Disturbances and Resilience in Common-Pool Resource Management Systems*

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In this paper, I take the analysis of common-pool resource management one step further by looking closely at how the users adapt to different types of disturbances. The analysis provides insights for how to analyze and promote resilience in common-pool resource systems. The main conclusion is that we need to start using a new tool-box if we are to further improve our understanding.

I analyze historical data from ten farmer managed irrigation systems in Nepal. By tracing the processes triggered by the most common types of disturbances, I am able to pinpoint the actions that are taken by the users to counter the negative effects of these disturbances. I find that the reactions can be grouped into decision-making, reconstructions activities, rule changes, conflict management and change of leadership or institutions. I also find that many of these activities are undertaken by a few key individuals, the leaders. Furthermore, the main threats to the sustainability of these irrigation systems are disturbances that change the composition of individual users and those that directly affect the institutional structure. This strongly suggests that we start using the tool-box provided by various organizational theories.

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1 Introduction

What makes some common-pool resources 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? These questions are crucial to the understanding and furthering of local management of natural resources, especially in a time of rapid change and globalization. This paper suggests a surprisingly simple way to analyze the resilience, or adaptability, of common-pool resource management systems: We should analyze them as we would any other systems managed by human beings.

The focus of this paper is on identifying characteristics that contribute to the resilience of common-pool resources management systems. I analyze 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 exposed to a number of similar or identical disturbances: There have been natural disturbances such as floods and droughts, and socio-economic disturbances such as massive immigration, road construction, marketization, external support for infrastructure improvements, increased income inequality, decreased land holding sizes and democratization. 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 has been smooth.

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, I describe the processes they have triggered and problems they have caused. In the next step, I analyze the reactions taken by the farmers in response to these problems. I find that the actions taken can be summarized in a fairly limited set of activities: Decision-making, reconstruction work, conflict management, change of rules and change of leadership or institutional structure. The most serious problems are caused by disturbances that change the composition of individuals in the group of users so that they become more heterogeneous, for example the immigration of individuals from a different culture. Disturbances that directly affect the institutional structure are also potentially serious, such as the offer of external support that requires the formation of a Water Users'

Association. The least threatening disturbance, at least in the long run, seems to be physical damages to the irrigation system, caused by floods and landslides.

Comparing these results with a previous, statistical analysis of the data,[1] I find an explanation for why individual leaders came out as highly significant for the level of cooperation in among the users. Many of the actions identified as important in the present analysis are carried out by single individuals. In the statistical analysis, the relative strength of the ethnic majority group, as well as an equal income distribution, was also highly correlated with cooperation, and again the present paper provides a description of the processes behind that result.

In the paper, I use a definition of institutions that is slightly wider than that of Ostrom (1992), and say institutions are not only sets of rules-in-use, but also the entities (human or organizational) that make and implement these rules. Regarding the definition of resilience, while in Scheffer et.al. (2002), resilience is defined as "…the ability of the system to return to the original state after a disturbance", I would rather refer to it as returning to the original path or purpose, as the purpose of an irrigation system in to change, and in the eyes of the users improve, a situation. Furthermore, I use the definition of disturbance as an "unusual event" provided by Scheffer et.al. (2002).

The paper continues with some background information about the irrigation systems analyzed and the way data was collected. I then provide an interpretation of what I mean by disturbances, processes and reactions, followed by a description of the disturbances, processes and reactions of floods and landslides, new users and offer and implementation of external support. Section Five analyses the actions taken and Section Six concludes the paper with a discussion of the results.

2 Background

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 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 depends on the state of the canals and

[1] Ternstrom (2002b).

intakes. The canals can be of a more or less permanent structure, being for example cement-lined, lined with mud or have no lining at all, and the intake can be made of cement or brushwood. An irrigation system with a brushwood intake and unlined canals will require more repair and maintenance and deliver less water than one with a permanent intake and cement-lined canals. Thus, 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 labor 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 are often organised in a water users' association, or has a leader appointed by other means, making decisions regarding the time and labor contribution for repair and maintenance, the distribution of water and the penalty for not following the rules, for example.

The data was collected from ten irrigation systems in three neighboring districts, Chitwan, Makwanpur and Nawalparasi, in the Terai region of Nepal. The land was formerly under jungle forest, 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 program in the 1950's and 60's, people from the hilly areas started to move in, which caused a period of rapid population growth. After the main inflow of migrants, the increase in the number of households has mainly been due to family separation, when ancestral land has been distributed among the sons of each generation.

There has been a series of government and/or non-government organization supported programs for improving the infrastructure of the irrigation systems, 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). Most of these programs have required users to contribute a (small) share of the total cost in the form of cash and/or labor.

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 also been functioning for some time. Systems with too severe cooperation problems will thus be excluded from the sample.

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. The questionnaire was developed by the author in collaboration with WMSP staff after a series of field visits, and tested and modified accordingly. Data were collected in discussions with groups of key individuals in each system. In many cases, the respondents were members of the Executive Committee of the Water Users' Association.[2] 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 to 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.

The data set contains information on a large number of variables. To get the historical information, the respondents were first asked to develop a time line over the main events in the history of the irrigation system. These events were then used as reference points in time when going through the questionnaire, which covers areas relating to irrigation, cropping pattern, socio-economic status and income distribution among the users, external income sources, institutional structure, conflicts, rule breaking and cost-benefit effects of major events. Of course, this way of collecting historical data makes the information less reliable than if there had been written records on all the information needed. There will be a bias for historical records, since some households and other data will have been forgotten.

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

Obviously, not all information in the data material will be used in this paper. For the purpose of the present analysis, the focus will be on the data provided by time lines and narrative information. The extensive amount of data, together with the detailed narrative information, provides plenty of opportunities for further studies of the functioning of these irrigation systems.

3 Disturbances, Processes, Reactions and Resilience

3.1 Disturbances

I define disturbances as "unusual events"[3] and have chosen to focus on exogenous disturbances. That is, I exclude disturbances or changes that are initiated internally, such 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. The disturbances that have occurred are: 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 neighboring system, population growth and introduction of multi-party system in the country, Note that the list of disturbances is based on the respondents' information, and my interpretation of it, and that there may be other disturbances that should be on the list, but that are not included in the data.

After going through the time lines and other narrative information in the data, I have selected three disturbances that are recurring over time and in different systems, and that capture the most frequent and important changes that have occurred. The selected disturbances are floods and landslides, extensive external support to infrastructure development, and different causes for immigration or inclusion of new users.

[3] See e.g. Scheffer et.al. (2002) in Gunderson et.al. (2002).

3.2 Processes

It is not the disturbance per se that cause a need for action. The disturbances trigger processes, which alone, or together with processes triggered by other disturbances, lead to a situation 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 lead to food shortage, which is what the farmers want to avoid. When new users enter the area, there may be conflicts between new and old users that need to be resolved. In the case of external support the processes that are triggered are much more complex and complicated to analyse.

The disturbances affect the physical structures, such as when a flood washes away the intake of a canal, the institutional structures, such as when a requirement for getting an offered external support is to write a constitution, or they can affect the composition of individuals, such as when a government resettlement project brings people with a different culture to the system.

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. The rules for labor contribution may need to be changed in response to an increased or decreased need for labor resulting from an investment in the physical infrastructure.

Analyzing the reactions taken will be my key to understanding which characteristics are important for accommodating or adapting to the disturbances. The requirements for being able to take a certain action are a combination of abilities and opportunities present in the irrigation system and its environment. For example, getting external support to repair the damages after a flood depends both on the ability of having the right connections and on the existence of funds that can be distributed. However, the data does not contain sufficient information on the opportunities at hand at different times, and the purpose of this paper is on understanding what internal characteristics are important for resilience. Therefore the analysis will, although recognizing that opportunities have an important role in the actions taken, focus on the abilities required.

4 Recurring Disturbances and the Resulting Processes and Reactions

In this section, the types of 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. In the Appendix, there are flowcharts illustrating the processes.

4.1 Floods and Landslides

In 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 neighboring irrigation system. At that time the Zamindaari system was prevailing. This is the traditional, feudal, leadership system where a local landlord is leader in the irrigation system as well as in other areas of village life. In terms of processes, the floods had the immediate effect of triggering reconstruction work by mobilising both internal and external labor resources. The end effect was a repaired irrigation system. In terms of abilities, planning, coordination, motivation and external connections were taken in use, and these were most likely the result of a combination of individual and cultural characteristics. The individual having the role of Zamindaar had been shaped by his own individual characteristics and the Zamindaar heritage.

In Mahadevtar, on the other hand, where a flood washed away almost half of the irrigated area, it took several years before the entire area was reclaimed, despite extensive repair work. Later, a flood control dike was constructed with the support of the District Irrigation Office. This suggests that an ability to mobilize external institutional resources, using external networks and political connections, was developed over time.

4.1.1 Disturbance

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

The immediate damages caused by floods can be washed away intakes, damaged canals, changes in water level or course of rivers, and washed away fields. Landslides can also damage the canal, especially where it passes through hilly terrain.

4.1.2 Processes

The next step is a decreased or ceased flow of water. If nothing is done, decreased crop productivity and/or harvest sizes will follow. To avoid this, the users can react by repairing or by repairing and improving the damaged structures at once or later on, with internal or external resources. A small damage can be repaired more quickly and with fewer resources than a large damage. In the case of improvement, this leads increased irrigation, which in turn may lead to an attraction or inclusion of new users, taking us into the processes in Figure 4.2. It may also lead to a need for new rules for repair and maintenance and for water distribution.

4.1.3 Reactions

What paths are followed depends on the choices made and actions taken, which in turn depend on the opportunities and abilities at hand. In the first choice it may or may not be physically possible to do more than repair the damage. If the damage is very large there may be no opportunity to repair it at once, and there may or may not exist external sources that could be mobilized.

The first action taken is to *make a decision* about when and how to repair. Next step is to *mobilize resources*, which, depending on the choice made implies *motivating* the users to come to the right place at the right time and *coordinating* them in doing the right tasks, or to *contact* external sources of funds and *persuade* them to contribute. If the irrigation system is improved or extended, and the old rules become inappropriate, someone has to *make a decision to change* them, *develop new rules*, and *get acceptance* for these.

4.2 New users

Baireni Kulo has existed for a long time. The users remembered that there was a flood in 1949, and that there was irrigation long before this. In 1970, the first Hill migrants came to settle in the area, starting a 25-year long period of immigration. The original inhabitants of the area are Tharu's, who according to their traditional ways were led by the Zamindaar, or local landlord. The Zamindaar was the leader not only of the irrigation system, but in all aspects of village life. The Zamindaar's word was with very few exceptions obeyed, and

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. The Hill migrants moving into the area had less understanding for the Tharu traditions, and the support for the Zamindaar started to decrease. As more hill people, or *Pahadiyas,* moved in, the strength of the Tharu majority decreased and with it, rule-breaking and conflicts increased. In 1981, a Water Users' Association was formed, in order to make the system eligible for FIWUD support. This Water Users' Association was active mainly for construction purposes. In 1990, the country adopted a multi-party system, causing the support for the traditional system to decrease further, and in 1995, in connection with another major infrastructure support (ERIP); another Water Users' Association was formed. This time, there was a shift from Zamindaar to Water Users' Association leadership 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 Zamindaar leadership. It is difficult to judge what the end effect of the leadership change has been, since it coincided with the infrastructure support which increased water availability and decreased the need for labor in maintenance to an eight of what it used to be. Thus, there is nowadays much less scope for rule breaking and less cause for conflicts.

4.2.1 Disturbance

The origin of this disturbance is 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 government resettlement programs, 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. The nature of the disturbance depends crucially on the individuals entering the system. If they are culturally and economically similar to the ones already there, the only effect seems to be to increase the number of users. If, on the other hand, they for example belong to another ethnic group, there may be severe problems. There is a difference in leadership traditions, in rules for labor mobilisation and in the preferred mode of contribution – cash or labor. If they also differ in economic or educational status, this further complicates the process.

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 harvests. The most efficient way to increase harvest sizes is to increase the amount and reliability of irrigation. If the irrigation system is improved, it may 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 may have to be adjusted. Furthermore, even more new users may be attracted to move into the area.

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 labor contribution rules (small holders tend to find labor contribution on household basis less attractive than large holders). If they are poorer, perhaps because their land has not been irrigated until now, they may have more difficulties in making contributions in cash. This can result in disputes and conflicts over labor contribution rules, and, if the rules are not changed, in rule breaking. 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.

If the new users differ ethnically or culturally from the old users, they often have different views on what is a fair way of distributing labor input. 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 labor contribution. The Hill migrants, having less respect for the Zamindaar, may start breaking the rules by not contributing their labor and not paying the fines for doing so. There may be conflicts and even violence between the groups. The authority of leadership is challenged and the institutional structure becomes weaker.

4.2.3 Reactions

If there is a need for increased irrigation, a *decision* must be taken to improve or extend the system. The construction work needs to be *planned*, the appropriate *resources mobilized* and *coordinated*. Afterwards, there should be an *adjustment of rules* and *maintenance methods*.

If new users are included by extension, there may be need for *conflict resolution*, *reorganization* and *change of rules*.

The entry of new cultures requires actions such as *conflict resolution*; sometimes it has been necessary to *involve an external mediator*. The users may decide to *change 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*.

4.3 Offer of Infrastructure Support

I have defined as exogenous 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, such that the farmers are organised 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 support in reconstructing 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 4.3 and 3.4, this disturbance is more complex to capture 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 changes to the physical structure.

The farmers in Chipleti Kulo got an offer from GTZ to get help in improving the structure 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, GTZ withdrew their offer.

In Baise, some ten years after the offer (and following implementation) of external support, the users brought charges against the chairman, who had been in that position since the Water Users' Association was registered to make the system eligible for the support. Although it was not stated in such clear terms by the farmers, this was most likely a case of an individual, seeing the opportunity of getting a huge contract which could easily be skimmed enough to

cover the required cash contribution, drawing up his own constitutions and rounding up a few friends to sign the registration and application documents in the name of the Water Users' Association. The result was an improved canal, but also two parallel institutional structures, one on paper and used in contact with authorities and construction activities, the other real but unofficial and invisible to the authorities. In Baise, the "fake" chairman was ousted before there were too severe damages, and replaced by a leader that has remained on the position ever since.

In Shivpur Martal Kulo, there have been increasing management problems after the ERIP supported improvement of the system. The users feel that it is no longer their system, but the government's. So why should they have to put their labor into the annual repair and maintenance of it? Furthermore, for the last years too few members have turned up at the general assembly for it to be able to take any decisions. This has among else made it impossible to replace the members of the executive committee who, including the chairman who has had the lead role in the system since it was first constructed some 30 years ago, would now like to retire from their positions.

4.3.1 Disturbance

The disturbance of the offer of a potentially huge investment in an irrigation system support has several sides to it. One has to do with agreeing on whether to accept or not, another with the amount of money involved, and a third with the changes in institutional structure or leadership that may result from the required formalities.

4.3.2 Processes

The processes triggered by the offer of major external support are concentrated mainly around issues regarding the institutional structure. First, there is the task on agreeing whether to accept or not. In Chipleti the process went from disagreement to conflict to violence, without any (successful) action being taken to interrupt it. There was an *opportunity* to get support, but no *ability* to reach and agreement about it.

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

real institutions and the one's on paper. If so, the paper constitution may be completely ignored, 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. There is also the case described above, when a contractor seizes the opportunity before the users have the chance to consider it. Here, as with the "blueprint constitution", the result is parallel institutional or leadership structures. The traditional rules and leadership start having less authority, 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 Reactions

The first reaction here is the farmers' *decision* to accept or not accept the offers, and in one case their *inability to agree or solve a conflict*. Next, 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 rule breakings and conflicts, there is need for *conflict resolution*, and a *change of rules*. If there are parallel institutional or leadership structures, the farmers may chose to *reorganise* the management structure (i.e. change the institutional structure), or to *change leadership*.

4.4 Implementation of Infrastructure Support

In Jayashree, the command and irrigated area was extended and new users included into the system. This resulted in management problems and later a restructuring of the organisational structure. The executive committee also had to adjust the annual maintenance 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 decreased labor need for repair and maintenance.

4.4.1 Disturbance

After registering the Water Users' Association, two more conditions have to be fulfilled: 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 their labor in the actual construction work. The impact of these 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 loss of cash and labor contributed in the construction process, there will be other disturbances once the construction is completed. The command or irrigated area may be extended, the availability and reliability of irrigation may improve, there may be a decrease in the amount of labor 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 after the construction is completed run along four paths. The most prominent change is often the decreased need for labor for regular repair and maintenance of the systems. In Chipleti the labor days per year decreased from 3,500 to 1,500, in Baireni from 1700 to 400 and later to 200. This makes the old rules for labor contribution obsolete, but also results in an increased supply of labor that can be used in the pursuit of income from other sources. This increases total incomes and decreases the relative dependency on irrigation, although it should be emphasised here that agriculture is usually the preferred source of income. Furthermore, it decreases the dependency of irrigation on the users' cooperative efforts.

A second effect is to change the maintenance methods needed, for example from labor to desilt canals to cement to repair them with. This also increases the need for cash contributions and acts as a push factor in the search for alternative income sources.

Thirdly, irrigation availability and/or reliability may be increased. Often, by the time these large programs were implemented, the farmers had already tapped their sources of water to such an extent that there was not much increase in water availability, although the reliability of irrigation was increased by the improved canal and intake structures. In some cases, this made it possible for the farmers to diversify their crops or use improved seeds to a larger extent than before, thereby increasing harvest sizes. The increased availability/reliability of

irrigation also had an effect on the extent of water stealing – sometimes increasing it, sometimes decreasing it.

A fourth effect is that when 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 the section above and in Figure 4.2.

4.4.3 Reactions

The first thing to do is to actually *mobilize cash* for the required deposit. Then, the required labor must be *mobilized* and *coordinated*, which in this case would have to be done at least partly be the contractor. If the old rules for labor supply become obsolete after the construction work was completed, there is a need to *develop new rules* that better fit the new situation. New maintenance methods may also require *changed rules*. In both cases, the new rules must be *implemented* and *accepted*. If the frequency of meeting for maintenance purposes decrease, there may be a need to create *new arenas for discussions*. 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.

5 Analysis

In this section, I summarize the reactions resulting from the processes and disturbances described above. I then discuss what is required for being able to take these actions. As you will already have noted, 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, contacts with these and persuasion 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.

Finally, in the case of external support the offer of support led to decision-making, conflict-management, negotiations, 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. The implementation of external support involves actions such as mobilisation of cash and labor, and development of new rules for labor contribution to maintenance and for water distribution.

I summarize these actions by arranging them in five groups. First, there is *decision-making*. Second, there is actions regarding *organizing and implementing repair work*. We then have *conflict management* and *change of rules* for labor contribution and water distribution. Finally, there are activities related to *institutional change*, including change of leadership and changes in the institutional structure. The reason for including change of leadership here is that in many cases, the leader and the institutions are quite inseparable. The table below illustrates the connections between the types of disturbances and groups of actions.

Action / Disturbance	Decision-making	Repair or reconstruction	Conflict management	Changing rules	Institutional change
Floods/Landslides	X	X			
New users same culture	X	X			
New users different culture	X		X	X	X
External support offer	X		X	X	X
External support implementation	X	X	X	X	

Table 5.1: Disturbances and Reactions.

Quite naturally, decision-making is the most frequent action taken. Some may question whether it should be regarded as an action, but without a functioning method 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, and especially changing the institutions are also irregular activities. Below, I look closer at the 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 two main 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 entity making decisions, though sometimes after consulting the other farmers. There are also other examples of systems where more or less all decisions seem to be made by one individual, such as in Shivpur Martal Kulo, although this individual was also the chairman of the Water Users' Association. In the latter days, and especially in systems run or dominated by Hill migrants, decisions are usually taken by the chairperson or by the Water Users' Association's Executive Committee or General Assembly. This is an example of when Ostrom's (1990) third design principle, about collective-choice arrangements, applies.[4]

Communication of decisions made can be done directly by the unit making the decision, such as when the Zamindaar or dedicated chairperson spends several hours daily walking the length of the canals. If decisions are made at the General Assembly, those present get 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 of decisions made are often among their chores. However, as in Jayashree, the users do not always listen to what the water guards or peons say, causing problems with acceptance.

Getting *acceptance of the decision* made is crucial. In the systems originally constructed by Tharus, the challenges to this are especially obvious. As long as all users were Tharus, the authority of the Zamindaar was not questioned, but rather appreciated, it seems. When the Hill migrants started moving in, this seems to have been the first thing that was affected. The Hill migrants, coming from a different culture and traditions, were not as prone to follow the

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[4] Ostrom (1990) p. 90, describes this principle as "Most individuals affected by the operational rules can participate in modifying the operational rules."

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 the leader and willingly follow his words.

5.2 Repair and Reconstruction work

Regarding repair and reconstruction after flood/landslide damages, the process is similar to that of project management. There is a quite specific task that needs to be accomplished within a limited time period. The project first need to be planned, using *technical skills* to decide what should be done, how, by whom and when. The required resources must be *mobilized*. If the decision is to use only internal resources, this involves *motivating* the farmers to contribute their labor, 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 system and the Water Users' Association system. In the Tharu dominated systems, the Zamindaar organised and coordinated repair and reconstruction work. There is an example, though, of a case when a Zamindaar took the initiative to organize a construction committee, but that was for a planned improvement of the canal. The chairman and possibly 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 exists someone, or some 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. Conflicts between few users regarding for example water distribution are different from conflicts that involve most users, or larger subgroups, and are based on cultural differences. The conflicts between few users are part of the daily

management of the irrigation system, and it is the Zamindaar or Chairperson that resolves them. The more serious conflicts often seem to be about rules for labor contribution at first. The parties are often the old versus the 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. In one such case, the conflict became violent, and had to be solved by an outside party, the Chief District Officer, that is, there was need for an *external mediator*.

5.4 Change of Rules

Acheson (2003) refers to the ability of making the farmers accept a change of rules as political skill. In the case he describes, this was a lengthy process involving quite a drastic shift in rules. Here, we are concerned with changing the rules for how to do things, rather than what to do, and rule-changing is more of a decision-making activity. However, it is possible to see a component of political skill in those rule-changes that involve a fairness aspect. 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 labor 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 conflict was solved. Similarly, but perhaps less with political skill and more with the force of a growing majority, the new (Hill) users of Baireni in time got the rule for labor contribution changed from household to landholding based, which according to their customs represented a fair distribution. Thus, sometimes *political skill*, and sometimes *strength of the majority*, is used for achieving rule changes.

The situation is different when a rule change is initiated by a change in the physical characteristics of the irrigation system, and we should perhaps then be talking about adjustment, rather than change, of rules. Here, there is need for a skill to *design rules* to achieve a certain behavior among the users. Then, the decision-making process is followed, i.e. *making the decision*, *communicating* the new rule and getting their *acceptance* for the proposed new rule.

5.5 Change of Leadership or Institutional Structure

As there is no instance of an 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 case where a Zamindaar was replaced with another leader, this was synonymous with changing the institutional structure of the irrigation system. 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. Thus, I have put change of leadership and change of institution under the same heading.

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 system, a farmer with previous experience from irrigation system management from another district 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 analyzed here, it seems that when dedicated and authoritative individuals have stepped forward, the users have willingly accepted them as leaders.

When groups of users have not supported the leadership, it has often been because of ethnic differences. However, Tarauli Kulo shows that this does not have to result in conflict and a shift of power, but can be solved by compromising. 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 probably made it easier for the Hill migrants to accept the Tharu chairman, and was a convenient solution for the chairman, who needed the assistance of someone who could read and write well.

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 the Tharus to the 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*.

Changing the institutional structure of an irrigation system may seem more fundamental, but I am not sure that it actually is. Furthermore, it seems that changes in the institutional structure are often initiated by changes in leadership, rather than the opposite. This was 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)[5] as stewards and leaders. Baireni is a less clear-cut case, partly because the individual and the institution were so closely intertwined.

For changing the institutional structure, there has to be an entity that has the *authority to change institutions*. Who has this authority varies over time and between systems. In the traditional Tharu systems, the Zamindaar had basically all power, but the main institution here was the traditions, so even if the Zamindaar could change parts of the institutions, he could probably not have changed the whole institutional structure. In other cases where the irrigation systems have been described as a "one-man show", this individual also had the power to change at least part of the institutions. Similarly, when a contractor has seized the opportunity of getting the contract for major infrastructure developments by making himself the chairman in a "fake" Water Users' Association, the institutions were also changed by an individual. 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. In such organizations we would find the different levels of that E. Ostrom (1992) discusses.[6]

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 is examples of need-based changes. The conflict-caused changes result from the inclusion of users not similar to the original users. In either case, there is the need to *develop new institutions*, which requires a skill in understanding how people will react and act in different situations. There is, unless when a single individual has the authority to change the institutions, a need for *discussions* and *negotiations* among the users and/or 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

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[5] Folke et.el. (2003) in Folke et.al. (2003), p.369.

[6] Ostrom (1992) p. 41.

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. 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 imply increased irrigation, as this may attract new users.

The most frequently used and possibly also the most crucial ability is that to make, communicate and get acceptance for decisions. Without this ability, even the simplest problem would be 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 actions in the irrigation systems.

Neither should we be surprised by the fact that many of the abilities rest on one or a few individuals. Regarding conflict resolution, Ostrom (1992) comments that "…those who are selected as leaders are also the basic solvers of conflict".[7] Again, we can draw a parallel to business organizations, where the leader (CEO, vice president etc.) is recognized as playing a crucial role in the success of the organization. This again suggests that we could 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)[8] who focuses a full chapter on 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 describe as the key to the reality of the adaptive management of complexity "that individuals and small groups of individuals exert extraordinary influence by performing certain distinct roles within and outside institutions". This can also give us a

[7] Ostrom (1992) p. 73.

[8] Westley, in Gunderson et.al (2002).

better understanding for why cultural heterogeneity seems to be such problematic issue. Alvesson (2001) makes the 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.[9]

Summarizing the previous section, it is obvious that the abilities used 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 of the analysis is thus that we should strongly consider using tools from organization theory for analyzing the resilience of institutions for managing irrigation systems, and probably also other common property resources. The tools that are more often used for analyzing common property systems, such as game theory, transaction cost analysis, the institutional analysis and development framework may be better suited for static analyses. Furthermore, they may be more useful in explaining why these systems exist, than how they actually function.

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 analyzing 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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[9] Alesina and La Ferrara (2002) and Bardhan and Dayton-Johnson (2002) also discuss effects of heterogeneity.

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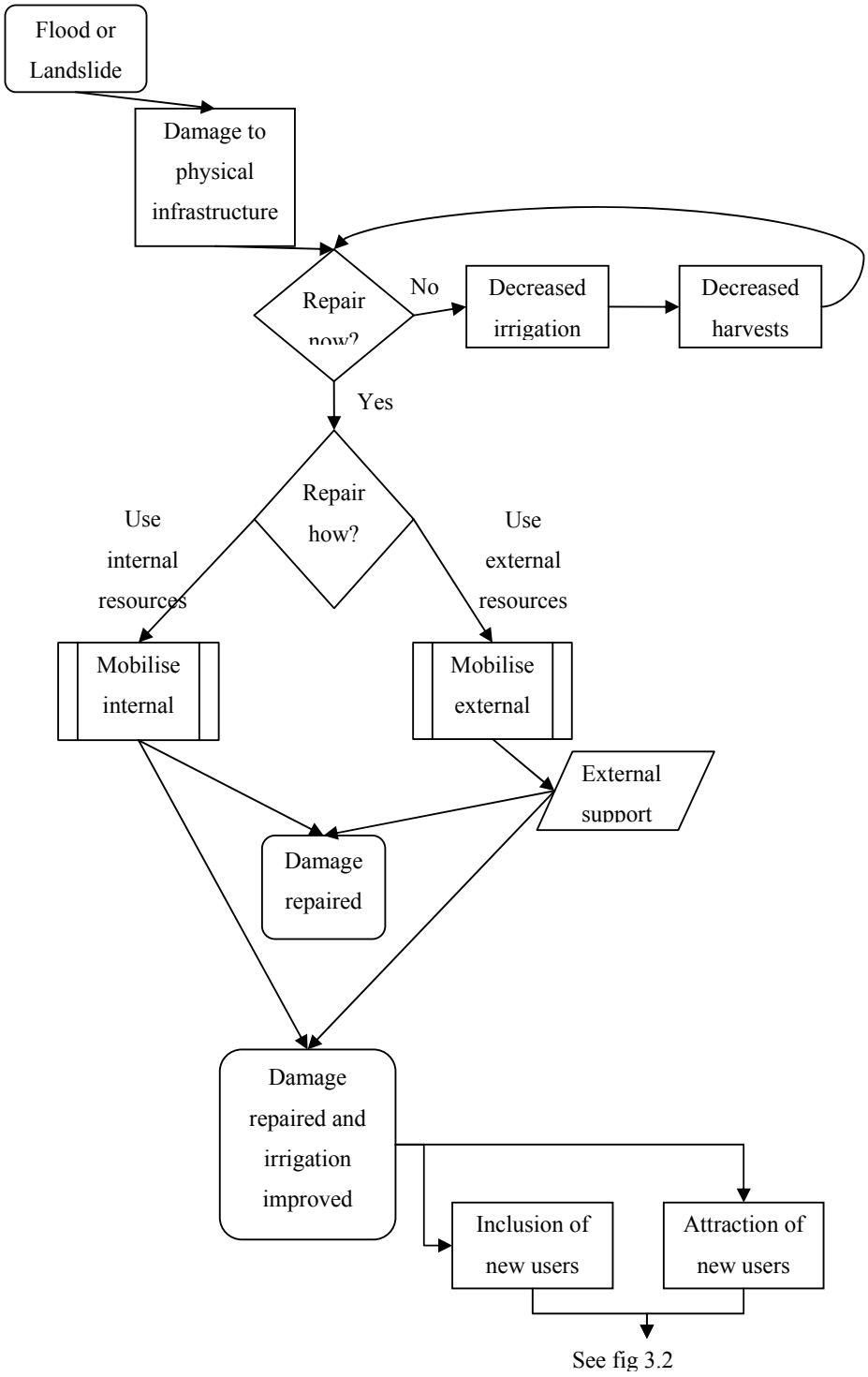
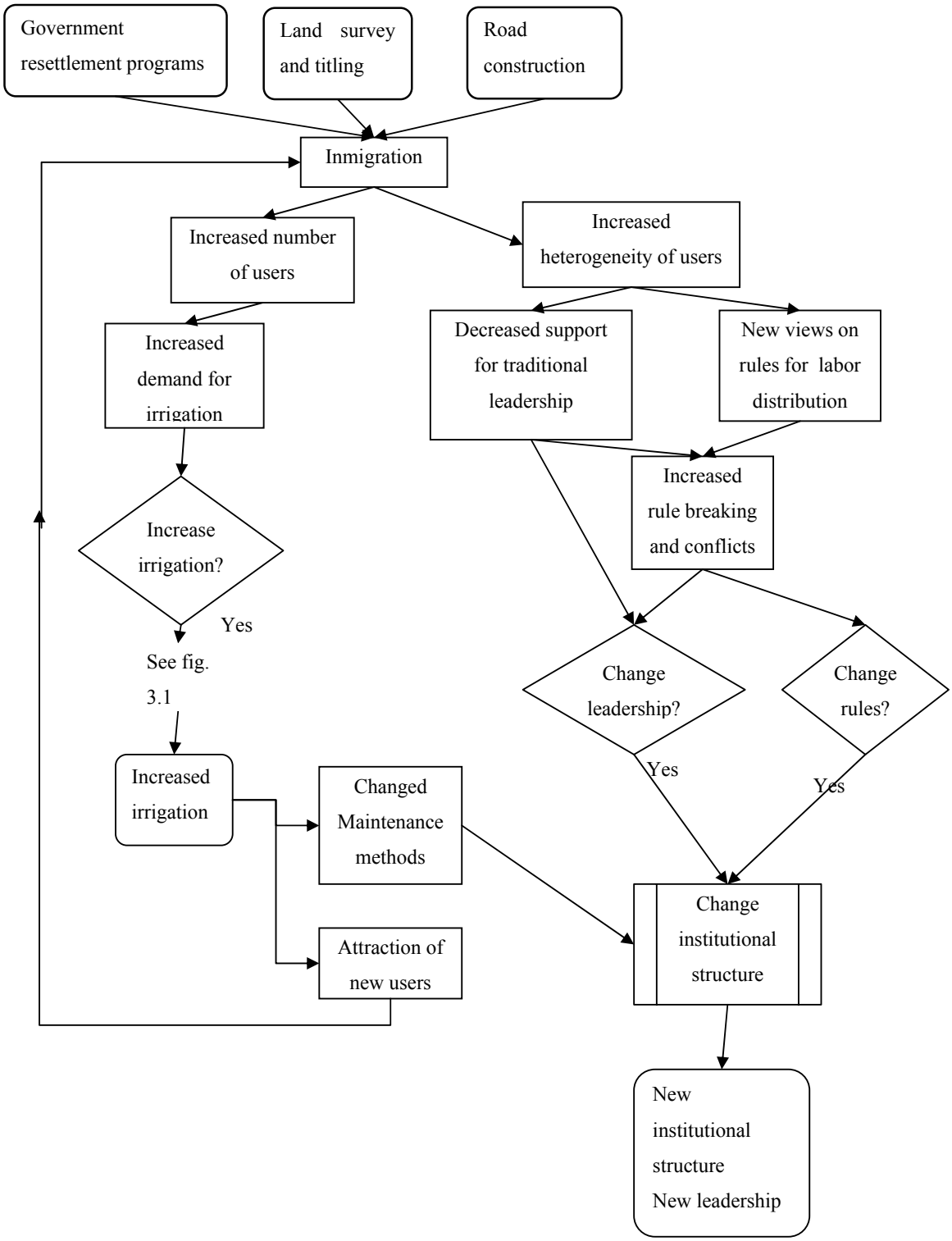
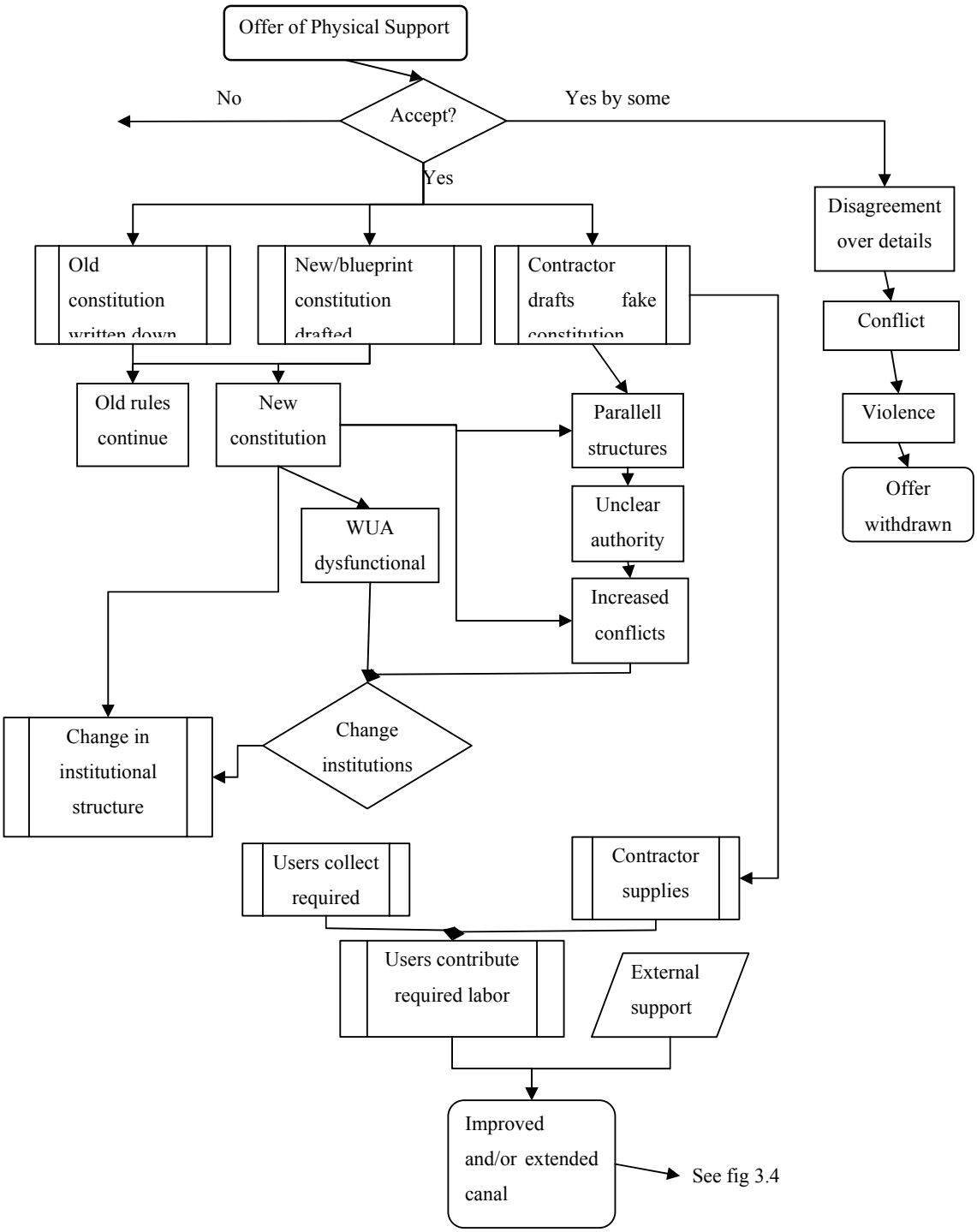
APPENDIX, Figure 4.1: Floods and Landslides Flowchart



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