Context and Institutions in Irrigation Management: Applicability of Design Principles in Nepal and Thailand[1]

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Abstract:
In this paper we assess the applicability of design principles (Ostrom, 1990) in irrigation management comparing the similarities and differences from Nepal and Thailand (considering the difference in economic situation and nature of irrigation systems). The information comes from the empirical study of 100 irrigation systems, 50 each from Nepal and Thailand representing major river basins and ecological regions in both countries. The results showed that most of the design principles proposed by Ostrom are applicable in irrigation management in Nepal and Thailand. But the level of applicability of each design principles varied across these two countries. Some of them were fully and mostly applicable in both countries. But others were more applicable only in one country, and rarely applicable in another. It was especially due to the difference in the irrigation infrastructure, besides other reasons. Design principle two 'congruence' and design principle five 'graduate sanctions'; could not fully capture the existing institutional settings. We have proposed some modifications for wider applicability in the specific conditions.

Key words: Irrigation, design principles, Nepal, Thailand

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1. Introduction

The irrigation management in Asia has faced many challenges associated with the rapid economic development, political and social changes in the recent decades (Moore, 1993; Shivakoti et al., 2005). Despite continuous efforts the performance of irrigated agriculture sector has often been assessed as poor relative to investments or expectations (Barker and Molle, 2005).

Nepal and Thailand both have a large irrigation sector in which rules and policies for irrigation have changed amid economic and political changes (Shukla, 2001; Shah and Singh, 2000; NPC, 2002; Budhaka et al., 2002; Shivakoti, 2000; and Suideee, 2002). Some studies noted that the performance of the irrigation systems varied across different mode of governance; pointing the importance of local institutions (Tang, 1992; Lam 1998). It shows the significance of local institutions and their effect on collective actions in the self-governing common pool resources (CPR).

Ostrom (1990) proposed eight 'Design Principles' for self-governing CPR institutions and emphasized the importance of these principles in crafting institutions for self-governing irrigation systems (Ostrom, 1992). These design principles were later tested in decision-making arrangements in community-based watershed management in northern Thailand (Wittayapak and Dearden, 1999) and community forestry in Nepal with suggestions for modifications or expansions (Gautam and Shivakoti, 2005). Other cases like irrigation in Japan (Sarker and Itoh, 2001) and Bulgaria (Theesfeld, 2004); agro-pastoral, irrigated and rain-fed farming villages in semi-arid Tanzania (Quinn et al., 2007) also proposed modifications in design principles for its applicability in specific conditions. Yet other studies based on community fisheries argue that presence of design principles for collective action does not necessarily lead to "successful" collective action (Steins and Edwards, 1999) and design principles have ignored the effects of contextual (biophysical, socioeconomic, and cultural) factors on CPR governance and management (Agrawal, 2002).

In her recent paper Ostrom (2008) examined the validity of the design principles after nearly two decades it was proposed. One major concern was on the study of robustness of CPRs, particularly on the self governing irrigation systems. In this context this paper will assess the applicability of design principles in irrigation management comparing the similarities and differences from Nepal and Thailand (considering the difference in economic situation and nature of irrigation systems). Efforts have been given to analyze whether it is influenced by the differences in physical attributes of the system, farming and other contextual settings. Finally we suggest whether any modifications needed on design principles for successful collective action in irrigation management, considering the cases from Nepal and Thailand

2. Data and methods

2.1 Sampled irrigation systems

This paper is based on extensive survey of 100 irrigation systems in Nepal and Thailand. Irrigation systems were selected based on three criteria – ecological region, economic characteristics and management structure – following a series of steps. In the first step we selected major river basins across all regions in both countries. In the next we focused on physical terrain: plains or hills (including undulating terrain and upper valleys). In each terrain type we selected a particular cluster, based on district in case of Nepal, and province in case of Thailand. In the final step irrigation systems were selected from different strata (management structure and economic characteristics) within the identified clusters. The forms of management structure considered were: farmer managed; agency managed, jointly managed and management transferred systems. The sample of 50 irrigation systems in Nepal covers major river basins of the country and different ecological regions (Table 1).

Table 1 Distribution of sampled irrigation systems in Nepal and Thailand

Regions and Basins	Ecological regions		Total
	Plain	Hills*	
Nepal			
Eastern Koshi	7	5	12
Central Koshi	-	3	3
Central Gandaki	6	3	9
Western Gandaki	4	8	12
Mid-Western Karnali	3	6	9
Far Western Karnali	2	-	2
Far Western Mahakali	3	-	3
Nepal sub-total	25	25	50
Thailand			
North-Ping	10	7	17
North-Kok	2	3	5
North-East-Nam Chi	4	3	7
Western-Mae Klong	3	3	6
Central-Chao Phraya	6	-	6
Eastern-Rayong	3	-	3
South-Songkhla	3	3	6
Thailand sub-total	31	19	50
Total	56	44	100

* It includes undulating terrain and upper valley regions as well

In Nepal, out of fifty, forty one systems were farmer managed irrigation systems (FMIS). The remaining nine systems were agency initiated systems (AMIS), of which three systems are under joint management (JMIS); whereas the management of other six agency-initiated systems was transferred to the users at tertiary level.

Likewise, in Thailand also a diverse range of irrigation systems covering all regions and seven major basins were considered (Table 1). Out of 50 systems 30 were FMIS, three AMIS and 17 JMIS. FMIS includes 12 management transferred systems as well.

2.2 Collection techniques and variables

This paper is based on information both at the irrigation system level. The system level information was collected by administering structured checklist to the officials from water user associations in the selected irrigation systems. The checklist included the variables covering physical attributes of the system, social context of the users, local institutional arrangements, and existing rules; besides others.

2.3 Analysis

Both quantitative and qualitative techniques were used to analyze the context of irrigation operation and the details on irrigation management. The context included the comparative perspective on the existing irrigation infrastructure; water use scenario including various crops and cropping intensities, and the resulting conflicts due to changing water use situation. These aspects were analyzed quantitatively.

Irrigation management was basically examined qualitatively based on the existing rules, enforcement mechanism and compliances to the existing rules. The design principles proposed by Ostrom (1990) was used as theoretical framework to examine the irrigation management in both countries. The eight design principles that characterize the configuration of rules devised by long-enduring CPR institutions are presented in Table 2.

Ostrom (1990) defined design principle as:

> "…an essential element or condition that helps to account for the success of these institutions in sustaining the CPRs and gaining the compliance of generation after generation of the appropriators to the rules-in-use".

According to Ostrom herself, these design principles are not the blueprint for analyzing CPR management, but they have been found consistently in many long-enduring CPRs. Thus in our analysis also we look on the comparative applicability of these design principles in cases of irrigation management in Nepal and Thailand. The applicability has been presented in five categories: not applicable, rarely applicable, partially applicable, mostly applicable and fully applicable. Based on the applicability situations some modifications are also proposed for its wider applicability in specific conditions.

Table 2 Ostrom's Institutional Design Principles for long enduring CPR Institutions

Design Principles	Explanation
1. Clearly defined boundaries	Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself
2. Congruence between appropriation and provision rules and local conditions	Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, material, and/or money
3. Collective-choice arrangements	Most individuals affected by the operational rules can participate in modifying the operational rules
4. Monitoring	Monitors, who actively audit CPR conditions and appropriator behavior, are accountable to the appropriators or are the appropriators themselves
5. Graduated sanctions	Appropriators who violate operational rules are likely to be assessed graduated sanctions by other appropriators, by officials accountable to these appropriators, or by both.
6. Conflict resolution mechanisms	Appropriators and their officials have rapid access to low-cost, local arenas to resolve conflicts among appropriators or between appropriators and officials.
7. Minimal recognition of rights to organize	The rights of appropriators to devise their own institutions are not challenged by external government authorities
8. Nested enterprises (for CPRs that are parts of larger systems)	Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

Source: Adapted from Ostrom (1990).

3. The context: Irrigation infrastructure, water use and conflict

3.1 Irrigation infrastructures in Nepal and Thailand

Traditional farmer managed irrigation systems are predominant mostly in hill/foot-hill areas of both countries and those systems feature the infrastructure made-up with the use of local construction materials. However, with changes in government policies, those traditional irrigation systems have also received support to improve their infrastructure. In Thailand, most of the traditional *Muang Fai* systems have changed their headwork as permanent concrete structure instead of using traditional construction materials which often needed annual repair and maintenance.

Both countries focused on expanding irrigation areas after initiation of planned development efforts during 1950s (Shah and Singh, 2000; Budhaka et al., 2002). As a result many large scale irrigation infrastructures were built in both countries. However, it differed across the countries and within countries itself. Thailand focused on construction of large scale irrigation canals supported by storage facilities mostly on central plain areas of the country. Subsequently, the irrigation infrastructures were expanded to other regions of the country as well. In Nepal most of the medium-large scale irrigation systems are built in *Terai* and valley areas and they are mostly of run-off-river types.

Table 3 shows that average age of the systems is higher in Thailand, largely due to the century old traditional systems from North region of the country. In terms of command area and number of users also, Thailand has higher average compared to the irrigation systems in Nepal.

Table 3 Distributions of sampled systems by age, command area and number of users in Nepal and Thailand

Characteristics	Country	Minimum	Maximum	Mean	Std. Deviation
Age (yr)					
	Nepal	10	>200	46.0	37.3
	Thailand	10	>300	66.4	62.2
Command area (ha)					
	Nepal	15	6200	501.0	985.5
	Thailand	80	55097	4672.1	10548.6
Number of users (hh)					
	Nepal	28	8000	868.9	1609.3
	Thailand	47	27100	2001.6	5044.3

The majority of the irrigation systems in Nepal were of run-off-river type (Table 4). The key difference we can see is the proportion of storage type system in Thailand.

Table 4 Percentage distribution of sampled systems in terms of provisioning water from source, and physical characteristics

Features	Nepal	Thailand
Type of system		
Run-off-river	98	44
Storage type	-	44
Pumping (incl. groundwater)	2	12
Headwork		
Temporary	30	6
Permanent	70	94
Canal lining		
Not lined	8	26
Partially lined	88	62
Completely lined	4	12

In Nepal, due to the existence of large number of local streams and topographic suitability, systems operated through gravity flow are common, which are cost effective as well. However, due to flood in monsoon and low water level during dry season (observed in data collection period also), this kind of system has low reliability compared to storage type. Similarly, in the context of growing competition in water use, storage and pumping systems provide opportunity for manipulating water supply and irrigation scheduling.

If we look on the type of headwork, again in case of Nepal a significant portion of systems have temporary headwork (Table 4). Due to the lack of budget, many systems in the hilly areas of Nepal have headwork made-up of wooden, stones and other local materials. This adds to low reliability of the run-off-river type of system found in Nepal. But, in contrary, in case of lining of canal [concrete] the proportion of canal having at least partial lining is higher in Nepal (Table 4). It is not clear though, but the existence of relatively higher proportion of systems with partial lining in Nepal may be due to the fact that in case of irrigation systems present in hilly areas of Nepal, they must have to build some lined portion in difficult terrain.

3.2 Water use and conflict

In both Nepal and Thailand, in most of the areas farmers can grow crops in more than one season allowing them to grow many crops around the year in the same piece of land. But actual cultivation depends on extent of water availability, and existing cultivation practices of the farmers, thus the cropping intensity varies across the systems in Nepal and Thailand, and head-tail end within the system (Table 5).

Table 5 Cropping intensity at head and tail end of the irrigation system in Nepal and Thailand

Cropping Intensity	Country	Minimum	Maximum	Mean	Std. Deviation
Cropping intensity at head end					
	Nepal	130	300.0	245.5	51.1
	Thailand	80	265.0	161.0	65.4
Cropping intensity at tail end					
	Nepal	144	300.0	238.2	47.9
	Thailand	50	250.0	159.3	63.0

The cropping intensity was higher in Nepal compared to Thailand both at tail-end and head-end areas. It was also noted that, unlike Thailand, in Nepal the intensity was slightly higher in rural areas (Bastakoti et al., 2008). It might be due to the existence of subsistence farming and the need to grow many crops as long as the weather permits.

Majority of the system areas in Nepal included the cereal crops, only few systems with some area under commercial vegetable farming. In Thailand also, the major crop grown is rice. It is staple food but at the same time one of the major commercial crops in Thailand since long period. Besides rice, major cash crops grown were vegetables, fruits, corn (Sweet corn, baby corn and normal corn), sugarcane, rubber and other cash crops such as soybean, peanut, and cassava.

Land use pattern and crop combinations are changing overtime in many areas of Thailand including; cereals to orchard; cereal to other farming activities; and shift to non-agricultural activities. These changes in types and number of crops grown overtime are due to the influence of external economic pressures (Shivakoti and Bastakoti, 2006). Mostly the changes have inclined towards high water demanding crops from other cereals to fruit orchards and commercial vegetable farming. The trend of cultivation for majority of the cash crops is increasing. In Thailand, growth in peri-urban vegetable production has been higher as compared to rural areas. This is mainly due to increasing urban demand for vegetables (Chunnasit et al., 2000).

In Nepal also in recent decades there is growing trend of commercial farming, especially vegetable production. But mostly it is concentrated on major road corridors and/or some pocket areas, still people largely depending on subsistence/traditional mode of farming. Some authors noted the trend of crop intensification, multiple cropping and increased vegetable production during recent decades (Brown and Shrestha, 2000). In such cases, many farmers indicated the increased demand for water resources and reported water shortages and lack of irrigation as one of the major production constraints.

The demand for water in non-agricultural sector increases with urbanization and that will intensify competition for water resource (de Fraiture and Wichelns, 2007). Conflicts in water use among agricultural and other non-agricultural uses are prominent phenomenon during recent period (Ruet et al, 2007). Midmore and Jansen (2003) also noted that demand for water by peri-urban vegetable production along with existing competition from residential and industrial users in limited supply environment, where marginal value product of water is high, has substantially amplified potential conflict.

The overwhelming majority (86%) of irrigation systems in Thailand reported some forms of conflict in their system. The most common forms of conflict in study area are presented in Table 6.

Table 6 Nature of water use conflict across irrigation systems in Thailand and Nepal, Chi-square = 21.10, df = 5, P-value = 0.001.

Nature of conflict	Nepal (%)	Thailand (%)
Among farmers	62	56
Among systems	8	2
Urban, residential, and industrial uses	-	12
Others	22	2

In Thailand, the conflict among farmers of head-end areas and tail-end areas is more common. Another prominent form of conflict was observed with urban uses including residential and industrial sectors. More than half of sampled systems in peri-urban areas reported conflict among residential or industrial uses. The nature of conflict in peri-urban area, involvement of various users, makes it relatively difficult to manage than rural areas where the main conflict was only among agricultural users.

In Nepal also, most of the systems (92%) reported conflict. But the nature of conflict was significantly different than that of Thailand (P-value <0.01). Mostly the conflict was in the form of dispute among farmers of head-end areas and tail-end areas. Other forms of conflict were found rarely in the selected irrigation systems of Nepal. One difference with Thai case was that in Nepal there were some cases of conflicts among the systems, which was not common in Thailand. The conflict situation was more pronounced in peri-urban areas in both countries.

4. Application of design principles in irrigation management

In this section we look on the applicability of the eight design principles in the institutional settings of irrigation management in Nepal and Thailand. We also relate our analysis with the irrigation management context discussed in the previous section.

4.1 Clearly defined boundaries

The ‘clearly defined boundaries’ was the first design principle proposed by Elinor Ostrom, later she added others (Ostrom, 1990; 1992). The definition of social, physical and biological boundaries around common property resources is undoubtedly a fundamental attribute and a first step in organizing for collective action. In some CPRs like fisheries it is difficult to define clear boundary of the resource, but in irrigation systems it is possible to define clear boundary.

Most of the sampled irrigation systems in Nepal and Thailand showed that they have clear delineation of the command areas. The typical irrigation system includes: head structure, main canal, branch canals, tertiary canals, and water control structures. While designing the irrigation systems user/agency involved in the system have clear planning for the areas to be covered from the proposed structure.

In most of the systems they had clear boundary rule. The boundary rules define; the eligibility to enter a position, the process determining which eligible participants may (or must) enter the position, and the process of exit (may or must) any position (Ostrom, 2005). Many irrigation systems have identified the command areas to be covered by the particular systems, thus even if some farmers are interested to join the system the boundary rule exclude them from entering the system.

The most common boundary requirement used as rule was land holding requirement. All but one system showed that land holding in the command area is must for being the member of the irrigation system. The common rule arrangement is that whoever's land comes in the command are he/she becomes a member automatically. It clearly shows that in most of the systems they had clear boundary rules for resource and the users as well. However there was some variation in this aspect in the systems across Nepal and Thailand. Specially, in case of some larger systems from Thailand some confusion was noted in the boundary of tertiary along with free riding problems that violate boundary of users. However, despite some confusion, we can say that this design principle is fully applicable in both countries.

4.2 Congruence between appropriation and provision rules and local conditions

In this design principle, Ostrom (1990) states that; the appropriation rules are related to local conditions and provision rules. The design principle of congruence between appropriation and provision rules and local conditions is the only one that attempts to address the sustainable use of the resources (Quinn et al., 2007).

This design principle has two parts: congruence between appropriation and provisions rules; and the appropriation rules and local conditions. In case of part one; it is mostly applicable in Nepal, whereas in Thailand it is partially applicable. In Nepal most of the irrigation systems are with simple provision structure and so the use at field level is directly match with the water extraction from the resources. But in Thailand, especially in case of large irrigation systems, the provision rules are significantly different than that of appropriation rules. Many large systems are fed by multipurpose reservoir that supply water to different other uses in addition to agricultural use. Thus sometime the appropriation by farmers may not match with the water level in the reservoir.

Similarly, the in case of part two of this design principle, congruence between appropriation rules and local conditions, it is mostly applicable in Nepal, whereas in Thailand it is partially applicable. In Nepal, in most cases, especially in FMIS, the water use is based on the water availability in the local streams. It also depends on the terrain and topography of the command areas. Not only the physical context, the appropriation rules are devised based on the social context of the command area. In Thailand also the situation is similar in case of smaller FMIS in northern part of the country. But in case of larger irrigation systems the appropriation rules does not necessarily reflect the local conditions, both in terms of physical and social settings. The rules are devised based on the water availability in the whole system and that are often suggested top to bottom without proper consideration of local social settings.

4.3 Collective-choice arrangements

The design principle three states that the most of the people those affected by the operational rules can participate in modifying the same (Ostrom, 1990). It has significant implications in the collective action for the management of CPRs. It has been noted that it is due to the tendency of the users to come together for collective actions that many CPRs are being managed by people without being privatized or managed centrally (Ostrom et al., 1999). Earlier Garret Hardin (1968) had cautioned that open access CPRs ultimately get vanished due to lack of any effective management strategies; and thus they should either be nationalized or privatized. The users adopt various coordinated strategies for appropriation of resource units (Ostrom et al., 1994). The appropriators use rules for ordering their own relationships, various attributes of the physical world and nature of the community where the action arena occurs.

It is noted that in community managed irrigation systems farmers develop a wide range of rules to specify rights and responsibilities among themselves (Tang, 1992) meaning that the people those affected by the rules can participate in modifying the same. But in some cases specially the irrigation systems constructed and managed by state agency, the rules at system level were suggested from higher level offices, not necessarily developed by the users (Lam, 1998) that certainly does not guarantee that the affected people can participate in modifying the same.

Similar to these findings, the result showed that mostly the FMIS satisfied the condition of this design principle. In case of FMIS both in Nepal and Thailand users can participate actively in modifying the operational rules. FMIS mostly operate on the collective decision making, for example if they need to decide anything important they need community consensus. Shukla and Sharma (1997) also pointed that in FMIS of Nepal users are involved from the very beginning and so they are bonded through collective efforts. But in most of the AMIS and/or JMIS and management transferred systems the operational level rules are influenced by the government agency. Thus, the design principle 'collective-choice arrangements' was mostly applicable in Nepalese irrigation systems whereas it was partially applicable in Thailand.

4.4 Monitoring

Monitoring is important to reduce the free-riding problem and to check any cheating by the individuals. Monitoring and sanctioning arrangements provide the evidence for the effectiveness of the existing rules (North, 1990; Lam 1998).

The result showed that most of the sampled irrigation systems in both Nepal and Thailand had some sort of monitoring arrangements. In some exceptional cases, there was no monitoring arrangement. The analysis showed the design principle on monitoring was mostly applicable in Nepal but partially applicable in Thailand

Mostly, the sampled irrigation systems showed the provision for hiring guard for water rotation. The water guard (monitor) is responsible for regulating the water allocation based on earlier agreed norms, so if there is any dispute between farmers the water guard has right to enforce the arrangements. Generally the water guard [or monitor] is hired within the water users. But sometime, it was also noted that they hire somebody as regular staff, who is not among the users. The later is the common feature in case of AMIS. In case of FMIS generally users rotate the monitor position among user themselves. Not only water guard or monitor, in many cases they had sub-committee that was responsible for distribution and monitoring of the water allocation.

4.5 Graduated sanctions

As discussed in the previous sub-section, the monitoring and sanctioning arrangements provide the evidence for the effectiveness of the existing rules in the irrigation systems. Graduated sanction is necessary to check the repeated breach of established [agreed] rules in the management of any common pool resources.

The design principle on graduated sanction refers that violators are assessed on the severity of their infractions by other resource users or officials acting on their behalf, and punished accordingly (Ostrom, 1990). The necessity of graduated sanctions comes from two reasons: to give appropriators the message that cheating will be noticed and punished; and to show that those breaking the rules repeatedly face heavy penalty. The cost of breaking rules becomes higher than the benefits they get from it and thus rule breaking becomes unattractive option for the users (Ostrom, 1990; 2000).

The sampled irrigation systems showed that in most of the cases they have payoff rules that provide provisions for sanctions in particular action situation. In their rules they have clear provisions for the graduated sanctions in terms of repeated violations of any rules. If any farmer cannot present during canal cleaning they need to pay fine, small fine first, then a bit more and if they do not comply again and again, they are not allowed to use the water. An example from irrigation system in Nepal showed that if the rule is broken for the first time then NRs 100 is fined. If same farmer repeats the same mistake then NRs 200 is fined and for the third time rule breaking, NRs 500 is fined and after fourth times he/she will not be allowed to use the water.

Similarly, we observed another example of graduated sanctions in case of water stealing. In case of first offense they fine NRs 151, second offense NRs 500 fine and for third offense, the whole canal is diverted into the field of the culprit, so that it will result in the complete failure of his/her crop due to excess amount of water.

This design principle was partially applicable in both countries. But this design principle as proposed by Ostrom (1990) cannot fully capture the existing situations in the irrigation management in Nepal.

4.6 Conflict resolution mechanisms

The design principle six assumes the presence of some sort of conflict in CPR management and the users [and officials] have access to low-cost local arenas to resolve the conflict (Ostrom, 1990). As discussed in section three, larger majority of the systems in both countries reported conflict in agricultural water use. The conflict situation varied across country and across the rural and peri-urban areas as well. The analysis showed that the design principle on 'conflict resolution mechanism' was partially applicable in both countries.

With the presence of conflict it was also noted that the sampled irrigation systems include different sorts of conflict resolution mechanisms as well. In case of competing water uses and conflicts, users in many cases have successfully managed it, and but in some cases have failed to do so. The ability to cope with scarcity was largely influenced by how well community organizations can coordinate in such situation.

The result showed varied level of the conflict resolution mechanisms. Water use related conflict was higher in peri-urban systems due to rapid increase in high water demanding crops and demand from non-agricultural sectors. Relatively weaker WUAs and lack of collective action among users due to large command area and number of users, conflict resolution was not effective as compared to rural areas. It was found that irrigation systems in the rural areas were capable of adopting various coping strategies in case of conflict situation. The local leaders play important role in conflict resolution in the Thai irrigation systems (Shivakoti and Bastakoti, 2006) as well as in Nepal.

In Thailand, the coping strategies followed by the farmers to deal with the conflict due to water scarcity situation were dependent on local context and changing situation. The common strategy adopted by the users was re-working of water allocation mechanisms. Farmers submit application mentioning water required for their crops and area to the head of WUA. Based on the received applications, WUAs allocate the turn to individual farmers or in groups based on their demand. It was mostly found effective in rural small-sized systems.

In some cases the WUA used to suggest farmers for growing crops in reduced area [especially in dry season], or growing in a cluster or group. Further to this, ‘area sharing’ was also observed specially in some systems of Chiang Mai valley, Thailand. In the area sharing arrangements, during dry season, water was supplied only to the head end area of the canal and the farmers in head-end area provided certain pieces of land to farmers from tail-end areas.

But in some cases, users were not able to cope with the water related conflict situation. Such instances were observed mostly in the agency managed system in both countries. In such cases, due to the lack of group cohesiveness the users were not able to come-up with effective conflict resolution mechanisms.

The result showed that this design principle; presence of conflict resolution mechanisms; is partially applicable in both countries. FMIS in rural areas have effective conflict resolution mechanisms whereas most of the AMIS mainly in peri-urban areas do not include such effective mechanisms.

4.7 Minimal recognition of rights to organize

This design principle states that the rights of the users to devise their own rules are not challenged by external agencies (Ostrom, 1990). It is directly related with the degree of autonomy of the irrigation systems. This design principle was mostly applicable in Nepal, partially applicable in Thailand. The result showed that overwhelming majority of the irrigation systems in Nepal have higher degree of autonomy to devise their own rules and institutional arrangements (Table 7).

Table 7 Degree of autonomy of WUAs to devise own rules and institutional arrangements in Nepal and Thailand, Chi-square = 11.15, df = 2, P-value = 0.004.

Degree of autonomy of WUAs	Nepal (%)	Thailand (%)
Low degree of autonomy	18	48
High degree of autonomy	80	48
Not applicable	2	4

Higher the degree of autonomy of the irrigations more will be the recognition of the users' rights to organize without external interference. Unlike in Nepal, nearly half of the sampled irrigation systems in Thailand showed low degree of autonomy, indicating that this design principle is not fully applicable in Thai context. The difference between Nepal and Thailand is highly significant (P-value <0.01).

4.8 Nested enterprises

This design principle is applicable in case of CPRs that are parts of larger systems. It refers that most of the management activities are organized in multiple layers of nested enterprises.

In Nepal this design principle is rarely applicable. Most of the irrigation systems are of small size and they are managed by single WUA independent to any other institutional settings. In some rare cases, especially in larger AMIS, the WUAs are responsible for management at tertiary level and they are part of larger system level management.

In comparison to Nepal, this design principle is more applicable in Thai irrigation systems. In case of most of the larger irrigation systems in central plain areas and other parts of the country the irrigation systems are managed as multi-layered management. The WUAs at lower level are performing all management functions though they are part of the larger system as a whole. However, in case of small FMIS in northern Thailand the management is performed by single WUA and thus this design principle is not applicable.

This design principle was rarely applicable in Nepal. But it was partially applicable in case of irrigation systems in Thailand.

5. Discussions

In the previous section we looked on the details of applicability of the each design principles in management of irrigation systems from Nepal and Thailand. Based on the analysis, Table 8 presents the summary of how the irrigation systems in Nepal and Thailand meet the conditions of Ostrom's design principles.

Table 8 Comparative applicability of design principles in the management of irrigation systems of Nepal and Thailand

Design Principles	Nepal	Thailand
Clearly defined boundaries	Fully applicable	Fully applicable
Congruence between appropriation and provision rules and local conditions	Mostly applicable	Partially applicable
Collective-choice arrangements	Mostly applicable	Partially applicable
Monitoring	Mostly applicable	Partially applicable
Graduated sanctions	Partially applicable	Partially applicable
Conflict resolution mechanisms	Partially applicable	Partially applicable
Minimal recognition of rights to organize	Mostly applicable	Partially applicable
Nested enterprises	Rarely applicable	Partially applicable

The findings showed that most of the design principles were applicable in irrigation management in Nepal and Thailand. But the level of applicability of each design principles varied depending on the local context and other factors across these two countries. The applicability varied from rarely applicable to fully applicable among different design principles.

It was too some extent affected by the variation in irrigation infrastructures and other contextual factors. Due to the presence of larger irrigation systems in Thailand the design principle ‘congruence between appropriation rules and provisions rules, and local conditions’ was only partially applicable in Thailand. The larger irrigation systems also made the monitoring activities more difficult in Thai irrigation systems thus making this design principle partially applicable in those settings. At the same time the larger infrastructure in Thailand provided the condition to adopt the nested enterprises for irrigation management at different layers of the larger systems that was rarely applicable in Nepal.

The design principles were basic and well configured. But, all design principles were not equally applicable in the given settings. Some of the design principles: design principle two ‘congruence’ and design principle five ‘graduate sanctions’; could not fully capture the existing institutional settings. We propose for wider applicability in the specific conditions.

Design principle 2 Congruence between appropriation and provision rules and local conditions: We agree with Gautam and Shivakoti (2005) that the Ostrom's definition of local condition does not fully explain the problem of congruence in the studied irrigation systems. This design principle does not explicitly discuss about the economic and social context. In our cases, the appropriation rules in most case are affected by economic and social conditions. Thus it needs some expansion incorporating 'topography, economic and social conditions' to represent the local conditions explicitly.

Design principle 5 Graduated sanctions: This design principle was partially applicable in both countries. But this design principle as proposed by Ostrom (1990) cannot fully capture the existing situations in the irrigation management in Nepal. In some cases the users have devised special arrangements to include strong enforcement mechanism in case of repeated violations of the rules. For example; some cases showed that if fines are not paid in case of repeated water stealing they refer to local government or even to the police station. Thus it needs expansion incorporating the clause for 'enforcement mechanisms' in case of repeated violation of the rules.

6. Conclusion and suggestions

Most of the design principles proposed by Ostrom are applicable in irrigation management in Nepal and Thailand. The design principles were basic and well configured. But the level of applicability of each design principles varied depending on the local context and other factors across Nepal and Thailand. Some of them were fully and mostly applicable in both countries. But some of them were applicable only in one country, and rarely applicable in another. It was especially due to the difference in the irrigation infrastructure. The larger irrigation systems made the monitoring more difficult in Thai irrigation systems. Similarly, larger infrastructure in Thailand provided the condition to adopt the nested enterprises for irrigation management at different layers of the larger systems.

Some of the design principles: design principle two 'congruence' and design principle five 'graduate sanctions'; could not fully capture the existing institutional settings. Thus some modifications have been proposed for wider applicability in the specific conditions.

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References

Agrawal, A. 2002. Common resources and institutional sustainability. In The drama of the commons, National Research Council, Committee on the Human Dimensions of Global Change, ed. E. Ostrom, T. Dietz, N. Dolak, P. C. Stern, S. Stovich and E. U. Weber, 41–85. Washington, DC: National Academy Press.

Barker, R., and F. Molle. 2005. Perspectives on Asian Irrigation. In G. P. Shivakoti, D. Vermillion, W. F. Lam, E. Ostrom, U. Pradhan, and R. Yoder, eds. Asian Irrigation in Transition: responding to the Challenges. New Delhi: Sage Publications.

Bastakoti R. C., Shivakoti G. P. and Lebel L. 2008. Community organizations in water resource governance: Rural-Urban interface of irrigation management in Thailand. USER Working Paper WP-2008-02. Unit for Social and Environmental Research, Chiang Mai University: Chiang Mai. Paper presented at 13th World Water Congress Montpellier, France, 1-4 September 2008.

Brown, S., and B. Shrestha. 2000. Market-driven land-use dynamics in the middle mountains of Nepal. *Journal of Environmental Management*, 59: 217–225.

Budhaka, B., M. Srikajorn and V. Boonkird. 2002. Thailand country report on investment in water. In "Investment in Land and Water" Proceedings of the Regional Consultation at Bangkok, Thailand, during 3-5 October 2001. Food and Agriculture Organization of the United Nations, Bangkok.

Chunnasit, B., Pages, J., & Duangnam, O. (2000) Incidence of Bangkok city development on peri-urban agricultural patterns and cropping systems evolution. Proceedings of the International Conference "*The Chao Phraya Delta: Historical Development, Dynamics and Challenges of Thailand's Rice Bowl*", 12-15 December 2000, (Bangkok: Kasetsart University).

de Fraiture C., & Wichelns, D. (2007) Looking ahead to 2050: Scenarios of alternative investment approaches. In D. Molden (Ed.) *Water for food, water for life: A comprehensive assessment of water management in agriculture* (London: Earthscan, and Colombo: International Water Management Institute).

Gautam, Ambika P. and Shivakoti, Ganesh P. 2005. Conditions for Successful Local Collective Action in Forestry: Some Evidence From the Hills of Nepal, *Society & Natural Resources*, 18:2, 153 – 171.

Hardin, G. 1968. The tragedy of the commons. *Science*, 162: 1243-1248.

Lam, W. F. 1998. Governing Irrigation Systems in Nepal: Institutions, Infrastructures, and Collective Action, Oakland, CA: ICS Press.

Midmore, D. J., & Jansen, G. P. (2003) Supplying vegetables to Asian cities: Is there a case for peri-urban production? *Food Policy*, 28(1), pp. 13-27.

Moore, M. 1993. Economic structure and the policies of sectoral bias: East Asian and other cases. *Journal of Development Studies*, 29(4):79 – 128.

NPC. 2002. The Tenth Plan 2002-2007. National Planning Commission, Kathmandu, Nepal.

Ostrom, E. 1990. Governing the commons: The evolution of institutions for collective action. New York: Cambridge University Press.

Ostrom, E. 1992. Crafting institutions for self-governance irrigation systems. San Francisco: Institute for Contemporary Studies Press.

Ostrom, E. 2000. Reformulating the commons. *Swiss. Polit. Sci. Rev.* 6(1):29-52.

Ostrom, E. 2005. Understanding Institutional Diversity. Princeton, New Jersey: Princeton University Press.

Ostrom, E. 2008. Design Principles of Robust Property-Rights Institutions: What Have We Learned? Presented at the conference on “Land Policies and Property Rights,” Lincoln Institute of Land Policy, Cambridge, MA, June 2–3, 2008.

Ostrom, E., J. Burger, C. B. Field, R. B. Norgaard, D. Policansky. 1999. Revisiting the commons: Local lessons, global challenges. *Science*, 284: 278-282.

Ostrom, E.; R. Gardner, and J. Walker. 1994. Rules, Games and Common-pool Resources. Ann Arbor, Michigan: University of Michigan Press.

Quinn, C. H., M. Huby, H. Kiwasila, and J. C. Lovett. 2007. Design principles and common pool resource management: An institutional approach to evaluating community management in semi-arid Tanzania, *Journal of Environmental Management*, 84:100–113.

Ruet, J., Gambiez, M., & Lacour, E. 2007. Private appropriation of resource: Impact of peri-urban farmers selling water to Chennai Metropolitan Water Board, *Cities*, 24 (2):110–121.

Sarker, A. and T. Itoh. 2001. Design principles in long-enduring institutions of Japanese irrigation of common-pool resources. *Agricultural Water Management*, 48: 98-102.

Shah, S. G. and Singh, G. N. 2000. Irrigation Development in Nepal: Investment, Efficiency and Institution. Winrock International Research Report Series No. 47. Winrock International, Kathmandu, Nepal.

Shivakoti, G. P. 2000. Participatory Interventions in Farmer-Managed Irrigation Systems in Northern Thailand: Dynamism in Resource Mobilization. Presented at "Constituting the Commons: Crafting Sustainable Commons in the New Millennium", the Eighth Conference of the International Association for the Study of Common Property, Bloomington, Indiana, USA, May 31-June 4.

Shivakoti, G. P., and Bastakoti, R. C. 2006. The robustness of Montane irrigation systems of Thailand in a dynamic human-water resources interface, *Journal of Institutional Economics*, 2 (2): 227-247.

Shivakoti, G. P., W. F. Lam, and U. Pradhan. 2005. Asian Irrigation Problems and Prospects. In G. P. Shivakoti, D. Vermillion, W. F. Lam, E. Ostrom, U. Pradhan, and R. Yoder, eds. Asian Irrigation in Transition: responding to the Challenges. New Delhi: Sage Publications.

Shukla, A. K. 2001. Policies, Processes, and Performance of Management Turnover in Agencies Initiated Intervention. In: Ganesh P. Shivakoti and E. Ostrom (eds.) 'Improving Irrigation Governance and Management in Nepal'. Institute for Contemporary Studies: California, USA.

Shukla, A., and K. R. Sharma. 1997. Participatory Irrigation Management in Nepal: A Monograph on Evolution, Processes and Performance. Kathmandu, Nepal: RTDB/IMD/Department of Irrigation.

Steins, N. A. and V. M. Edwards. 1999. Collective action in common pool resource management: the contribution of a social constructivist perspective to existing theory. *Society Nat. Resources* 12:539–557.

Suiadee, W. 2002. Thailand. In APO (2002): Organizational Change for Participatory Irrigation Management. Report of the APO Seminar on Organizational Change for Participatory Irrigation Management , Philippines, 23–27 October 2000.

Tang, Shui Yan. 1992. Institutions and Collective Action: Self-Governance in Irrigation. San Francisco: ICS Press.

Theesfeld, I. 2004. Constraints on Collective Action in a Transitional Economy: The Case of Bulgaria's Irrigation Sector, *World Development*, 32 (2):251–271.

Wittayapak, C. and P. Dearden. 1999. Decision-making arrangements in community-based watershed management in northern Thailand. *Society Nat. Resources* 12:673–691.