpose of the institution was to get external support and therefore the institution had no relation to the canal functioning. In these cases, users purposely kept the canal in a relatively bad condition in order to secure financial assistance from government or donor agencies that was not then spent on the canal. In the second type of case, the deteriorating physical condition of the canal indicated its overall success: the canal functioned so well in the past that the users were able to move to cities and away from agriculture. In this latter case, the users no longer had reason to maintain it because, paradoxically, the past performance of the canal made itself obsolete.

These two types of counterexamples question the underlying assumption that a well functioning canal is the only desirable outcome of well functioning institutions of this type. The success of an institution, defined in terms of its effect on those using it, may be reflected in a deteriorating canal as well. Aside from these two types of cases which are instructive but also rare in this dataset, it is justified to assume that the main purpose of the institution is to maintain the canal and the performance of the canal therefore reflects the performance of the institution when other confounding factors have been accounted for.

In the remainder of this study, the two indicators of the physical condition as assessed by enumerators, and the three indicators of user perceived functioning (two in the first round) that I have used to perform the analysis in this section represent canal performance. Except for the counterexamples described here, these five indicators represent different dimensions of institutional functioning in this dissertation. Correspondingly, the known counterexamples are removed from the analysis.

1.7 A Sharpened Question

Without any organized attempt to maintain the canal one would expect to find a relationship between the duration of time that has passed since the first observation and at least the physical condition, if not the user perceived functioning (after controlling for outside assistance, and complexity of changes). But, as the evidence above shows, time does not have this expected effect in these cases. It is now justified to assume that this decoupling of performance from the natural effects of time is due to active maintenance of the canal, which there is good reason to believe is because of the rules in use to manage it, i.e. the institution that governs it. It is also clear that the canals experienced complex changes, and that some adjusted while others did not.

In terms of simply survival, approximately 85% of the canals still exist. The reasons that former users who were still in the area gave for the canals having declined cited shocks that originated outside of the control of the institution. However, a thorough examination of these reasons in the existing cases did not provide any supporting evidence that the complexity of changes alone was related to performance. Thus, it becomes necessary to examine the specific characteristics of the institutions themselves that may relate to variation in performance and survival/decline. This result has turned attention away from external changes to the characteristics of local institutions that may relate to sustained cooperation and therefore performance.

The examination so far has left behind a sharpened question of why, in the face of complex changes, some locally based institutions adapt, change and survive while others do not, keeping in mind that adaptation and change are a consequence of cooperation as well as a cause of it. This question directly asks what characterizes institutions and mechanisms that can sustain cooperation over long periods, in the face of difficult circumstances. As such, it lies in the intersection of three literatures that I describe next.

In the remainder of this dissertation, I propose two required conditions for institutions to sustain cooperation over extended periods, and in difficult situations. First, the users of those institutions must continue to cooperate with the rules and to each other. And second, the users must change the rules when circumstances significantly change. But why do users continue to cooperate with a set of rules or stop doing so? And, how do users know what new rules to adopt?

The answers that emerge suggest that two aspects of the canal, one more than the other, come to play an important role: perceived fairness and perceived flexibility. First, users continue to cooperate with institutions when they perceive them to be fair. Thus, users face not only the challenge of creating rules that fit changing external circumstances and the long term benefits to farmers but also an additional one: they must also create rules that fit users' sense of fairness over time.

And second, they learn what new rules to adopt, in part, by normally tolerating some flexibility in rule application. This flexibility can take the form of making exceptions for unusual individual circumstances, calibrating the rules in specific instances, enforcing penalties less often or less strictly, and generally allowing some deviation from the rules to exist. However, when the institution is otherwise perceived to be unfair, this flexibility increases the sense of unfairness. In turn, what otherwise was beneficial comes to have detrimental effects on the institution's ability to sustain user cooperation with the rules and with each other.

Therefore, it is instructive to view the theory that I propose as positing four extreme forms of cooperation between users and their institution in terms of how likely the cooperation is to be sustained. Although I refrain from classifying the cooperation as one of our types, it can be useful to imagine that at any time, an observed instance of cooperation is closer to one or the other.

Robust cooperation arises when users perceive the institution as fair, and the insti-

tution is also boundedly flexible. *Fragile cooperation* arises when users perceive the institution to be fair, but the rules are too rigidly applied. *Gradual non-cooperation* arises when users do not perceive the institution as fair, and the rules are applied rigidly. *Rapid non-cooperation* arises when users do not perceive the institution as fair, and the rules are applied flexibly. The core arguments of the theory are taken up in greater detail in Section 2.6.

2 Alternatives and Their Limitations

In Chapter 1, I described three immediate observations that did not match the predictions of the CPR model when I revisited the same cases between 16 and 37 years later. First, survival, decline and performance were unrelated to the number, type and frequency of external changes. Second, changes in performance over time were similarly unrelated to external changes. And third, while all of these institutions experienced external changes, a significant number that experienced complex changes survived and performed well, while a significant number that experienced simpler changes declined. Thus, the original theory of The Commons that this data was collected to illustrate likely overstated the significance of external changes to the performance of these institutions. So why, in particularly complex conditions, were some shared irrigation canals well maintained and performing well, while others were not, even when doing so would benefit everyone who shares them?

This question stands at the intersection of three literatures: the new institutional economics literature, the institutionalist literature, and the literature on interpersonal cooperation. I turn next to an analysis of the three in order to do two things: one, to illustrate why the rational choice approach may have overemphasized the role of external changes; and two, to formulate alternative explanations of my observations. These are broad literatures with myriad interconnections, for example the commons explanation for why individuals self-organize to create institutions in Ostrom (1990, p. 184) relies on concepts of social capital that is explored in a prominent example of the third literature (Putnam, 1993, p. 166). At the same time, the commons approach also shares an emphasis on institutions as a set of rule like statements that are causes of behavior with the sociological subset of the institutional literature (Mahoney & Thelen, 2010a, p. 5). In order to clarify the differences in these and other approaches, I will attempt to apply them to the current set of cases.

The irrigation canals at hand are cases of a shared resource that shows variation in performance over time in the face of changing circumstances. A rational choice analysis begins with the belief that the users of this resource are more or less rational, as analyzed in Elster (2009). From this assumption, there are two lines of argument based on the extent to which people are assumed to be self-interested. A moderate assumption of self-interest such as in Ostrom (2005) and Putnam (1993) identifies the main problem to be that such individuals are suspicious of each other. This approach recognizes that sustaining the canal requires cooperation between individual users. And overall, this literature claims that the main task for evoking cooperation is to find ways to convince individuals to make long term commitments to maintaining the canal.

There are two branches to the moderate self-interest school. In the rational-choice institutionalist literature, such as Ostrom (1990) and Williamson (2000), the main challenge is to devise rules, i.e. institutions, that individuals can rationally commit to, and that match the particular conditions of the canal that might also influence their incentives. In the rational-choice cooperation literature, such as Putnam (1993) and Farrell (2009), the main challenge for users of these canals is not the creation of institutions primarily. Instead, the literature points to the need for trust, norms of reciprocity, social connections between users, and social capital more generally as described in Putnam (1993).

These two approaches rely on each other, as I have noted above. But they are distinct because in the former, institutions are self-reinforcing once they have been created in the sense that the is nothing more that a rational user can do to change their institution when it functions well. In the latter, social capital underlies interpersonal relationships and could lead to cooperation even without rules to ensure credible commitment. The CPR framework tries to blend these two approaches by

emphasizing institutions during times of "stability" and emphasizing social capital when institutions need to be changed.

A third approach within the rational choice school makes a stronger assumption of self-interest such as in Knight (1992). This approach suggests a different reason for changes in canal performance. All human interactions are believed to be guided by distributional conflicts in which each individual or group seeks control over the canal for themselves. The institutions that arise, and that might seem to result in cooperation, are a consequence of these distributional conflicts. If the canal is deteriorating it would be considered a consequence of the interests and the power[65] of the dominant group- whether users or not. In this view, any collective benefits that accrue to users not in the dominant group is a byproduct of larger struggles. This results in two explanations of declining performance over time. One explanation is that the dominant group did not find it in their interest to maintain it. Another explanation is that maintaining the canal was in their interest but they could not. This could be because they could not maintain it themselves and did not have the power to compel other users to participate in maintenance.

While this strongly rational egoist approach appears to be dramatically different from the commons framework, they appear interrelated when applied to these cases. In particular, both approaches address distribution of water. The commons framework explains how rational users come to craft institutions that fit their external circumstances. However, when there are multiple sets of rules that would all lead to adequate maintenance of the canal how do users choose one of them? Distributional issues, but not explicitly conflict, come to the fore here as users are said to form coalitions based on who will get more or less water from each proposed rule. And, finally,

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[65]Power here is defined as the ability of one group to impose its will on another.

the winning coalition's rules are said to be adopted. Knight's approach explicitly points to differences in power between the two groups and says that those who make the rules do so because they can. In contrast, Ostrom's approach points to the existence of "collective choice arenas" where discussion, persuasion and ultimately voting determine the rules that are chosen.

As I noted at the beginning of this chapter, there are several ways to distinguish the literature that is relevant to the cases in this dissertation. I have so far described the explanations that would arise based on the rational choice approach, the strictness of the self-interested assumption, and the primacy of institutions to cooperation. Next, I turn to the distinctions that appear in the literature when I focus on cooperation and competition as well as a focus on institutions.

2.1 Competition and Cooperation

When focusing on how individuals interact with each other, there are theorized to be two general types of interaction: competition and cooperation. There is no theoretical attempt to describe what distinguishes the two in terms of outcomes. It is possible that an observed pattern of human behavior could be the result of either competitive or cooperative interactions, although some outcomes such as sharing resources are taken to be difficult without cooperation. Whether cooperation or competition is the default mode of group behavior is still being debated in the literature, although it has not changed the basic convention that people are motivated by self-interest at heart. Gintis & Bowles (2011) give a recent summary of the argument that individuals have evolved to cooperate rather than compete whereas much of the rational choice literature begins from the assumption that human beings are "creatures honed by millennia of evolutionary processes" to be self-interested. (Ostrom, 2005)

Nevertheless, when describing human interactions axiomatically at least two as-

sumptions are always kept intact: either that people are narrowly rational, or they are reliably self-interested. Cooperation and competition are therefore defined in terms of the conditions under which they arise, and sometimes in terms of the outcomes that are achieved. More specifically, when individuals can communicate with one another and form groups, it is assumed that cooperation is at work. When they cannot form groups, it is assumed that cooperation is absent and the default mode - competition - is prevalent. Competition is a mode of behavior, therefore, in which every person is looking out for his own interests only without knowledge of others, or with a stylized presumption of them.

Cooperation may also be characterized as each person looking out for oneself, but it has one basic difference: there may be agreements between the individuals. It was one of the great achievements of the last fifty years to show that neither cooperative behavior nor competitive behavior can reliably be assumed, without reference to the conditions in which the interactions are taking place. The seminal distinction between the two types of behavior is made in Nash (1950, 1951) in the context of two people bargaining. The eventual finding that the conditions for competition require maintenance even when the individual players are highly motivated to be selfish is in Williamson (1975) and that the conditions for cooperation require maintenance is in Ostrom (1990). Based on the current state of knowledge in this area, it is impossible to distinguish whether a particular result is a consequence of competition or cooperation. For example, simply by observing the behavior of canal users it would not be possible to attribute canal functioning to either cooperation or competition between them.

In subsequent theory, therefore, structuring factors - the external conditions that influence behavior- are regarded as being important for deciding what form of behavior resulted in the observed outcome. They are referred to as institutions. Institutions

have various definitions, but all of these definitions have in common that institutions are intangible objects with a "rule-like quality" (Hall, 2010) that influence how individuals and groups behave. Nevertheless, they cannot be observed separately from those whose behavior is subject to it. In other words, according to this conception, an institution cannot be identified unless it is affecting someone's behavior. Whether or not an institution is affecting an individual's behavior, again, is a consequence of what the observer expects of human behavior by default. This leads to an unending loop. The loop is most often terminated by making assumptions about how people normally behave and attributing differences between prediction and observation to institutional effects.

The relationship between people and institutions thus defined is not straightforward. People are subject to institutions, but they are also the ones responsible for changing them and for manifesting their effects. Similarly, over time institutions appear to outlast individuals. However, they do so only because of individuals and groups that propagate them. This interdependence of people and institutions as rules is not a consideration when the analysis is restricted to a single point in time. However, over a stretch of time - as in the case of the canals in this dissertation- this interdependence makes causality difficult to establish.

Ostrom (1990) has convincingly argued that in these canals, individuals are in a situation in which they can talk to each other and therefore can form coalitions, or make long term commitments. The large body of work using these cases, as well as my own fieldwork, firmly establishes that the maintenance of the canals requires cooperative behavior. This behavioral approach does not establish that institutions are essential for cooperation, but it does highlight the importance to sustained cooperation of relationships outside of the immediate interaction. Overall, the cooperation-competition literature points to an important source of breakdown in our cases: com-

petitive behavior that arises from a lack of communication between users.

A different set of alternative explanations arises when I examine the institutional literature, which is not concerned with cooperation or competition, but the properties of institutional change instead.

2.2 The Literature on Institutional Change

There are currently three main approaches to the study of institutional change[66]- the historical, rational choice, and sociological. Their explanations of patterns of change differ from each other in emphasis and focus. There are also important differences between theories within each of these categories. Consequently, the empirical bases of these arguments are also distinguishable by their units of analysis, their methodologies and the types of institutions that they focus on.[67](Hall & Taylor, 1996) These theories generate another set of explanations of why some canals decline while others don't, but some are more easily applied to the current set of cases than others.

All three approaches to explaining institutional change rely on a definition of institutions as rules, or "regularized practices with a rule like quality." (Hall, 2010) This definition includes conventions, rules and norms of behavior as institutions. Set against the fluidity of human behavior, institutions appear as patterns in behavior that are relatively stable. The different schools of thought admit that institutions can change, although they offer different explanations of the processes of change. In all of these theories therefore, sustained cooperation over long periods of time indicates the presence of institutions that are themselves changing (even when the cooperation

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[66]This tripartite classification can be found in Mahoney & Thelen (2010a, p. 4). The current account is based on their account.

[67]A recent discussion of methodology for studying institutions can be found in Mahoney (2010)

is the result of norms, and not rules). But, their focus on the process of institutional change doesn't directly explain why some institutions continue to perform well while others do not. In order to use these institutionalist theories to explain the variability in canal functioning that I presented in the first chapter, I am forced to turn to the question of why some processes of change lead to the "wrong" institutions for the particular canal, while others lead to the "right" ones.

The sociological approach[68] focuses on informal conventions and shared scripts which may not be codified in language but nevertheless are reproduced and regulate behavior. These institutions change when new "interpretive frames" are forced upon people or their context by some outside force or actor. This compels them to change their scripts accordingly. These frames are imposed by people who are not subject to the old way of doing things or have broken free. And they may or may not succeed in destabilizing established practices and imposing their own. (Mahoney & Thelen, 2010a, p. 5) In some variations of this approach, institutions might actually become gradually similar to each other even as rational actors change them. (DiMaggio & Powell, 1983) This provides some alternative explanations for deterioration. First, the scripts might lead to behavior that does not result in the canal being maintained. Another explanation is that in the face of external changes, the "shared scripts" themselves failed to change. Based on this approach, these problems would be predicted to be either because not enough people broke free of old ways of doing things, or those who broke free could not break others free. When applied to the current set of cases, this view appears to suggest that decline resulted when users did not figure out how to change their behavior when conditions changed. In a slight variation of

[68]See for instance Powell & DiMaggio (1991, p. 183-203) for a definition of institutions, and DiMaggio & Powell (1983) for one description of change. There are several other variants within the sociological approach which are surveyed in Mahoney & Thelen (2010a, p. 5).

this, it might also be because an outside authority, such as a government agency, did not force them to change their behavior. Institutions as a source of inertia are also described in March (1989) and with a functional bent in Parsons (1954).

Next, the rational choice approach to institutional change focuses on rules, formal and informal, that "shape human interaction" as has been described above. (North, 1990, p. 3) They may not be written down, but are in some form or another, known to all who follow them. This knowledge of the rules is then taken into account by individually rational actors to devise strategies of action. Institutions result in Pareto-optimal equilibria, or subgame perfect strategies to avoid collective action problems. Given a set of institutions, the actors themselves can do nothing differently to change them, unless external conditions change (for example, through political violence) to make their strategies no longer optimal. (Hall, 2010) These changes could also be, for example, the imposition by a more powerful entity - such as a national government - of new rules in the form of regulation, or legal precedent. Most of the hypotheses that are generated by the rational choice approach emphasize external changes, but the empirical evidence in Chapter 1 does not seem to match these predictions.

The historical approach combines both the sociological and rational choice views, and considers much longer stretches of time. In this approach, institutions have a coordinating function but they are primarily the political result of historical struggles between groups. (Mahoney & Thelen, 2010a, p. 6-7) They might come to perform roles opposite of those originally intended by the creators. For example, in the case of the institutions for managing canals, institutions that users created to help coordinate actions might eventually serve the primary purpose of ensuring that certain groups always receive more water than others. At heart, the power of coalitions and the distributional effects of institutions create stability over long periods. This approach would not regard stability as arising from the fact that stable, or sustained coopera-

tion leads to continued collective benefits. Applied to these cases, the approach suggests that the question of which groups get how much water is more important than keeping the canal functioning - unless one of the groups makes keeping the canal functioning their primary interest.

There are two main explanations of change in the historical approach. The first one posits change as occurring through "critical junctures" that weaken the constraints that institutions place and possibly open up opportunities for "historic" agents to change them. (Katznelson, 2003) Applied to the current set of cases, this approach would try to identify coalitions within these user groups and identify their interests. I would then be directed to identify points in the history of the canals between the first and second observations that could be regarded as "critical junctures" which made it possible to change the rules. Faced with the evidence in Chapter 1 of some institutions adapting and others not, this approach would suggest that the difference was either because some experienced "critical junctures" and had "historic agents" or didn't. However, for the sort of "micro" example of institutions for managing irrigation canals, it is difficult to know what "critical junctures" are, and what sorts of agents are "historic" to a canal.

The second historical process emphasizes incremental changes arising from ambiguity about the meaning and scope of institutional rules. In this view, rules are limited in their specificity and individuals are limited in their cognitive abilities. This leaves many points of ambiguity about the application a general rule to specific situations. This ambiguity gives opportunities to change agents to gradually alter institutions. In the case of the canals that I study here, some rules do indeed seem to be ambiguous in this sense. At the same time, the rules cannot be so ambiguous that users cannot coordinate their actions. Some rules, in fact, must be highly specific- for example, the order in which users take water. A bigger hurdle for applying this

theory however, is that it is not clear in our cases what "change agents" might be. Indeed, even if we could identify change agents we'd still be left with the question of how these agents know what to change. There is a second concern having to do with the pace of change. In he face of rapid and complex changes such as those faced by the canals, rules may have to change dramatically and suddenly rather than through incremental processes.

In this theory, institutional changes occur when two conditions are met. First, those subject to institutional rules, or those tasked with enforcement, interpret the rules differently; and second, those who seek to defend old institutions are weakened by the political context. Here, the level of discretion of the change agent and the power of opponents of change determine the type of change. (Mahoney & Thelen, 2010b) According to this approach, the success and failure of the canals, then, is a consequence of the change agent's competence, or relative power. In order to explain why rules are changed in particular ways, this approach would suggest examining who benefits from a particular set of rules and who does not. Yet, it is still not clear how, in these cases, users know which rules to change and how.

This approach is the most difficult to apply to the current set of cases, although it suggests a wide range of possible explanations for how rules change. The primary reason for this difficulty is that rules and institutions are regarded as serving the purpose of those who control it. This leads to an explanation of decline that is similar to the rational-choice approach with strong self-interest as described above: the canals declined because those who controlled the institutions did not want it to survive, or could not get it to survive. The notion of institutions that is being described in the historical approach also appears to resemble organizations more than institutions as the sets of rules for governing a canal. This theory might apply to the user's associations that are set up to manage some of these canals, but the institutions referred to in this

study are the rules that gave rise to the users associations, and not the associations themselves. In other words, the associations are means to an end for the users of the canals rather than an end in themselves. Indeed, not all canals in the sample have functional user's groups to manage the canal.

There is an even more basic problem with applying the historical approaches to the current set of cases. This arises from the characteristic assumption of these approaches: that group interests are the cause of rule changes. More specifically, these theories do not address why people continue to work together as a group in the first place. True, they implicitly assume that common interests are enough to hold these subgroups together and to define them. For example, one group at the tail end of the canal may be adversely affected by a rule change, while a group at the head end might benefit. The actions of these groups would then be the locus of explanation of why rules change or don't. Keeping aside for the moment the issue of how these groups figure out what rules to change and how, in order to meet complex and changing circumstances, the original question remains largely intact. How do users of these subgroups continue to cooperate with each other to achieve an objective that benefits them all? Why do they commit to a group, and how do they decide whether to continue their commitment to the demands of the group? Finally, what enables the individual members of these subgroups within the group of canal users to both coordinate their actions and to put aside short-term self interest for longer term benefits? These are largely the questions that we sought to answer with respect to sustained canal maintenance, but they have merely been refocused to these subgroups.

Thus, the historical approach, which focuses on group dynamics, changes the question but does struggles to explain sustained cooperation between individual users, whether as a whole or within subgroups that they form based on shared distributional interests. However, the idea of rule ambiguity that is described in this theory

comes to play an important role in my explanation. In my usage, this ambiguity is not a space for contestation between competing interests but is instead a source of experimentation for individual users as described in Chapter 4.

The historical institutionalist approach does suggest that institutions which were designed to manage canals may have ended up having other distributional effects over time. It might also imply that the dominant groups changed the rules to favor themselves. But what is not apparent is why this should lead to decline or not, unless the rules failed to change appropriately. Overall, the hypotheses that I have derived from the historical literature are all akin to the hypothesis that the users did not adapt their rules to match changing conditions, possibly because those who knew how to update their rules (change agents) did not have the power to do so. In other words, the historical theories do provide explanations for how certain rules came to be chosen but they do not explaining how a set of alternatives that would continue to maintain the canal in the face of changed circumstances came about.

The exploration of the mechanisms of institutional change is relatively new, compared to the theories of how institutions come about and how they sustain themselves. The evidence of institutional change, whether gradual or sudden, that is accumulating in the literature has come from examinations of various large, national level institutions. This evidence has also focused on industrialized countries, and studies in developing countries are much fewer in comparison. This has led to a mismatch in the empirical evidence between the different schools of thought: rational choice approaches focus on relatively simple interactions at a small scale and then work up to emergent patterns, whereas historical and sociological approaches seem to favor big, national level changes involving many actors and institutions.[69]

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[69] An influential example is Acemoglu et al. (2005)

Having examined the three literatures to which my question relates, I now turn to defining the terms that I use in the rest of this dissertation.

2.3 Institutions

Institutions, having once emerged, must change and disappear like all other phenomena. But, some last longer than others, grow slower than others, sustain longer, or decline only to rise again. They appear all around us, binding us and freeing us at once. Some institutions outlast individual lives, yet the fates of others are closely tied to the fates of certain people. What, one might ask, isn't an institution? Such is the ubiquity of the word 'institution' that even without defining it, the answer appears difficult.

A general definition of institutions is elusive for those who have devoted great time and effort to studying them. Yet, a general sense is nearly universal among those who use the word. We all seem to have some notion of what an institution is, and certainly every English dictionary contains a definition. We may not agree on a meaning, or we may choose different meanings in different contexts. But, the word has working meanings for each of us.

There is much in common underneath this variety of meanings. All uses of the English word institution, whether narrow or broad, are characterized by their implication of fixity, order, establishment, regularity, form and foundation.(OED-Online, 2014) As a verb, the act of institution suggests a beginning and therefore a change from one state to another - from a condition before institution to after. But referred to as a noun after having come into being, it stands in contrast to change. It is the opposite end of disorder and formlessness.[70]

[70]As a noun, it is also used to refer to an organization or association and sometimes a physical

Leaving aside the allusions to organizations and physical structures, the word implies human practices, customs, principles or regularities in behavior. Such regularities or order in human behaviors may be the first indication of the existence of an institution. Without such regularities, an observer cannot directly detect the presence of institutions even if they are otherwise present- and even such regularities, as explained above, might be attributed to individual rationality alone.

In a similar vein, it is also a common experience that while an institution may manifest in patterns of behavior it may be more than the pattern itself. After all, it is a different thing to say what an institution consists of than it is to say how to recognize its possible presence. This is similar to the various skills of a tracker. It takes training for a tracker to learn the skill of detecting footprints in moist soil, or identifying when broken blades of grass and twigs represent a pattern worth paying attention to. Yet, she will need a different sort of training to identify which animal it was, in which direction it was moving, and how long ago it was there.

Finally, every use of the word 'institution' includes a notion of time because of its inevitable reference to a relative lack of change. In order to say that an object is unchanging, one must make a comparison between its current state and its state in the past, however near or distant.

All of this leads to a partial definition of institutions in terms of one of its possible effects. An institution's effect here refers to patterns in human behavior that appear unchanging over some period of time. Nevertheless, there may be several sources of regular patterns in human behavior. Indeed, several situations may demand that people behave in a particular way - even when there aren't institutions present. It is also not immediately obvious what constitutes a pattern amidst the variety of behav-

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building. In this dissertation, I distinguish between institutions and organizations.

iors that human beings exhibit in their finite lifetime.[71] But before institutions can be studied, it is important to identify patterns of behavior that may reasonably be related to the presence of institutions. I have already suggested two such patterns that might not occur in the absence of institutions: sustained cooperation or sustained competition. In this dissertation, I focus on sustained cooperation because, I argue, the users of a shared canal live in such a situation that continued use of the canal requires it.

2.4 Rules and Institutions

Rules to which individuals have committed themselves to following are a common reason that behaviors become patterned. However, discerning which behaviors are rule affected and which are not is not straightforward. For the purposes of this study, an institution is a set of working rules, shared by one or more individuals.

A rule is a language statement that is understood in a particular way by the individuals in the group. In the minds of the individuals, the rule either ignores, forbids, permits or requires an action. For any individual, it is possible that the rule is unclear, or that they understand it differently compared to another person. Therefore, while a particular rule is understood as forbidding an action by one person in the group, it might be taken by others to permit related actions not explicitly forbidden by it.

When this rule is expressed in English, we would also recognize it as doing one of the four things. However, an observer might assign it differently to the four categories than how those in the group might. Nevertheless, an institution is a symbolic

[71] This is analogous to the difficulty of finding regularities in finite sequences of numbers. This is a long standing problem in Computer Science and Mathematics. In the former, the challenge is to find algorithms that can do so in a reasonable amount of time for fairly long sequences. In the latter, the challenge is to prove that it can or cannot be done. This analogy also implies something stronger: even if we could measure every aspect of human behavior, we could not be sure that we have found all patterns in it.

statement in relation to which individuals of a group behave.

The behavioral response of an individual to a rule depends on whether or not they are aware of the rule, how they understand it, how they decide to respond to it, and how capable they are of responding in the way they decide. To affect behavior, the rules must be acknowledged in some way. That is, an individual must know about it or acknowledge it's existence by referring to it in some way (even if they feel that it is to be opposed). Thus from the perspective of a rule's effects, both active opposition and active following are equivalently shaped by the rules. It is possible for an individual to know about a rule but remain indifferent to it. In this case their behavior may not have any relation to the rule about which they know. [72]

Discerning whether or not a particular behavior was a consequence of rules seems to require knowledge of both the conscious and unconscious status of the rules for a particular person. However, one can be confident that if there are rules and if individuals have committed to them, the behaviors that are observed are shaped by the rules. There are also other ways that behaviors might be shaped - norms, customs, traditions, a combination of individual reason and external circumstances among others.

In order to clarify the relationship between an institution and a rule, a rule is defined as a statement regarding an action that when translated into English appears to do one of four things: permit, require, forbid or ignore the action. When these statements are available in written form, I call these the formal rules. When the statements are commonly known to a group, and are said to be used in practice, I call these the

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[72]In addition, it may also be possible for behavior to be shaped by rules indirectly. That is, it may be possible for an individual's behavior to be altered because of their surroundings which have been influenced by rules. For example, responding to one whose activities are influenced by rules might be regarded as a response to rules. Similarly, facing a choice between options which have been presented, according to the rules, in a particular sequence might influence the response.

working rules. The working rules might differ from the formal rules - that is, if an observer were to look at the rules as written and then ask users what rules they use they might encounter differences between the two.[73] For example, the likelihood of a punishment being levied might create this texture as might a consensus that the formal rule should not be followed.[74] Furthermore, this gap between the formal rules and the working rules might be vast or slight.

The patterns of behavior that indicate the presence of an institution might come about because of rules, norms, customs or other shared understandings. However, since rules are the easiest to identify and the best studied, this study takes the collection of working rules that users know about to represent the institutions for managing the canals.[75] Therefore, for the remainder of this study, broadly defined institutions are equated with one of their accessories: the working rules. Hence an institution, for this study, is the collection of working rules that users follow and that influence the patterns of behavior of canal users.

Using this meaning is a simplistic representation of institutions compared to more sophisticated accounts. It is also not a general definition of institutions, but a narrowing of our scope to those institutions that can be fruitfully represented as rules in the English language, using a fourfold classification.[76] Institutions can outlast individu-

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[73]This difference is often regarded as resulting in *de facto* and *de jure* rights.

[74]It is also possible that the formal rules are not in place to govern behavior in the first place, but to indicate a sense of formality and legitimacy to donor agencies or to government. The purpose of these rules would not be the patterning of behavior but the evocation of a particular response from outside agencies.

[75]This choice is also influenced by the definitional choices of our predecessors. The questions that they have asked focus on rules, and this gives us limited space to deviate from this definition at this stage.

[76]Indeed, some readers might distinguish between institutional rules rather than institutions as a whole.

als as knowledge about the rules gets transmitted from one person to another. Therefore, over time we can refer to institutions as possibly existing in relative permanence when compared to individual human lives, and behavior but never independently of them.

In the next section, I define these terms more precisely in order to describe a theory of institutional adaptation and sustained cooperation that I use to explain the results presented in this dissertation.

2.5 The Purpose and Limitations of a New Theory

The central objective of the theory that follows is to provide an answer to why some institutions adjust and adapt while others do not, based on the observations presented in the following chapters. Before proceeding, it is important to note that the theory that I present arose from an examination of the observations in the following chapters, although in writing I present the theory first.

In this theory, whether or not an institution adapts and adjusts to changing circumstances is a consequence of both the characteristics of the institution as well as its circumstances. I argue that the fate of an institution hinges on its ability to sustain cooperation. Overall, understanding why some canals continue to perform well while others don't requires focusing not merely on inter-personal relationships between individuals but also the relationship between the individual and the institution.

Based on two dimensions of perceived fairness of the institution by users and the flexibility with which rules are applied, I regard the cooperation underlying an institution to be closer to one of four categories than the other three : robust cooperation, rigid cooperation, gradual non-cooperation, and rapid non-cooperation. Faced with changing circumstances outside of the institution, these four qualities of cooperation are respectively more susceptible to such changes.

I do not posit an equilibrium condition where individuals might move and thereby "vote with their feet", thereby instigating a process that, over time, selects out the institutions perceived as unfair by their users. In the theory that I present, it is possible for unfair institutions to persist although they are predicted to be less adaptable to changing circumstances than if they were perceived as relatively fairer. It does not require a notion of equilibrium, nor direction of movement towards collapse or adaptation. The process is assumed to be one of directionless change in many dimensions, which can be characterized as more or less susceptible to external change when and if they arise. Finally, the assessment of how adaptable the institution is does not allow institutions to be compared to each other, and is only allows for the comparison of the institution with itself at different times. While it is tempting to use it to rank the ability of different institutions to adapt, this would go beyond what the theory can justify.

Institutions decline as cooperation by those upon whom the institution depends also declines. However, in any given circumstance not all of the users might be important to the continuity of the institution as others. In this theory therefore, outside conditions can be characterized as altering the relative importance of different groups of people within the institution. The groups are in turn defined with respect to the knowledge they have about the resource, about the institution, their connections to outside assistance, or other assets-tangible or not- that are relevant to the institution's functioning.

What an institution might need at a given time is specific to the situation that it is in. It is also difficult to know at the time of need how to overcome the new condition. This, too, can be highly specific to the resource, the institution and the condition. In retrospect, however, we can assess variation in the performance of a given institution and how well it was able to meet changing circumstances. So this theory doesn't

provide advice on how to improve the functioning of a shared resource, but it does suggest ways of assessing its likely ability to sustain cooperation over time.

Fairness alone, however, does not appear to be enough. Indeed, it is possible that entirely fair systems show variation in performance in changing circumstances. Thus, the question of what is to be done is easier for institutions to address when they are in close communication with the outside - in particular, government agents in technical departments - and when the users themselves have had the latitude to experiment, and tweak the rules within reason in the past. Yet, when perceived as unfair, this flexibility can backfire.

The second variable that appears relevant- flexibility of rule application - therefore improves the chance that the users themselves will figure out, or search out, solutions to problems that they may face. In general, therefore, those institutions that are the most robust and resilient are able to elicit reliable cooperation from a broad range of their users, and they are also able to tolerate as well as harness a certain degree of experimentation that takes the form of rule stretching, or latitude in interpretation.

Every institution with respect to its own history might be more or less fair, and more or less flexible. Similarly it may be classified as being of one of these four types at any point in time. Again, this theory does not allow us to compare institutions, although it does allow an analyst to say that one appears to be becoming more or less fair or flexible than itself at some time in the past. It is a theory that explains what characteristics can make an institution resilient (relative fairness and flexibility) in the face of rapid changes and which ones will not, in addition to the variables that are already used to make such assessments (whether or not the rules fit the canal, and whether or not they fit the external conditions).

2.6 The Core Argument

The core argument of this study consists of two parts. It is an inductive argument, deriving from an examination of patterns in our observations. First, institutional adaptability is a consequence of individual decisions to cooperate or not **with the institution** as well as **with each other**. This implies that any explanation based only on a study of the conditions under which individuals cooperate **with each other** is incomplete. One way to see this distinction is to imagine a scenario in which individuals cooperate with each other to not cooperate with an institution. One example might be if a group of users feel that they are consistently disadvantaged by the rules as they are, and decide that, come what may, they will all refuse to follow them as a group.

Second, institutional survival and decline is a consequence of two primary variables: **perceived fairness** of the institution and **perceived flexibility** of rule application, both by the users. In the extreme, there are four types of cooperation with the institution that result from the four combinations of two stylized extremes (low, high) for each variable. Although, most institutions are conceived to be somewhere between the extremes and also rarely halfway between the two extremes.

Both perceptions affect persistence (the ability to function when conditions are relatively unchanging) and adaptability (the ability to change appropriately in response to changing conditions, either gradual or sudden). Strong perception of fairness results in greater persistence, irrespective of flexibility. However, the move from persistence alone to adaptability is influenced by the flexibility of rule application. This is illustrated by considering the question of how to change the institution in such a way that it meets the new circumstances favorably. In particular, users must have a way to know which new rules will work better than the old ones. Flexibility of rule application, that is, tolerating some rule breaking, is one way that users learn what

rules will match changing external conditions as well as changing notions of fairness amongst users.

Nevertheless, the perception of fairness has a dominant influence on the performance of the institution over time: when there is a weak perception of fairness, flexible application of rules is worse than a rigid application for both persistence and adaptability. This is illustrated in Figure 5.

		Perceived fairness	
		Fair	**Unfair**
Perceived flexibility of rule application	**Flexible**	*1. Robust Cooperation*	*4. Rapid Non-cooperation*
	Rigid	*2. Fragile Cooperation*	*3. Gradual Non-cooperation*

Figure 5: The Types of Cooperation in the Face of Changing Circumstances: This table shows the four extreme types of cooperation that result from combinations of perceived flexibility of rule application and perceived fairness of the rules. The numbers in the cells indicate the most through the least adaptable institutions. It is important to note that the borders are not conceived to be sharp, and the diagram is for illustrative purposes only. The type of cooperation found in an institution is admitted never to be one of the four, but always closer to one than the others.

I now turn to a general definition of the elements of the theory, with some clarifications as they apply to the theory.

2.7 The Elements of the Theory

In this section, I cast the arguments made so far into working definitions for the theory. The definitions that I use in this dissertation are not the most general ones that are

found in the literature. Instead, I tailor the definitions to fit the needs of the argument that I seek to make.

2.7.1 Institutions

In the most general sense, institutions in general have three parts: their accessories (such as rules), an established pattern of observed behavior (by which it can be recognized), and an objective (according to which its performance can be assessed). The accessories of the institution consist of rules, norms, traditions, conventions and customs that serve to influence the behavior of those subject to the institution. In this dissertation I focus on the rules of an institution, and assume that the objective of the institutions that I am studying is to manage their irrigation canals. I take the rules to derive from the nature of the tasks that need to be done in order to maintain the canal.

Rules are statements in a language that do one of four things - permit, require, forbid or disregard an action. There are three types of rules. First, the rules as they are written in official documents (in our case, the constitution or founding documents of the canal users groups for instance). Second, there are rules that are actually used and known to all users (working rules). Finally, there are the rules as they are applied in practice (the applied rules). The differences between the second and third arise because of flexibility.

2.7.2 Institutional Change

I define an institutional change as a change in any of these three elements of an institution. An assessment of change requires a comparison of two institutions - either the same one at different times, or two different ones. I say that an institution is completely different from another when all three elements have changed substantially. In

this case, I say that the institution has **transformed**. I say that an institution is the same but has **changed** from an earlier form when any two of the three aspects are different in comparison to the earlier form. Thus, the assessment of whether an institution has merely changed or completely transformed depends on the two instances that are being compared.

2.7.3 Institutional Performance

I assess the performance of the institution in relation to its objective. In all of the cases I examine, I take the objective of the institution to be the maintenance or upgrading of the canal. There are many factors that influence a canal's condition and functioning. After ruling out the most prominent ones, I take the functioning to be a consequence primarily of the institution. Therefore, I assess institutional performance with respect to the condition of the canal. I equate the condition of the canal with the condition of the institution after ruling out other factors. Thus, when I refer to functioning of the institution, I imply the functioning of the canal and vice versa. This argument is elaborated and addressed empirically in Section 1.6 and Section 3.1.

2.7.4 Condition of the Canal

A canal consists of two main parts: the headworks and the water channels (sometimes called the canal). The headworks is the intake, or the point at which water enters the canal. The canal, although sometimes used to refer to the entire structure, is the network of channels which transport water. I use the term 'canals' interchangeably, and only distinguish the general use (referring to the entire irrigation canal including the intake) from the specific (referring only to the channels) when ambiguity is likely. The canal is said to transport water from the head (the intake), to the tail (the outlet), or the last point that water reaches. The areas between the head and tail are called

the middle of the canal.

I assess the condition of the canal by observing its physical appearance (both of headworks and channels), as well as the perceptions of users about reliability, adequacy and timeliness of water availability. Here it is important to note that the condition of the canal is usually worse the further one moves from the head, although not always the case.[77]

2.7.5 Institutional Adaptation

An institutional adaptation is an institutional change that affects the ability of an institution to meet its objective. A successful adaptation is one that results in the objective continuing to be met by the institution. In the case of the canals in this study, a successful adaptation is a change in rules that does not result in declining canal function between the first and second rounds. Thus, the change might improve functioning or maintain it in the face of changing circumstances. In this study, I do not assess whether these institutions have met objectives other than canal maintenance. This is a necessary restriction because it is difficult to assess how a canal is performing when I do not know what the users want the canal to do. I have argued in Section 1.6 that indeed the objective of the institutions in this sample is not something else.

2.7.6 Change in Circumstances

Institutions are subject to various changes in their circumstances. Some of these circumstances are caused by the institution itself, while others arise from the outside. Furthermore, some of these circumstances demand that the institutions adapt in or-

[77] In the case that there are inlets into the canal from other sources downstream, or in the case that the canal also collects spillover from other irrigation systems, those downstream will receive more water.

der to continue to function. In the case of irrigation canals, the changes in the circumstances of the institutions come from the following sources, based on earlier studies and on interviews with users of the canals. I have listed these changes, or "shocks" in Table 1.5. My approach to identifying what changes an institution may have to respond to thus differs from the approach taken in the IAD framework as presented in Ostrom (2005). In that framing, shocks are defined as external changes that alter the internal cost and benefit assessment of users.

In my case, since I do not assume that the internal cost and benefit assessment is the only dimension of a user's reasons that is relevant to the canal, the set of relevant changes is possibly much larger. Therefore, when I examine "changed circumstances" I refer specifically to those circumstances that users, in all the canals taken together, have reported as affecting a canal's functioning. To ascertain whether a particular canal has been subject to particular changes (as distinct from whether or not the change has affected the canal), I ask the users themselves.

An alternative approach is to use data that has been collected by other sources - government agencies, or donor agencies in particular- to examine whether or not a canal has experienced a particular "shock." I do not do this here, instead relying on user responses to questions about whether certain changes had occurred in the past decade, roughly.[78] Using other data sources could corroborate these responses, but it is not usually not available at the village level.

Economic changes: The first are economic changes measured as increase or decrease in trade, and changes in local production. This is influenced by the opening up of roads and connections to urban markets. It is also influenced by the relative

[78]I say "roughly" in order to represent the fact that user recollections, and senses of historical time in rural areas tend to be coarse.

importance of agricultural production compared to other economic activities, among other variables. In Table 1.5, this would include decreased agricultural activity, land used for other purposes, new roads, and water used for other purposes.

Conflict: The second type of change is the civil war between 1996 and 2006 which is indicated by recollections of respondents about how conflict affected their institution's functioning. Interestingly, as I noted in Chapter 1, users did not report that the conflict was a reason for decline in those canals that are no longer in use. Table 1.2 shows that nearly half reported being affected by it in some way.

Movement of people: The third is the movement of people in and out of the locality for work or other reasons. This most directly impacts the availability of labor for canal related tasks, although there are other impacts as well. For example, when users of a canal leave for a time and come back they might bring new ideas about how to manage the canal. Similarly, in one of the cases a large number of people were resettled by the government in a particular area because of floods in their village. This sudden influx overwhelmed the canal because they all wanted to use it, and it became dysfunctional.

Past rules: The fourth source of changes is the distribution of tasks and resources by the rules in the past. For example, the rules often allocate certain tasks to certain people. Over time, these people develop a tacit knowledge of the task and a nuanced knowledge of the particularities of the canal itself that others do not possess. This leads to the distribution of skills to change over time. This is one of the reasons that bringing in workers from the outside to work on the canal may not be as desirable as paying some current users to work extra. I explore the distribution of work in Section 3.2.2. In a similar manner, if the rules have allocated more water to some people or groups consistently in the past, they are likely to be better off economically than those who have received less for that time. This unevenness in outcomes of

the rules may not be apparent without the passing of time. Thus, although the rules themselves may not have changed their effects become more visible. This particular aspect is central to my discussion of fairness in the next chapter.

Natural environment: The final source are natural conditions such as floods, change in river flow, and landslides. These are listed under "Disasters" in Table **??**.

2.7.7 Perception of Fairness

I come to a concept of what perceived fairness means by listening to the interviews with users. Rather than a definition, I come to a set of four characteristics that make up to varying extents, a user's perception of fairness. The perception of fairness is defined inductively as consisting of several components in Chapter 3. These four aspects of a perception of fairness are: the water gap, the work gap, qualification and exclusion. See 3.8 for a detailed elaboration of these components of fairness. I define fairness in this way without giving a fixed definition to allow for different perceptions of fairness. However, I claim that at least two of these components of fairness will appear in any discussion of it in relation to the canals. Fairness is thus taken to be a multi dimensional concept. In order to understand how the user relates these components, an observer must listen and speak to them as well as exercise their own reason. This is closely related to how I define human reasoning.

2.7.8 Reasoning and Rationality

I assume that individual users behave rationally, in a bounded and limited fashion as defined in Ostrom (1990) but that this is not characteristic of human behavior. Instead, I assume that individuals makes reasoned decisions, that might depart from narrow rationality, along multiple considerations. One of these considerations is an internal cost and benefit assessment. How these individual considerations are related

in the final decision may be highly specific to an individual, shared between groups or possibly universal. However, this theory does not require defining this. Instead, it requires that the observer attempt to understand what the components of reasoning are, and how they are related for a group of users. I use this idea to introduce the notion of fairness as a reason for continuing to commit to an institution, and I distinguish between this reasoning which relies on an assessment of outcomes with an assessment of expected cost and benefit. This is elaborated in Chapter 3.

2.7.9 Cooperation

The primary stance of this theory is that while users may depend on institutions for various things (in particular, possibly guidance about how to act, and as a means to ensure a credible commitment), over time the institution depends on the cooperation of its users as well. For adaptability in particular, cooperation of this form is necessary.

Recall that I draw a distinction between two types of cooperation based on that which the users cooperate with. The first form of cooperation is between an individual and another individual - I call this interpersonal cooperation. The second form of cooperation is between an individual and an institution - I call this institutional cooperation. When I use cooperation in general, I refer to a mix of both.

2.7.10 Flexibility of Rule Application

This refers to the extent of difference or the gap between the rules as applied and the working rules. It may come about because of the likelihood of penalty enforcement, whether or not exceptions are made for unusual user circumstances, or ambiguity of the rules. Flexibility provides an way for users to experiment with new rules in small ways. Flexibility is bounded on two sides. On one side, too much flexibility can be

perceived as unfair. On the other side, too much flexibility can also cause behavior to deviate so much that the needed tasks are not done and the canal deteriorates. I elaborate the idea of flexibility in Chapter 4.

2.8 Assumptions of the Theory

A basic assumption of the theory is that every institution requires at least some of the people upon whom it depends to cooperate with it. This is assumed to be a common observation that doesn't require justification. This claim is taken to be a consequence of the definition of institutions that we use. From this, I infer that sustained non-cooperation with an institution can cause its decline. Another way to say this is that an institution cannot continue to exist if nobody adheres to its patterns of behavior. In the current cases, the performance of the institution is equated with the performance of the canal. Hence, the required patterns derive from the tasks needed to maintain the canal. At this stage, it is not necessary for us to define what is necessary for its survival. I need only that an institution requires something from its users for survival, and the withholding of this leads to its decline.

Thus, the survival of an institution requires at least one pattern of behavior to occur. More often, there is more than one task that needs to be done in order to meet the institution's objectives. Although, these tasks may not be completely known at any time. Indeed, an institution's survival might depend critically on its ability to encourage the finding out of these tasks, especially in changed circumstances.

In our cases, an institution whose purpose is to govern a canal requires that a canal exist. The existence of a canal requires particular actions such as regular cleaning. Thus, the institution requires that someone clean the canal regularly. Conversely, the failure to do certain things at certain times will lead to the decline of the institution. This is an example of non-cooperation, whether intentional or not, leading

to institutional decline. Non-cooperation by some need not always lead to decline, however, although non-cooperation by all must by definition.

The final major assumption that I make is that tasks require skills and abilities for their completion. These skills may not be uniformly distributed in the general population of users. This implies that depending on the task that needs to be done and the time at which it needs to be done, the cooperation of some people with the institution may be more important than the cooperation of others. For example, cleaning the canal is a physical activity which demands a certain physical fitness. When the canal needs to be cleaned, those who can physically meet this demand are more important to the performance of the task than those that cannot.

I can thus classify the users of the institution in relation to the tasks. The relative importance of different people to the institution's survival may change with time and circumstance. For example, suppose the canal above experiences a flood that causes severe damage to the headworks where water enters the canal from a river. Suppose further that this damage is severe enough to require technical engineering skill that none in the locality have. Here, the need to repair the headworks will confer greater relative importance to those who have this knowledge, or those who have a way to secure the cooperation of a government engineer.

Non-cooperation may be manifested in many ways. People may continue to use the institution but refuse or neglect to contribute their knowledge or abilities to it. They may contribute, but do so half heartedly, and partially hold back. They may obstruct or alter other required patterns of behavior. They may also leave the institution i.e. exercise exit. Finally, they may cooperate with each other in non-cooperation. In effect, this is the same as cooperating with each other but not the institution. It is worth mentioning here that the possibility of non-cooperation by exit confers some importance to every individual. Non-cooperation arises as a user's commitment to

the institution decreases.

Having discussed the necessity of cooperation and the changing relative importance of different people to the institution at different times, I now move on to an examination of the hypothesized relationship between adaptability and cooperation.

2.9 The Arc of Theory

The arc of the theory of institutional adaptation to be described here begins with the claim that the confluence of two characteristics of institutions influence adaptability. The first factor is how fair it is perceived to be by the people upon whose cooperation it depends in order to function. The second factor is how flexibly or rigidly the rules are perceived to be applied to those whose behavior deviates from an institution's patterns. This gives rise to four stylized extremes of fairness and flexibility, shown in Figure 6, that are helpful in orienting the subsequent discussion.

The three dimensional cartesian axis illustrates two key features of this theory: first, the institutions will fall somewhere between the undefined extremes at any time; and second, how fair they are perceived to be or how flexibly the rules are applied may change with time. No other mathematical relationships are implied.[79] There are four general directions in which an institution can move over time - towards more or less flexibility and more or less perceived fairness.

The metaphor illustrated above suggests four domains:

1. Robust cooperation Flexible application, and a strong perception of fairness.

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[79]The axes are marked but not labeled with numbers in order to avoid any suggestion that the theory claims the measurability of these factors. For our theory, we need only some assessment of more or less and not how much more or less. Therefore, the relative distance between points has no meaning, although the orientation does. There are other caveats - it is not intended to imply that flexibility and perception of fairness are orthogonal (i.e. independent). The solid line between quadrants is also not an implication that the border is sharp.

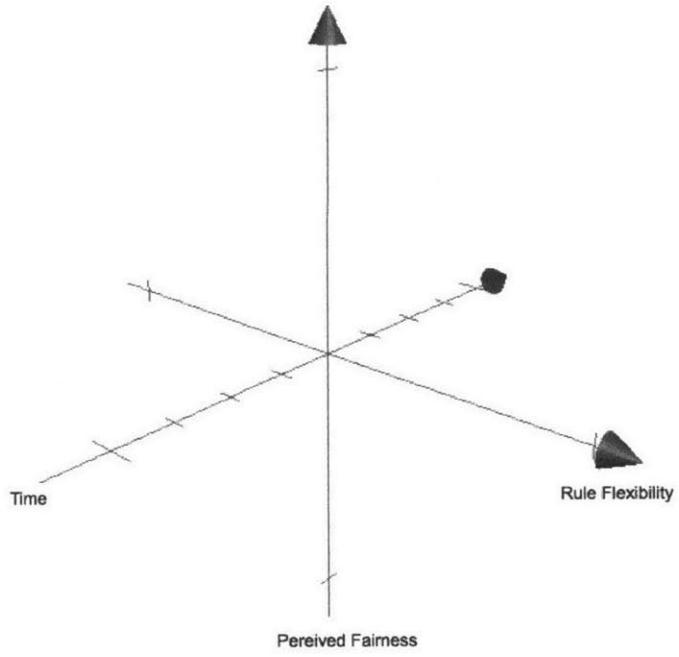

Figure 6: Schematic representation of the three dimensions of this analysis. No numerical properties are implied.

2. Fragile cooperation Rigid application, with a strong perception of fairness.

3. Gradual non-cooperation Rigid application and a weak perception of fairness.

4. Rapid non-cooperation Flexible application and a weak perception of fairness.

2.10 Predictions of the Theory

The following broad predictions arise as a consequence of the theory. Adaptation is a consequence of the type of cooperation or non-cooperation with the institution that comes about. One or both of either cooperation with each other, or cooperation with the institution are required for successful adaptation. The type of cooperation or non-cooperation that comes about depends on how flexibly the rules are applied and how fair the institution is perceived to be. In the face of changes and regardless of the

type of change, an institution will be more resilient if it is perceived to be more fair and its rules are applied flexibly. Next, will be those which are perceived as fair but rules are applied more rigidly. Then those which are perceived as unfair, and rules are rigidly applied. And finally, those which are perceived as unfair and whose rules are flexibly applied. This implies, overall, that the rules that users devise to use and manage a shared resource have to match both the conditions of the resource and its environmental conditions as well as the sense of fairness of the users of the resource.

In the next two chapters, I examine the empirical evidence in relation to the main claims of this theory.

3 Fairness

Chapter 1 introduced five indicators of institutional performance in addition to simply whether or not the institution exists. The motivation was to directly examine and assess changes to institutional performance over time using two observations per institution. This was necessary because none of the reasons that former users gave for their canal's demise were unique to those canals. Instead, these conditions were experienced by others which had survived.[80] Thus, it could not be that these reasons alone, or even primarily, were responsible for decline.

The additional indicators reflected the physical condition of the canal together with how the users assessed the timeliness, adequacy and reliability of its water delivery. [81]

Subsequently, Chapter 2 used three main theories of institutional adaptation to explain the observed variation in performance of the surviving institutions. As this chapter shows, in each case the explanations appear unnecessarily limited. This chapter turns away from aggregate statistics and returns to the conversations with users in order to explain the variation in institutional performance across local irrigation management institutions.

In this chapter, I show that a notion of perceived fairness of the rules matters to the functioning of the institution when external conditions are controlled for. This notion of perceived fairness emerges inductively from 827 interviews with users. It is not a

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[80]It could be argued that unique experiences that users did not know about were responsible. But testing this would require further specification of which conditions these might be.

[81]In the second round, users were also asked about timeliness. This was not asked about in the first round. At each location, enumerators spoke to three people on average. They assessed the physical condition by walking from the village to the headworks, along the canal and spoke to people that they met. They made an effort to speak to poorer users as well as officials of the user's association if any. See section 1.4 for details of the methodology.

definition of fairness, but a set of four elements that appear together in discussions of fairness across cases. The analysis in this chapter shows that perceived fairness relates to performance in the current dataset, as well as the original one. It also shows that changes in performance relate to changes in perceived fairness over time. Thus, it emerges as a key variable for understanding why some institutions in our sample perform better than others over time. This relationship only appears, however, in those cases in which users remember having received assistance from government or outside agencies. The chapter ends by pointing out that even within the institutions that are considered relatively fair, there is variation in performance.

3.1 The Factors Affecting Canal Functioning

To understand why some institutions are associated with better performing canals while others are not, it is necessary to look more closely at the factors affecting canal functioning. Until this point, this analysis has relied on two types of indicators for institutional performance under the assumption that the canal's performance is directly affected by the institution associated with it, when other confounding factors can be ruled out. These two sets of indicators - of canal function and of the physical condition - are interrelated.[82]

A change in the physical condition of the canal affects its ability to deliver water. There are two very common physical reasons that lead to a canal delivering less water: the canal takes in less water at the source or the flow of water decreases as it is carried by the canal. Leakages due to cracks or obstructions caused by siltation or weeds in the canal itself reduce the amount of water available to downstream users.

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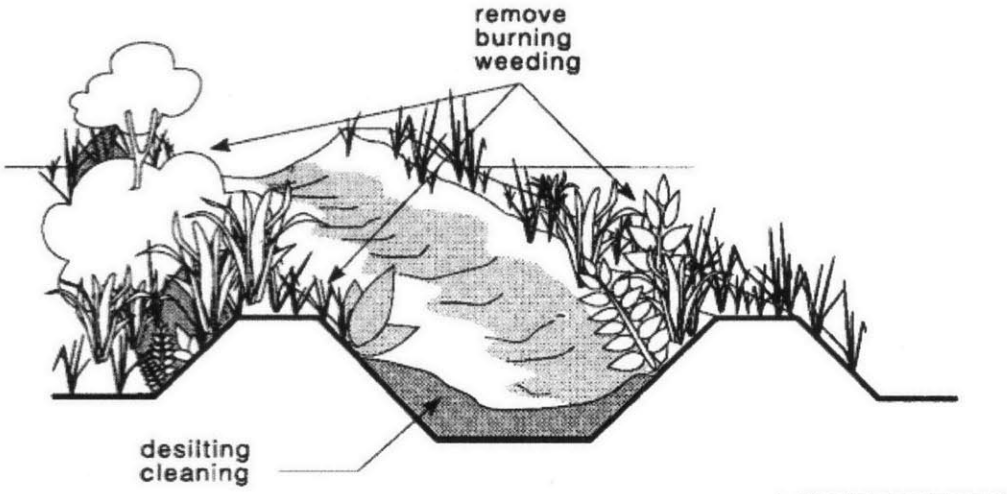
[82]See Appendix A

Figure 7: Aspects of canal cleaning: This figure is from a handbook on canal maintenance published by the United Nation's Food and Agriculture Organization.(FAO, 1985) It was intended for users of canals and government extension officers. It illustrates the different cleaning related tasks that a canal requires. These tasks have to be performed along the entire length of canal, which in this sample averages about 4km. Failing to clean a part of the canal has effects on those downstream from it.



Some aspects of maintenance are shown in Figure 7. Similarly, a damaged headworks is able to collect less water from the water source, such as a river, into the canal. This makes less water available to all users. [83]

Whether the canal function either deteriorates because of damage or improves because of repairs or upgraded technology[84], there are likely to be many other factors

[83]Handbooks for irrigation produced by aid agencies in the mid-1980's typically contain a simple explanation of these aspects. For example, between 1985 and 1993 the Food and Agriculture Organization of the United Nations published a series of Training Manuals for Irrigation Management intended "for use by field assistants in agricultural extension services and irrigation technicians at the village and district levels who want to increase their ability to deal with farm-level irrigation issues." (FAO, 1985) Training Manual Number 7 on Canals is still a useful document for understanding how irrigation canals were technically understood at the time that the first round of data collection was done.

[84]Upgrading usually takes the form of improvements to the canal and headworks. A common improvement to the headworks is the building of a more permanent intake which is less susceptible to changes in the water source, such as one that is made of concrete as opposed to temporary materials

that influence how users assess this change in terms of timeliness, adequacy and reliability of water delivery. For example, a crack in the canal only affects the water available to those downstream of it and would thereby only impact certain users and not others.[85] Eventually, a canal's ability to deliver water affects the crops that it is used to irrigate, which impacts the livelihoods of the users of the canal. For example, a sustained decrease in flow reduces the amount of land that can be used for agriculture, reducing the amount of crops that is produced. This may not always occur, for instance users might change the crops that they grow, moving from water intensive crops or varieties to less intensive ones.[86] In general, however, a change in canal functioning impacts users in relation to how economically dependent they are on it.

Most farmers cannot easily increase the resources available to them for agriculture. Additional seeds, land and labor might be available but the farmers require money in order to purchase them. Most of the time, farmers with smaller plots usually work their own fields. Thus, for months at a time their own labor and time becomes a scarce resource to be invested wisely. Missing a day of work during the planting season might impact their crops substantially. For example, when growing rice in Nepal using traditional methods[87] it is very important to plant the fields according to when the first monsoon rains will arrive. It is essential to have the fields

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such as rocks and twine. Depending on the specific upgrade, such as from a gabion box to a concrete weir, the input of trained civil engineers might be needed for both building and repairs.

[85]This is addressed in the study by revisiting the same locations along the canal as far as possible. Alternatively, users might generally be happy with the canal in a way that is not related to its functioning and their assessment might reflect this happiness more than actual canal performance.

[86]They may also adopt water saving methods of cultivation such as the System of Rice Intensification or SRI. See Uphoff & Kassam (2009) for details.

[87]Which involve transplanting rice into flooded fields, and then keeping the fields flooded to control weeds.

tilled and ready for planting well before.[88]

Canal cleaning and maintenance is a labor intensive activity and there are no machines that can do it except in the case of large and relatively advanced canals.[89] In user managed canals, it is the users themselves who contribute to these activities whether by paying wages to others or by going to work on it themselves. The interviews consistently reveal that their commitment to investing in the canal's maintenance and upkeep is a direct consequence of how they feel about it's potential performance.

While users may increase their investment in the canal when it underperforms, it is very unlikely that they will keep it up for more than a few seasons. Eventually, if they continue to feel that the canal is not performing adequately most farmers will be forced to look for alternatives to it, such as digging a private bore well. When this is not possible, and the crops that they grow are not enough for their economic well-being, they usually leave agriculture altogether or attempt to supplement their income in other ways. In this way, a sustained perception that the canal is not performing well will likely reduce a user's commitment[90] to maintaining it. The eventual disinvestment eventually shows up as persistent physical deterioration in the canal. And in turn, this deterioration reduces the performance of the canal further.

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[88]For a sense of how important a single day can be during the planting season consider the concerns surrounding the date for the 2013 Constituent Assembly elections in Nepal. A major concern about the date on November 19 was that many farmers in particular areas would not come to the booths if it corresponded to the first day of harvesting.

[89]Even if such machines were available, they would most likely be beyond the means of most farmers to purchase them.

[90]The use of commitment here is similar to that used in Sen (1977). In particular, the word denotes a reason for making choices that do not appear to be maximizing ones preferences, for example investing in a declining canal when a user knows it will not be enough to sustain their agriculture. The use here is closely described in relation to "work motivation" (Sen, 1977, p.333).

In the case of institutions for managing a shared canal, the relationship between how users perceive the canal's functioning and their willingness to maintain it has a particular significance. This becomes clearer by looking at how man made resources such as physical infrastructure differ from renewable ones such as some natural resources like fish stocks.

3.2 Significant Particularities

There are two main differences between renewable resources[91] and man made resources, of which irrigation canals in Nepal are an example, that are significant to the research question. One set of differences stems from the nature of man made versus renewable resources. The second set stems from the specific type of work that is required from users to keep these resources productive. These differences require taking an approach that is broader than the Common Pool Resource (CPR) framework which was used to initially study these canals. There is also a third set of considerations that directs the approach of this study. It arises from the specific question that is being asked, which is about institutional change rather than emergence.

Before focusing on the interviews with users, it is necessary to examine the implications of each of these three considerations in turn.

3.2.1 The Nature of the Resource

The physical condition of man made structures such as canals depends on regular maintenance. It is a common experience that in the absence of regular upkeep, such resources fall into disrepair, their performance declines, and they become useless.

[91] The word "renewable" is used here to refer to resources that replenish themselves if left alone. This conceptualization is described in some detail in Clark (2005).

In order to be used, an irrigation canal first requires that it be cleaned in order to remove silt that has deposited along its floor, the weeds that may have grown in it or branches and leaves that may have fallen in. It must also be checked for cracks and leakages, and these must be repaired before the canal can be used. The headworks also requires similar inspection. When the headworks is made of temporary materials such as a gabion box made of rocks and twine or wire, it is common for it to be washed away by the the previous year's monsoon rains. Thus, this requires rebuilding. These activities represent an investment of work, and possibly other materials in proportion to the canal's length.[92] Even leaving aside the initial construction of a man made resource, continuing productivity depends on continuing investment of work and other resources first.

This is in stark contrast to the case of renewable resources such as natural fisheries and forests which, in the absence of human interaction, flourish. Without humans, fish multiply and forests spread naturally.[93] While they may invest work and resources to increase the availability of the resource, the resource is productive without them.[94] In order for a renewable resource to remain productive, users need only

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[92]In the current sample, this ranges from approximately 500m to 50 km with the average around 4km. Based on user estimates, the canals in this sample required the equivalent of at least 10 days of work to maintain per year, excluding emergency repairs and assuming that one person was working on it. The average was 200 "person-days," which is ten days of work for twenty people.

[93]"Natural" is defined as the absence of direct human interaction. It might be argued that humans are natural, and that human interaction is natural. However the intention here is not to identify the essence of what is "natural." Instead, the intention is to identify those resources that require human intervention in order to be used and those that replenish themselves. For example, fish in the ocean do not have to be fed and grown in order to be caught and consumed, although they may need to be caught, processed and transported. It is possible that there are few resources left in the world which do not require human interaction. If this is the case, this only extends the applicability of this study.

[94]There is a broad range of resources which might be considered "natural" but that require upkeep. For example, community forests which have species of trees that require upkeep might be closer to man-made resources as defined here. The key distinction is whether or not human intervention is required to bring the resource into being.

make sure that they do not overexploit it.

As a man made resource the productivity of the canals in this study depends on how willing users are to maintain it. How regularly or adequately water has been available to a user in the past is likely to be a consideration for them in deciding how much to contribute to the canal's maintenance in the future. As noted before, for instance, characteristics of water delivery eventually affect the willingness of users to contribute work to the canal, particularly when they work without pay. The unwillingness of some users to work on the canal matters less if there are others who are willing to work in their stead. But there is often a difference in the work done by users and non-users: those who don't interact with the canal regularly often are often not as familiar with it and lack the intimate knowledge of the canal that makes user contributions more effective.

There are many ways that a canal might be damaged, such as by floods or landslides and even normal wear and tear. Yet, there is only one reason that this damage will persist: the inability or unwillingness of the users to repair it once the problem has been detected. Certain types of damage are beyond the abilities of the users to fix because they require too much investment, too much work, or inaccessible expertise. For example, when a flood damages elaborate concrete intake structures, such as weirs built by engineers, users often do not know how to repair it.

Whether the demands of maintenance are too much for a group of users is an assessment of the nature of the work that needs to be done against what is available to them, or their capacity to do the required work. In the 16 to 37 years since these canals were first studied, their main source of labor and money for regular upkeep has remained relatively unchanged. Occasionally, there is assistance from government agencies, or donor agencies. But most of the resources for regular upkeep and maintenance come from the users themselves.

Thus, in the case of man made, user managed resources such as the irrigation canals in this study, deterioration in the physical condition is a direct consequence of how willing users are to contribute to is maintenance. In those canals where the demands of maintenance have not changed, then any deterioration must be because less of what is needed is available to the users, or the users are willing to contribute less than they used to. Similarly, a well maintained canal indicates that contributions continue to be made to it in required measure, although who is contributing what might not remain the same.

3.2.2 The Nature of Work

For users devising institutions to govern a man made resource, there is an additional challenge when compared to a renewable resource. However, it is not apparent without looking at the specifics of the work required of users. First, consider the similarities between the two. In both cases, the users might create rules that provide for key roles in the resulting institution such as that of monitor or guard, as well as leaders - elected or otherwise.[95] Furthermore, all of these positions, if they exist, will require people to fill them. So, the two types appear similar when comparing the work required of users to keep the institution functional.[96]

The differences arise because the nature of the work that has to be done is different in the two cases. Consequently, what an institution's rules are aimed at getting users to do is also different in the two cases. The main challenge for users of a shared renewable resource is to devise rules that stop users from using too much, in order

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[95]These positions are not universal. There are many institutions that do not have these positions, where users monitor each other instead.

[96]A functioning institution does not always correspond to a functioning canal, although the reverse is rarely the case. A well functioning canal is usually accompanied by a well functioning institution.

that the resource may replenish itself. Whereas, when the resource is man made, the main objective of the rules is to encourage regular contributions from users in the form of work or money. While institutions governing man made resources do seek to stop users from using water out of turn, or from using too much water, the purpose is so that water reaches more people.[97] This difference is due to the need to first "produce" a man made resource before it can be distributed.[98]

For the sake of simplicity, we might regard the general task of institutions in both cases as being the same. They appear to be regulating natural, human tendencies in order to produce patterns of behavior that are eventually more beneficial to all. In one case, the regulation prevents overuse while in the other, it prevents laziness- both common human tendencies.[99]

However, this shorthand use of the word regulation misses a critical difference in what the institutions are required to do. In one case, the institution is asked to give reasons to users to stop using a resource in which they have invested nothing. In the other case, the institution is tasked with the opposite - it is asked to first give reasons to users to invest in a resource to be made usable. Without a critical number of users invested in maintaining the canal, it cannot function for even a single season due to siltation and blockages.[100] If it is hit by natural disasters such as landslides or floods,

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[97]And, as a consequence, the chance is increased that the minimal labor and resource contributions needed for the canal to be maintained will be forthcoming.

[98]We also note that in this way, in the case of man made resources, the success of the institution depends on the condition of available labor.

[99]We could argue further that in both cases the users are exercising their will, and this being the real task, the distinction we have made is frivolous.

[100]This is why the canals are cleaned before the rains every season. The sources of water are also at some distance from the nearest fields. This means that often even the first user depends on the canal condition, although less so than those further downstream. Thus, it is most often the case that a group of people are required to make it even minimally productive every season.

its productive interval shortens further.

The loss of meaning that a one-sided use of the word 'regulation' entails is now more clear. It is important to our study to maintain the broader meaning of regulation as patterning behavior generally without implying only the prevention of undesirable behavior.[101] The type of mistakes that we would otherwise make is illustrated by the following example.

Suppose we were to use the narrow meaning of what an institution is expected to do to explain a deteriorating canal. Suppose further that after studying the costs and benefits of a well functioning canal to these users, it appeared that all of them would benefit from maintaining it collectively.[102] We would rightly deduce that its users are not able or willing to maintain it. A reasonable conclusion would be that either the canal is beyond the ability of the users to maintain given the resource available to them, or the institutions they are using are flawed.[103] This line of reasoning would lead to a focus on the undesirable behavior of users such as "shirking, free riding, or otherwise acting opportunistically."[104] The logical diagnosis would recommend finding ways to counter temptations to engage in these activities through punishment and monitoring. [105]

Thus, relevant questions that the broader meaning of regulation would suggest

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[101]"A rule or principle governing behavior or practice." Oxford English Dictionary

[102]In other words, everyone would be better off without making anyone worse off.

[103]In the sense that the rules fail to align the incentives of individual users in such a way as to produce the behavior that would result in the desired maintenance by preventing laziness.

[104]Indeed, this is the classic formulation of collective action problems defined in terms of the postulates of rational choice theory. This was how these institutions were first studied, and is the standard analysis of the Commons Framework in Ostrom (1990). Opportunism is defined in Williamson (1975)

[105]A classic analysis of why individuals do things, and don't do them is Becker (1968). In this model, the act of breaking the law is modeled as a cost-benefit calculation by a rational individual seeking to

are ruled out by using the narrow meaning of regulation as prevention of certain behaviors. In the first instance, it does not appear important to ask why fewer potential users were now invested in the canal, and therefore the institution, compared to the past. And in the second instance, it does not appear important to ask why or how the commitment of users to institutions that had been successful in the past had now changed.[106]

3.2.3 The Nature of the Question

Although these cases have been studied in the past, there are important differences between those studies and this one. The question in this dissertation is aimed at understanding the reasons that existing institutions exhibit adaptation, resilience and decline. The concern is not with understanding why such institutions emerge in the first place from a group of self-interested individuals.[107] Instead, what is sought are

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maximize his utility function U_j:

$$EU_j = p_j U_j(Y_j - f_j) + (1 - p_j)U_j(Y_j)$$

For person j, EU_j is their expected utility from not complying, p_j is the probability of conviction per offense, f_j is the monetary punishment per offense, and Y_j is his income (monetary and "psychic") from the offense. Every rational individual might therefore break the law for the same reason that they comply with it: the benefits of doing so. By leaving the "psychic" component in our assumptions, we are able to simplify human motivation. However, we also close off the possibility that the reason for not doing something having once started might not have much to do with cost or benefit, even though the initial decision to start might have.

[106]In effect, we would be turning to our assumptions about why people behave as they do for an explanation instead of trying to find out why it was in this case. In the case that the users have no choice of a livelihood beyond agriculture that depends on the canal, the distinction is not useful. However, when users do have alternatives - although perhaps not as desirable - the narrow meaning leads us to commit a systematic error. Consequently, questions that may have tested our theory about human motivations are not asked and we risk assuming our theory is true even in cases where it may not be. This situation would be analogous to a Type I error where a false positive is generated.

[107]If indeed they do emerge from groups of individuals in the first place. As later chapters explain, there are reasons to believe that at least some of these institutions arise due to the requirements of donor projects and not because the users spontaneously self-organized.

the conditions under which individual users who are already committed to an existing institution, which they may or may not have devised, change it or don't in the face of changing circumstances. How the institution came about is an important part of the answer but explaining why certain conditions led to its emergence is not the focus of enquiry.

This entails a different focus than if the question were to ask about individuals who come together for the first time to devise institutions to solve the collective action problems associated with self-organization. In the traditional setting, there is a group of individuals who are self-motivated and share a resource. When revisiting these cases, however, the group of users have already collectively managed a resource for decades and are facing changing circumstances.

These two areas of focus lead to substantially different enquiries, although they are related. All studies of these cases in the past have sought the conditions that might lead uncommitted people, whose reasons for action were well understood, to make a commitment to a collective agreement. This study seeks the answer to why some decide to adapt and change the institutions to which they have already committed to meet changing conditions- and therefore continue their commitment, while others decide to end their commitment to the institution of which they were a part.[108] By not assuming that these reasons are the same, this framing admits of two possibilities. First is the possibility that an individual's current position- whether committed or not- may influence their decisions about their future commitment. And second, it allows for the possibility that people may have different reasons for taking each of these three actions- committing to an agreement for the first time, renewing their

[108]It should be noted here that the question of institutional change is folded into the question of institutional emergence in traditional approaches. Thus, a change in rules is regarded as analogous to committing to a new set of rules from a position of never having committed.

commitment, and discontinuing their commitment.

Overall, these distinctions suggest that it is important to remain aware of the tasks that users are required to perform in order to use the canals, as well as the position of the users in relation to an existing collective agreement.

3.3 Looking Deeper

In view of this, the empirical search undertaken below allows for the different reasons that users may give for committing to a canal institution for the first time, and stopping or continuing to do it after having once started. It also recognizes that the significance to the users' decision making process of these different reasons might be incommensurable. In order to place the following analysis of the interviews with users in a theoretical context, it is useful to briefly point out how the interviews were approached. It was informed by the discipline of foregoing convenient assumptions about human reasoning.[109] In particular, the interviews are not assumed to reveal the elements of an internal cost and benefit assessment that guides user decisions.[110] A comparison of overall cost and benefit no doubt approximates the logic structuring some of the reasons that the users give. However, the analysis is taken as far as it will go without universally projecting a unitary structure of reason onto all respon-

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[109]The intent of these simplifications about human motivations are usually to ease the modeling process. However, we are interested in first understanding user reasoning and so the simplifications are not as critical to the task ahead as they might be if we were intending to model behavior.

[110]Our concern is with the structure of that type of reasoning, which assumes that different reasons are commensurable and weighed in a unidimensional way. It is not with the units of valuation, which are allowed to be non-financial. We regard the reason of cost and benefit to oneself as an undeniable, convenient, and very versatile, type of reasoning. However,it is also regarded as one of many types of reasoning.

dents.[111]

3.4 A Crucial Distinction

The interviews with former users illustrate the reasons for not continuing to work on the canal. These reasons appear to be substantially different from the reasons that current users gave for working on it. The most common reason why users stopped their commitment to the canal came from a comparison of their economic condition with that of others who used the canal. In particular, they had come to recognize the many ways that other users had become better off over the years than themselves. This difference in outcomes would not have been as perceptible to prospective users at the time of committing to the institution as it had become after decades of following to its rules.

Two types of users that were interviewed highlighted the different reasons for starting, stopping and continuing to be part of the local canal management institution. The first set were former users who no longer worked on their canal. The second set were current users who had, for one reason or another, reduced their involvement in the canal.

The following is a typical conversation with former users of the canal: [112]

> I used to work on the canal. Everyone who used water had to work. For

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[111]For instance, there could be multiple cost-benefit type assessments with different units such as satisfaction, or utility. Not accepting a singular unit of reason allows for the consideration of how one type of reason may relate to another.

[112]The questionnaire was not designed to survey reasons that individuals or groups stopped working on the canal, but there were incidental interviews with former users in cases where the canals were no longer in use. Most of these conversations occurred during the detailed case study conducted after the survey. While not representative even of this sample of cases, it offers a starting point for examining why people stopped in other instances.

many years, I worked. I have a small amount of land. That was enough for us. My brothers and I worked all day sometimes. They paid us.

Q: Did everyone have to work as much as you?

(His tone turned serious and hinted at resignation) I can't speak about others. Our houses (pointing to the cluster of ten houses nearest his), you see how we are. (pause) You also talked to others, so you saw how they are. How much they worked on the canal, you probably know better than me. They are able to send their kids to boarding schools... (he tapered off into silence and peered down at his hands)

This response is both typical and remarkable in how it draws on three implicit comparisons the respondent associates with the canal's rules.[113]

The first comparison is between the respondent's economic condition and that of others. This respondent, Mr. Darai, compares his family with those are far better off. He has three sons with two living in a foreign country doing low skill work, and the third one unemployed.[114] The families to which he was comparing also did not have their youngest members living in the village. A typical one had a son working as a journalist and another as a middle-man for "manpower" agencies that recruited potential migrant laborers. Their fields, which were larger than Mr. Darai's, were fallow. People that Mr. Darai knew used to work for them, but refused to do so now.

Mr. Darai also remembered how in the past everyone - including "they" - worked

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[113] It is also notable on first reading how the respondent appears to not answer the question. However, this is a typical way of "saying something without saying it" that is the mode of speaking in rural parts of the country, especially by less powerful people. Despite not making the comparisons himself, he suggests doing so and in his tone he also suggests the result of his own comparison - which remains unsaid.

[114] In this case, one was a construction worker in Qatar and the other in Malaysia. their mother had passed away after giving birth to the youngest,15, who stayed with his father.

physically on the canal. It was common at the time for all users to contribute labor themselves. This included cleaning, inspection and repair work on the canal. It was also more common than it is now to require that every user perform an equal amount of work, measured by the length of canal that they cleaned or the number of days that they served as a guard. This universal participation lent a sense that the conditions of most users were similar with respect to work.[115]

These rules for allocating labor have changed towards requiring work in proportion to the amount of water used from requiring everyone to work equal amounts. In many canals this change happened because those with less land did not want to do a disproportionate amount of work. Overall, 64% of the institutions now have rules that require work in proportion to the amount of land the users irrigate or the amount of water they use. In the past, only half of the canals had this kind of rule. This pattern is apparent in Table 3.1 which shows that about two thirds of those that used to divide the work equally between all users no longer do. There are large shifts away from using equal allocation and towards proportional allocation. There is also a large shift away from allocating work based the amount of water used towards the amount of user's land that is irrigated by the canal. This is likely because it is difficult to measure how much water is being used, but easier to check how much land is being irrigated: this is reflected in how much land has crops.

The second comparison suggested by this response is between those who he remembered having worked on the canal in the past and those who still worked on it. Mr. Darai compared this past where everyone worked on the canal to a present[116]

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[115]There were also large landlords then who would oversee the work, but they were regarded as always different from everyone else.

[116]The interview was conducted in October of 2013

Table 3.1: Shifts in how canal work is assigned: The table shows how the percentage of institutions using each basis for assigning work on the canal in the past (indicated in the rows) has shifted towards other bases (shown in the columns). Equal refers to an equal division of the total work between users. Land and water refer to work assigned in proportion to the amount of land irrigated, and amount of water used respectively. Mix refers to a mix of these along with the practice of assigning work only to those who are present when work is to be done. In order to show the shifts, percentages are computed taking the total number in each row as 100%. Each cell indicates the percentage of institutions that changed their basis for allocating work from the row label to the column label.

	How work was assigned on revisiting(%)				
How work was assigned on first visit	Equal	Land	Water	Mix	Row Total
Equal	31.82	51.52	4.55	12.12	100
Land	19.39	68.37	7.14	5.10	100
Water	33.33	66.67	0.00	0.00	100
Mix	28.57	50.00	7.14	14.29	100
Total	24.86	60.77	6.08	8.29	100

N=191. 10 responses were missing in the original sample.

where only some worked while others did not. The emergence of a group that performs most of the physical work on the canal is consistent across cases. During the first survey, it was common for institutions to have rules that allowed users to send someone else to work in their place when they could not work. Most often, users sent their own family members. When they could not, they would hire others to work for them. Paying money instead of finding someone to work was rare. Doing so was normally associated with paying a penalty or indicated an unusual circumstance. As shown in Table 3.2, there is now a much greater proportion of canals where users are required to pay money instead of sending someone to work in their place. Of those institutions which required users to find someone to work in their place, 84% now require the payment of money instead.

And finally, he identifies an 'us' that he feels are like him as distinct from 'them' who did well and don't have to physically work on the canal if they don't want to. This hints at a greater sense of closeness to his people who do most of the work, and

Table 3.2: What is required in place of work: The table shows that most institutions that required users to send someone to work in their place when they themselves could not now require the payment of money instead. What is required when one cannot work is indicated in the rows and columns. Hired Labor means that the user must pay someone to work in their place. Money means that they are required to pay money. Other indicates any mix of these two. Percentages are computed taking the total number in each row as 100%.

	Substitutes for work on revisiting(%)			
Substitutes for work then	Hired Labor	Money	Other	Total
Hired Labor	15.56	84.44	0.00	100
Money	14.29	78.57	7.14	100
Other	16.98	77.36	5.66	100
Total	15.58	79.87	4.55	100

N=154. 48 responses were blank in one of the two observations.

a greater sense of distance from the others who do not work but pay money instead. This dichotomy is also apparent across cases. The emergence of a subset of users who do most of the physical work has resulted in less interaction between those who increasingly work because they can't pay someone else to do so, and those who can. Often those who do physical work on the canal are paid to work extra, as in Mr. Darai's case. The other users consider this better than hiring outside workers because the local users often have more experience with the canal.

These apparent inequalities in the amount of physical work that users perform also overlap somewhat with ethnic divisions. This is because in every case in which an increasing number of users pay money instead of physically working, the work is given to particular ethnic groups and not others. Mr. Darai's 'us' appears to refer to a mix of three groups: the group of people of his ethnicity, the group of people who appear to do most of the work on the canal, and the group of people who have not done as well as others by using the canal.

These comparisons of how ones condition has changed to how others' have changed do not appear when other users were asked why they continued to work on the canal or started doing so many years ago. When the positive question was asked, respon-

dents referred to the need for water for agriculture, its significance for agrarian livelihoods, a desire to grow crops, or a lack of alternatives to their way of life. They stressed how working together worked well for all villagers, and in some cases how if they were to survive they should continue work together. Overall, they tended to refer to what we may recognize as economic reasons. Indeed, the reasons for starting to work on the canal or continuing to work appear to be reliably characterized as the reasons of individual or collective economic benefit.

During these positive conversations, no respondent suggested distributional, or comparative, issues over time. There are also no references to uneven economic outcomes that they may have observed amongst those already working on the canal. Further, no respondent mentioned what results they expected to come about after working on the canal for many years. This pattern of mentioning distributional concerns when explaining why they stopped, but not mentioning then when talking about why they continue was common. It emphasizes that the reasons for not using the canal may be related not just to ones own economic benefits but to a comparison of ones benefit with those of others over time.[117]

3.5 The Perception of Fairness

Focusing on the comparative assessments that users made around questions of distribution[118] revealed a group of topics that appeared connected to each other in the

[117]Thus the meaning of "proportional cost and benefit", which is considered central to the existence of these institutions, broadens to include a comparison across users and not only a comparison of ones costs with ones own benefits.

[118]Respondents made these assessments not only in discussions about why they stopped but also why they may have decreased their involvement.

expressions of respondents.[119] When one of the topics in this group came up in conversation, often at least one of the others was also brought up by the respondent themselves.

The following sets of comparative statements appeared connected to each other in interviews with respondents. Together, they seem to loosely indicate what might be recognized as 'fairness', a word that does not have a direct translation into Nepali. Table 3.3 shows this group of topics that appeared in interviews with users and non-users along with representative phrases that were taken to indicate each comparison.[120]

Table 3.3 was compiled by listening to each interview and marking when a comparison was made followed by a reference to another comparison without prompting by the interviewer. For example, if the interviewer asked whether some did more work than others, the answer would be a comparative statement. However, to be included in this table the respondent would have had to mention another of the comparative statements also in the table without prompting when answering the question. Figure 8 shows how many times one comparison led to another, without prompting, in the interviews. For instance, if the user subsequently mentioned on his own that the rules benefitted the wealthy, then this would be noted down by increasing the number in row 4 column 8 by 1. Each comparative statement may have been

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[119]I should note here that this method gets at a roughly "collective understanding" more than an individual understanding because of the study design. I did not distinguish whether characteristics of the respondents led them to make certain connections and not others between the concepts. So, I take the respondents that I spoke to as representative of the "local" understanding of fairness. This is akin to assuming that the working rules are "common knowledge".

[120]As the enumerators walked along the canal to the headworks, where reachable, they also spoke to any users, particularly poorer looking ones (or ones with smaller plots), that they met along the way. This was primarily because those who were the first to talk to us were often better off, or were performing some role in the User's Association. Speaking to people along the canal was a way to get a broader opinion.

Table 3.3: Comparisons that resemble fairness: This table lists the comparative statements that appear to correspond to an idea of fairness, along with representative phrases from interviews. The comparisons in this table recurred in conversations and were connected to at least one other comparison. The indicative phrases are expressions that were taken to refer to their corresponding comparisons.

Comparison being made by user	Indicative phrases from interviews
Whether or not respondents want the rules to change because they are inappropriate to the current social situation (the word translated into "appropriate" is "uchit")	"Appropriate to the situation." "Acceptable, ok."
Whether or not there is discrimination by the rules against some users, particularly the poorest	"Not treating the poor badly." "Not giving some a lot and others less."
Whether the poorer members receive their share of water	"Giving the poor their water"
Whether the rules favor the wealthy and those with more land	"Not giving benefits to the wealthy." "Not that the wealthy get water first."
Whether the rules are easy to understand	"Easy to understand."
Whether they are sensible in the sense of satisfactorily fitting the general circumstances	"Matching the conditions." "Satisfying to ones mind" (the phrase used was "chitta bujhdo")
Whether the rules treat people uniformly	"The system treating everyone in the same way." "The rules giving some water to everyone." (the word for custom was "niyam," which translates to a particular rule or set of rules)
Whether some people do much more physical work than others	"Everyone does the same amount of work" "We are the ones who work" "If we don't do it who will?"

Figure 8: Frequency of connections between comparative statements: The figure shows the number of times the comparative statement listed in each row, and numbered accordingly, corresponded to another one indicated in each column. The numbers in each column represent the numbered statements in the rows. Each number indicates how many times the statement in its row corresponded to the statement in its column. There were 827 individual interviews.

Comparison		2	3	4	5	6	7	8
Rules are appropriate	1	30	40	88	78	32	67	58
Rules discriminate against poor	2		113	45	58	49	54	52
Poorer users receive water	3			97	48	20	117	91
Rules favor the wealthy	4				72	114	81	22
Rules are easy to understand	5					45	60	76
Rules are sensible	6						44	71
Rules treat people uniformly	7							106
Some do more work than others	8							

connected to many others in the same conversation. The table does not include those statements that were not connected to any others. In 103 interviews, there were no connected statements primarily because the respondents were not eager to engage in conversation, but were only willing to answer the questions that were asked.

This method led to an inductively constructed concept of fairness. This resulting concept finds the intersection of what I recognize as fairness on the one hand and on the other, those distributional or comparative notions that respondents appeared to connect the elements of in their speech. In other words, this concept is the users' perception of a group of elements that I recognize as fairness; and thus that I call fairness. The elements of this concept appeared together in a connected fashion. More specifically, the connection was that when a user was asked about one of them they brought up another one without prompting. Recall that not every user made these connections, nor did any user connect all of them.

This approach gives one greater confidence that the users also conceive of a connection between these comparisons. Nevertheless, it is important to emphasize that

because there isn't a direct translation of fairness into the Nepali language - and in fact, the mother tongue for many respondents was not Nepali but other regional languages- effectively, we who are conducting the study supply the notion ourselves. This compound concept is the respondent's *perceived fairness* of the institutional arrangement associated with the canal.[121] There were individual differences in which of the comparisons a particular user conveyed as connected in this way. However, across all individuals who were interviewed, at least two of these notions were likely to appear in a connected fashion.

This method has consisted of tracing the connections between notions of fairness in the responses of a single respondent and then gathering elements that appear connected when I consider all of our conversations together. It has not narrowed down on a universal notion of perceived fairness across all cases, but it has delimited the set of concepts from which at least two are likely to appear in any individual notion of fairness that users might convey.[122] The following sections attempt to refine this idea of fairness by first identifying questions in the survey that indicate the separate comparative statements, and then examining how user responses to these questions relate to performance of the institution.

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[121]If these same respondents were to learn English and then be asked to talk about 'fairness' in this new language, they might not touch upon the same elements, and their understanding of the term may thus be different. However, we would expect some overlap.

[122]If I were to regard this notion of fairness as a norm that is internal to the individual, and possibly highly specific, I have found commonly connected elements of all the norms I encountered while at the same time allowing for individual variation. It is important to note here that while we may be tempted to infer that this is evidence of "shared norms" common to a group, I would need to specify what this group is. In our cases, most of the respondents have not had contact with each other and live far apart. Furthermore, they are from a wide variety of ethnic groups, castes and cultures. This removes the usual groupings from consideration.

3.6 Fairness and Institutional Performance

If the above argument that decreasing commitment by users, or fewer committed users, leads to a decline in institutional performance is correct, it should appear in the survey data as well. When other reasons for decline can be ruled out in these cases, there should be a relationship between the indicators of perceived fairness and those representing canal performance.

For a thorough assessment of perceived fairness I examine three aspects: how the concept relates to performance in each of the two points in time; and also the relationship between changes in perceived fairness and changes in performance over time. The latter relationship of changes to fairness and performance will become more precise presently. This section takes up each of these aspects in turn, after first going over some preliminaries related to measurement of perceived fairness including confounding variables that relate to both fairness and performance.

3.6.1 Mapping Responses to Questions

Since the questionnaire was not designed to get at a user's perception of fairness, only some of the questions map directly onto the comparisons that have been identified above. For example, the question of whether the rules favor some over others was asked in the questionnaire. Other comparisons were not directly asked about and I approximately matched concept to question. When this mapping was done fo each time period, this resulting in two sets of indicators of perceived fairness - one for each round of the survey.

It is necessary to preempt interpretation with a word of caution to the reader. In conversations with users of any particular canal, it was never the case that all of the notions of fairness in Table 3.3 came up. Therefore, it is not possible to say whether the other notions in the cluster are related to each other in cases where they were not

mentioned.

However, by proposing to examine the relationship between all of the notions in the cluster and performance in all of these cases, there is a subtle implication that such a universal connection might exist. In other words, in motivating these comparisons, I have assumed that even in cases where specific notions did not appear, they might have appeared had enough people been spoken to or had the same people been spoken to differently. In this way, the analysis has moved from individual notions of fairness to a common set representing the general elements of any notion of fairness (while allowing for individual variation).

The results below support this assumption, but it should be noted that the assumption itself cannot be taken for granted.[123]

3.6.2 Confounders

Based on observations in the field there are two variables that may affect both perceived fairness and performance at the same time. These are whether or not the canal has received government assistance, and whether or not it was in the original study. The more prominent of these unexamined factors is whether or not the canal has received assistance from government or any outside source.[124] It is very common for canals and other infrastructure to receive assistance from government agencies, or donor agencies. In these cases, 80% were reported by users as having received assis-

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[123]Particularly because fairness is often fruitfully regarded as a "norm" that is internal to an individual, or that is shared amongst one's group - whether cultural, religious, ethnic, social or otherwise. It is not usually regarded as having any universal elements among people who otherwise appear unrelated. In contrast it is a variable that is given responsibility for explaining why different individuals or groups appear to assign different weights to the variables in a universal cost-benefit calculation.

[124]The question asked was: "Has any private agency, government or donor given assistance?" (Yes/No) The respondent was then asked to elaborate based on their memory.

tance. In nearly all of the cases (98%), users had reported having received assistance when the canal was first constructed. This assistance comes in the form of money, expertise or direct assistance with repairs or maintenance. The stated rationale behind all of these forms of intervention is to improve the functioning of the canal.

In response to persistent criticisms from scholars that improving physical infrastructure alone is inadequate, assistance has also taken the form of "local capacity building" and similar exercises aimed to improve governance of the infrastructure.(Chambers, 1988) For example, it was common for donor agencies to give aid for assisting in the formation of Water User's Groups, and "handing over" government run canals to these groups. In other instances, the formation of such associations was made a prerequisite for receiving any formal government assistance.[125] Overall, government assistance attempted to improve the effectiveness of local governance as well as assist with physical maintenance. At the same time, many international aid agencies and charities were also lending support - usually in the form of physical infrastructure - to these canals. In all but a handful of cases in this sample, the interventions were seen by users as coming from "government" or *sarkar*. Thus the remainder of this chapter refers to outside assistance and government assistance synonymously - although there might be very significant differences.

Regardless of whether these interventions achieved what they were intended to, having a formal and visible relationship to the government can be a significant influence on the perceived legitimacy of the institution governing a canal. The following example typifies one way that this influence manifests.

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[125]In Nepal's case, changes to the Nation's laws facilitated this process through the Water Resources Act of 1992 in which it was stated that all such associations, if formed, would be "Corporate Bodies" registered with the national government.

The respondent was an older man, retired from the "Indian Police"[126], and receiving a monthly pension from the Indian Government. He worked as a guard for a Water User's Association of a canal in the Mid Western Hills of Nepal. The position of monitor, or guard, is one of the most difficult to fill in these local bodies. The individual users are normally very familiar with each other and having to enforce penalties against these same people with whom there are myriad other connections is unpleasant. The position is also seasonal and commonly underpaid, as evidenced by the fact that few want to do it.

In this case, Mr. Gurung had agreed to be the guard because he was convinced that it might become a permanent, pensioned, government position. The officials of the User's Association, he reminded us, had good relationships with the government "sir's" at the district headquarters. He had even acted as a guide during their visits with foreigners who came to study the canal in order to evaluate a previous intervention, and to assess whether to provide more assistance. The secretary of the association had promised to take up his demand of an office, which would be a step closer to an official position, with the people who visited. This was one way that assistance connoted the greater possibility of a longer term relationship with government agencies. Having received assistance already indicated an existing relationship with the government.

A second example illustrates how important this perceived connection with an outside entity- especially government- can be. In a canal in Eastern Nepal, one man had led the Water User's group since its establishment 20 years ago. He mostly lived in the city nearby, and rarely visited his village land. But, he was known for his ability to get government projects for the canal and the village. Indeed, even before

[126]Which could have meant the army, a police force, or working as a guard for a security company.

the group was registered, he had been a sort of local leader. And although the rules required elections every three years for a new head, he had been re-elected every time. The users of the canal- regardless of position along it, whether head, middle or tail- admitted that these connections were what made him the most legitimate option. As one of the users said, "we even visit him sometimes to plead with him to remain the leader."

In light of these findings, the main variable that relates to both a user's perception of an institution and the condition of the canal appears to be whether users remember assistance by government, or from the outside. While the ability of a water user's association to get such support might appear to be a relevant quality of the institution, it may be the result of other factors that are less related to the institution itself. For example, the canal may have been selected by a donor agency sponsored project by the department of irrigation for reasons of convenient location or because it was already "on the radar" (meaning, it was familiar to them). At the same time, government assistance or outside involvement can appear to confer legitimacy on the institution or impact the user assessment of fairness as well. Not controlling for it could be severely misleading.

This is connected to a second, less prominent variable that might increase the chance of government assistance: the fact of being in the original study. Recall that the initial case selection upon which this dataset was built came from existing studies at the time. Many of these studies were done before or after assistance had been provided to the canals. In the original sample, all but two had received such help. Thus, when I returned to the same cases I would be returning to cases that have been "on the radar" for three decades or more. Because this particular dataset has been widely studied and scrutinized, there is a chance that even more attention has been paid to the cases in it.

To check the possibility that being in the study might foreshadow subsequent government assistance (even if the users don't remember it), an additional random sample was added to the second round as a comparison. Table 3.4 below shows that any relationship between the two of them can be attributed to chance. There does not appear to be a relationship between being in the study and receiving assistance. Although the reasoning appears plausible, the evidence is not compelling enough to control for this variable also.

Table 3.4: The connection between sampling and assistance Being in the original study does not relate to having received receiving some form of assistance from government or other sources.

	In the original study?		
Received outside assistance?	Yes	No	Total
No	38	10	48
Yes	156	29	185
Total	194	39	233

Fishers Exact=.391

3.7 The Significance of Fairness

In order to control for the effects of outside assistance, the cases were divided into two groups: those in which users remember having received government assistance at some point and those in which they don't. It was then possible to examine the relationship between indicators of fairness and performance in each group separately. This procedure was repeated for each round. In the first round nearly all canals had received government assistance, so it was not necessary to control for it.

Overall, many indicators of fairness have a significant relationship to indicators of performance. This relationship is also in the direction that would be expect from the interviews and the earlier discussion: the more fair the institution is perceived to be by its users, the better it seems to perform. There are also much fewer significant

relationships between fairness and performance in the group that has not received memorable government assistance.[127] These are shown in Table 3.5, Table 3.6 and Table 3.7. These tables show that when looking at the two time periods and the two groups, the perception of fairness is related to institutional performance.

The relationships from the most recent round are in tables 3.5 and 3.6. They show that about half of the indicators of fairness relate to perceived performance and the other half to both perceived performance and physical condition. The indicators of fairness that relate only to perceived performance pertain to characteristics of the rules that might eventually lead to uneven distributions of water or work. The indicators that relate to both perceived performance and physical condition pertain to the distribution of water and work at that time. In particular, they relate to inequalities at the time in the distribution of water across space, the distribution of water across people, and the distribution of work across users. [128]

The first survey round shows differences and similarities with the most recent one. The most prominent differences are that in the first round, there are many more indicators of fairness that relate to performance (ten rather than seven).[129] Furthermore, none of these variables relate to the physical condition of the canal but only to perceived functioning. This was most likely because, having just received assistance

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[127]Nearly all of the cases in the sample had received some form of government or donor assistance around the time that they were first studied. Thus, when in the second round users did not remember it, this was attributed to the intervention not being memorable enough for users.

[128]A remaining variable that relates to perceived performance asks whether the gap between those who get the most and the least water is getting bigger. Of the questions asked, this asks most directly about the changes in the relative distribution of water. However, the relationship to performance is weak, and is apparent only in the case that there has not been government assistance. Changes in perceived water gap is examined more closely in another, more reliable, way in a later section on the dynamics of fairness.

[129]This is despite looking at timeliness in the second round, which was missing in the first.

from government and donors, the physical condition of the canal was in a relatively good condition already. This initial assistance functions as a rest for this study by bringing the physical conditions of all of these canals to a relatively higher level at the start of the study.

Table 3.5: *[with government assistance, second round]* Association between indicators of fairness and performance, of institutions with memorable outside assistance (N=184). Out of 35 possible relationships, 10 are significant at the 0.01 level. The values of the fairness variables are either yes or no. The values of the performance variables are poor, fair and good. $\Delta\%$ is the percentage of good performing cases in the fair group minus the unfair group. P-values are from Fisher's exact test.

	Observed Physical Condition				**User Perceived Functioning**					
	Canal		Head		Reliability		Timeliness		Adequacy	
	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p
Do some parts get less water than they want?	19.87	0.004**	3.69	0.634	28.35	0.001**	32.61	0.000***	30.46	0.000***
Are rules about who can be a user well defined?	−10.00	0.349	−13.19	0.100	−1.25	0.204	−4.31	0.123	12.78	0.007**
Are there users who consistently get less water?	17.44	0.003**	2.90	0.289	15.56	0.025*	20.08	0.038*	20.02	0.027*
Is the water gap getting bigger?	5.05	0.374	6.68	0.808	−5.47	0.279	8.94	0.527	−3.80	0.112
Do rules give some groups a preferred season?	10.00	0.272	3.61	0.810	1.25	0.806	20.28	0.008**	−12.78	0.358
Do the rules give some groups unequal duties?	7.16	0.005**	10.90	0.317	−4.95	0.787	−3.61	0.457	−15.94	0.155
Are the rules perceived as legitimate?	−14.55	0.160	7.27	0.497	11.52	0.008**	2.42	0.018*	35.15	0.001**

**Note: *p<0.05, **p<.01, ***p<.001*

Table 3.6: *[without government assistance, second round]* Association between indicators of fairness and performance, of institutions without memorable outside assistance (N=41). Out of 35 possible relationships, 1 is significant at the 0.01 level. The values of the fairness variables are either yes or no. The values of the performance variables are poor, fair and good. $\Delta\%$ is the percentage of good performing cases in the fair group minus the unfair group. P-values are from Fisher's exact test.

	Observed Physical Condition				**User Perceived Functioning**					
	Canal		Head		Reliability		Timeliness		Adequacy	
	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p
Do some parts get less water than they want?	3.26	1.000	7.43	0.870	24.28	0.139	2.35	0.432	19.74	0.060
Are rules about who can be a user well defined?	7.36	0.540	−5.84	0.921	18.62	0.075	7.58	0.202	9.53	0.368
Are there users who consistently get less water?	7.06	0.785	19.76	0.218	16.73	0.226	1.41	0.299	26.41	0.049*
Is the water gap getting bigger?	28.21	0.210	30.77	0.167	20.83	0.008**	−6.41	0.522	28.53	0.011*
Do rules give some groups a preferred season?	9.04	0.909	11.90	0.227	−4.76	0.794	−40.71	0.037*	−18.57	0.052
Do the rules give some groups unequal duties?	30.56	0.028*	21.47	0.307	3.29	0.156	10.86	0.544	11.62	0.209
Are the rules perceived as legitimate?	11.11	0.501	8.34	0.066	−19.44	0.020*	−2.77	0.758	−11.11	0.172

**Note: *p<0.05, **p<.01, ***p<.001*

Table 3.7: Past association between indicators of fairness and performance, of institutions with memorable outside assistance ($83 \leq N \leq 186$). Out of 40 possible relationships, 13 are significant at the 0.01 level. The values of the fairness variables are either yes or no. The values of the performance variables are poor, fair and good. $\Delta\%$ is the percentage of good performing cases in the fair group minus the unfair group. P-values are from Fisher's exact test.

	Observed Physical Condition				**User Perceived Functioning**			
	Canal		Head		Reliability		Adequacy	
	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p	$\Delta\%$	p
Have members of this group invested their own labor or resources?	3.41	0.817	−3.98	0.863	−24.23	0.020*	−37.35	0.000***
Can users predict which parts will get less water?	−6.80	0.760	3.89	0.709	4.80	0.155	48.92	0.001**
Have any users been consistently disadvantaged?	−7.14	0.545	−11.35	0.186	29.83	0.000***	39.02	0.000***
How complex are the rules?	7.68	0.701	−7.88	0.588	24.54	0.038*	40.48	0.001**
Do the rules assign substantially more duties to some groups?	4.95	1.000	−3.51	1.000	59.47	0.000***	15.25	0.040*
Are some groups given better positions/seasons/locations?	8.29	1.000	−4.61	1.000	65.18	0.000***	21.54	0.007**
Do the rules give substantially more privileges to some groups?	4.13	1.000	−4.03	1.000	58.04	0.000***	22.02	0.005**
Do the rules give substantially more water to some groups?	10.42	0.677	1.05	1.000	49.65	0.000***	10.57	0.208
Do some parts get considerably more water than others?	5.22	0.548	11.49	0.192	14.75	0.024*	31.46	0.000***
Have the relatively worse off been deprived?	5.48	0.815	−2.18	1.000	30.06	0.008**	22.61	0.053

**Note: *p<0.05, **p<.01, ***p<.001*

Consequently, this also suggests that over time those variables which pertain to distribution come to affect the physical condition faster than those that pertain to the structure of the rules. Their appearance, however, only seems to occur in institutions which in which the users remember having received government assistance.[130] In the unassisted cases, only one variable- the water gap- appears to relate to performance by the second round, and that too weakly. [131]

At the same time, however, the condition of the headworks - in contrast to the channels- exhibits no relationship with perceived fairness in either of the two rounds. This is likely a consequence of the fact that the intake is the only part of the canal that affects every user: it determines how much water is available to everyone. Other parts of the canal affect only those that have fields downstream of them. For this reason, government and donor assistance is likely to focus on the headworks. Similarly, users also pay greater attention and effort to keeping it working and it is usually in a better condition than the other parts of the canal.

3.8 The Components of Fairness

Comparing the indicators of fairness that appeared significant in the first and second rounds leads to a further refinement of the meaning of perceived fairness. The similarities in the two rounds is shown in Table 9. This overlap is a consequence both of how I have chosen to study the cases and of the observations themselves. It is possible, as discussed below, that the notions of fairness change over time. These

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[130]There is the possibility that the type of assistance given subsequently was different from the first. I take this up in the next chapter.

[131]It should also be noted that there are many more missing responses in these first round cases and so the total number of observations, N, for each test differed ranging from 83 to 186. In the first round, none were missing. Nevertheless, this variation in the usable sample per test does not impact our questions as I use an exact test to compute the significance statistic.

Figure 9: Elements of fairness then and now: This figure shows the questions about perceived fairness that appeared to be significant to performance in each of the two survey rounds, along with those that were in common in the two. The shaded boxes indicate that the question was significant in that round. The overlap suggests that the elements appear to be largely similar over time, although their relative significance might differ.

	Round	
Question	**1**	**2**
Are the rules perceived as legitimate?		
Do users contribute their own labor or assets?		
Do some parts get predictbaly less or more water?		
Are there any users who have been cosistently disadvantaged?		
Do taking rules give consistent advantage?		
Do boundary rules give consistent advantage to some subgroups?		
Do rules assign unequal work to some subgroups?		
Have the relatively worse off been deprived?		
How complex are the rules?		
Are rules about who can be a user well defined?		
Is the water gap getting bigger?		

commonalities suggest that this change comes from shifts in the relative emphasis of their constituent elements in an overall assessment, while the basic components do not appear to change.

To get at the components, it is necessary to more carefully examine the possible reasons that this overlap might appear. Recall that the notion of fairness was first constructed inductively from concepts that appeared related in conversations with users and that, at the same time, were also recognized as corresponding with my understanding of fairness. In the next step, I selected those questions from the survey that reasonably indicated each of these concepts.

Since this survey was not designed to examine fairness, it did not ask about all aspects of fairness as I understand it. Similarly, the questions were derived from an earlier survey which was itself based on a particular framework (the CPR framework). Thus the questions were more detailed versions of the questions that our those con-

ducting the first study[132] suggested might be significant enough to include in their survey. Their framework did include a notion of relative distribution of resources, the proportional allocation of work and characteristics of the rules.[133]

The notion of fairness in their understanding was different in basic ways from the one that emerged through our interviews.[134] At the time of the first survey, the meaning of fairness was taken to be known by those conducting the study. All of them were trained to use the underlying framework and the study was designed to find evidence supporting it. The enumerators were asked to assess, for each case, whether they thought the arrangements that they saw appeared fair.[135] The first round of the survey thus captured the notion of fairness as perceived by the users of that framework, and not necessarily the users of the resource.

In light of this, the elements of fairness that is used in this study arose from three overlapping perspectives. The idea of fairness that the current analysis has ended up with was formed with elements that met three criteria, implicitly: I recognized them as elements of fairness; the original surveyors recognized the their possible significance although they may not have known how; and users expressed them in a connected fashion. This resulting compound idea of fairness cannot claim to completely capture either the users' understanding of fairness nor our own understanding of fairness. However, it does capture the intersection of these understandings and

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[132]Ostrom's team.

[133]Although the words "relative" and "proportional" are used in that theory as a comparison of the work one does with the resources one receives not as a comparison with others.

[134]For example, fairness is taken to be a component of performance, and not a determinant of it.

[135]In fact, there was another level of interpretation as well. The cases in the original study were coded from other studies that had already been done. Although some of them were revisited later, most were meta-analyzed.

represents a sort of minimally recognizable set of elements of perceived fairness.

It is now clearer how I have projected a notion of fairness onto the responses of users. Overall, it is much more likely that this sort of projection has no relationship to performance. But the evidence, from multiple angles, confirms that this is not so. As this analysis has shown the projection has shown to be much more related to performance than can be passed off as a fluke. Not only that, these associations appear in two moments in time. That these indicators demand explanation in this way provides some needed confidence in them as the analysis proceeds to examine their changes over time.

Over time, it is reasonable to expect that these notions of fairness change. Instead, however, recall that the elements of fairness that relate to performance appear to have stayed largely the same, although their effects appear to have changed. This suggests that there is some temporal stability to these elements that I have found, although their importance may change more frequently.[136]

In each of the two survey rounds, these indicators of fairness fall into two categories in terms of what effects they have, and what aspects of the institution they refer to. One category consists of indicators of outcomes - the actual distribution of water and work. Changes in these aspects of fairness affect the physical condition eventually. The second category consists of indicators of the rules - more specifically, uneven treatment of users by the rules at points in time. These latter aspects of fairness appear to affect the perceived adequacy and reliability of the canal but not the physical condition.

This dichotomy within fairness between outcome and rules matches a similar dis-

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[136]I also note that in both rounds, several fairness-related variables that I expected to relate to performance did not.

tinction in the Nepali language. Recall that there is no direct translation of the word "fairness" into Nepali. When one looks for a translation, two concepts in the language that appear to relate to fairness in general usage. The first is the notion of whether or not an action was done in a rule bound manner. The word used here is *niti purna*, or *niti baddha* which means rule-ful or rule bound. The second notion resembles fairness in outcome. The word for this is *nyaya-purna* or embodying a sense of just outcomes. These ideas map, imperfectly but informatively, into the English notions of fairness in process and fairness in outcome. As seen above, forms of these two aspects also recur in discussions of fairness with respondents as well as the survey data - including the data collected between 16 and 37 years ago.

Similarly, the elements of fairness that were uncovered empirically can also be assigned loosely to these two aspects. To summarize, the first aspect refers to assessments of the rules based on outcomes attributed to them, or their features. The second aspect refers to outcomes that are not explicitly tied to the rules. These confluence suggest the following classification into four overlapping components that affect the perceived fairness of the institutions under study:

1. **Water Gap** : This refers to the relative distribution of water between users. It includes the questions of whether the difference in amounts of water received by the biggest user and the smallest user is increasing; whether some users get more water than others; whether some parts get predictably less water than others; and whether the relatively worse off have been deprived of water.

2. **Work Gap** This refers to the relative assignment of work by the rules amongst users. It includes questions of whether the rules assign disproportionate duties to some subgroups of users; and whether users are required to contribute their own labor and assets to the maintenance of the canal.

3. **Qualification** : This refers to the rules about who qualifies to use the water and who doesn't. It includes questions of whether the rules about who can be a user are well defined; and whether the rules for becoming a user assign consistent advantage to some subgroups.

4. **Exclusion** This refers to the exclusion, or marginalization, of some qualified users for long periods. This includes questions of whether the relatively worse off have been deprived of water; whether there are some users who have been consistently disadvantaged; and whether the rules give some groups consistent advantages.

These four components of fairness encapsulate the findings so far about what perceived fairness means and how it can be detected. Having thus reached a more precise idea of fairness that is common to the two survey rounds, it becomes possible to examine how changes to perceived fairness of the institution relate to changes in performance.

3.9 Dynamics of Fairness

In the above analysis, there are two fronts that are weaker than the others. First, the analysis of perceived fairness and performance to this point has only looked at their static relationship. No mention is made of time or changes to performance and perceived fairness. However, this is an important aspect to look at because it offers an answer to the question of whether changes to perceived fairness of the institution relate to changes in the performance of the institution. Table 9, which shows the overlaps in the questions that indicate various aspects of perceived fairness , sets the stage for this analysis.

Second, there is a question raised by the static comparison of these two aspects

that remains unanswered. This question pertains to why different aspects of canal functioning appear to be related to perceived fairness in the two rounds. In the first round, as shown in Table 3.7, perceived fairness appears to relate only to user perceived aspects of canal functioning - the adequacy and the reliability. There does not appear to be any relationship to the physical condition of the canal. However, by the second round, as shown in Table 3.5, two indicators of perceived fairness - the Water Gap and the Work Gap - appear related to the physical condition of the canal. This suggests two immediate explanations. One is that the relative importance of the different aspects of fairness has changed. More specifically, the water gap and the work gap are now much more important than before. A second explanation is that the relative importance of the different aspects have not changed. Instead, the deterioration in the physical condition is due to the cumulative effect of a persistent perception of unfairness. Both possibilities are likely, but trying to distinguish them would clarify how perceived fairness has an effect over time.

To distinguish which of these two processes of change might be more prominent it is necessary to examine the relationship between changes in fairness and changes in performance over time. Having found comparable indicators of fairness for the two rounds, it was possible to compare the two values for the same canal and generate a third variable that indicated whether each indicator had increased, stayed the same or decreased.[137] This is shown in Tables 3.8 and 3.9, again controlling for government

[137]This has no absolute meaning however, as the answers were coded as Same, Better or Worse. It should also be noted that the idea of "changes" may be ambiguous because the same respondents were rarely asked these questions. More likely, the users who used the canal in the first round were different from those who used it in the second. It is the case that the respondents in the two rounds may have different ways of evaluating the same thing. However, just as the simplification is made that respondents are reliable in their answers, a similar assumption is made here. Namely, that speaking to more than one person more or less at random provides an assessment of the canal that is more or less representative of most users.

assistance.

While we see that the changes to perceived fairness do relate in the expected way to changes in perceived performance i.e. those that came to be perceived as more fair were associated with improved performance, they do not relate to the physical condition. Thus, changes in perceived fairness appear to be related to changes in user assessments of the canal's functioning but not the physical condition. The relationship over time is also weaker than at either point in time.

This gives more support to the second interpretation that the perceived unfairness of an increasing, and persistent, Water gap and Work gap accumulate over time. So, this suggests that the reason that there was no relationship between fairness and physical condition in the first round was because the effects user perceived inequalities in work and water had not accumulated to the point of affecting the canal physically.[138] This suggests an analogy between our notion of fairness and an idea of 'marginal' perceived fairness that has a marginal effect on perceived functioning - an effect that accumulates over time and eventually results in visible deterioration. The dynamic notion of fairness that emerges is one in which the components of user perceived fairness largely remain the same, and perhaps their relative importance changes, but their effects accumulate over time.

Decreases in the other two components of fairness- Exclusion and Qualification- appear to act as a sort of warning that perceived fairness is declining. In much the same way that a fever alerts a physician to the fact that something is amiss inside the human body, but does not pinpoint the cause, these two aspects pertaining to the rules alert the observer that perceived unfairness may be accumulating in the users.

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[138]However, since there is no information about these cases before the first round, this assertion cannot be checked in this way.

To the extent that the rules are responsible for the Water and Work gaps, they also alert one to a possible cause.

These dynamics, however, appear to be set in motion or to be enabled by a memorable relationship between the institution and outside government bodies. This is examined next.

Table 3.8: *Changes over time, with assistance:* Association between changes in indicators of fairness and performance, of institutions with memorable outside assistance ($63 \leq N \leq 145$). Out of 16 possible relationships, 4 are significant at the 0.01 level. The values of the fairness variables are either yes or no (coded as 1 and 0). The values of the changes in performance variables are worse, same and better (coded as -1, 0 and 1). r is the correlation coefficient to indicate direction. P-values are from Fisher's exact test.

	Observed Physical Condition				**User Perceived Functioning**			
	Canal		Head		Reliability		Adequacy	
	r	p	r	p	r	p	r	p
Are the rules perceived as legitimate?	0.14	0.306	0.26	0.056	0.04	0.965	0.19	0.018*
Do users contribute their own labor or assets?	−0.09	0.655	0.04	0.068	−0.08	0.009**	0.06	0.184
Do some parts get predictbaly less or more water?	−0.16	0.239	0.05	0.517	−0.13	0.046*	−0.01	0.003**
Are there any users who have been cosistently disadvantaged?	−0.18	0.083	−0.05	0.954	−0.15	0.256	−0.23	0.034*
Do taking rules give consistent advantage?	0.18	1.000	0.03	0.470	−0.40	0.005**	−0.14	0.242
Do boundary rules give consistent advantage to some subgroups?	0.18	0.887	−0.02	0.585	−0.29	0.022*	−0.11	0.476
Do rules assign unequal work to some subgroups?	−0.31	0.263	−0.24	0.330	−0.35	0.018*	−0.11	0.128
Have the relatively worse off been deprived?	0.08	0.368	0.03	0.761	−0.17	0.009**	−0.18	0.078

**Note: *p<.05, **p<.01, ***p<.001*

Table 3.9: *Changes over time, without assistance:* Variables coded as above. No significant relationships at the 0.01 level.

	Observed Physical Condition				**User Perceived Functioning**			
	Canal		Head		Reliability		Adequacy	
	r	p	r	p	r	p	r	p
Are the rules perceived as legitimate?	−2.78	0.643	−2.78	0.712	21.57	0.380	9.15	0.977
Do users contribute their own labor or assets?	80.65	0.098	80.65	0.262	−16.13	0.640	−40.62	1.000
Do some parts get predictably less or more water?	33.33	1.000	25.00	0.077	0.00		0.00	
Are there any users who have been cosistently disadvantaged?	−18.18	0.152	1.82	0.941	45.00	0.089	41.90	0.409
Do taking rules give consistent advantage?	0.00	0.643	−25.00	1.000	38.89	0.015*	27.78	0.207
Do boundary rules give consistent advantage to some subgroups?	−16.67	1.000	−33.33	1.000	40.00	0.132	10.00	1.000
Do rules assign unequal work to some subgroups?	−57.14	0.200	28.57	1.000	54.17	0.105	19.44	0.818
Have the relatively worse off been deprived?	−27.27	0.770	−31.82	0.203	86.36	0.036*	63.64	0.192

**Note: *p<*.05, **p<.01, ***p<.001*

3.10 Fairness and Government Assistance

In the results above, changes in perceived fairness almost never exhibit a relationship with performance in those cases where users don't remember there having been government assistance. Similarly, over time, changes in fairness do not appear related to changes in the physical condition whether in a fashion that is unrelated to whether users remember government assistance. However, if the users do remember government assistance, there is a relationship between indicators of fairness and canal condition by the second round. This suggests that the relationship of fairness of performance expands to physical condition more rapidly in those cases where there has been memorable government assistance.

This raises a further possibility that the notion of fairness that is being used here was introduced with the first intervention, and then memorable interventions subsequently sustained that idea of fairness locally. Since all the cases had an intervention in the beginning, it cannot be ruled out that this notion of fairness that was derived inductively was actually introduced and sustained through interactions with the "outside". This is consistent with the observation that the relationships do not arise in those which did not see subsequent intervention after the initial one. Thus, while the notion of fairness that has been used so far was derived from interviews with users, it is not possible to rule out that the idea of fairness did not originate locally. For example, it is possible that the users learned these ideas of fairness during the process of the government intervention.

From the view that fairness is purely intrinsic to individuals and groups, and therefore not likely to be shared with outsiders, there is a different implication of these patterns. From this perspective, the differences in the number of significant relationships might suggest instead that the interactions with more powerful outside entities facilitated the expression of latent notions of fairness. For example, weaker

and poorer users who felt excluded felt more able to express themselves when they felt there as a long standing government commitment to the canal. Thus, the effect of government intervention would be understood to encourage the expression of a user's perceived fairness, rather than to influence the meaning of fairness to the user.

While both possibilities are suggestive, at this stage there is not enough evidence to argue that either is more the case than the other. Thus these cases suggest that there may be learning between users and government about what fairness means, and users may feel more confident speaking about and acting upon perceived unfairness when a government agency has shown long term involvement in their institution.

3.11 Conclusion

This chapter has explained how I reached the conclusion that perceived fairness affects whether or not users of an institution continue to cooperate with it. Beginning with the interviews, I listened to why users continued to work on the canal as well as why they stopped. These reasons appeared different, and therefore prompted me to examine whether this was a systematic relationship. The data showed that there was indeed a relationship between perceived fairness and sustained performance, both over time and in the two time periods. This relationship held for changes as it did for static comparisons.

Thus, I concluded that perceived fairness was an important factor in whether users continued to cooperate with an institution. The elements of fairness - the water gap, the work gap, qualification and exclusion - do not define fairness but they do indicate what the elements of fairness are in these cases. This brings distributional considerations to the fore, although not in the manner that prior theories have done. Instead of being the cause of institutions, or the cause of institutional change, perceived fairness as it is defined here affects performance of an institution and its

ability to adapt to changing circumstances. Perceived fairness is not enough to explain the variation however, as users still have to find rules that match the external conditions as well as the internal notions of fairness. In the next chapter, I take up this question and identify a feature that helps to explain this: the flexibility of rule application.

4 Flexibility

The last chapter demonstrated that how fair an institution is perceived to be relates to its performance, as well as its long term survival. However, being perceived as fair does not ensure that the institution will perform well. Indeed, even such a relatively fair institution may gradually decline. This is because perceived fairness is one of many factors in a user's decision to cooperate with a set of rules that are aimed to regulate their behavior. Analogously, one of the many requirements for an institution to last is that its users continue to cooperate with it. A second requirement for the institution to perform well over time is that it continue to change in congruity with its circumstances, broadly considered. If the canal is faced with the damaging effects of floods and landslides for example, the rules may also have to change in order to fit the new conditions.

Even when they perceive the rules to be fair, users still have to devise rules that fit their changing circumstances. In the face of rapidly changing circumstances, these rule changes may have to be made quickly. In this chapter, I show that an important source of new rules is the experimentation that is already occurring among users. These "experiments" are allowed for by gaps between rule implementation and the working rule. However, too much flexibility can easily contribute to a perception that the institution is unfair. Here I present a notion of bounded flexibility which is normally tolerated by users and that serves as a source of new ideas when rules have to change. The empirical analysis that follows shows that rule flexibility is associated with better performance when the institution is generally perceived as fair. However, when it is perceived as unfair, the association reverses: the less flexibility the better.

This finding contrasts starkly with the existing rational choice assumption that rules have to be clear and well enforced in order to be effective. (Ostrom, 2005). It suggests instead that too much rigidity can be harmful to the ability of users to up-

date their rules to match changing circumstances. It also shows the significance of rule ambiguity, as defined by the historical institutionalist school (Mahoney & Thelen, 2010a), to learning by users when the institution is otherwise perceived as fair. Thus, although flexibility enhances already fair institutions, it worsens those that are perceived as relatively unfair.

4.1 What Cooperation Looks Like

When the institution is well adapted to its circumstances, canal management by farmers resembles a well synchronized dance. Each canal has its own version of the performance, and this is most visible during canal cleaning days. Usually well before the rainy season, farmers gather to perform a ritual to begin the planting season. Then they break up into groups and move to different parts of the canal, carrying shovels. One of them uses his stick to measure out, end on end, how much each person needs to clean, although this can vary. The same stick is used every year, and is the unit of measure for assigning cleaning work. In most cases, a farmer who irrigates twice the land that another does is assigned twice as many stick-length units of canal to clean. They might also work in groups[139], sharing the work between them and alternating roles. If so, at each location, one man stands in the canal and shovels mounds of sand out of the channel, and onto the ground alongside it. They break for a mid afternoon meal (*khaja*), work through the remaining daylight, and go home as the sun sets. These "labor days" go on until the canal is clean and ready to carry water to their fields. Throughout these work days, the individual farmers behave as though they know exactly what needs to be done, and what other farmers will be doing.

[139]The groups might be small teams of four or five people at various locations along the canal, or a majority of users working in a particular location at once.

This synchronicity continues into the planting season. The morning of the first day of watering, the owner of the plot closest to the canal's water source starts the day by diverting the channel to his fields. He leaves, and comes back to meet the next person in line at their appointed time with a greeting and conversation, usually about the canal or the water. He stops the diversion of water into his land[140], leaving the next in line to divert the water to their fields. A third man walks along the canal regularly to make sure that the canal is operating as it should, checking for cracks and blockages. As each person in line alternates into the irrigator position, all the fields become watered down to the very end of the canal. It usually takes a week to water all the fields depending on the crops, the amount of water and the rules for distribution. Months later, depending on what the users have planted, crops all over the irrigated area mature in sequence of their watering, ripening and changing color reflecting the order in which the farmers got their water - a closing scene that can be awe inspiring.

The pattern of performance rarely plays out in similar fashion every year. Rivers change course, are flooded, farmers leave for work; new people who don't know the rules buy land in the command area; arguments become heated; someone may complain that they are not receiving enough water, and so on among many other possibilities. Sometimes, the farmers may need to temporarily adjust their performance. At other times, they may need to alter the rules governing their practices. Every change has uneven effects on farmers. For instance, some may end up getting less water, others may end up with a more preferred position in line, yet others might end up with a higher burden of cleaning.

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[140]This diversion may consist of a hole in the mud lining of the channel, or it may be a more advanced control structure such as a metallic gate that is lowered and raised by twisting a handle.

Nevertheless, the farmers remain uncertain about what new conditions may arise and how that might affect the water they receive, and ultimately, the crops that they will be able to grow. The working rules that farmers use to synchronize with each other are subject to changing circumstances, mostly beyond the farmers' control. Yet, to keep the canal functioning they must coordinate their actions and work together. The result of dancing to different tunes is often a season of reduced crops, tightened belts, borrowing money, and possibly wage labor as porters in town. Of course, a set of rules has no agency of its own, even though it might outlast individual farmers and be passed on across generations. It is the farmers themselves who must ultimately change the rules that comprise an institution. This too requires cooperation between the farmers. First, the farmers must cooperate with each other to change their rules, and then they must cooperate with the institution's rules in order for it to function as intended.

Successful canal governance institutions are able to give farmers reasons to cooperate in the face of double uncertainty. Farmers are always uncertain about how their circumstances might change. Therefore they cannot know how they might have to change their rules as a result. It is only when something actually changes that they must figure out how to solve the problems that it causes. At times, they end up copying another institution's rules, or asking for the advice of a government engineer. At other times, they widely adopt a practice that only a few deviants had been doing against the rules of the institution. Some groups are better able to meet the challenges of change, and some institutions are more permitting of such adjustment than others. The question of why this variation in the ability to adapt occurs is explained in the remainder of this chapter.

4.2 Common and Uncommon Circumstances

There are many complex circumstances to which institutions may need to be adapted by their users, including changing relationships between users, external conditions of their environment, and technology among others. Some of them are specific to particular institutions or locations. For example, about 20% of canals in the sample are frequently damaged by natural disasters such as floods and landslides while the remaining 80% are not. The rules must accommodate these conditions. There are many more such conditions that only some institutions experienced, and that fewer may have had to respond to. Consequently, over time each institution accumulated an increasingly specific history of circumstances that it has faced. The uniqueness of this history is also reflected in the rules of the institution. In the GD Canal, which I describe next, it was only after a new headworks had to be built because the old one was damaged by a flood that the institution included a rule specifying what was required of users in emergency situations such as building a new headworks. In a similar way, a location's particular history is one of the reasons that the specific rules of these institutions differ even though, on the whole they are all intended to help manage the canal.

Along with these differences, there are also circumstances that most of these institutions are likely to have encountered.[141] For example, an existential decision that a group of users must take is who qualifies to use the water from their canal and who does not.[142] The specific criteria used by these institutions to grant access to the canal

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[141]This prediction that cooperation between self-interested individuals faces particular challenges comes from game theoretic analysis of the decisions and strategic situations faced by users. See Gardner et al. (1994) for a detailed analysis.

[142]In nearly all of the cases, this criteria is expressed as a rule, and in this way it is made a part of the institution.

are shown in the first column of Table 4.1. It is common to find combinations of these requirements, such as both the ownership of land to be irrigated and the payment of a seasonal water fee.[143] Most institutions in this sample contain rules concerning the allocation of water, of work that has to be done on the canal, and for punishing rule breakers, monitoring activities and resolving disputes.[144] Similar to the variety of rules that define eligibility, there is a range of specific rules that address each of these situations.

Table 4.1: This table shows how many institutions have a particular requirement for becoming a user. The leftmost column contains the various requirements. The remaining two show the number in the first and second visits. The second round of visits shown includes the added sample of 39 together with the 202 that are still surviving from the original sample.

Requirements for becoming a user	First visit	Second visit
Be a resident of the locality	3	46
Be of a certain ethnic group or caste	0	1
Be a member of a certain organization	54	39
Own shares in the canal	4	12
Own or lease rights to water	12	17
Pay a seasonal water fee	20	52
Own or lease land in the location	193	146
Have continuously used water in the past	4	19
Use water only for agriculture	21	23
Get rights through a lottery	0	1
Own shares in an organization	1	2

Note: 78 in the first round and 100 in the second require multiple criteria.

Table 4.1 has several notable features. The requirement that a user be a resident of the locality is becoming more widespread, as are the requirement that users pay a seasonal fee to use the water or that they have used the water continuously in the

[143] 33% of institutions in the first round and 36% in the second required a combination of criteria in order to use the canal.

[144] These comprise the six important aspects that are addressed by long-surviving institutions. See for instance Ostrom et al. (2009) for a discussion. Although hypothesized to be common features of these institutions, it is not clear in these cases whether rules governing these six aspects were introduced by donor projects during the first intervention, or whether they arose independently of that.

past. At the same time, two requirements are becoming less common. These are that users be a member of a particular organization in order to use water, and that users own or lease land in the command area. The particular organizations referred to here are Water User's Associations or similar organizations, which may or may not have been established according to the rules of the institution. While the table does not indicate why particular rules changed as they did, there have been attempts to develop methods for studying the relationship between rule changes and changes to external circumstances such as in Ostrom & Basurto (2011).

Before moving onto an analysis of the factors that influence adaptability across institutions, it is useful to examine the process of change in more detail. Indeed, this intertwined complexity of change, learning, trial and error, and adaptation is common to all durable canal management institutions. But it can also be highly specific to particular institutions. Nevertheless, this complexity is best illustrated by a specific example that contains both common and particular aspects in order to make concrete the subsequent examination of the commonalities.

4.3 An Illustration

The GD Canal in Western Nepal has been in continuous use for nearly sixty years. A year after it was upgraded to have a large concrete weir at the headworks and handed over to the users to manage in 1995, it was severely damaged by a flood. Funding for this project had been provided by the Agricultural Development Bank, a major government bank. The handover was implemented as part of a "Community Irrigation Project" funded by multiple international donor agencies through the setting up of "federated" user's associations that were formally registered with the Department of Irrigation of the Government of Nepal. As part of the handover, and with help from the Department of Irrigation, the users adopted a constitution that stated the rules for

how the canal was to be used.

Each village had its own Water User's Association. The four villages jointly managed the canal through an umbrella association that had representatives from each village, in proportion to the division of water between them. Each of the four associations had its own constitution, written at the time of the handover. The constitution followed a common template. These constitutions allowed for the election of a local chairman although users reported that these leaders were chosen by consensus before the election, which was seen as a formality. This position was usually assumed by the largest landholder, or the person who already held the position of leader in the local government of the area, such as the former *pradhan pancha*.[145]

A concrete aqueduct that carried water over the river to fields on the other side was among the parts damaged by flood. This relatively advanced - and expensive- structure served two villages. More importantly, the headworks itself was also damaged. The umbrella association eventually received money for the repairs from the Department of Irrigation. The users repaired the headworks and created a diversion to bypass the aqueduct and get water to the two villages. The new diversion was damaged the following year, this time stopping water from flowing to one of the two villages on the other side of the river. Because the required repairs served only a single village, the umbrella association decided that the village association should bear the costs. The repair that resulted was temporary and unreliable, primarily because the users in this village did not know how to repair it properly, and had less money

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[145]Five years after moving to a democratic constitution from an absolute monarchy, villages in Nepal were still dominated by families that had governed during the Royal Administration, or the Panchayat System. For donors who were looking for efficiency, and because of the practical difficulties of holding elections for these Water User's Associations, letting villagers choose a leader by "consensus" was the most reasonable and practical thing to do. Few locals wanted to upset locally powerful families by opposing the candidacy of the former leaders, or *pradhan panchas*.

available to do so than the parent association would have had..

4.3.1 The Politics of Change

After being neglected by their parent association, the users in this fourth village that was left to itself decided around 2007 at their General Assembly meeting that they would formally separate from it. By this time, "The People's War" waged by the Maoist Party had forced large landholders to stay away from the village for many years at a time. Consequently, the landowners' influence over the Water User's Association had weakened and the chairman, who had been the chairman from the very beginning and was a prominent representative of the largest landholders, stepped aside "to give others a chance."

The new chairman - also chosen by consensus[146]- was the head of two other local organizations. He was the elected chairman of the Village Development Committee for his village, which is the lowest level administrative body of the Government of Nepal.[147] But more importantly, he was the chairman of the local branch of the Nepal Communist Party (UML).[148] This new chairman had proposed the separation after being confident that he would get support because of his formal and informal connections with the District Development Committee and the UML.

Prior to the split from the parent Water Users Association, it had been difficult

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[146]Although nearly all of the canals had formal mechanisms of elections for leaders - a required feature of donor-supported Water User's Associations- they seemed to use elections only to resolve difficult disputes. At other times, the elections merely formalized agreements that users had already reached amongst themselves and outside of these formal, and foreign, mechanisms.

[147]There are many wards per village, many villages per district, and 75 districts in the country.

[148]This party is also called the UML, or Untied Marxist Leninist which is different from the Maoist Party. As the major opposition party at the time, the UML had been in and out of power multiple times since the country had moved to a multiparty system in 1990. During the People's War, the UML was also targeted by the Maoist rebels.

for him to justify using resources from the Village Development Committee(VDC) for the canal because it was the formal responsibility of the Water User's Association. His party superiors had also indicated that the funds that they had secured for him through administrative channels should be used for other things such as seed distribution.[149] This was a logical way to counter the power that the other political parties[150] had gained through their dominance of the umbrella water user's association. But in the face of changed circumstances, discussions with his fellow comrades turned up a new idea: repairing the canal in the name of the party in order to fill the political vacuum that was being created with the departure of the old chairman.

By showing the promise of support from his party, and with Rs. 5000 [151] of discretionary funds from the VDC, he could now ask other users to contribute towards the construction of a new headworks downstream from the aqueduct. According to this plan, a simpler headworks was to be built with stones and twine. It would be in such a position on the river bank that it could funnel water into a part of the old channel that was sufficiently upstream from the village to irrigate most of the fields that used to be irrigated. Once approved by a meeting of users, the committee hired brick and cement workers (*mistris*) from a nearby town. Other villagers carried stones and other materials as needed to save on wages that would have been paid to day laborers. The same group of users also donated materials such as stones and brick, loosely based on how much land each user irrigated.

According to the rules of their institution, none of these additional contributions

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[149]This emerged through interviews of the chairman, as well as party functionaries at the district level.

[150]In this case, the major party was the National Democratic Party (RPP), and the Nepali Congress.

[151]This was about 70 USD in 2007. The monthly salary of an entry level government employee at the time was around Rs.5000.

were required from users. In fact, the old rules did not address emergency situations in which a new intake had to be built. Instead, there was an informal understanding between the representatives from the four user's associations that they would all help each other as needed. Thus, this was the first change in rules because of the shock. The institution now requires mandatory contributions to cover emergencies and unexpected circumstances in proportion to the water that a farmer uses.[152]

The most difficult contribution to secure, and also the most contentious, was the land to build the new intake. None of the farmers whose land could have been used for this purpose wanted to lose a piece of fertile land bordering a canal without being compensated adequately. However, paying them market rate would have made the whole project unaffordable. Here again the UML came into play - other officials in the local party organization convinced a farmer who was also in the party to donate some land for a token amount. [153]

4.3.2 An Invisible Glue

Eventually, all the different dynamics came together and the headworks became functional. Despite money coming from the Village Development Committee, and all of the other contributions of labor, materials and land coming from users, the common refrain amongst farmers was that "our own party made it." The role of a non-local political party in the resilience of local canal governance institutions like this one is very common but also relatively invisible to a passing observer.

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[152]According to users, the General Assembly adopted this rule because a user had seen that other similar groups also had it

[153]Respondents would not disclose what the deal entailed, but it was clear in interviews with the farmer in private as well as the other party members that he had been promised something in return by the district level party organization.

On the surface, this appears to be a classic case of collective local decision making, the entrepreneurial spirit of a local leader, and spontaneous self-organization by users in the management of a canal. All three were the explicitly intended goals of handover projects like the one that established the Water User's Associations. Yet, the glue that held many overlapping resources together was a national political party, not the local irrigation institution.

There is a second reason that an observer who is unfamiliar with the party politics in Nepal might wrongly conclude that formally recognizing local self-governance is responsible for adaptation in this case. It is very difficult for an observer - especially one that does not speak Nepali - to become aware of the political currents in these local institutions without carefully listening to farmers. Even for native Nepali speakers, deciphering subtle verbal gestures can be difficult because the mother tongue in many locations is not Nepali but another regional language. There is also an active effort by local leaders to show that they are conforming to what is expected by observers. Thus, the second reason that party-politics remains invisible has to do with how the outside observer gets her information about the canal.

For example, in the GD Canal one of the the chairman's strengths was that he could communicate with donors and consultants who came to study the canal, and evaluate their aid investments. As the chairman admitted, one of his qualifications was that he "knew the answers." The chairman's job was also that of an ambassador who, with help from people he knew in his party, understood what the donors were looking for. Across canals, the chairmen knew that "working together," "voluntary villager contributions," "cooperation," "local resolution of disputes," "regular meetings," "inclusion of ethnic minorities" were keywords to be mentioned. They knew never to talk about the involvement of political parties, but to always stress cooperation.

Indeed, he would not have told such a visitor that "our party did it." Once a good

impression was made that a well functioning former development project that did not suffer from "political capture" and "elite capture," the chairman would hint at problems that required financial aid such as the damaged aqueduct, or the need to upgrade the wall linings. This kind of framing helped to secure financial assistance.[154] Formal visits from donor agencies were always announced beforehand, and word made its way down to the chairman before the actual visitors did.[155] So, he was always prepared.

4.3.3 Changed Conditions

The new intake created a new set of operational challenges. As described earlier, the new structure was not as advanced as the original one and less water was available to users. It was also less reliable because it could be more easily blocked by rocks and debris; and it was more prone to damage from yearly swelling of the river. In turn, this meant that for water to reach the tail end users, others had to limit their usage more than before. There were many who were reluctant to reduce their share, especially those who lived closer to the head- because they were used to taking as much water as they wanted.

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[154]As a journalist with whom I was travelling noted, it was his experience that donor agencies had their own constraints, especially when doing field visits. They liked to have a list of "model" examples that were neither too successful nor too dismal for easy intervention when needed. Although this sounds cynical,the extent to which the local leaders of these water users associations knew what visitors might be looking for, and the extents to which every respondent went to identify which donor agency the visitor was associated with, made it hard to dismiss.

[155]In a similar manner, in nearly all of the systems surveyed the most visited users had devised informal ways to handle outside assistance as well. In the case of this survey, the enumerators all identified themselves as students and explicitly denied having any association with donor agencies, the government of Nepal or media outlets. Showing the villagers university issued identification cards reassured the most skeptical, to an extent. In contrast to other visitors, with students the respondents tended to feel that they needed to explain "how things worked" in their village, resulting in more detailed replies.

The rules stated that each farmer would receive water in proportion to the land they irrigated, and in return each user was required to contribute labor in proportion to their irrigated land. When the old canal was functioning anyone could take as much water as they needed during their time slot. At the beginning of the time slot, the next person would make sure that the opening before theirs was closed before directing the water to their fields. Because of the abundance of water, it was common for the next in line to wait until morning even if the handover time was in the middle of the night. During a time of relative abundance, the turn based sequence was primarily intended to make sure that everyone got water in time. It wasn't aimed to limit water use.

With the new headworks, and the much smaller amount of water available, the turn based system turned into a way to limit the amount of water that each user took. Before the new headworks, the general feeling amongst users was that they were all making do with a temporary arrangement. However, having invested heavily in a new construction, all expected more than was available.

Monitoring of handovers became more strict. The guard who was responsible for checking for damage to the canal now started enforcing penalties for overuse. Arguments between users over water became common, and there were incidents of vandalism: the most common form was taking a shovel to another's field channels, preventing them from taking water in turn. The next user in line would sometimes camp out all night to make sure that he got his water. If the prior user did not stop drawing water, there could be a physical confrontation. And the issue would be brought up at the meeting of the User's Association, making these meetings more contentious and longer than before. Paying the fine for taking more water became seen as a necessary cost by some farmers who could afford it : after all, once water had been absorbed into the soil, there was no way to take it back. So, increasingly some wealthier farm-

ers upstream began taking more water than they were allowed. Reduced water use also reduced the amount of labor that people contributed to maintenance. The length of canal that had to be maintained was the same, but fewer man-days were available to maintain it.

Another set of institutional challenges came from the location of the new intake. Water now entered the canal further downstream from the original intake. Before, the water would flow over a long length of canal before reaching the village, and would deposit silt along the way. But now water reached the village directly from the river, thereby carrying more silt into the village's channels. This demanded cleaning more often lest the volume of the canal decrease. The headworks also required more maintenance and oversight as it was no longer a permanent structure. Any damage to the headworks would eventually result in less water in the canal, so users had a good reason to detect problems early. But increased inspection meant more work for users.

Conflicts had also increased with non-users. For instance, a group of people from Rolpa, a mountainous district to the North, had fled the People's War and settled upstream of the new headworks. They made a living by operating a water powered grain mill, which diverted a substantial amount of water from the river when it was in use. This hadn't mattered before because the previous intake was upstream of the mill. But now, their water use had caused direct confrontations with the users of this canal. A group of five to ten farmers would occasionally visit these non-users at night and demand that they stop. Not many farmers wanted to go on these intimidation visits, and their rules did not require it or compensate them for their extra effort.

The old rules were not working with the new conditions. Table 4.2 shows the old rules, the problems arising from changed conditions and the new rules that came into being. How they came into being is described next.

Table 4.2: This table shows the old rules, the new conditions and the problems as well as changes that arose from them in the GD Canal.

Old Rules	Changed Condition	Resulting Problems	New Rules	Resulting Solutions
Association was governed by an umbrella association, which received funds from government agencies for repairs to member canals	Repeated damage to the intake of this village's Canal reduced water availability and reliability.	This village was forced to repair the damage on its own without assistance because the damage did not affect the other villages.	Formal separation from the umbrella association.	This allowed the group to make decisions independently of the umbrella association, and receive direct funds from government agencies.
No specific rules requiring the contributions for emergency repair.	A new headworks had to be built because of repeated damages to the old one.	Farmers were not willing to contribute. They were unclear about how much or what to contribute, and whether others would also contribute.	Rules requiring voluntary contributions for emergency repairs. Contributions in proportion to land irrigated by each farmer.	This made it more clear what an emergency situation was, and what each farmer would be required to contribute.
Mandatory labor contributions from farmers in proportion to the land irrigated. No outside labor used.	A smaller intake, made of temporary materials. Less water in the canal.	Less water available meant less land was irrigated. This reduced the amount of man-days of labor available for maintenance.	Allow the use of hired labor from outside of the village.	This increased the available labor pool beyond what users were willing to do.
Water applied to the fields based on time slots that were enforced by users themselves.	Less water available, downstream users camping out at night to make sure transfer was on time. Increased user vigilance.	Increase in arguments and suspicion between users. Relationships between users becoming contentious.	Rotate yearly whether the tail end gets water first or the head.	Users were more confident that they would get water. But the rule changes alone did not solve the contentious relationships.
Payment of a fine for using too much water.	Much less water available overall.	Wealthier users upstream regularly used more water allowed, and paid a fee.	Rotate yearly whether the tail end gets water first or the head.	Those at the tail end had equal opportunity to abuse the fine.
No rules about how to resolve disputes with non-users	The new intake was downstream of a grain mill that used the same river's water.	Reduced water in the canal when the mill was in operation. Conflicts with the mill operators.	Informal agreement with mill users diverting a proportion of water to them regularly. Remaining sent to the canal.	A clear division of water between the mill and canal.

4.3.4 Institutional Adaptation

The result of mixing old rules and new conditions was that the canal began to deteriorate. Much less water was available, especially to downstream users; fewer workers were available to maintain the canal; and the group of users became highly suspicious of each other. The user's group meetings were dominated by disputes between farmers. Yet, the institution changed eventually and still exists. There were three elements of this adaptation: experimentation, withdrawing of cooperation, and another political party.

The new canal intake required more labor input to maintain, increased the expectations of users, and demanded voluntary contributions from farmers whose time was already scarce in the planting season. In response, the farmers at various points along the canal - the head, middle and tail- adopted different strategies to cope with these changes.

The users who were closer to the head were also wealthier, and had larger plots of land. The chairman's plot was in the middle of the canal, but closer to the head than the tail. His was also the area where the UML was strongest, and even those with smaller plots in the middle had more influence now because of their party's control of the Water User's Association. But the rising prominence of the UML in the canal's association had made it more difficult for party members to punish each other for breaking the rules and taking more water.[156]

Those farmers who were further downstream began to lose hope that the canal would serve them. They were normally the poorest, and belonged to an indigenous

[156]Interestingly, this suggests that in this case, political homogeneity made enforcing rules more difficult, which is in contrast to the prediction that heterogeneity is more of a challenge to local self-governance than homogeneity.

ethnicity, not the now dominant Tharus. Although the largest landholder had his land close to the tail, his family had not returned to the village with the same power as before the People's War. His land was one of the main reasons water continued to flow downstream towards the tail was because of this man's land. So, his relative powerlessness resulted in less water at the tail. Instead of working in agriculture, the tail enders began to seek work for a daily wage in the nearest town. The journey was too long to make frequently, and so they began spending more time away from the village.

In the past, most of the workers for upper parts of the canal had come from these villages at the tail. Farmers at the head end had sent their children to schools in town, or were themselves teachers and grain merchants. Their families, although large, were not in the village regularly. In fact, although the institution's rules didn't allow it, these users often hired wage laborers from other villages and towns to work on the canal instead of family members as required.[157] However, that these users were breaking the rules had never been a point of contention with the other users - "they were doing their own things, we were doing our own things," was how one tail-ender described it. But now the tail enders used this as an example of how the powerful people "always broke the rules" and they also claimed that "the rules are just to keep us poor."

Another change had resulted in alternative economic and social options for the tail enders. A few years before, Christian missionaries had begun to convert people living at the tail with the promise of a better living and also instant freedom from an oppressive caste system. Those affiliated with this new religion appeared economically better off, and received regular support from Christian organizations in

[157]This was not explicitly allowed in this institution, although it was in many others.

Kathmandu and abroad. Priests in particular were paid a regular salary, and others received training in sewing, crafts, and other work. This was drawing more and more tail enders away from agriculture, especially the younger ones who enjoyed the singing during church, as well as bible reading gatherings.[158] Indeed, the poorest tail enders - those who were most likely to work on the canal for wages - gradually began severing all interdependence with those further upstream, effectively distancing themselves not only from the canal institution but the society of canal users as it was.

As the tail enders began to move towards other occupations, they effectively withdrew their cooperation with the institution for managing the canal. Consequently, a major source of labor dried up too. This made it even more difficult for other users to keep the canal in functioning order. Another direct result of this was that the user's association changed its rules to allow hiring labor from outside to do work on the canal. This turned an activity from the realm of rule breaking to the norm, because it seemed to work in this new situation. Other users even relied on the networks of people that the former rule breakers had used to secure workers. But this was not a solution: not everyone could afford paying for workers, and without willing workers from amongst the canal users, the shortage continued to he felt.

As those furthest from the head stopped engaging in agriculture, those who were previously in the middle of the canal became the new tail end canal users. There were many in the former middle who still engaged in agriculture, and unable to receive regular water or speak up at the user's association meetings they tried another approach. In town, a few of them met with members of a second political party, The

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[158]There was a visible difference in villages in which Christian missionaries had organized the locals. They were defined by a prominent church made of concrete, and bright colors. And homes could often be seen displaying portraits of Christ that were placed directly adjacent to the main entrance so as to be visible to passerby outside, as if to announce independence from generations of religious and economic oppression.

Nepali Congress, to try to broker a deal with the leaders of the UML controlled user's association.

However, the users who had turned to this other party later felt the effort did not work primarily because the Nepali Congress was not powerful enough to force a compromise. In fact, they said that turning to another party had made it more difficult to be "heard" by the leaders of the user's association. However, the chairman who had overseen the building of the new canal eventually stepped aside. Like his predecessor, he said it was "to give other people a chance." More likely, his party had come to sense that a political opportunity was opening up for an opposing party.[159]

Under the new chairman, the rules changed again. The boundaries of the canal were now drawn closer to the head. This excluded those at the furthest end of the canal, the former tail-enders, from the user's association.[160] They changed their rule for allocating water between the remaining users. Instead of the users at the head end receiving water first every season, they alternated with the tail. If this season, those at the head end took water first and the sequence moved down, then next season those at the tail would take water first and the sequence would move up. The leaders of the user's group also came to an agreement with the mill owners upstream to divert a certain percentage of water to them and the remaining to the canal users.

This modified institution appears to be meeting the needs of users so far, and those who are using it report that the canal is functioning in a relatively timely, adequate and reliable manner. The physical condition of the canal is also good, although the headworks is damaged almost yearly. However, the users have repaired it quickly

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[159]This is an educated guess based on hints dropped by other users. Because the change had taken place in the last two years, no one appeared to want to directly confirm what had happened.

[160]This was decided at the general assembly which those downstream had not attended, having stopped taking part in the institution.

every time so far, with financial assistance from the Village Development Committee.

4.4 A Note on Analysis

Two assumptions are very important to discuss before moving the analysis forward. They are common to all studies of institutions as rules, but are often left implicit. One assumption is that these institutions have a function; and that they are not, for instance, residual customs that have no practical use. In the cases of canal management institutions, it is normally assumed that the institutions exist for the management of a canal. Another assumption is that these institutions are necessary for canal management, and that the canal would not be managed well without them.

In one view, the institutions enable users to cooperate with each other in order to reach an outcome that would otherwise be unreachable. For example, canal management institutions are taken to serve two primary functions. One, they encode many years of experience about canal management and specify what needs to be done when in order to keep that particular canal functional. And two, they are agreements between individual users regarding monitoring and punishment that make it easier for them to believe each other. Ostrom (2005)

An alternative explanation is that institutions exist primarily to enable one or more social groups to control others. In the case of canals, this would imply that the main purpose of the canal management institutions is to ensure that the more powerful groups can secure more of the water for themselves than other groups.[161] In some situations, this argument is compatible with the view that the institutions might assist in canal management. For instance, if the dominant group needs the

[161] See for instance Knight (1992) for a detailed statement of this argument.

help of others in order to continue using the canal then the institution would include a way to get their help so as to keep the canal functioning.

The main point of difference between the two is the greater role given to social conflict in the latter compared to a greater role for cooperation in the former. Both are incomplete however because one, in order to fit the specifics of the canal the institution will need to have certain types of rules. And since there are often many possible rules that could be adopted by a group of users to maintain the canal, there must be a way to choose between such rules. Even the first view admits that there is a choice of possible rules. But, the process is formalized as groups of users getting together to discuss and vote on the proposals, with the dominant coalition having their proposal accepted. When framed as social conflict, even the very process of voting compared to, say, decision by a leader results from the relative power of opposing groups.

Neither view addresses how these groups form and what defines a group. In the case of these canals, the groups are formed in two ways. On the one hand, they uneven effects on users of external changes and rule changes may lead to the formation of groups of users who are similarly affected. On the other hand, groups also appear to form based on the changing needs of the canal. In particular, depending on what the canal needs at any time users may be divided into groups based on whether they can do useful work, or whether they have social connections to people that can be of use. Thus, groups appear to form because of external conditions or the changing needs of the canal. Furthermore, the relative power of each group appears to come from how important their cooperation is to the continued functioning of the canal at that time. How powerful any group of users is appears to change over time and circumstance.

4.5 Institutional Variety and Performance

Thus, institutions for managing canals contain a wide variety of specific rules, even to address those situations that all are likely to have faced. Furthermore, even the most basic rules, such as those for eligibility, may need to be changed eventually. Thus, rule changes are not peripheral but central features of these institutions over time and dynamic environments. As an example, consider that in the current sample of cases, 63 institutions, or 27% of the original sample, no longer require users to own land in the area in order to use the canal. Of these 63, 20 (or 32%) have started to require that users be local residents, 15 (23%) now require membership in the water user's organization, 11 (17%) require the payment of a seasonal water fee, 6 (10%) require that users have some right to the water, and 9 (14%) now require that the individual has continuously used the canal in the past.[162] In contrast, some rules have remained the same as shown in table 4.1: of the institutions that require ownership of land in order to use water more than half had this requirement before.

In this way the evolution of a particular institution may be influenced by many other factors that are not apparent, and require a closer look into its history. These causes are not always environmental or due to economic conditions, but also include other reasons such as conflict among the users, configurations of power between national and local political entities, as well as distributional issues resulting from the use of new technology.[163]

Amidst all of these complexities, the performance of institutions over time is re-

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[162] It should be noted that just because a requirement is stated, it does not mean that "the requirement" is or can be enforced.

[163] As such, the rules are both historical markers of local group struggles (Knight, 1992) and responses to changing conditions of the canal (Ostrom, 2005) among other influences.

lated to two factors of prominent significance: the extent to which they are able to secure the continuing cooperation of their users; and, the extent to which they respond to the specific needs of any canal. As I have argued in Chapter 3, perceived fairness plays a role in eliciting continued cooperation from users of an institution in the face of changing circumstances. However, a perception of fairness does not imply that the rules are appropriate to the other conditions facing the canal: something more is needed. The remainder of this chapter examines how the rules are changed in the face of changing circumstances, and where the new rules come from.

4.6 The Role of Flexibility

Recall that when confronted with a reduced labor pool, the users of the GD Canal adopted a practice that was formerly considered a form of rule breaking i.e. the hiring of workers from outside of the village. When conditions changed, this practice came to be widely adopted for two reasons. First, the former rule breakers had developed contacts with people that they could rely upon to find workers. Second, this kind of rule breaking activity had been tolerated by the other users in the past. The rule-abiding users hadn't stamped it out either through more vigilant monitoring or by imposing punishment. Instead, there appeared to have been an implicit acknowledgement that the circumstances of those who were breaking rules differed to some extent from others who followed the rules.

Once conditions changed, however, the idea of how to adapt the institution came from an existing practice, albeit against the rules and practised only by those users who were relatively more powerful. In retrospect, this resembles learning from an unintentional experimentation process. Such experimentation is one of multiple ways new rules emerge when the old ones have become ill suited to new circumstances. Other possible reasons are communication with government agencies, donor agen-

cies or NGO's; communication with other user groups; as a result of interacting with visitors or talking to researchers, political parties and elder users. [164] During the interviews, the users also mentioned sharing ideas in discussion with each other.

There may be other forms of experimentation that arise because the working rules are inherently ambiguous. The resulting vagueness makes individual behavior deviate slightly across users and over time because they may understand the same rule slightly differently. Such ambiguity arises because the working rules are usually not written down, and are instead transmitted between generations through learning by doing or observing.[165]

But even when they are written down, they are written in Nepali, which may not be the mother tongue of users. Similarly, illiteracy is high among Nepali farmers, so rules are usually written down only for the purpose of registering the users association but not referred to thereafter.[166] In day to day activity, the users tended to use working rules that differed from the written rules to some extent.

4.7 Ambiguity of Rules

This question of how clear or ambiguous the rules are to users distinguishes two main theoretical approaches to the study of institutional change. It also raises a fundamental question of whether the purpose of the rules is really to facilitate cooperation or

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[164]Respondents tended to be curious about what other canals were doing during interviewing, and admitted to trying to learn from other groups. 35 (about 10%) admitted to having learned rules from another user group.

[165]36% had rules available to users in written form. Only three of 232 (9 No Responses) reported that the next generation of users learned the rules by reading them, while the remaining said they "learned by doing" or "learned by watching."

[166]A common response to the question of whether they had written rules was "Yes, you can find it in the district headquarters at the Department of Irrigation."

something else. In one approach, rules are regarded as clear and their implications for individuals are assumed to be largely known to each participant. In the other approach, rules are regarded as inherently ambiguous because they require the application of a general statement to many specific situations. Thus, users may not clearly know how any specific rule will affect them in practice, and they may have different understandings of what a rule means.[167]

Those who assume clarity also assume that the rules are known by all reliable respondents. The rules are analyzed in terms of their syntax: whether they permit, forbid or require an action, for instance. In this view, institutions are structures of logical rules that can be both expressed symbolically and also compared across cases.[168] In this study, I begin with the assumption that the working rules are known by every user, and that every rule can be expressed as permitting, forbidding or requiring any particular action. However, the purpose of this assumption is not to facilitate analysis but to make the current study comparable to the earlier one.[169]

In contrast, those who focus on ambiguity make yet another assumption. They must, first, explain the conditions under which a relatively common, shared understanding might arise among a group of users before jumping to sophisticated symbolic analysis. This leads to a semantic approach which begins with an examination

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[167]See Mahoney & Thelen (2010b) for an unambiguous elaboration of a theory of institutional change based on the presumption of ambiguity.

[168]In fact, this assumption opens up any analysis to more sophisticated tools derived from Boolean Algebra. An example of the general method as applied in the social sciences can be found in Ragin (1989), and as applied to these specific cases in Ostrom (2005) and Ostrom & Basurto (2011). An early exposition can be found in Boole (1854, Sec. V-XII).

[169]Another reason is that it makes a cross-case study such as this possible. If it is assumed that the understanding of rules in relation to actions are highly variable even within an institution, any study must ask enough users to be confident that the relevant variation is understood. In these cases, every institution's rules were gotten from 2 to 4 users. The survey did not reveal multiple, conflicting understandings of the rules, although they might exist.

of what any rule may mean in any particular situation and to whom. It is premised on the idea that clarity of the rules varies across individuals, institutions and time. So attention turns to other conditions that might affect the clarity of rules. Only after addressing this can one explain the role that rules actually play in any given institution. For my research, this approach would mean, first, a justification of why the rules might be relatively clear; second, why such a clear understanding is necessary for the institution to function; and finally whether rules really do play a coordinating role or primarily serve some other purpose.[170]

In the cases I examine, I assume that working rules are known to a large extent and in a similar way to most users. My research focuses on the working rules - that is, a set of functional rules about actions relating to a canal such as how work is assigned, or water is allocated. There is no ambiguity among users that these tasks have to be performed to have a functional canal, although they may have slightly different views about the frequency of tasks to be performed, how such tasks are carried out and such other issues. Second, the canals are regarded as needing coordinated behavior in order to continue to function. It is reasonable to characterize these situations as ones in which there is a level of common understanding that allows for coordination. Another element that contributes to this common understanding is communication between users. These are cases in which the rules cannot be so ambiguous that users cannot coordinate their actions to accomplish joint tasks such as cleaning, or repair.

Nevertheless, although a certain level of mutual understanding is necessary for the users to work together on a canal, ambiguity, as defined in the second approach is a prominent element in adaptation.[171] In every case there is a certain degree of

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[170]For instance, of excluding some users.

[171]Similarly, although I have assumed that the primary functional purpose of the institution is the

ambiguity about what the rules are, and there are gaps between the rule and their implementation. Such ambiguity provides an impetus for users to experiment with new rules, or try out deviations on old ones - because their needs might different slightly from each other.

In this way, flexibility can make users learn how to change under changing circumstances by providing room for deviation. However, the users are aware of this ambiguity and of the gap between any rules and their implementation. Indeed, users tend to be quite sensitive to any deviations from the rules when it might significantly impact how much water they receive.

Institutional adaptability results from how the users regard these gaps and the ambiguity, and deviations from the rules, as they understand them. In other words, it is related to how much variation the users can tolerate and what the canal needs. User perceptions of institutional flexibility both affects and contributes to how fair they perceive the institution to be. But more importantly, the overall effect of flexibility on performance is influenced by how fair they already perceive the institution to otherwise be.

4.8 Capacity and Knowledge

Over decades, most conditions that affect a resource and its users change. In the case of Canals in Nepal, the changes have been rapid and multidimensional. On average, each canal has experienced 4 such changes since it was first visited. These changing conditions have led to variations in the specific rules over time. Consequently, none of the institutions has remained unchanged in this period.

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maintenance of the canal, there are cases where the the institution exists to secure external support and the canal is actually kept in disrepair by "users" to justify the demand for financial help.

Amidst this complexity, some groups of users simply may not have the capacity to come up with appropriate institutions that can continue to elicit cooperation.[172] Yet, even after rules have been devised and users have committed to cooperating with the rules of the institution, there is always the question of whether the change will work. After all, the behavior that results from following the institution must keep the canal adequately functioning. Even if the rule change was imported from another canal, it may not have the desired effects in the new case.

In the face of this complexity and unpredictability, how do users know what rules to change, and how do they know what to change the rules to? A version of this problem is regarded in the literature on institutional emergence as the problem of institutional supply, as opposed to the problem of compliance.[173] In this literature, the prevalent hypothesis is that local users learn which rules work by trial and error. This leads to a process in which the rules are changed, the results assessed, and the change either kept or rejected, or changed further. Over time, this process of "search" is predicted to result in rules that "fit" given conditions most appropriately.[174]

There is a hint in this hypothesis, although not an explicit statement, that the conditions of the institution are relatively slowly changing. That is, the conditions are changing slowly enough for new rules to be tried out and assessed for fit. This assumption poses serious problems in settings where the conditions change rapidly. In

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[172]See Moore (1984) for an early critique based on the "capacity" of local users.

[173]In this view, good institutions are defined as those that are already able to elicit full compliance to the rules through penalties and monitoring. These penalties and the frequency or nature of monitoring require adjustment. This is the problem of institutional compliance.

[174]This argument about the complexity of local conditions is similar to the argument laid out in Hayek (1945) against centralized planning. They both rely on the presumption that at least some information relevant to the task- devising appropriate institutions the former and allocating resources efficiently in the latter- is unavailable to non-locals. The notion of search that is implied here is described in Simon & Simon (1962).

these situations, the process of adopting the new rules, and iterating in light of reflection might be too slow. Rapidly changing rules may also be concerning for users who look to institutions to reduce uncertainty about their future payoffs. In these cases, such users would not find much reason to cooperate with institutions that change as rapidly as the conditions. In light of the importance of fairness, it is also not difficult to imagine that constantly changing rules that have uncertain effects on different users might make the institution appear less fair.[175]

Adaptable institutions appear to change in order to fit their conditions, yet they don't seem to be so rapidly changing as to deprive users of a reason to continue to cooperate. All the same, the new ideas about rule changes must come from somewhere, and there is likely a process of learning by doing whether the doing is intentional or not.

Similar to earlier accounts, a central part of learning, adaptation and change is the importance of how the rules are enforced and monitored. In contrast to these explanations, however, these cases illustrates a relatively complex - but still systematic - role of flexibility and rigidity of rule application in successful institutions. Every institution exhibits some flexibility through a gap between the working rules and their implementation in practice. Overall, flexibility of rule application is an important source of experimentation and learning. However, the effect of this flexibility is not always positive. Instead, it relates to how fair the institution is perceived to be.

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[175]That any change in rules entails uneven impacts for different users has been documented widely. See for instance Knight (1992) and Ostrom (2005) for two examples from contrasting approaches.

4.9 Flexibility, Fairness and Performance

The forms of flexibility that the rules of an institution possess are reflected in three features of the institutions themselves. One form is the existence of gaps between the rule and practice. For example, if the rules forbid the transfer of water apart from land but users do it anyway, this gap makes the rules more flexible than they are. The tolerance of these gaps is indicated by the severity of punishment that the rules allow for.

A second form is the accommodation or discretion of those who are monitoring the implementation of rules. For example, if the likelihood that the fine for transferring water apart from land will be enforced is lower at one time than another the institution is more flexible.

A third form is how the rules are transmitted to new users. For example, if new users primarily learn whether or not such a transfer is allowed by observing what others are doing, or by trying it out in contrast to relying on a written or spoken rule, then the institution more flexible.

From these definitions alone, it is easy to see that flexibility in some respects might be detrimental to canal functioning. A gap between rules and practice can easily lead to users to lose confidence in the credibility of the institution. This may provoke some to fear becoming "suckers" by following the rules while others do not. The discretion exercised by monitors or officials could have a similar effect of reducing confidence in the institution. Finally, if everyone learns by doing in this fashion, this would propagate rule breaking behavior rather than behavior in accordance to the institution. Overall, too much deviation from the rules by other users can then lead to users not knowing what to expect from their neighbors. This could lead to situations characterized by "free-riding" or "shirking" and "otherwise acting opportunistically". Consequently, the difficulties in coordinating activities would lead to deteriorating

canal performance.

Thus, while flexibility might appear to enable experimentation, too much can easily undermine institutions by making users less confident about how others will behave. How much is too much is an assessment by the users of the institution, and it is set against the backdrop of how fair they perceive the institution to otherwise be. Furthermore, the availability of a space for experimentation does not mean that users will learn from it or even use it.

A systematic examination of the relationship between flexibility and performance overall does not show any significant relationships. However, separating the cases into groups that are generally considered fair and those that are not shows that there is indeed a relationship. Furthermore, this relationship existed then and it does now as well.

This relationship is more complex than it first appears because of the effect of fairness. As shown in Fig 10, when the institution is generally perceived as otherwise fair, flexibility is tolerated and does not have a negative effect. As discussed above, these tables show the indicators of flexibility and performance, separated into two groups in each table: those perceived as relatively unfair and those perceived as relatively fair. Keep in mind that there isn't a single indicator of fairness. Therefore,each cell in this table indicates the most significant relationship between the indicator of flexibility corresponding to its row and the indicator of performance indicated by its column. I separately control for each indicator of fairness from Table 3.5 for Round 2 and Table 3.7 for Round 1. Then, I show the p-value from the most significant of the relationships that arise when each component of fairness is controlled for in the cell. Note that these relationships are only examined for the cases which users remember having received government assistance, because the relationship between fairness and performance is otherwise not significant.

Figure 10: *The interrelationship between fairness, flexibility and performance*: The figures show, for each round, the significance of the relationship between indicators of performance (columns) and flexibility (rows), controlling for perceived fairness. The strength of all significant relationships (Fisher's exact, α=0.01) are indicated in the corresponding cells. Blank cells indicate no significant relationship. All relationships in the unfair group inversely relate flexibility to performance , while all relationships in the fair group positively relate them.

Round 1

	Fair				Unfair			
	Canal	Head	Adequacy	Reliability	Canal	Head	Adequacy	Reliability
How likely is the guard to impose a punishment?	0.001	0.007			0.008	0.008		
How likely are others to impose a physical punishment?		0.008					0.001	
How likely are others to impose a social punishment?		0.008						
How likely is the fine for missing a work day to be enforced?			0.001			0.002	0.000	0.009
Are there different punishments for different violations?				0.008				0.009
For how long can a user lose the right to take water?								0.003
Do they have the right to participate in canal management?							0.006	
Are the rules available in a written form?					0.007			

Round 2

	Fair					Unfair				
	Canal	Head	Adequacy	Reliability	Timeliness	Canal	Head	Adequacy	Reliability	Timeliness
How likely is the guard to impose a punishment?				0.006					0.001	
How likely is the fine for missing a work day to be enforced?					0.002	0.005				
How likely are others to impose a social punishment?	0.004					0.004		0.003		
Are there different punishments for different violations?	0.001									
Have they every used violence to enforce the rules?						0.001				
Have they used violence to change the rules?										0.007
Are the rules difficult to understand?								0.007		
For how long can a user lose the right to take water?								0.009		
For how long might they be shunned for rule breaking?								0.008	0.002	0.009
Have they ever tried to change the rules?						0.002				

For example, the question of whether there are different punishments for different violations shows two significant relationships. Both are with the reliability of the canal, but one appears when it is otherwise perceived as unfair (0.008) and the other when it is perceived as unfair (0.009). In the former case, the cell is green indicating a positive relationship. That is, the presence of "graduated sanctions," which indicates greater flexibility in rule application, is positively related to perceived reliability of the canal. In contrast, the relationship to reliability when it is otherwise perceived as unfair is the inverse, and thus indicated in a red cell. Having different punishments for different violations does not appear significantly related to any other indicator of performance (hence the blank cells) while controlling for any of the indicators of fairness.

In other words, each cell indicates the direction and p-value of the most significant relationship between the corresponding indicator of flexibility (row) and fairness (column) among the relationships that arise when each indicator of fairness is controlled for. As discussed above, I consider flexibility to manifest in three ways: the likelihood of punishment, the severity of punishment, and the content of the rules.

In this table, the less the likelihood of punishment the more flexible I consider the rules to be, as I have argued above. Different punishments for different violations are also indicative of flexibility. The use of violence to enforce the rules indicates rigidity, while rules that are difficult to understand are indications of flexibility as I have discussed above. Permanently losing the right to take water from the canal indicates rigidity, temporarily losing the right is more flexible and not losing the right is most flexible. I follow a similar interpretation of shunning, or barring, from participation in local society as a form of punishment. The ability to participate in canal management indicates flexibility, while the rules being available in written form indicates rigidity. Finally, having tried to change the rules indicates the possibility of it, and

thus is indicative of relative flexibility. None of these indicators display a negative relationship to performance when the institution is considered relatively fair by users - all relationships are non-negative. On the other hand, all significant relationships are negative when it is otherwise considered unfair.

Thus flexibility shows a generally positive effect on performance when there is a relationship. There is more that determines whether flexibility is fruitful, but it is clear that when otherwise perceived as fair, the space for flexibility does not have a detrimental effect on performance. When it has a relationship, it is positive. However, as the institution comes to be perceived as relatively unfair, this same flexibility has a strongly negative effect.

4.10 Conclusion

In this chapter, I have argued that one way that users learn how to change the rules when circumstances change is by learning from what other users are already doing. Overall, without a certain degree of bounded flexibility, institutions become delicate because of their inability to match changing circumstances. These findings are in consonance with a general understanding that when one feels that a rule is unfair, even slight rule breaking evokes a sense of further unfairness, and possibly a feeling of wanting to see the rule breaker punished. If they are not punished, then this can evoke questions about the larger system that the individual is following. Yet, when one has a general sense that the overall situation is relatively more fair, a few deviations can be tolerated and do not have this strong a negative effect. However, this tolerance only exists to a point and too much deviation by others to rules that one is bound by can have a similar effect of evoking a sense of unfairness, or the unsettling sense of a lack of a system. This has detrimental effects on its performance, and eventually undermines the institution as a whole.

Thus, when combined with the findings in the last chapter, the ability of institutions to adapt depend on two factors: perceived fairness and flexibility of rule application. This adaptability is thus primarily a consequence the extent to which users cooperate with the institution, which is influenced by how fair they perceive the institution to be and how flexibly the rules are applied.

5 Understanding Sustained Cooperation

Whether focused on institutions or individuals, the theories that I presented in Chapter 2 appeared to incompletely characterize the institutional foundations and mechanisms underlying sustained cooperation for using and maintaining a shared resource. The analysis that followed in Chapters 3 and 4 showed that two additional variables- the perceived fairness of the institution by its users over time, and the perceived flexibility of application of the institution's rules- become significant when looking at the same institutions over decades. It strongly suggests that the performance of long enduring institutions for managing shared resources depends on how well the working rules fit the users' sense of fairness over time, along with the commonly emphasized features of the resource and broad environment. I stopped short of a single definition in order to reflect the observation that it is multi-dimensional. The idea of fairness is open to discussion, although the discussion revolves around four key topics.

I explained this by arguing that perceived fairness underlines the commitment of users to cooperate with the institution's rules over long stretches of time. When the rules have to be changed, cooperation between users is necessary and this again is influenced by a user's commitment to the institution.

Thus, the findings in this dissertation provide evidence for a different way to understand why individuals sharing a resource continue to cooperate in difficult situations by bringing fairness to the forefront as a reason underlying institutional adaptation. In the rest of this chapter, I outline the contours of a theory of sustained cooperation built on the idea of perceived fairness, while highlighting the questions that it raises. This is a continuity of the discussion started in Section 2.5. I also summarize the stages of empirical investigation that led to this framing, in order to appropriately qualify the findings.

5.1 Empirical Foundations

Even though the objective is to understand sustained cooperation broadly, at this stage, the theory presented here is tied to a particular set of cases and a particular research design. The question in this dissertation was motivated by preliminary fieldwork during which I noticed a more complex reality than that which I had learned to expect by extant theories of cooperation. In particular, the institutions for managing shared canals in Nepal appeared much less isolated from non-local factors than they were said to be, and they also appeared to have survived conditions that were predicted to be the most difficult to overcome for this type of institution. This mismatch led me to replicate a prior study conducted by Ostrom and her team (Lam, 1998), in order to see whether these differences were systematic or not. In order to replicate this study, I interviewed most of those who had originally done the study and those whose studies of the canal had formed the basis of the earlier study. This represented the historical research stage.

Recall that the observations in this dissertation derive from a particular set of canals in Nepal which were studied at two points in time. While I had no control over the initial sampling of canals nor any claim to representativeness of a larger set of canals, I restricted the tools that I used to examine the data to non-stochastic methods and their corresponding interpretations. I added a set of 39 randomly selected canals, but these were not in the original dataset and so could only provide a recent snapshot.

The canals in this study are located in a single country (Nepal), albeit a diverse one with respect to geography and other features. These canals were subject to a similar set of complex circumstances during this time, and all had received assistance from government or donor agencies at the time of being included in the dataset originally. These largely external circumstances were rapidly changing and multidimensional -

the very characteristics predicted by those who had originally studied it to be most challenging for these institutions. They represented an example where sustained co-operation was unlikely.

The paneling of a long established dataset, the Nepal Institutions and Irrigation Systems (NIIS) database, is the main empirical approach of this study. This allowed me to examine the conditions faced by canals that were no longer in use, which earlier studies did not have information about. Using the data that I collected, I was also able to examine changes in the variables that related to canal performance over time. This analysis revealed that external conditions - regardless of complexity and frequency - did not significantly relate to performance. In order to do this however, I used a questionnaire that contained all of the questions from the first study. This had the advantage of allowing me to compare these variables across time, but I did not have control over the variables that were collected in the prior questionnaire. I did add questions based on my own fieldwork, but it was not possible for me to know what their answers would have been in the past. This limits any explanation that I provide to the data that has been collected. But, it also led me to collect interview data alongside survey data.

In this way, the second source of data was unique to my study out of necessity: 827 semi-structured interviews with respondents who were still using these canals, as well as former users of now defunct canals. These interviews formed the foundation of the exploration of fairness in Chapter 3. There were on average 3 interviews per canal, which were conducted with an official of the Water User's Association or user's group, any other user and a user belonging to a poorer looking household. An immediate improvement in this method would entail a more representative survey of the sense of fairness within these groups of users.

The turn to fairness was a result of trying to understand why some canals declined

while others did not even though they were all subject to challenging circumstances. And as such, it relied on the argument that when other factors can be ruled out, the performance of a canal is caused by user's willingness to maintain it. In cases where the functioning of the resource is not a direct consequence of user willingness to maintain it- such as shared fisheries- this argument may have to be made differently. It is only because a canal requires constant maintenance that I could make this argument.

I relied on the interviews in order to understand the reasons why users maintained the canal or stopped doing so. This is the major conceptual point of departure of this study from earlier studies of these same canals which assumed that the reasoning process of users was known to resemble rational choice, strictly defined. Systematically comparing the reasons users gave about why they stopped working on the canal, or lessened their work on it, revealed a common set of interconnected concerns. These concerns were also different when they spoke about whey they continued to work on it. Without a direct translation of fairness into Nepali, the conversations did not contain the word fairness directly. To go around this I used the interconnections between reasons given by a user and inductively constructed a multi-dimensional concept of fairness. There are 11 languages spoken by at least 1% of the population in Nepal, and the interviews were all conducted in Nepali. Nevertheless, most of these languages derive from Sanskrit and thus possess similarities in particular the ideas of Niti and Nyaya as described in Chapter 3. It must be noted here that this step of listening to interviews to understand the reasons for action is not necessary, or justified, if one begins with the assumption that users are behaving rationally in the narrow sense, and responding largely to a structure of economic incentives. The reason listening to interviews was necessary was the observation that the reasons for continuing to cooperate might differ from the reasons for stopping one's commitment.

In order to examine this concept of fairness systematically, I looked for questions

in the survey that could stand for each aspect of fairness thus constructed. Using the same questions in the two points in time, I was able to statistically compare performance to fairness over time. This revealed their significant positive relationship to each other.

The next part of the data that led to a notion of perceived flexibility of rule application consisted of ethnographic-type field visits of two cases. I selected these two cases because they were accessible and located in geographically different parts of the country. Following an approach similar to perceived fairness, I documented the relationship between flexibility, fairness and canal performance. The resulting analysis showed that flexibility and fairness could characterize the different qualities of cooperation that I observed, based on how likely it is to be sustained.

With this in mind, the question remains whether shared resources of a different type, in a different country, or at a different time may also show perceived fairness to be significant to sustained cooperation. A more general question would seek to understand a wider variety of situations in which cooperation is imperative, not just shared resource situations such as this one. Similarly, a more precise idea of fairness would be possible with a set of questions that are explicitly designed to distinguish the different elements of fairness that are described here. At the beginning of the study, I did not know that this notion of perceived fairness would come to explain sustained cooperation. Therefore, the empirical instruments that I used were not as refined as they could have been had I explicitly been in search for the effect of fairness. But even if I had known, I would have been restricted to the questions that had already been asked in the prior study. Instead, I have relied on non-stochastic statistical tests to detect relationships between concepts which I came to identity inductively from the interviews, and from direct observation of canal performance.

All said and done, this approach is a systematic observational study, which makes

strong claims based on the strength of multiple sources of evidence. Much more specific investigations of fairness and sustained cooperation may be possible through studies using a random, representative sample along with questions about the aspects of fairness in greater detail. Although, these studies too will have to contend with limited time series data, inherited sampling, and a set of variables which may imperfectly indicate the concepts to be examined. In any case, it will be necessary, to an extent, to begin with the definitions used by the earlier studies in order to ensure comparability across datasets as I have done here.

All of these implicit choices imposed limitations on what a straightforward analysis of the data can reveal, while at the same time providing a way to directly examine the dynamics of the phenomenon to be studied. The methods used in this dissertation offer a way out of the major limitations, however, by demonstrating the promise of turning to interviews. This departure would have been even more promising had there been comparable interviews to analyze from the earlier studies. As it is, I could only compare survey data across time periods.

5.2 Theoretical Implications

In order to understand why some institutions adapt and adjust while others decline in the face of changing circumstances, it is necessary to recognize that focusing on external conditions alone may not provide an adequate explanation of patterns that arise over long periods of time. The specific case studied here of users who are living in an interconnected situation created by the fact that they share a canal is an example where sustained cooperation is essential for individuals to achieve desirable outcomes. Indeed, as I have shown above, without sustained cooperation the canal will decline and become useless. The cases here are therefore not representative of institutions generally, but of situations in which sustained cooperation is essential.

There are two types of cooperation that must be distinguished based on who is cooperating with what. When I refer to sustained cooperation, I mean an intermixture of both of these. The first type of cooperation is interpersonal, and refers to cooperation between users. The second type of cooperation is between a user and the rules of an institution, which is usually indicated by the user obeying the rules, or continuing to commit to the rules. Making the distinction between the two of them clarifies the fact that what might be needed for people to cooperate with each other might be different from what is required for an individual to cooperate with an institution. Both types are necessary for institutions to adapt however: interpersonal cooperation appears to be of greater significance when rules have to be changed, and cooperation with the institution appears to be important at other times.

Furthermore, continued performance of the canal requires sustained cooperation to be directed appropriately. It is necessary for the users to know what to do when, how to allocate water, who can qualify to use the canal, how to resolve disputes and other operational guidelines. This direction is also provided by the rules for using the canal, which I have called the institution. In other words, even if users are willing to cooperate, they should be cooperating in such as way as to achieve the desired outcome. Therefore, cooperation alone might not result in desirable outcomes. Indeed, cooperation might even lead to undesirable outcomes when it is misaligned with what is to be achieved. Both organizations and institutions might direct cooperation, although in this case I am concerned with institutions.

The distinction between organizations and institutions is important here. Recall that in some cases, users had established associations to manage the canal, with formal membership and leadership positions such as a chairman. These Water User's Associations are organizations whose purpose is to manage the canal, they were created according to a more basic set of rules which are part of the actual institutions

that I refer to. The institution is the set of working rules which includes the rules that allowed for the organization.

Some of the working rules may have originated from an organization, and the organization may have been established because of other working rules. Furthermore, not every set of users might form an organization. The institution and the organization are different elements of these cases, but only institutions are part of the theory that is being elaborated here. I do not seek to understand what characteristics of organizations for managing a canal affect its performance. This is a legitimate question, but one that is not within the scope of this study. Institutions are the main focus here, and they are both dependent on users and also shape user behavior. Institutions thus defined as working rules need to be maintained, updated and changed. This, again, requires cooperation between users as well as an idea of what the changes should be.

Thus, the starting point of the theory is to conceive of a group of individuals who can achieve desirable outcomes through continued cooperation and coordinated action. They are in an interdependent situation where the actions of one affect the actions of others. In particular, there are strong reasons to shirk, free ride and otherwise act opportunistically for individuals who seek the maximum gain for themselves in the short run. They use a set of working rules, or an institution, to give them reason to cooperate or to direct their existing cooperation. Institutions may not be needed for cooperation, although some rules are likely to be required to convey accumulated knowledge about where to direct cooperation from generation to generation.

At any point in time, each user might make a decision about whether to continue to cooperate at the same level with the rules and with other users or to change their commitment either by increasing it or reducing it. When not at such a point of reflection, users continue to engage with the institution and with other users as they have been doing. This raises an associated question about the conditions under which

users reconsider their current commitment. I do not answer this question here, and assume that the changing awareness of users might make a user reconsider or question their current engagement. For example, they might learn from relatives about better opportunities elsewhere and decide to leave. Or they might become aware, through discussions with political activists, that over many years that the institution has been unfair to them and decide to look for alternatives. This question of what affects a user's sense of fairness is a question to be explored in future research. In particular, the connection between political activity and changing sense of fairness is yet to be explored in the current data.

Because a user's engagement with the canal and with other users is a continuous one, this theory differs from approaches that emphasize repeated interaction of users at particular points in time while regarding the other interactions as only indirectly relevant to cooperation. Thus, instead of a series of strategic situations strung together over time, this theory begins with the view that the level of commitment to the institution is reflected continuously in the interactions of a user with other users, and with the institution. These interactions might happen asynchronously - that is, they may occur out of turn and at different times. This distinction rules out modeling the interaction as n-person repeated games with "action situations" at which point users makes strategic decisions about whether to cooperate or not. Although particular situations might be amenable to this approach, it is inadequate to represent the general condition of user interactions in these cases.

The underlying decision of a user, therefore, is the extent to which they will continue their existing commitment to the rules and to other users. This commitment is reflected in the quality of cooperation that they exhibit, but need not always show up as a blind following of the rules. Instead, it is more akin to a caring about the spirit of the rules as well as their continued engagement with other users. This view allows

some space for discussion about whether specific instances of rule breaking can be considered to have been committed in the spirit of the rules, and allows the theory to explain the bounded effects of flexibility.

Over time, this commitment is primarily affected by how fair the users perceive the rules to be. In the case of a shared resource, perception of fairness depends on at least two of the following four considerations. One, how the user perceives the difference in the amount of work done by those who do the most and the least. Two, how the user perceives the difference in the amount of the resource allocated to those who receive the most and the least. Three, how the user perceives the rules for who qualifies to use the resource and who does not. And four, how the user perceives exclusion or systematic disadvantaging of qualified people from using the resource. It is important to note that I do not assume any particular relationship between the four components. For example, although prior studies have identified the first two - allocation of work and allocation of the resource - as important aspects of successful institutions, they have always spoken of them in terms of cost and benefit and thus collapsed them into a uniform measure. Here, I keep them separate and actively resist attempts to collapse them in order to faithfully represent the fact that users also spoke about them separately and not as two sides of the same coin.

It is tempting to think that these are four variables that go into an algorithmic decision making process about whether the institution is fair. However, this would be misleading. These are instead considerations that individual users discuss, think about, ponder and reflect on over long periods of time. Thus, it is unlikely that a sudden change in either of these aspects would alter a user's perception of fairness. There is also a great deal of reasoned judgement exercised by the user, which is very difficult, if not impossible, to model using a single-dimensional measure such as utility. This is the reason why I have not attempted to collapse these four com-

ponents of fairness into more basic conceptual building blocks as is common in such techniques as factor analysis, or principal component analysis. Aside from the need to make probabilistic interpretations, these methods are not purely algorithmic and themselves require that I exercise judgement about what constitutes a close enough association. This collapsing of reason substitutes the respondent's judgement with my own, which I do not seek to do: after all, I seek to understand their reasons not replace them with my own.

One of the central claims of the theory of the commons, later the IAD framework, is that users are intelligent and can figure out the rules that they need to follow. Indeed, the main conceptual message of theories derived from this framework is to view individuals as capable of stepping back from their immediate situation as it were and considering what rules they should subject themselves to in the future. However, when modeling user intelligence and ability to distance themselves from their immediate situation researchers severely limited this intelligence to that of an algorithm that weighed costs and benefits implied by various variables.

I take this assumption of intelligence further by admitting that human reasoning is more complex, multi dimensional and less automatic than the logic of internal cost and benefit. The evidence presented here suggests strongly that in order to understand how users conceive of fairness, and how users reason about the relative significance of these components of fairness, there is no substitute for listening to and talking with individuals. While the assumption that individual reasoning is fundamentally uni-dimensional appears to explain patterns across countries, situations and examples, it is unable to explain outcomes over time. For that, it becomes necessary to understand how users reason about outcomes that they observe and that they attribute to their earlier commitments.

This theory, therefore, leaves space for understanding the reasoning, discretion

and judgement of users themselves without assuming a universal logic or reasoning process. No doubt, there are some users who will behave in predictable ways when faced with particular circumstances. In these cases, the main problem in the way of cooperation may be that rules for monitoring rule breaking, and ensuring punishment are inadequate and users find it difficult to make long term commitments. Yet, even here, it is difficult to argue that over time this cost-benefit view will remain the primary consideration for users considering how to calibrate their level of commitment.

It is also unreasonable to deny that the structure of the situations in which we find ourselves can shape our understanding of it. Therefore, this theory does not substitute earlier theories which have started from this premise but adds to them. Yet, it would be equally dismissive if not more so to assume as they do that the language that we use to express our reasons for action can always be collapsed into a basic algorithm, and that our understanding of the world is therefore similarly homogenous. This study provides strong evidence that phenomena such as cooperation that seemed to be adequately explained by earlier 'collapsed reasoning' theories, might not be as usefully characterized when they are looked at in the same way over time.

Earlier theories largely assumed that it was no longer necessary to understand how individuals view an interdependent situation, such as a shared resource, and that attention of researchers should go towards identifying the external variables that "structure the situation". This dissertation challenges the view that these "external" approaches will be enough to understand why people continue to cooperate with each other and with their institutions over time. It also challenges the view that should we open up the pandora's box of human reasoning, we shall have no alternative but to judge people to be fundamentally different. Fundamental difference and fundamental similarity are equally flawed assumptions of human behavior.

While those who are used to working with "objective" data might hesitate to attempt to understand the multi-faceted, nuanced and rich area of human reasoning for fear of having to declare some people different from others, this fear is unfounded. Others might fear that listening to the reasons that people give for their actions is not the work of science. As this research shows, turning towards interviews and listening to reasons that people give for actions might actually show that we have broadly similar components of our reasoning when it comes to fairness - we might actually care about similar things, but in slightly different ways. We do not know whether these sorts of broad commonalities will arise in other realms of reason as well. However, it is likely that we will be forced to admit the existence and incommensurability of reasons for action and inaction. This will challenge our models of reasoning in significant ways, but the prospect of facing a difficult challenge is not a good reason to hold on to narrow models of rationality and human behavior against the demands of compelling evidence.

5.3 A Statement of the Theory

At any point in time, the emergence of cooperation might be characterized by a variety of features such as the characteristics of the institutions that help bring it about. Over time, however, two features come to the fore. When looking at cooperation over time, there are four general qualities of cooperation based on how likely they are to be sustained. This is not a theory of how cooperation comes about, but how cooperation that already exists might be sustained or not. The quality of cooperation that already exists is characterized by two features: the perceived fairness of the rules or the terms of cooperation, and the perceived flexibility of their arrangements. While illustrative to think of each as having two values- high and low - such a classification is artificial. Furthermore, fairness and flexibility are not orthogonal : perceived flexibility

affects perceived fairness to some extent. It is more helpful to think of each type of cooperation as being perceived as more or less fair or flexible than it was, rather than absolutely so. Placed in a continuum in this way, the same instance of cooperation can be compared at different points in time as being more or less flexible, or more or less fair. In general, the theory predicts that a cooperative situation which comes to be perceived as more fair is more likely to be sustained than that which come to be perceived as less fair. And, when perceived as fair, individuals in those cooperative arrangements in which rules are perceived to be applied flexibly are more likely to find ways to sustain that cooperation than when rules are rigidly applied. When perceived as unfair, cooperation is more likely to be sustained if the rules are perceived to be applied rigidly.

This formulation of the findings in this dissertation makes it easier to relate it to earlier theories. In addition to the emphasis of the older theories on the rules underlying cooperation, the environment, and the fit between the two, this theory adds a third domain that appears to be important to cooperate over time: perceived fairness. In addition to the external environment, this theory posits that the rules must fit the individual's sense of fairness. Simply allowing the individuals who are cooperating to make the rules themselves does not ensure that the resulting rules will be perceived as fair over time, nor does the rules having a particular structure guarantee fairness either. If in the past, the frameworks in use emphasized how the rules fit external conditions, the results in this dissertation stress the need to understand how fair the rules and cooperative arrangements are perceived to be - and how flexibly the rules are applied.

The main challenge of such rules is not enabling self-interested individuals to make credible commitments to each other. Hence the main objective of the rules is not effective monitoring and appropriate sanctioning, although this does have some

importance. The main challenge is for the rules to match the cooperator's sense of fairness as well as the external environment in such a way that users perceive the institution as fair and can adapt the rules as needed. The requirements for this are that the individuals be able to make fair commitments to each other, and that the monitoring and sanctioning are appropriately flexible to allow for individuals to learn how to do this.

5.4 Application of the Theory

This theory has implications for those who work in the field and attempt to assess the robustness, or sustainability, of arrangements in which individuals must cooperate with each other. In the case of canals in particular, assessments based on earlier theories would require that one ask about the characteristics of the canal, the environment and the structure of the management arrangements such as the decision making processes, the capacity of the users and the availability of resources for maintenance and upkeep. In light of these findings, assessors would be wise to ask about how fair users perceive the arrangements to be, and how flexibly the rules are being applied.

There are four aspects that it is important to understand users' perceptions about: the distribution of work, the distribution of water, the criteria for qualifying to use the canal, and the exclusion of otherwise qualified users. In addition, the observer would have to speak to users to understand how they consider the relative importance of each of these four aspects. This process would allow for a reasoned assessment of how fair the arrangements are perceived to be as well as how flexibly the rules are seen to be applied. The fourfold classification can then be used as a comparative guide to position the specific case along the continuum of fairness and flexibility. The claim of this theory is that based on these two assessments, one can understand how likely it is that the cooperation needed for the canal to be maintained will be sustained

over time. It also brings the judgement and understanding of the observer to the center of the analysis. It should be noted here that what is proposed is not a means to compare different cases to each other, but to compare the possibilities of a single case to itself over time. It may also suggest actions that would improve this sustainability. My claim is that this additional information, combined with assessments of the usual variables, will give a more reliable sense of the sustainability of the canal, or other cooperative situation that would not otherwise be thought of as relevant.

5.5 Limitations

The analysis of the empirical stages of this research above has already indicated some of the limitations that arise because of choices made during the early stages of the research. It is useful to bring them together in one place with the limitations that this theory inherits from the conceptual choices that I made in order to explain the empirical findings. I do this next.

The major empirical limitations of this study were that it was restricted to a single country, a single history, and a relatively short period of time compared to how long these canals had been in use. A second limitation arose from the sampling, which was not random, and the lack of any knowledge about the universe of cases from which they were drawn. Third, I did not have control over the questions that were asked in the first study, although I did add new questions this time around. Together these severely limited the use of probabilistic reasoning for generalizing from findings, and also prevented me from meaningfully assigning relative weights to different factors. Instead, I used exact tests and non-stochastic interpretations which provide strong evidence but limit the statements that can be made to the realm of observation alone. While it is obvious that a study such as this one could not be done without inheriting these limitations, it does imply that there are ample opportunities for better studies.

The reliance on interviews was a novel break from earlier studies, but there are questions about the extent to which this method leads to an accurate representation of user perception in each location. It remains to be seen whether a more robust assessment of user perceptions will lead to a similar result. Although it would surely provide a more detailed understanding of what constitutes fairness.

There wasn't a reliable way to find out, in comparable detail, what had happened to those canals that did not survive from the first study. I attempted to reconstruct what had happened through interviews with respondents who self-identified as former users, but this history could probably be recreated more systematically and possibly more reliably.

Thus, the movement from looking at survival and decline to looking at performance was necessary, but also made certain limiting assumptions. First, I made the argument that in these cases that change in performance was a direct consequence of the characteristics of the institution, and that the level of cooperation of users was a consequence of the institution as well. Hence, I was able to use changes in canal performance to represent what I called "institutional performance". I also made the claim that a canal that stops functioning always deteriorates in performance before stopping, unless there is a major disaster. This requires ruling out the major confounding variables that could also affect the canal. While I have ruled out the main ones- disasters and outside assistance- this could still be refined, possibly by using better statistical methods to include more variables. This would, in turn, require a study that could exert more control over the sampling and study design in all time periods. The sample size is currently too small to control for more variables using exact tests, and contingency tables.

Next, rather than using outside measurements of the effect, magnitude or occurrence of changes such as migration, I have relied on user recollections of these

changes. On the one hand, this is true to the principle that users would know better whether a particular change has had an effect on the canal at a higher resolution than aggregate data. On the other, the current approach could be augmented or corroborated with data from government agencies, or other data sources as well.

I made a further assumption that the five indicators used here: the physical condition of the head and canal, as well as three aspects of user perceived functioning, are useful for indicating canal performance. Other studies have also tried to use agricultural productivity to represent canal functioning. While this can be useful, isolating the effect of the canal alone on agricultural productivity was not possible with the data collected here. In the absence of that, I have used user perceived functioning and physical condition: one is subjective to the users and the other to the enumerators.

This research is framed around the assumption which was made during the first study that canal performance is a consequence of institutional "fit". However, there is no measure of fit provided other than the functioning of the canal. At the same time, this study is intended to understand sustained cooperation in difficult circumstances. There are many more situations where sustained cooperation is necessary other than a shared canal setting, and difficult circumstances in each of these settings might take different forms. As such, this assumption can be questioned. The question of whether or not there are institutional requirements for cooperation is also not addressed by this data. Instead, it begins with the assumption that there are because of the specific case that is being studied: shared canals in Nepal.

A final, and major, distinction upon which the explanation of findings rests is the distinction between interpersonal cooperation and the cooperation between an individual and an institution. This distinction is related to the previous point about the institutional pre-requisites for cooperation. But how useful is this distinction?

Answering this question requires choosing a model to represent human beings - for example, whether in these situations, they are better characterized as rational, self-interested and utility maximizing or something else. Such usable alternative models of human beings are few, although this research suggests that one might consider representing individual decision making over time as guided by a desire for fairness. However, lacking behavioral foundations does not nullify the usefulness of the results. Here the behavioral foundations of the theory are not worked out, instead assuming implicitly that it does not matter over long stretches of time as much as a common desire for fairness.

This analysis of limitations leads naturally into the next section, which explains where the next steps of this research might go.

5.6 Next Steps

There were several questions that could have been answered using the data already collected, but that I have kept for the next steps of the research. Of these three are prominent and are mentioned here in no particular order.

One question is why, despite being exposed to civil war, there wasn't a systematic effect of conflict on canal functioning. This question is concerned with the relationship between conflict and sustained cooperation. In the current study, I did not make an attempt to separate the specific effects of different external shocks except in terms of survival and decline or in aggregate in terms of canal performance. The current dataset contains detailed information on conflict. Since the earlier study was done before the conflict began, this can be examined systematically even though no questions about conflict were asked then. Users of about half of the canals reported difficulties in meeting and performing the day to day tasks associated with the canal while the other half did not. In particular, there are detailed responses in the interviews and

survey data about the effects of conflict on various aspects of canal functioning. Besides illustrating the strategies that were used to cooperate in the face of conflict, studying this would be illuminating as a way to examine the relationship between conflict, fairness and cooperation.

A second question pertains to the observation that although there was variation in both perceived fairness and performance, these two variations are only connected to each other when users remember that they had received external support from government agencies. This is a subtle point because the observation is not that government involvement makes the institutions become perceived as more fair than otherwise. Instead, it is a claim that, in a way, fairness matters to performance when users remember government assistance. There is a second subtlety, which is that the question asks users what they remember, rather than cross-checking with official government documents about whether indeed there was some sort of assistance. Since all the canals received assistance when they were entered into the database between 16 and 37 years ago, this question asks about how memorable the connection to government is.

So this raises another question with urgency, particularly for planning: what were the specific forms of interaction with government agencies and at what administrative level (central, district, village), that led to fairness becoming relevant to performance? What variation can be observed in this connection depending on the specific intervention or the specific nature of the relationship between the local users and the government, whatever the agency? I have collected data on the types of interventions and the timing of the interventions according to the respondents. This can be augmented with available data from government agencies to construct a more complete picture of the nature and type of intervention. It would provide a way to examine the relationship between external assistance and fairness, and eventually sustained

cooperation.

The third question relates to the observation that while the four components of fairness appeared in a connected fashion across all interviews, no respondent cited all four of them together but all respondents cited at least two of them. Thus, there is variation in which of these components appear to be important considerations for fairness across users. An initial question is whether there is variation in the contents of fairness with respect to certain variables of location and time, or broad characteristics of the respondents. A further question that has more widespread implications is why there are different notions of fairness and how they relate to political parties. For instance, if a particular political party is dominant in the area in which a person lives, will they consider different components of fairness to be significant than those in another area? Next, how does this content vary with conflict and is there any relationship? Finally, do opportunities to discuss fairness with each other or those outside of the locality alter the components of fairness or lead to greater perceived fairness?

All of these are significant questions on their own. While the data to begin to answer them is contained in the current sources, they are future directions in which this research is likely to proceed.

5.7 A Challenge for Social Science

In addition to its main findings, this research has attempted to re-introduce the idea of revisiting old, well established topics in the social sciences. While it has been custom to take established explanations as the final word on their respective empirical cases, it may be fruitful in the sense of generating more findings, to revisit them. Even if the conclusions are found to still hold, this will be a significant service to the endeavor of learning about social phenomena. In the very least, one will have contributed an-

other set of observations that can be used to study the dynamics of the phenomena of interest. Repeating earlier studies is one way to approach the task of verifying earlier results, and given the advances in technology since the early studies, replication should be less costly.

While the focus has recently been on refining research designs to be more thorough, the scientific mindset can never take evidence as final. Indeed, more than any research design, the ability to reproduce the findings of others plays a significant role in scientific enquiry. This is a challenge to social science because it is tempting for those working on limited research budgets to think that finding out something "new" by directing ones research focus to areas and ideas that have not yet been studied is more promising. Documenting ones choices and research findings carefully with a reader in mind can also seem like an unnecessary investment when nobody is going to use it to do the study again. This is especially true in light of the possibility that research that is well done is likely to come to conclusions that hold up to scrutiny of this sort, and to be robust in that sense. Thus, for a scholar seeking something new the confirmation of the old can be a disappointment. The point, however, is that social research can always be done better, or at least done differently in ways that might not be anticipated when it is first done. Without the means to relate new methods and data to old ones, the possibility of reliable findings is lessened. Finding reasons to revisit established cases and established conclusions is a challenge to social science. However, it is one that should not be dismissed out of hand if we are to stand on rigorous foundations.

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Appendix A Tables

In all of the tables in this section, N=233 unless otherwise indicated. Those not tabulated are either missing or ambiguous. Notes specific to each variable accompany the corresponding table. All Round 1 variables are from the NIIS dataset. All Round 2 variables were from my fieldwork.

A.1 Indicators of Performance in Round 1

Table A.1: Physical condition of the canal in Round 1.

	Number	Per cent
POOR	7	3
FAIR	169	80
GOOD	36	17
Total	212	100

Table A.2: Physical condition of the headworks in Round 1.

Condition	Number	Per cent
POOR	3	1
FAIR	168	80
GOOD	40	19
Total	211	100

Table A.3: User-assessed adequacy of the canal in Round 1.

	Number	Per cent
No	130	58
Yes	95	42
Total	225	100

Table A.4: User-assessed reliability of the canal in Round 1.

	Number	Per cent
No	55	24
Yes	170	76
Total	225	100

A.2 Indicators of Performance in Round 2

These tables include the added sample, but do not include those that are no longer in use. Thus, for all the tables in this section, N=241.

Table A.5: Physical condition of the canal in Round 2.

Condition	Number	Per cent
POOR	56	24
FAIR	124	53
GOOD	55	23
Total	235	100

Table A.6: Physical condition of the headworks in Round 2.

Condition	Number	Per cent
POOR	72	31
FAIR	83	35
GOOD	80	34
Total	235	100

Table A.7: User-assessed timeliness of the canal in Round 2.

	Number	Per cent
NA	6	3
Not good	44	19
Passable	71	30
Good	112	48
Total	233	100

Table A.8: User-assessed adequacy of the canal in Round 2.

	Number	Per cent
NA	6	3
Not good	44	19
Passable	95	41
Good	88	38
Total	233	100

Table A.9: User-assessed reliability of the canal in Round 2.

	Number	Per cent
NA	7	3
Not good	53	23
Passable	77	33
Good	96	41
Total	233	100

A.3 Performance and Frequency of Shocks

The frequency of shocks was calculated by dividing the number of shocks by the number of years between the first and second observations. This was then multiplied by 10 to indicate the number of shocks per decade and then grouped by range.

Table A.10: Number of shocks per decade, grouped.

Range	Number of canals	Per cent
0	31	14
(0,1]	5	2
(1,2]	97	43
(2,3]	76	34
(3,4]	14	6
Total	223	100

Table A.11: Frequency of shocks by physical condition of the canal.

	Physical condition of the canal			
Shocks per decade	POOR	FAIR	GOOD	Total
0	0	0	2	2
(0,1]	2	2	1	5
(1,2]	26	53	18	97
(2,3]	17	43	16	76
(3,4]	6	7	1	14
Total	51	105	38	194

Fisher's exact=0.274

Table A.12: Frequency of shocks by physical condition of the headworks.

	Physical condition of headworks			
Shocks per decade	POOR	FAIR	GOOD	Total
0	0	0	2	2
(0,1]	2	2	1	5
(1,2]	32	38	27	97
(2,3]	24	26	26	76
(3,4]	5	6	3	14
Total	63	72	59	194

Fisher's exact=0.801

Table A.13: Frequency of shocks by perceived timeliness.

	User perceived timeliness			
Shocks per decade	Not good	Passable	Good	Total
(0,1]	0	2	2	4
(1,2]	17	26	50	93
(2,3]	17	24	34	75
(3,4]	4	6	4	14
Total	38	58	90	186

Fisher's exact=0.539

Table A.14: Frequency of shocks by perceived reliability.

	User perceived reliability			
Shocks per decade	Not good	Passable	Good	Total
(0,1]	0	2	2	4
(1,2]	19	34	39	92
(2,3]	23	23	29	75
(3,4]	5	5	4	14
Total	47	64	74	185

Fisher's exact=0.590

Table A.15: Frequency of shocks by perceived adequacy.

	User perceived adequacy			
Shocks per decade	Not good	Passable	Good	Total
(0,1]	0	2	2	4
(1,2]	16	39	37	92
(2,3]	17	31	28	76
(3,4]	5	7	2	14
Total	38	79	69	186

Fisher's exact=0.452

A.4 Performance Changes Since Round 1

In order to look at the duration, I grouped the years between visits into into 5 year intervals starting at 15 and ending at 40. The following tables show the relationship of the intervals thus grouped and changes in the four indicators of canal performance. Adequacy and reliability are restricted to the tail.

Table A.16: Distribution of the number of years since the first visit, grouped.

Years	Number	Per cent
16 to 20	76	40
21 to 25	87	45
26 to 30	25	13
31 to 35	3	2
36 to 40	1	1
Total	192	100

Table A.17: Changes in canal performance and years between observations. The table shows the relationship between changes in performance between the two visits and the number of years between visits, grouped into 5 year ranges. User perceived functioning is restricted to tail users. There were no observations separated by more than 35 years at the tail. p-values are from Fisher's exact test.

		Years between observations						
		16-20	21-25	26-30	31-35	36-40	Total	
Condition of the canal	Worse	28	28	5	1	0	62	
	Same	35	43	13	2	1	94	$p = 0.768$
	Better	10	12	6	0	0	28	
	Total	73	83	24	3	1	184	
Condition of the head	Worse	26	40	9	1	0	76	
	Same	29	26	6	2	0	63	$p = 0.462$
	Better	19	18	7	0	1	45	
	Total	74	84	22	3	1	184	
User perceived tail adequacy	Worse	1	0	0	0		1	
	Same	11	10	2	0		23	$p = 0.269$
	Better	5	12	3	2		22	
	Total	17	22	5	2		46	
User perceived tail reliability	Worse	2	3	1	0		6	
	Same	15	15	2	2		34	$p = 0181$
	Better	0	4	2	0		6	
	Total	17	22	5	2		46	

Table A.18: Changes in canal performance and frequency of shocks. The table shows the relationship between changes in performance between the two visits and the frequency of shocks expressed as number per decade. User perceived functioning is restricted to tail users. p-values are from Fisher's exact test.

		Number of shocks per decade					
		(0,1]	(1,2]	(2,3]	(3,4]	Total	
Condition of the canal	Worse	2	31	21	8	62	
	Same	3	48	38	5	94	$p = 0.536$
	Better	0	13	14	1	28	
	Total	5	92	73	14	184	
Condition of the head	Worse	3	38	28	7	76	
	Same	2	36	21	4	63	$p = 0.385$
	Better	0	18	24	3	45	
	Total	5	92	73	14	184	
User perceived tail adequacy	Worse	0	1	0	0	1	
	Same	1	15	5	2	23	$p = 0.712$
	Better	1	11	9	1	22	
	Total	2	27	14	3	46	
User perceived tail reliability	Worse	0	5	1	0	6	
	Same	2	17	12	3	34	$p = 0.794$
	Better	0	5	1	0	6	
	Total	2	27	14	3	46	

Table A.19: Changes in canal performance and external assistance. The table shows the relationship between changes in performance between the two visits and whether or not users reported receiving external government assistance for the canal. User perceived functioning is restricted to tail users. p-values are from Fisher's exact test.

		Received assistance			
		No	Yes	Total	
Condition of the canal	Worse	15	47	62	
	Same	14	81	95	$p = 0.234$
	Better	7	21	28	
	Total	36	149	185	
Condition of the head	Worse	19	58	77	
	Same	8	55	63	$p = 0.217$
	Better	9	36	45	
	Total	36	149	185	
User perceived tail adequacy	Worse	0	1	1	
	Same	5	18	23	$p = 0.210$
	Better	1	23	24	
	Total	6	42	48	
User perceived tail reliability	Worse	1	5	6	
	Same	5	30	35	$p = 0.636$
	Better	0	7	7	
	Total	6	42	48	

A.5 Indicators of Fairness in Round 1

These are the indicators of fairness found in Chapter 3 that related to indicators of performance in the first round. Here N=233.

Table A.20: Have any users been consistently disadvantaged?

	Number	Per cent
No	153	73
Yes	56	27
Total	209	100

Table A.21: Do the rules give substantially more privileges to some groups?

	Number	Per cent
NA	169	64
No	46	17
Yes	49	19
Total	264	100

Table A.22: Do the rules assign substantially more duties to some groups?

	Number	Per cent
NA	169	64
No	47	18
Yes	48	18
Total	264	100

Table A.23: How complex are the rules?

	Number	Per cent
Simple, easily understood	178	91
Relatively complex, understood through experience	17	9
Total	195	100

Table A.24: Are some groups given better positions/seasons/locations?

	Number	Per cent
NA	176	67
No	39	15
Yes	49	19
Total	264	100

Table A.25: Do the rules give substantially more water to some groups?

	Number	Per cent
No	40	42
Yes	55	58
Total	95	100

Table A.26: Do some parts get considerably more water than others?

	Number	Per cent
No	93	48
Yes	102	52
Total	195	100

Table A.27: Have the relatively worse off been deprived?

	Number	Per cent
No	111	82
Yes	25	18
Total	136	100

Table A.28: Have members of this group invested their own labor or resources?

	Number	Per cent
NO	28	13
YES	190	87
Total	218	100

Table A.29: Can users predict which parts will get less water?

	Number	Per cent
Missing	107	51
Highly predictable	18	9
Predictable	67	32
Mildly predictable	13	6
Unpredictable	3	1
Total	208	100

A.6 Indicators of Fairness in Round 2

These are the indicators of fairness that appear related to performance in the second round. This does not include the random sample, and N=202.

Table A.30: Does it seem like the gap between those who get more water and less water is getting bigger?

	Number	Per cent
NO	165	85
YES	29	15
Total	194	100

Table A.31: Do some parts regularly get less water than they want?

	Number	Per cent
NO	86	44
YES	108	56
Total	194	100

Table A.32: Are there any takers who consistently get less water?

	Number	Per cent
NO	109	56
YES	85	44
Total	194	100

Table A.33: Are the rules about who can take from the canal well defined?

	Number	Per cent
NO	45	23
YES	149	77
Total	194	100

Table A.34: Because of these rules, do some subgroups consistently get a more preferred season?

	Number	Per cent
NO	150	77
YES	44	23
Total	194	100

Table A.35: Do these rules seem to assign unequal duties to some subgroups?

	Number	Per cent
NO	142	73
YES	52	27
Total	194	100

Table A.36: Are the rules perceived as legitimate?

	Number	Per cent
No	47	20
Somewhat	25	11
Yes	163	69
Total	235	100

A.7 Indicators of Flexibility in Round 1

Indicators of likelihood were coded in the order of likelihood, whether increasing or decreasing although they may be displayed out of order in the tables below.

Table A.37: How likely is the guard/monitor to impose punishment?

	Number	Per cent
Very likely	55	28
Likely	42	21
Neither	9	5
Unlikely	41	21
Very Unlikely	51	26
Total	198	100

Table A.38: How likely are the users to face physical sanctions?

	Number	Per cent
Very likely	2	1
Likely	9	4
Neither	24	11
Unlikely	58	28
Very Unlikely	116	56
Total	209	100

Table A.39: How likely are users to face social sanctions?

	Number	Per cent
Very likely	14	7
Likely	43	20
Neither	26	12
Unlikely	47	22
Very Unlikely	80	38
Total	210	100

Table A.40: Are there fines for missing work days?

	Number	Per cent
No	36	17
Low, well enforced	99	47
Low, not enforced	36	17
High, well enforced	39	19
Total	210	100

Table A.41: Are there different sanctions depending on severity of infraction?

	Number	Per cent
Wide range	43	23
Moderate range	43	23
Limited range	20	11
Little range	49	26
No rules	30	16
Total	185	100

Table A.42: Can users lose the right to use canal?

	Number	Per cent
No	95	51
Yes, temporarily	79	42
Yes, permanently	4	2
Yes, unclear duration	10	5
Total	188	100

Table A.43: Do the users have the right to participate in canal management?

	Number	Per cent
Yes, de jure	130	58
Yes, de facto	82	37
No, neither	10	4
No, de jure	1	0
Total	223	100

Table A.44: Are the rules available to users in writing?

	Number	Per cent
Yes	134	63
No	78	37
Total	212	100

A.8 Indicators of Flexibility in Round 2

Table A.45: How likely is the guard to impose a punishment?

	Number	Per cent
LIKELY	11	6
NEITHER	12	6
UNLIKELY	17	9
V LIKELY	69	36
V. UNLIKELY	85	44
Total	194	100

Table A.46: How likely is the fine for missing a work day to be enforced?

	Number	Per cent
LIKELY	69	36
NEITHER	21	11
UNLIKELY	14	7
V LIKELY	55	28
V. UNLIKELY	35	18
Total	194	100

Table A.47: How likely are others to impose a social punishment?

	Number	Per cent
LIKELY	86	37
NEITHER	37	16
UNLIKELY	39	17
V. LIKELY	46	20
V. ULIKELY	27	11
Total	235	100

Table A.48: Are there different punishments for different violations?

	Number	Per cent
NO	73	38
YES	121	62
Total	194	100

Table A.49: Have they ever used violence to enforce the rules?

	Number	Per cent
NO	31	16
YES	163	84
Total	194	100

Table A.50: Have they used violence to change the rules?

	Number	Per cent
NO	75	39
YES	119	61
Total	194	100

Table A.51: Are the rules difficult to understand?

	Number	Per cent
Yes	182	77
No	53	23
Total	235	100

Table A.52: For how long can a user lose the right to take water?

	Number	Per cent
No	122	46
Temporarily	127	48
Permanently	15	6
Total	264	100

Table A.53: For how long might they be shunned for rule breaking?

	Number	Per cent
No	199	75
Temporarily	50	19
Permanently	15	6
Total	264	100

Table A.54: Have they ever tried to change the rules?

	Number	Per cent
NO	150	64
YES	85	36
Total	235	100