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Adaptation to Disturbances in Common-Pool Resource Management Systems*

Ingela Ternström**

This paper takes the analysis of common-pool resource management one step further by looking closely at how the users adapt to disturbances. The analysis provides insights on how to analyse and promote adaptability in common-pool resource management systems. The most important conclusion is that we need to broaden our theoretical horizon if we are to fully understand how these systems work.

The processes triggered by disturbances in farmer-managed irrigation systems in Nepal are traced and the actions taken by the users to counter them are pinpointed. These actions, highly consistent over time and space, can be grouped into decision-making, reconstruction activities, rule-changing, conflict management, change of leadership and more extensive changes in institutional structures. A large part of these activities are undertaken or initiated by leaders. The most serious disturbances are those that change user-group compositions or directly affect the institutional structure. The results point to extensive similarities to other types of organisations.

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1 Introduction

What makes some common-pool resource management systems able to cope with change better than others? Which disturbances are more likely to cause conflicts among users? Can characteristics be identified that make some common-pool resource management systems more sensitive to these disturbances than others? Such questions are crucial to the understanding and furthering of local management of natural resources, especially in a time of rapid change and globalisation. Often, theoretical analyses of common-pool resources involve the use of non-cooperative game theory or a fairly static analysis of the institutions in place.[1] A different approach is to view the resource and its users as a whole, and analyse the resilience of the resulting social-ecological system.[2] While resilience is defined as the ability of a system to return to its original state after a disturbance, the literature on resilient social-ecological systems uses the term adaptability to describe "the capacity of actors in a system to influence resilience", and transformability to describe "the capacity to create a fundamentally new system…".[3] This paper looks at how the users have adapted to various disturbances to social-ecological systems. The analysis is focussed on the internal reactions to disturbances and hence gives a good picture of "adaptability at work". The results strongly suggest that apart from a more dynamic approach, we also need to bring theories of organizational development and management into the analysis of common-pool resource management.

The analysis uses historical data from ten farmer managed irrigation systems in Nepal. The irrigation systems are located in the same geographical area, use the same kind of resources and technology, and have similar history. The ten systems have over time been

[1] See for example Ostrom (1990, 1992).
[2] See for example Walker et.al. (2004), Berkes et.al. (2003, 1998), Gunderson et.al. (2002).
[3] Walker et. al. (2004) p. 3.

exposed to a number of similar or identical disturbances: There have been natural disturbances such as floods, landslides and droughts, and socio-economic disturbances such as massive immigration, road construction and increased market access, external support for infrastructure improvements, increased income inequality, decreased land holding sizes and democratisation. In some cases, the disturbances have led to severe conflicts among the users or complete changes in the institutional structure, while in other cases adjustment to the effects of the disturbance have left nearly no trace at all.

I first isolate the disturbances that have occurred several times or in several systems: Floods and landslides, immigration or inclusion of new users, and offer and implementation of major external support. Focusing on these disturbances, I develop flowcharts that trace the processes, problems and reactions they triggered. Analysing the actions taken by the farmers to solve or avoid the problems, I find that they can be summarized in a fairly limited set of activities: Decision-making, physical reconstruction work, conflict management, change of operational rules, change of leadership and change of institutional structure. These issues are regularly dealt with in other organisations of human beings, such as business enterprises, and are well studied in other literature. It is not farfetched to conclude that the characteristics that make common-pool resource management systems able to adapt to change are similar to those that make business organisations successful. Hence, there is reason to believe that we have a lot to learn from various organisational theories. Furthermore, many of the actions identified as important in the present analysis are carried out by single individuals, the leaders, suggesting that one of the most crucial characteristics of a well-functioning common-pool resource management system is a well functioning leadership.

The results are in line with and provide explanations for the results of previous statistical analyses of the data,[4] showing that having an individual who takes the role as a single leader and a homogeneous group is strongly correlated with the level of cooperation among the users. The results also give empirical support and explanations for why economic inequality can have a negative effect on cooperation.[5]

The disturbances that cause the largest and most long-lasting change in the irrigation systems studied are those that change the composition of the group of users so that they become more heterogeneous, and those that directly affect the institutional structure. Interestingly, despite the amount of damage they cause, floods and landslides seem to be the disturbances that are easiest for the users to handle. A relevant difference is that while floods and landslides are unusual events, the more serious disturbances are also unexpected events.

The paper continues with some background information about the irrigation systems analysed and the way data was collected. Section Three provides an interpretation of the terms disturbances, processes and reactions and Section Four describes the disturbances, processes and reactions triggered by the selected disturbances. Section Five analyses the actions taken and Section Six concludes the paper with a discussion of the results.

2 The Data

Before proceeding, let me offer a generalized picture of the irrigation systems under study. The typical irrigation system consists of an irrigation canal with its intake in a river. The water may be divided into several branches and sub-branches before reaching

[4] Ternstrom (2002a).
[5] See for example Ternström (2002b).

the farmers' fields. The amount of water each farmer obtains depends on the amount of water in the river and on how much of it that reaches his fields, which in turn depends on the state of the canals and intakes and on how water is allocated among the farmers. Using the irrigation system implies that the canals must be repaired and desilted more or less frequently, the intake may have to be rebuilt or repaired annually or after floods, and the water must be distributed among farmers' fields. For these purposes, the farmers need to cooperate, for example by agreeing on some set of rules for contributing labour and distributing water, and by following these rules. An irrigation system thus consists of institutional as well as physical structures. The farmers using the system may be organised in a water users' association, often, they have a leader appointed by democratic or other means, who makes decisions regarding the time and labour contribution for repair and maintenance, the distribution of water and the penalty for not following the rules, etc.

The data was collected in ten irrigation systems in three neighbouring districts, Chitwan, Makwanpur and Nawalparasi, in the Terai region of Nepal. The land was formerly covered by jungle, and most of it was not inhabited until malaria was eradicated in the 1950's. In a few places, however, Tharus, who are the original inhabitants of the area, had developed settlements and irrigation canals long before that date. With the eradication of malaria, the construction of the East-West Highway and the government's resettlement and land titling programs in the 1950's and 60's, people from the hilly areas started to move in, causing a period of rapid population growth. There has been a series of government and non-government organization supported programs for improving the

infrastructure of irrigation systems in the area, for example the Irrigation Line of Credit (ILC), the Nepal Irrigation Sector Project (NISP), the Farm Irrigation and Water Utilization Division (FIWUD) and the East Rapti Irrigation Project (ERIP).

Irrigation systems were selected on the criteria that they be farmer managed, located in similar environments, have a fairly long history and preferably, some written records. These selection criteria will have affected the sample by only including systems that are functioning at present and have been functioning for some time. Irrigation systems with too severe cooperation problems are thus excluded from the sample. The systems that were included in the study are: Baireni Kulo, Baise Kulo, Beltari Kulo, Chipleti Kulo, Jayashree Kulo, Mahadevtar Kulo, Nawalpur Tallo Tal Kulo, Pithuwa Sinchai Subyastha Samiti (branch no. 10), Shivpur Martal Kulo and Tarauli Kulo.[6] Throughout the paper, whenever I refer to the irrigation systems, the source is the data set described in the next section. For a more thorough presentation and a statistical analysis of the irrigation systems, please see Ternström (2002a).

The data was collected by a team at the Water Management Study Program (WMSP) at the Institute of Agriculture and Animal Science, Tribhuwan University in Rampur, Nepal. The data collection was initiated in May 1998, but the main part of the work was carried out in 2000 and 2001. Data was collected in discussions with groups of key individuals in each system. In many cases, the respondents were members of the Executive Committee

[6] Please refer to Ternström (2002b) for descriptive data and more information.

of the Water Users' Association.[7] Wherever possible, the given information was cross-checked and complemented by written records.

In the discussions, considerable effort was put into getting the respondents' explanations for what had occurred. The purpose was to obtain as accurate a picture of the connections shaping the history of the systems as possible, to have a way of verifying the credibility of the information given by the respondents and to capture as much of the information not covered by the questionnaire as possible. The result is a data set that does not only contain figures, but also a large amount of background information and a very detailed description of the intricate connections between different variables throughout the history of the irrigation systems.

3 Disturbances, Processes and Reactions

The method used is to first identify the most common types of disturbances in the data material. I then trace the effects of these in the narrative information provided by the respondents. The results are illustrated in flowcharts, one for each disturbance (see the Appendix), and described in more detail in Section Four. There, I make the distinction between disturbances, the processes they trigger and the actions the users take to counter the negative effects, that is, to adapt to the disturbance in such a way that the irrigation system can maintain its original function. Below, I define and give examples of the way I use the terms disturbances, processes and actions.

3.1 Disturbances

I define disturbances as "unusual events"[8] and have chosen to focus on exogenous disturbances. That is, I exclude disturbances or changes that are initiated internally, such

[7] There is therefore a risk that the information has a positive bias for periods when the respondents themselves were in power.

[8] See Scheffer et.al. (2002).

as decreased landholding sizes resulting from the distribution of land among the sons of a household, and improvements to the irrigation system that are initiated by the users themselves (even if they include externally mobilized support), without being triggered by an external disturbance. By going through the time lines and the narrative information in the data the following disturbances were identified: Floods, landslides, drought, decreased soil fertility, road constructions, bridge construction, government resettlement programs, malaria eradication, land surveys and land titling, immigration, large-scale and small-scale external support, changes in outside income sources, introduction of new techniques, conflict with neighbouring system, population growth and introduction of multi-party system in the country. The disturbances that were most frequently recurring over time and in different systems were floods and landslides, immigration or inclusion of new users, and offer and implementation of major external support. These represent disturbances to different aspects of the irrigation system: Floods and landslides damage the physical structures; the inclusion or immigration of new users changes the composition of the user groups; the offer of external support has repercussions on the institutional structure and the implementation of it improves the physical structure.

3.2 Processes

A disturbance per se is not what causes a need for action. A disturbance triggers various processes, which alone, or together with processes triggered by other disturbances, can lead to situations where there is a need for the users to react. In the case of floods, the link is fairly short – a flood that washes away part of a canal or an intake will reduce the amount of water to the fields and may result in food shortage, which is what the farmers want to avoid. When new users enter an area, there may be disagreements between new

and old users regarding the rules that control day-to-day behaviour. These may develop into conflicts, which may escalate into violence. Or, the disagreement may result in some groups breaking the rules, making the canals less well-maintained, with a reduced flow of water and hence reduced harvest sizes as a potential effect. In the case of external support the processes that are triggered are even more complex and complicated to analyse, they may for example involve the creation of multiple institutional structures.

The processes triggered by a disturbance often carry over to other aspects of the irrigation system. For example, when the canal is repaired after a flood, the users may improve it to avoid future damage, but this attracts new users to the system, which leads to disputes, conflicts, etc.

3.3 Reactions

When the processes lead to situations where there is a problem, the farmers can choose to take action in order to prevent further damage. The physical structure of the system may need to be repaired after a flood, or extended to accommodate an increased demand for water after the immigration of new users. This implies deciding how and when to repair or rebuild it, to organise labour and perhaps get construction materials from external sources. The rules for labour contribution may need to be changed in response to an increased or decreased need for labour resulting from an investment in the physical infrastructure.

Often, several actions are triggered by the same disturbance, and it is important to include all these into the analysis. Furthermore, it is important to note who takes or initiates the action. By analysing the actions taken it will later on be easier to understand what really is required in order to have an adaptive management system.

Of course, which actions the users take also depends on the opportunities present in the irrigation system and its environment. For example, getting external support to repair the damage after a flood depends both on the ability of having the right connections and the skill to use them, and on the existence of funds that can be distributed.

4 Recurring Disturbances and the Resulting Processes and Reactions

In this section, each of the disturbances that are recurring over time and space are described together with the processes and reactions they evoke. Each disturbance can trigger multiple processes, and at any one point in time and space, several processes may run parallel. The processes triggered by different disturbances can become intertwined or give rise to the same need for action. The processes and reactions are illustrated in flowcharts in the Appendix. For each disturbance, I start with some examples, and then try to give as detailed a picture as possible of the disturbance, the processes and the actions triggered by it. Because of its two-sided nature, the offer of external support is presented as two separate disturbances, one being the offer of support and the other the implementation of support.

4.1 Floods and Landslides

In one irrigation system, Baireni, there were severe floods in 1949, 1954 and 1970. Each time, the canal or intake was damaged and each time the system was immediately repaired. In repairing the damage, help was taken from farmers in a neighbouring irrigation system. At that time the traditional, feudal system with a local landlord, the Zamindaar, being the leader in all areas of village life, including the irrigation system, was prevailing. In terms of processes, the floods had the immediate effect of damaging the canal or intake, which triggered the decision to reconstruct it, and to mobilise both

internal and external labour resources to do the work. The end effect was a repaired irrigation system. The reconstruction work involved activities such as planning the work, coordinating and motivating the workers and getting external support. Except for the physical work of repairing the canal, the majority of these actions seem to have been carried out by the Zamindaar.

In another system, Mahadevtar, a flood washed away almost half of the irrigated area. There, it took several years of despite extensive repair work before the entire area was reclaimed. Years later a flood control dike was constructed with the support of the District Irrigation Office.

4.1.1 Disturbance

The immediate damages caused by floods are intakes that are washed away or damaged, damaged canals, changes in the water level or course of rivers, and fields that are washed away. Landslides also damage canals, especially where they pass through hilly terrain, and are sometimes large enough to destroy whole fields.

Both floods and landslides are seemingly uncontrollable disturbances. However, in several irrigation systems the users commented on the increased frequency of floods after 1943, and connected it with increased deforestation upstream. In one of the systems, Mahadevtar, the users organised a forest user group to protect and regenerate the forest upstream of their canal.

4.1.2 Processes

The immediate damage causes a decreased or interrupted flow of water. If nothing is done, decreased crop productivity and harvest sizes will follow. To avoid this, the users react by repairing the damaged structures. They can do this at once or after some time has

passed, and with internal or external resources. Small damages can be repaired more quickly and with fewer resources than large damages. Sometimes, the farmers take the opportunity to make improvements to the physical structures while repairing them. This leads to increased irrigation, which makes the area more attractive to new settlers, resulting in a new disturbance in the form of immigration (see section 4.2 below). Changes in the physical structure sometimes also lead to a need for new rules for repair and maintenance and for water distribution.

4.1.3 Actions

The first action is to *decision making* about when and how to repair – now or later, with or without making improvements, using which resources? The next step is *resource mobilization*, which implies *informing* the users and *motivating* them to come to the right place at the right time and *coordinating* them in carrying out the right tasks. If external resources are to be used, the external sources of funds or labour are to be *contacted* and *persuaded* to contribute. Finally, it has to be *decided* whether the old rules have become inappropriate, and if so, how they should be changed. If there is a need for it, *new rules must be developed* and *become accepted* by the users.

These actions are carried out by different individuals or groups of individuals. In most cases, the leader (the Zamindaar or Water Users' Association chairperson, depending on the type of institutional structure) is the person making decisions about emergency repair. The leader is also often the most well-connected person, thus he also contacts and mobilises external resources. The actual physical work of repairing (and improving) the damaged structures are carried out by the users, but under the supervision of the leader. Sometimes the secretary of the Water Users' Association assists the leader in these tasks.

Although there may be rules stating that for example the general assembly is the body that decides about changes in operational rules, and perhaps also improvements to the canals, such changes are often initiated or suggested by the leader.

4.2 New users

In the oldest system, Baireni Kulo, the users remember a flood in 1949 and that there was irrigation long before this. The original inhabitants were Tharu's, living by the rule of their Zamindaar in all aspects of village life. The Zamindaar's word was with extremely few exceptions obeyed, and the people trusted him to make good decisions. Rule-breaking was promptly punished – the farmers recalled that one person had had to move to another village after breaking a rule – but rarely occurred. In 1970, the first Hill migrants came to settle in the area, starting a 25-year long period of immigration. The Hill migrants came from another cultural and ethnic background and had other traditions regarding both leadership and operational rules, and were not as ready to give the Zamindaar their support. As more people from the Hills moved in, the strength of the Tharu majority decreased and rule-breaking and conflicts increased. In 1981, a Water Users' Association was formed, in order to make the system eligible for external infrastructure support from the FIWUD program. This Water Users' Association was active mainly for construction purposes and the Zamindaar continued to be the actual leader of the system. In 1990, when the country became a democracy with a multi-party system, the support for the traditional system decreased further. In 1995, in connection with another major infrastructure support (ERIP), another Water Users' Association was formed. This time, there was a shift in leadership, from the Zamindaar to the Water Users' Association, also in practice. The period from 1981 to 1995 can be characterised as a

leadership transition period, with quite high levels of rule-breaking and conflicts, and a steadily decreasing support for the persisting Zamindaari system. The change in leadership coincided with infrastructure support which increased water availability and decreased the need for labour in maintenance (to an eighth of what it used to be!), thus, decreasing both the scope for rule breaking and the cause for conflicts. Hence, it is difficult to judge what the effect of the leadership change *per se* has been.

4.2.1 Disturbance

The origins of this disturbance are not really "new users", but rather the push and pull factors that make people move into the area. Of course, population growth in the areas that migrants come from is the main "push" factor. Among the "pull" factors, there has been a government resettlement program, land titling programs, the eradication of Malaria which made it possible to live in the area, road and bridge constructions which eased transportation and increased market access, etc. These all contribute to new people entering the area, either by buying land from the initial settlers, or by clearing new land.

The immediate nature of the disturbance depends crucially on who the individuals entering the system are, and on how they enter the system. If they are culturally and economically similar to the ones already there, and they enter by buying land already irrigated, the only effect seems to be to increase the number of users. If, on the other hand, they belong to another ethnic group, with different traditions, there may be severe problems. There is often a difference in leadership traditions, in rules for labour mobilisation and in the preferred mode of contribution to maintenance – cash or labour. If they also differ in economic or educational status, this further increases the difference in preferences. If, on top of this, they settle on land that was not previously irrigated from

the canals, but is within the command area of the system, it also raises issues of canal extension and rights to water.

4.2.2 Processes

An increase in the number of users often leads to deceased landholding sizes. This is followed by decreased food sufficiency and an increased need for outside incomes and/or increased crop productivity. The most efficient way to increase harvest sizes is to increase the availability and reliability of irrigation. If the irrigation system is improved, it may also become possible to increase the number of harvests, diversify the crops grown and to introduce improved varieties. After an improvement of the irrigation system, rules and maintenance methods often become inappropriate and need to be adjusted. Furthermore, even more new users may be attracted to move in to the area.

If the new users differ ethnically or culturally from the old users, they often have different views on what is a fair basis for calculating the required contributions to maintenance. According to Tharu traditions “every able male from every household” must join the repair and maintenance work force. The Hill migrants view landholding size as the fair basis for labour contribution. Having less respect for the Zamindaar, they are not as hesitant to break rules, and often protest by refusing to contribute their labour for maintenance work and by not paying the fines for doing so. This has led to conflicts and even violence between the groups. The authority of leadership is challenged and the institutional structure becomes weaker.

If the new users are included by system extension, land holding sizes are not affected except on the aggregate. The new users may have smaller or larger holdings, which may affect their preference for labour contribution rules (small holders tend to find labour

contribution on household basis less attractive than large holders). If they are poorer, perhaps because their land has not been irrigated until now, they often have preferred making contributions in labour rather than in cash. This can result in disputes and conflicts about the rules for contributing to canal maintenance. Often, this escalates to rule breaking which either changes the level of contributions by those still abiding by the rules, or leads to decreased water flow. There may also be a need to change the organization of the Water Users' Association or its executive committee to better represent the new users.

4.2.3 Actions

If there is a need for increased irrigation, a *decision* must be taken on whether and how to improve or extend the irrigation system. Implementing this requires the same actions as for repair work above. The construction work needs to be *planned*, the appropriate *resources mobilized* and *coordinated*. Afterwards, decisions must be taken regarding *adjustments of operational rules* and *maintenance methods*. If the entry of new cultures results in disputes or conflicts, it requires *conflict resolution*; sometimes it has been necessary to *involve an external mediator*. The users may decide to *change operational rules* to accommodate the new users. If the old leadership becomes too inefficient, there may be a *shift in leadership* or a more large-scale *change of the institutional structure*. If new users are included by extension, there may be need for *conflict resolution*, *change of operational rules* and *changes in the organisation or institutional structure* to better represent the new users.

Again, many of these actions are carried out by the leader of the irrigation system, be it the Zamindaar or the Chairman of the Water Users' Association. The leader has the key

role in making decisions and plans about improvements to the canals, as well as in leading the actual construction work. However, for more substantial work, a contractor or specialists in canal digging may be called in to develop the technical plans. The other users usually supply the man-power to do the physical work, and sometimes also make cash contributions to materials purchasing.

Similarly, the leader is most often the one to mediate in the conflicts between old and new users. However, on a few occasions the scale or type of conflict has been such that an outsider, e.g. the chief district officer, has been called in to help the users solve conflicts.

The leader also seems to be the key person in implementing changes of operational rules, although the demand may come from subgroups of users, and the formal decision is made by the general assembly if one exists. For major changes in the institutional structure and for change of leadership, there seems to be more involvement of the executive committee and general assembly of the Water Users' Association. However, it is not uncommon for an incumbent leader to be the key person in proposing and implementing these changes.

4.3 Offer of Infrastructure Support

I have defined as exogenous such irrigation infrastructure development support that is given in the name of larger programs, offered by government on non-government agencies to a large number of irrigation systems in an area. Under these programs, support is offered on certain conditions, almost always including that the farmers organise themselves in a Water Users' Association with a written constitution that is registered with the appropriate agency. That is, I have not included external support that the farmers themselves have taken the first step to get, such as when they approach e.g.

the District Irrigation Office to get emergency support to reconstruct the canal after a flood. Such support is also on a very different scale, often at most a few ten thousand rupees, while the support under the larger programs can amount to several million rupees. As mentioned above, and as is obvious from Figures A.3 and A.4, this disturbance is more complex to trace and describe. In order to make it more easy to grasp, I have divided the flowchart and description in two parts, one focussing on the processes triggered by the offer of support, and one focussing on the processes triggered by the actual implementation of the support.

The farmers in Chipleti Kulo got an offer from one such program to get help in improving the infrastructure of their irrigation system. The offer led to discussions about whether the command area should be extended to include new areas or not, and through whose fields the new canal should run. The farmers disagreed, the disagreement turned into a conflict between the users and the conflict escalated to violence. At that point the offer of support was withdrawn.

When Baise Kulo was offered external support, a Water Users' Association was registered in order to make the system eligible for the support. However, the person registered as Chairman was not the de facto leader of the system. It seems that this was a typical example of what sometimes happens in response to the offer of large-scale external support: An individual sees the opportunity of getting a huge contract, easy to skim enough to cover the required cash contribution, and hurries to write up a constitution and round up a few friends to sign the registration and application documents in the name of a Water Users' Association. The result is an improved canal, but also two

parallel institutional structures, one on paper and used in contact with authorities and for construction purposes, the other real but unofficial and invisible to the authorities. Some ten years after the offer and implementation of the external support, the users of Baise Kulo got tired of the situation and brought charges against the chairman. He was replaced by a leader that has remained on the position ever since.

The canals of Shivpur Martal Kulo were greatly improved under another large-scale irrigation-system development program, but now the system is experiencing management problems. The reason is that the users feel it is no longer their system, but the government's. So why should they have to put their labour into the annual repair and maintenance of it, and why should they come to the meetings? During the last years the turnout at the general assembly has been so small that they have not met the requirements for being able to take decisions. The executive committee members, including the founder and chairman since 30 years, have grown tired of the situation and would like to retire from their positions, but can't – there is no one to take the decision to replace them. It has become a catch 22 situation: the rules don't work because of a low attendance at meetings, and the low attendance makes it impossible to change the rules.

4.3.1 Disturbance

The immediate disturbance of the offer of a potentially huge investment in an irrigation system support has several sides to it. First, there is a chance to improve irrigation and thereby incomes for all users of the irrigation system. Second, there is a chance to increase irrigation and power even further for those who get canals running through their land. Third, there is a chance of making a lot of money as a contractor, and fourth, there is scope for changes in the distribution of power in the system. These immediate

disturbances trigger a number of different processes in both individual users, in the group of users, and in individuals outside the irrigation system.

4.3.2 Processes

The processes triggered by the offer of major external support are concentrated mainly around issues regarding the institutional, rather than the physical, structures. First, there is the task on agreeing whether to accept or not. This process involves agreeing on what to apply for, on where the improvements or new physical structures are to be located, and whether to apply as a "true" Water Users' Association or via a contractor.

Once the users agree to accept the support, they need to draw up a constitution and get the Water Users' Association registered. Here, the path is divided among those systems that draw up their own constitution and those that get a "blueprint" constitution from the project personnel. In the first case, nothing much may happen to the institutional and leadership structures of the system. In the second case, there may be no or little correlation between the institutions in use and the ones on paper. If so, the paper constitution may be completely ignored except by the authorities and donors, and again the old institutions may continue to persist. On the other extreme, but less likely, is a complete acceptance and transition to the new constitution. The most common situation seems to be one of more or less confusion about whether to let the old ways or the new constitution rule. It seems rather common that such confusion leads to management problems.

In some cases, the actual users are bypassed in the process of deciding whether to accept or not – a contractor may simply fill out the required forms and get the support going without involving them at all. Here, as with the "blueprint constitution", the most

common result seems to be parallel institutional and leadership structures. Over time, this undermines the authority of the traditional rules and leadership. In some systems, there are parallel developments of improved physical structures and deteriorating institutional structures: There is an increase in rule breaking and conflicts; it gets more and more difficult to get those breaking rules to pay the penalties for doing so, less people turn up for repair and maintenance, the conflict resolution mechanisms start to malfunction, and so on.

4.3.3 Actions

The first reaction here is the *decision* to accept or not accept the offers, made by either farmers or a contractor. This sometimes involves *conflict resolution* before an agreement is made. Next, before being eligible, the Water Users' Association must register and hand in their constitution. This requires *contacts with authorities and project staff*, and the drafting of a constitution. If a "proper" constitution is drafted, this requires extensive *discussions* and *negotiations* among the users, or putting in print the already existing rules etc. If a contractor seizes the opportunity, this is done by the *use of connections or political skill*. A Water Users' Association executive committee must be *appointed* or *elected* if one does not already exist. If the new constitution causes confusion or increased frequency of rule breaking and conflicts, there is need for further *conflict resolution*, and probably a *change of rules*. If there are parallel institutional or leadership structures, the farmers may chose to *reorganise* the management structure, to *change leadership*, or to *change the whole institutional structure*.

4.4 Implementation of Infrastructure Support

In Jayashree, when the irrigated area was extended new users were included into the system. This resulted in management problems and later a restructuring of the organisational structure. Furthermore, the executive committee had to adjust the annual maintenance work to the new methods and materials that were required after the reconstruction of the system. This led to an increase in the frequency of meetings in the executive committee. The rest of the users, on the other hand, could enjoy a decrease in the amount of labour needed for repair and maintenance. In Shivpur Martal Kulo, the negative effect coming from the users' perceived loss of ownership of the system was partly compensated by an increase in the availability and reliability of irrigation, resulting from the physical improvements.

4.4.1 Disturbance

After registering the Water Users' Association, there are usually two more things that the users (or the contractor) have to do to be eligible for support: A certain amount, or a certain share of the total construction cost, has to be supplied by the users in cash, and they have to contribute some labour in the actual construction work. The impact of these actions depends on the method for registering the Water Users' Association. If the process is driven by a contractor, he usually supplies the cash without involving the farmers. Otherwise, cash is collected from the farmers on the basis of landholding sizes.

Except for the contribution of cash and labour in the construction process, there will be other disturbances once the construction is completed. The command or irrigated area may be extended and the availability and reliability of irrigation improved, there is often a decrease in the amount of labour that is needed for repair and maintenance of the system, and there may be a change in the methods needed for maintaining the system.

4.4.2 Processes

The processes triggered by the need to supply cash or labour are fairly straightforward. If the users themselves supply the cash, this is mostly done on the basis of landholding sizes. The money is deposited in a bank account, often in the name of the Water Users' Association. Labour may be supplied either on a household basis or on a landholding size basis, and the work is often carried out under the directions of an engineer or project personnel.

The processes after the construction is completed run along four paths. The most prominent change is often the decreased need for labour for regular repair and maintenance of the systems. In Chipleti the need decreased from 3,500 to 1,500 man-days per year, in Baireni from 1700 to 400 and later to 200. This obviously makes the old rules for labour contribution obsolete, but also results in an increased supply of labour that can be used in the pursuit of income from other sources. This, in turn, increases total incomes and decreases the relative dependency on irrigation, although it should be emphasised that agriculture is often said to be the preferred source of income. Furthermore, it also decreases the dependency of irrigation on the users' cooperative efforts.

A second effect is to change the maintenance methods needed, for example from raw labour used in desilting the canals to cement used for repairing them with. This increases the need for cash contributions, which may make it more difficult for the poorer users to contribute their share.

Thirdly, irrigation availability and reliability may be increased, making it possible for the farmers to diversify their crops or use improved seeds to a larger extent than before, thereby increasing harvest sizes. However, by the time these large programs were implemented the farmers in some of the systems had already tapped their sources of

water to such an extent that the main change was in the reliability of irrigation. The increased availability or reliability of irrigation also had an effect on the extent of water stealing – although sometimes increasing it, sometimes decreasing it.

A fourth effect is that when the canals were extended, new areas were included in the irrigation systems and when irrigation increased, new users were attracted to move in. The processes following this are described in Section 4.2 above and in Figure A.2.

4.4.3 Actions

The first thing to do is to *decide* on a basis for cash contributions, and then to actually *mobilize cash* for the required deposit. Then, the same *decision* had to be made regarding labour and the required labour must then be *mobilized* and *coordinated*, which in this case would have to be done at least partly be the contractor or engineer in charge of the construction work. If the changes to the physical structure result in changes in the required maintenance methods, for example in terms of the amount and kind of labour and materials that are needed, there is a need to *develop new rules* for labour and cash contributions that better fit the new situation. The new rules must be *implemented* and *accepted*. If the frequency of meeting for maintenance purposes decreases, there may be a need to create *new arenas for discussions and problem solving*. A change in the flow of water may create a need to *change rules* for water distribution and may increase, or decrease, the need for *communication* among the users.

The decision on the basis for contributions seems to be taken by the general assembly, and the actual collection of money is often made by the secretary of the Water Users' Association. The physical work is quite extensive and requires specialist knowledge; hence it seems usual that an engineer is leading the work. Regarding changes of rules

after the completion of the physical improvements, the decisions are taken either by the leader alone or by the executive committee or general assembly of the Water Users' Association, depending on the resulting institutional structure. Changes in maintenance practises were mainly decided by leaders or their executive committees.

5 Analysis

In this section, I summarize the farmers' reactions to the processes and disturbances described above. I then discuss what is required in order to be able to take these actions. As you will already have noticed, there is limited variation in the actions taken.

In the case of floods and landslides, there was decision-making about what to do and when and how to do it; there was organization, mobilisation and coordination of physical repair or reconstruction of damaged structures, and if external resources were to be mobilized, these needed to be contacted and persuaded to help: There was sometimes also the need to develop new rules.

In the case of new users, there was again decision-making, organization, mobilisation and coordination of extension work, development of new rules and maintenance methods; in some cases there was need for conflict-resolution, change of rules, reorganization, change of leadership and even change of the institutional structure.

The offer of external support led to decision-making, conflict-management, negotiations, and the use of external connections, appointments or elections, choices between parallel structures, change of rules, reorganization of management or institutional structure and change of leadership.

Finally, the implementation of external support involved actions such as mobilisation of cash and labour, and development of new rules for labour contribution to maintenance and for water distribution.

I summarize these actions by arranging them in six groups. First, there is *decision-making*. Second, there are actions involved in *organizing and implementing physical repair or reconstruction work*. We then have *conflict management* and *change of operational rules* for labour contribution and water distribution. Finally, there are activities related to *change of leadership* and *change of institutional structure*. The table below illustrates the connections between types of disturbances and groups of actions.

Action / Disturbance	Decision making	Repair or re-construction	Conflict management	Change of rules	Change of leadership	Change of institutions
Floods and Landslides	X	X		(X)		
New users: Same culture	X	(X)	X	(X)		
New users: Different culture	X	(X)	X	X	X	X
External support: Offered	X		X	X	X	X
External support: Implemented	X	X	X	(X)		

Table 5.1: Disturbances and Reactions.

Quite naturally, decision-making is the most frequent action taken. Without appropriate methods for making decisions, there are few organizations that would function. Together

with repair and reconstruction work, this is what I would like to define as regular activities. Management of less severe conflicts can also be seen as part of the regular activities of irrigation system management. However, the management of more severe conflicts, particularly those that involve all users, or involve or challenge the leadership, I would classify as irregular activities or organization development. Changing rules, replacing individuals on key positions as well as changing the institutions are also irregular activities. Below, I look closer at these groups of actions.

5.1 Decision-Making

There are three key elements to decision-making. First, the decision has to be made, second, the decision has to be communicated to those that are supposed to follow it, and third, the decision has to be accepted by these persons.

Making the decision requires the existence of a *decision-making entity*. Among the irrigation systems covered here, there are mainly two types of decision-making entities: The single leader and the Water Users' Association. In the old days in the Tharu dominated systems, the Zamindaar was the single leader, making more or less all decisions, although sometimes after discussions with the other farmers. In many cases there is in practise a single leader also in the systems that do have a functioning Water Users' Association. There are many statements in the narrative information pointing at this, such as “Without this person the system would not work”. One example is Shivpur Martal Kulo, where the chairman of the Water Users' Association has run the irrigation system more or less run alone for 30 years. In the latter days, and especially in systems run or dominated by Hill migrants, decisions are more often taken by the chairman or by the Water Users' Association’s Executive Committee or General Assembly.

Communicating the decision can be done directly by the unit making the decision, such as when the Zamindaar or a dedicated chairman spends several hours per day walking the length of the canals and talking to the farmers. If decisions are made at the General Assembly, those present are instantly informed, and decisions taken by the Executive Committee can be communicated at such or other meetings of the Water Users' Association. When a water guard or peon is employed in the irrigation system, informing the users about decisions made are often among their chores. However, the users do not always listen to and accept what water guards or peons say.

Getting *acceptance for the decision* made is crucial. In the systems originally constructed by Tharus, this became a main challenge after migration brought new users with different traditions to the area. As long as all users were Tharus, the authority of the Zamindaar was appreciated, rather than questioned, it seems. The Hill migrants, coming from another culture, were not as prone to follow the word of the Zamindaar. In the other cases of personalized leadership, there seem to have been a situation similar to that of the Tharu communities, where people listen to and willingly follow the words of the leader.

5.2 Repair and Reconstruction work

The management of repair and reconstruction work after floods and landslides can be compared to project management. There is a well contained task that needs to be accomplished within a limited time period. The project has to be planned, using *technical skills* to decide what should be done, how, by whom and when. The required resources must be *mobilized*, which involves *motivating* the farmers to contribute their labour, and if needed, cash. There seem to have been little problems with this for the kind of emergency repair we are looking at here. If external resources are required, *contacts* and

political skill are needed to persuade the external agency to supply the cash wanted. When it is time to actually carry out the work, the resources have to be *coordinated* and used according to the plan.

Again, there is a difference between the traditional Tharu systems and the Water Users' Association systems. In the Tharu dominated systems, the Zamindaar organised and coordinated repair and reconstruction work. There is, however, an example of a Zamindaar who took the initiative to organize a construction committee for a planned improvement of the canal. The chairman and sometimes secretary of the Water Users' Association seem to be the persons responsible for managing emergency repair and reconstruction in the irrigation systems with functioning Water Users' Associations. Except for carrying out the physical work, one or very few individuals are involved.

5.3 Conflict Management

At least three parties are involved in conflict management or resolution: The two (or more) parties in conflict with each other, and the one trying to mediate between them. The requirement is thus that there is a person, or an institution, that can *act as mediator* or negotiator. Furthermore, both parties have to *trust* this person or institution to act fairly. As indicated above, I find it useful to make a distinction between conflicts on the basis of who is involved and what the conflict is about. Minor conflicts, between few users regarding for example water distribution, are different from major conflicts, which involve most users or larger subgroups and are based on cultural differences. Minor conflicts are part of the daily management of the irrigation system, and it is the Zamindaar or chairman that resolves them. The more serious conflicts often started as conflicts about the rules for labour contribution. The parties are often old versus new

users, but it can also be small- versus large holders, i.e. rich versus poor farmers. When this coincides with the parties being Tharu versus Hill migrants, the conflict seems to be about more fundamental issues, and often develops into a conflict about leadership and institutional structure, that is, about power, and may even turn violent. It is at this level that it may become necessary to bring in an *external mediator*, such as the Chief District Officer.

5.4 Change of Operational Rules

Here, I am referring to changing operational-level rules. At this level, rule-changing is more of an adjustment to minor changes in the way the users and the irrigation system works. When for example the users of the fifth region were included in Nawalpur Tallo Tal Kulo in the last canal extension, they argued that it was unfair to let the labour contribution for maintenance be household based. These were poor farmers with small land holdings, who would prefer contributions to be based on landholdings. After arguing their point for quite some time, the rules were changed. This is an example of when Ostrom's (1990) third design principle, about collective-choice arrangements, applied.[9]

Similarly, but perhaps less with the use of political skill[10] or collective-choice arrangements and more with the use of the force of a growing majority, the new Hill users of Baireni in time got the rule for labour contribution changed from being household to landholding based, which according to their customs represented a fair distribution.

Thus, there is a great variation in how and why rules are changed; What triggers a change in rules can be changes in the physical characteristics of the irrigation system or changes

[9] Ostrom (1990) p. 90.
[10] See e.g. Acheson (2003).

in the composition of the users of the irrigation system; The rules are changed sometimes authoritatively by a *single leader* and sometimes via *collective-choice arrangements*; and by the use of *political skill* or through the *strength of the majority*.

5.5 Change of Leadership

As there is no instance of irrigation system that has actually ceased functioning, at least not among our ten systems, the most severe action has been to change the institutional structure of the irrigation system. In the cases where Zamindaars were replaced with other leaders, this implied changing the institutional structure of the irrigation systems. Similarly, when charges were raised against the "contractor-chairman" in Baise, this also implied a change of the institutional structure as the users formed a Water Users' Association and introduced democratic elections in order to accomplish this. Hence, changing leadership can be closely connected to changing institutions.

Changing the leadership requires first the ability to *identify a new leader*. If there is not already an individual that can take on the role of leader, there has to be some kind of *leadership development*. It is crucial that the new leader can be *recognized* and *accepted* by (sufficiently many of) the users. In for example Pithuwa, where there was a state of anarchy after the government constructed the physical structures, a farmer with previous experience of irrigation system management took the initiative to get the users organised. This farmer was accepted as a leader of his branch level system, and the initiative was soon followed in the other branches. In the irrigation systems analysed here, it seems that when dedicated individuals have stepped forward and showed a willingness to take on the task of leadership, the other users have often willingly accepted them as leaders.

When groups of users have not supported the leadership, it has often been because of ethnic differences. However, an example from Tarauli Kulo shows that ethnic heterogeneity does not have to result in conflicts and shifts of power. The chairman since long was a person belonging to the Tharu ethnic group. When the number of Hill migrants increased in the system, he appointed a Brahmin as a secretary of the Water Users' Association. This made it easier for the Hill migrants to accept the Tharu chairman, and was also a convenient solution for the chairman, who needed the assistance of someone who could read and write well. The data indicates that there is more concern about the need to find good leaders, than about power struggles between individuals for the leadership. However, one side-effect of the democratisation process has been to increase the tendency to use irrigation system leadership as platforms for political parties. There must also be a way to actually get the old leadership to step down. In the case of Baireni, there was almost 25 years of struggle before the power was shifted from Tharus to Hill migrants. There, there was a gradual decrease of the Zamindaar's power. In Baise, the process was quicker and involved the creation of a *forum for leadership replacement*, the Water Users' Association.

5.6 Change of Institutional Structure

Changing the institutional structure of an irrigation system may seem more fundamental than changing the leadership, but the data suggests that maybe it is not. It seems that changes in the institutional structure are often initiated by changes in leadership, rather than the opposite. This was obviously the case in both Pithuwa and Baise, mentioned above, and in Mahadevtar where the Zamindaar took the initiative for creating a Water Users' Association to simplify the process of canal reconstruction. The roles taken by

individuals here are similar to those described in Folke et.al. (2003)[11] as stewards and leaders. Baireni is a less clear-cut case, partly because the individual and the institution were so closely intertwined in the role of the Zamindaar.

For changing the institutional structure, there has to be an entity that has the *authority to change institutions*. Who has this authority differs over time and between systems. In the traditional Tharu systems, the Zamindaar had basically all power. However, his power was solidly based in the traditional institutional structure, so the questions is whether even a Zamindaar could change more than a part of this institution. In other cases where the irrigation systems have been described as "one-man shows", these individuals had the power to implement substantial changes in the institutional structures. Similarly, when a contractor seizes the opportunity of getting the contract for major infrastructure developments by making himself the chairman in a "fake" Water Users' Association, he changes the institutions. In yet other cases, the institutions have been changed by external agencies, such as when constitutions were drafted after the District Irrigation Office's blueprint. Finally, there are those systems where the users themselves have created Water Users' Associations, controlled by the General Assembly of the users and run by an Executive Committee. These irrigation systems are the ones that most closely resemble the organizations described by Ostrom (1992).[12]

Changes in institutions seem to be either need-based or conflict-caused. An offer of external support or a change in for example the size of the system causes a need for changes. The conflict-caused changes result from the inclusion of individuals that are in some important way different from the original users. In either case, there is the need to

[11] Folke et.al. (2003) in Folke et.al. (2003), p.369.
[12] Ostrom (1992) p. 41.

develop new institutions, which requires a skill in understanding how people will react and act in different situations. There is, except when a single individual has the authority to change the institutions, also a need for *discussions* and *negotiations* among the users and person having this authority. A *formal decision* has to be taken, *communicated* to the users and *accepted* by them before it can actually be *implemented*. If the change involves new positions, there have to be *appointments* or *elections* to fill these.

6 Discussion and Concluding Comments

The most serious disturbances seem to be those that affect the institutional structure directly, such as an offer of external support that requires registration of a Water Users' Association and the drafting of a constitution. Similarly serious, and also affecting the institutional or leadership structure, are the processes triggered by having users from a different culture enter the system. Both these disturbances imply a period of competing rules, one with a system-level boundary (between the irrigation system and the government system) and one with an ethnic boundary (between old and new users). The disturbances that come in the form of physical damage to irrigation structures seem to have no long-run effect at all, except when their remedy brings increased irrigation, as this may attract new users. One difference between these disturbances is that while floods and landslides may be unusual, they are not totally unexpected events. Immigration and external interventions in the institutional structure, on the other hand, are both unusual and unexpected events. Thus, we may conclude that the extent to which an event is unusual is perhaps less important than the extent to which it is unexpected.[13]

[13] This can also be compared to what Argyris (1977) refers to as single-loop and double-loop learning.

The most frequently used and possibly also the most crucial characteristic is that to be able to make, communicate and get acceptance for decisions. Without this ability, even the simplest problem would become a serious challenge. According to Jackson and Carter (2001), "Organization is the ongoing process of decision-making. Organization requires a process of management and the process of management implies decision-making". Thus, we should not be surprised by the amount of decision-making activities in the irrigation systems.

Neither should we be surprised by the fact that many of the characteristics rest on one or a few individuals. Regarding for example conflict resolution, Ostrom (1992) comments that "…those who are selected as leaders are also the basic solvers of conflict".[14] Again, we can draw a parallel to business organizations, where the leaders and management are recognized as playing a crucial role in the success of the organization.[15] This again suggests that we would benefit from using organizational theory, and in this case theories about leadership, for understanding resilience in common property resource management. One step on this way is taken by Westley (2002)[16] who describes the case of one individual manager in a series of resource management challenges. Motivating her effort, Westley cites Gunderson, Holling and Light (1995) when they state that "that individuals and small groups of individuals exert extraordinary influence by performing certain distinct roles within and outside institutions" is the key to the reality of the adaptive management of complexity[17]. This can also give us a better understanding for why cultural heterogeneity seems to be such problematic issue. Alvesson (2001) makes the

[14] Ostrom (1992) p. 73.
[15] See for example Mintzberg (1973) p. 5 and Milgrom and Roberts (1992) p. 114.
[16] Westley, in Gunderson et.al (2002).
[17] Note the similarity to Foss (2001) who, referring to Galbraith (1973) and Thompson (1967), states that "The essence of organisation is a coordinated response to volatility".

point that "leadership is not only about a leader acting and a group of subordinates reacting in a mechanical way, but a complex social process where the meanings and interpretations of what is said and done are imperative" (my translation). Of course, when people come from different cultures, there is an increased risk that their interpretations differ.[18]

Summarizing the previous section, it is obvious that the characteristics needed for countering the effects of the disturbances are very similar to those used for running a business organization. Decision-making and physical repair or reconstruction, and to some extent conflict resolution, can be compared to the activities involved in the daily management of a business organization or to project management. Changing rules, leadership and institutional structures can be interpreted as organizational development activities. Management or resolutions of larger scale conflicts that evolve from the incorporation of users with a different culture are similar to the situation after a merger between two business corporations with different organization culture.

One important conclusion is thus that we should strongly consider using tools from organization theory when analysing the resilience of institutions for managing irrigation systems, and most likely also other common property resources. The tools that are more often used for analysing common property systems, such as game theory, transaction cost analysis and even the institutional analysis and development framework may be better suited for static analyses. Furthermore, some of them are definitely more useful in explaining why these systems exist, than how they actually function.

[18] Alesina and La Ferrara (2002) and Bardhan and Dayton-Johnson (2002) are examples of quite different ways of discussing the effects of heterogeneity.

Another important conclusion is that the way institutions change, and hence develop and evolve, depends to quite a large extent on the people managing them. Of course, the institutions are adapted to the environment in which they exist, but exactly how this adaptation is made is decided by the individuals who happen to be in charge.

The present analysis has dealt with the internal reactions to external disturbances. Of course, there are many other disturbances that could have had more devastating effects, and other irrigation systems that have poorer abilities to counter the effect of the disturbances. However, irrigation is such a crucial input in farming that it is very hard to find irrigation systems that have actually failed. Perhaps this makes them less suitable study objects for analysing resilience – the dependency may simply be too high to allow failures – or perhaps they are an excellent choice – as they simply have to have adaptive capacities.

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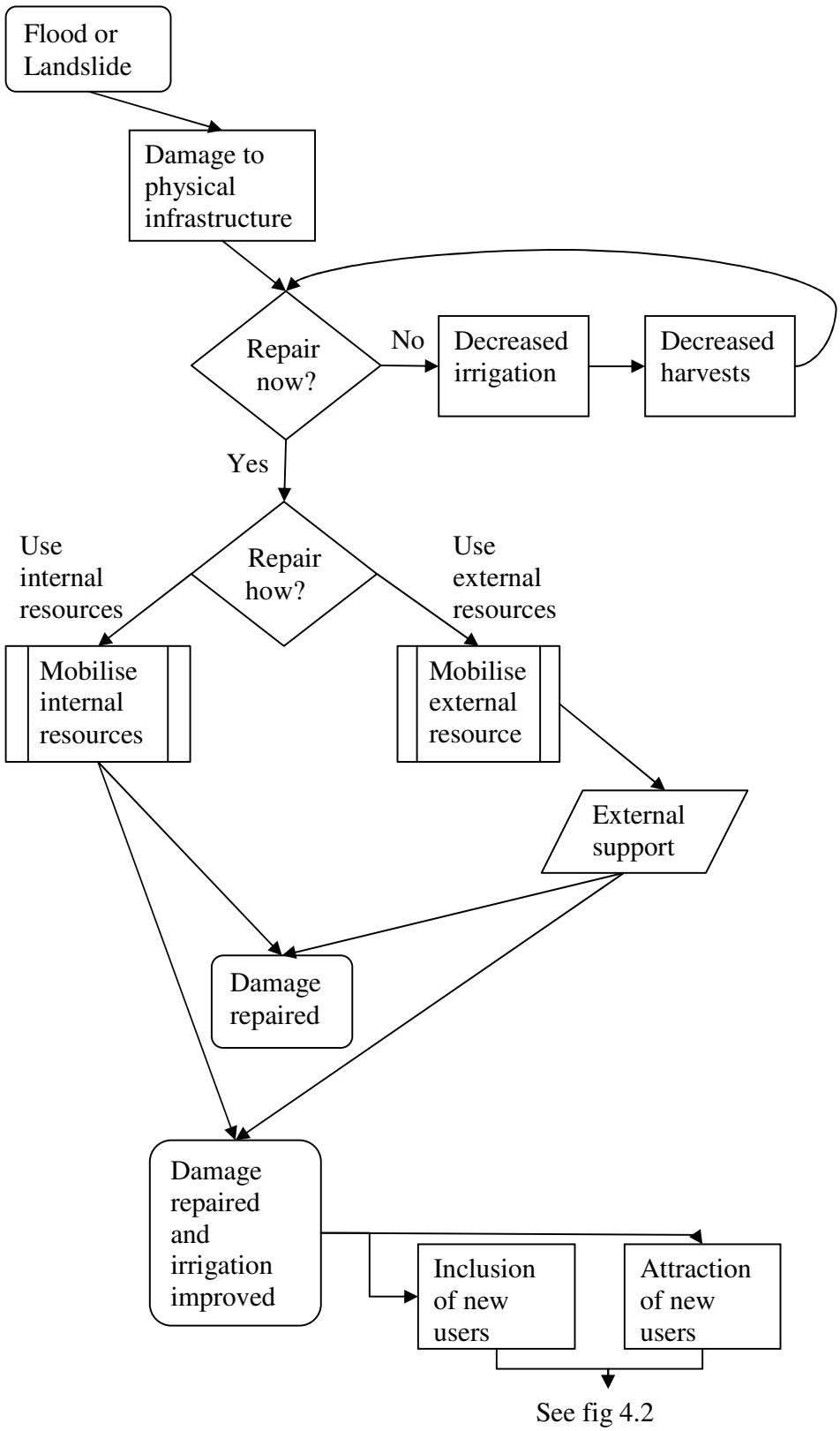
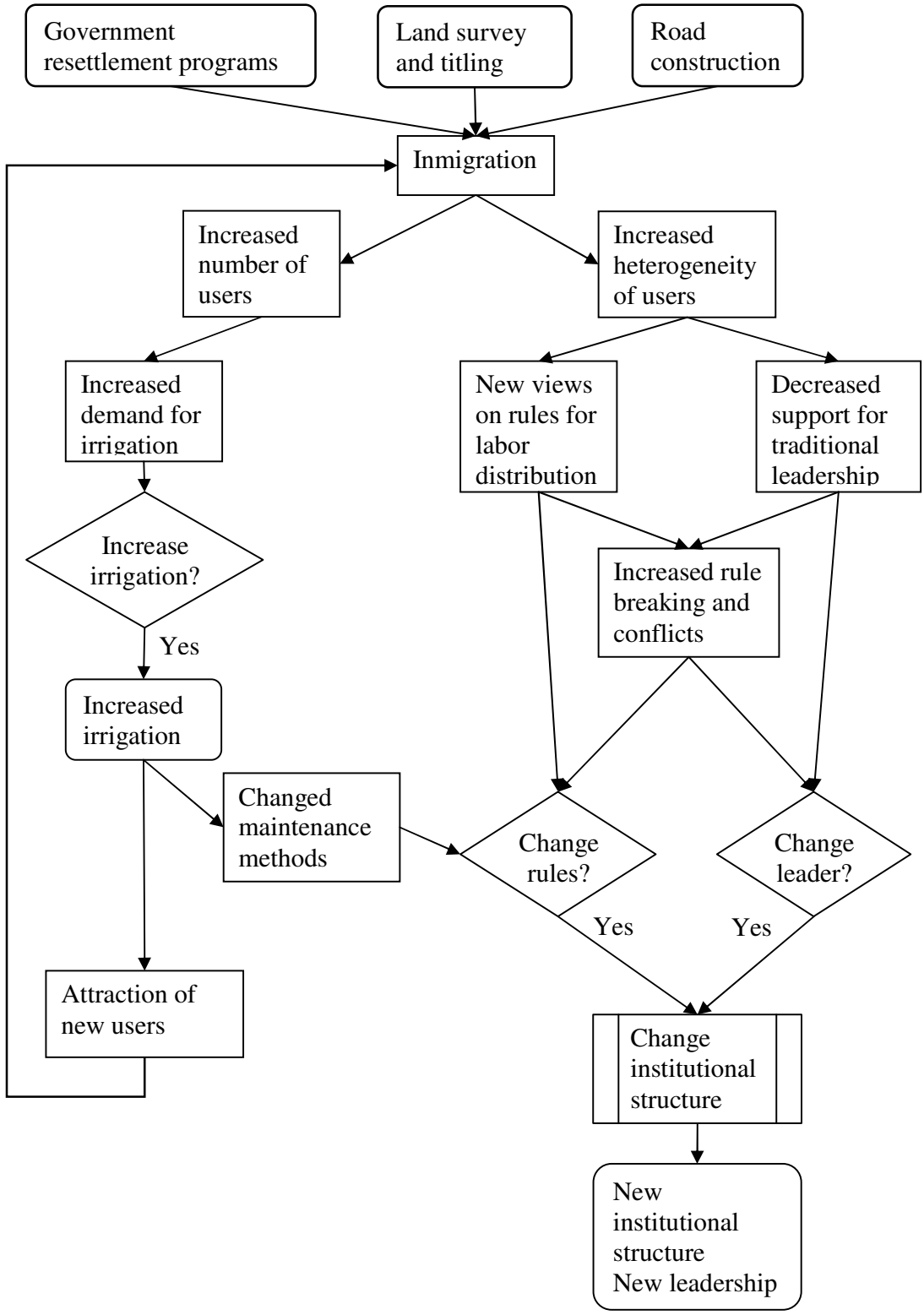
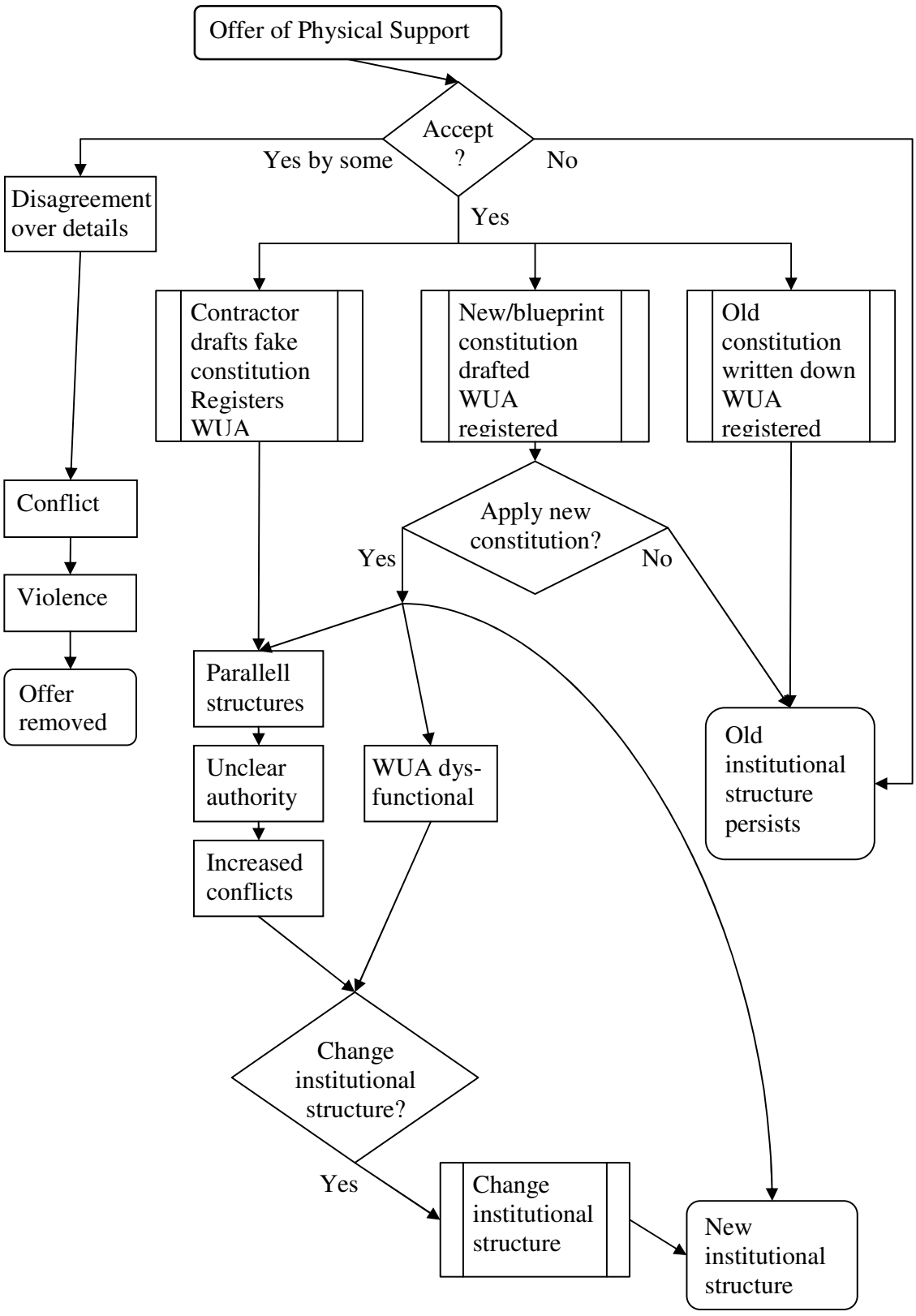
APPENDIX, Figure 4.1: Floods and Landslides Flowchart



APPENDIX, Figure 4.2: New Users Flowchart



APPENDIX, Figure 4.3: Offer of External Support Flowchart



APPENDIX, Figure 4.4: Implementation of External Support Flowchart