Design Principles and robustness of Spate community managed irrigation systems in the Punjab, Pakistan[1]

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Abstract

The spate irrigation is among the oldest and largest community managed irrigation systems in Pakistan and is providing livelihood to local communities through indigenously developed, maintained and managed techniques. The "*Riwajaat-e-Aabpashi*" (irrigation customs) codified in British rule are main guidelines for irrigation in lowland systems while upland systems are governed through locally known customs. The upland systems with higher community involvement and free from government interventions in decision making and monitoring are robust compared to similar systems in lowlands with government involvement in decision making and management. The article presents cases from Dera Ghazi Khan (Punjab, Pakistan) where these systems have endured despite of water scarce and unpredictable resource availability by creating situation of equity, impartiality and obeying the rules. This study compares communities against Ostrom's design principles to know the comparative institutional robustness of these systems.

Keywords: spate irrigation, design principles, local institution, common property, collective action, community based management, Punjab, Pakistan.

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Introduction

Out of a total cultivable area of 24.6 Million hectares in Pakistan; 18 Million hectare are under irrigation with canal, wells, tube-wells, springs etc. and rest 6 Million hectare is under Indigenous water harvesting systems including runoff farming, spate irrigation, mountain irrigation etc. (PARC, 1995). Spate irrigation called *Rod Kohi* in Punjab and NWFP provinces, *Sailaba* in Balochistan and *nai* in Sindh and Punjab (Ahmed, 2000), is a type water management system unique to semi-arid environment where flood water is generated by heavy rainfall in upper catchments (Mehrai et al., 2005[a]) and these systems use occasional flow of floods to operate intermittently throughout the year (Vincent, 1995).

The existence of mountainous topography generates run-off and the deep soils storage with enough moisture for the crops during dry periods (Mehrai et al, 2005[b]). The difference of spate irrigation from run-off irrigation is that the dependency is on the incident rainfall and localized run-off in case of run-off systems (Ahmed and Khan, 2007). Steenbergen (1997) described uncertainty about occurrence of flood water as well as timing and size of the flood as major factors leading to variation in cropped area as well as crop failure. Water rights in such systems are found to be complicated and conflicting as different users have different rights depending upon the type of flows (Vincent, 1995). The major challenge of spate system as compared to other systems is cooperation among the users to manage a resource which is uncertain and distributed in different amount among the members (Ghebramariam and Steenbergen, 2007).

Spate irrigation dates back to 330 BC as an economic source to some civilizations in areas now in Pakistan and was also observed by the land forces of Alexander the Great in these areas. It is practiced over around 10% of the total cultivable areas of the country (Ahmed, 2008) and is considered as to be the least developed and unattended type of farming and has got very little attention due to marginal returns, lack of scientific investigation, low asset base, subsistence nature of farming and lack of awareness in the local communities (Mumtaz, 1989). The situation gets further aggravated by diversion of water by upstream and powerful landowners in the area (Ahmed and Choudhry, 2005).

Globalization has brought about changes in many remote corners of the globe with changed economic opportunities and increased movement of goods, services, people and information. The indigenous irrigation systems are facing new threats because of openness to the new world, commercial interests of farmers, rise in cost of maintenance, increased competition of water and weakened social cohesion due to reasons including state interventions (Barker and Moley, 2005; Lam, 2001). The spate irrigation systems have been fulfilling livelihood needs of the inhabitants of command areas since centuries. Due to the location of these systems in the remote areas with poorest of the poor communities of the country and low returns in farming, very little has been done in terms of research and development. The literature on spate irrigation is very scanty and the small amount of studies is mainly focused towards engineering challenges and production systems and general rules of resource utilization.

The current research is probably first of its kind using household information while dividing spate systems into two separate categories based on differences in resource

predictability and abundance as well as different management structures. The study is specifically focused on answering three main questions:

1. How spate irrigation management systems evolved and changed overtime?
2. What are different operational rules under two different resource availability and management situations in the recent period?
3. What are local perceptions about the operational rules and how these can be used to compare effectiveness of community based resource management?

Geographical and socioeconomic settings

The study area lies between Indus River and the Suleman range where gravity flow drags water into the Indus from these mountains with part of it diverted for spate farming. The study area is located between 30°15' N - 31°15' N longitudes and 70°15' E - 70°45' E latitudes and is a part of Dera Ghazi Khan District adjacent to Dera Ismail Khan of NWF Province at the northern extremity and on the west of the study area is the Balochistan Province. The study area falls in arid sub-tropical continental monsoon regions characterized by distinct seasons, which are summer and winter. The mean annual precipitation is 269 mm at D.I.Khan which is situated at the western periphery of the Project area. About 50% of the total precipitation is received in the monsoon season and the remainder during the rest of the year. The mean annual, summer and winter temperature are 24°C, 33°C and 14°C respectively at D.I.Khan. The hottest month is June with mean maximum temperature 41.5°C, whereas January is the coldest month having the mean minimum temperature of 4.2°C at D.I.Khan metrological stations. The climate is mainly arid sub-tropical continental characterized by low rainfall, hot summer and mild winters. The soils are moderately fine to medium and coarse in texture having

low to high infiltration rates and inherently low nutrient content. In most places groundwater is saline and unfit for irrigation which signifies the reliance of farming on these systems (ADB, 2005).

Table1 Brief Description of systems

System Types	Perennial	Non-Perennial
Upland systems	Water rights are well known to farmers but not codified. The sequence of irrigation is determined by 'lottery system'. Run-off as well as rainfed farming is other major farming system.	Water rights defined under local customs. The sequence of irrigation is based on 'one plot in a turn' basis. Flows bring fertile soil and are difficult to be manipulated because of very high speed.
Lowland Systems	Water rights codified in 'Riwajaat-e-Aabpashi' (Irrigation customs) and necessarily follow fixed time slots in a pre-determined sequence. Rainfed farming is practiced in non-haqooq lands. The revenue department (spate wing) has supervisory role in all related issues.	The codified water rights dictate head to tail (*saropa-paina*) sequence of irrigation. The flows with fertile soils are brought to fields through different diversion structures by collective action. The revenue department (spate wing) has supervisory role in all related issues.

Table 2: Summary of prominent features of the selected sites

Features/Characteristics	Lowland Non-perennial	Lowland Perennial	Upland Perennial	Upland Non-perennial
Name of the selected system	Rod Kaura	Rod Vehoa	Sanghar Lahr	Lirin (Seemar) Lahr
[1]Catchment Area (Kms.)	523	2634	4913	1000 (est.)
[1]Command Area (Hectares)	17310	26730	25770	-
Households (Nos.)	1500-2000	1500-2000	1000-1500	1000-1500
Villages (Nos.)	8	10	12-15	8-10
Governance type	Semi-government type	Semi-government type	Community Managed	Community Managed
Mutually agreed resource governance rules	Codified	Codified	Not organized/codified	Not organized/codified
Relative Resource Scarcity	Highly Scarce	Scarce	Scarce	Highly scarce
Unpredictability	High	Low	Low	High

Source: [1] Govt. of Punjab. 2002. (Note: The figures of command area are those taken before canal project. The actual figures are lower than those taken from the source)

Study area

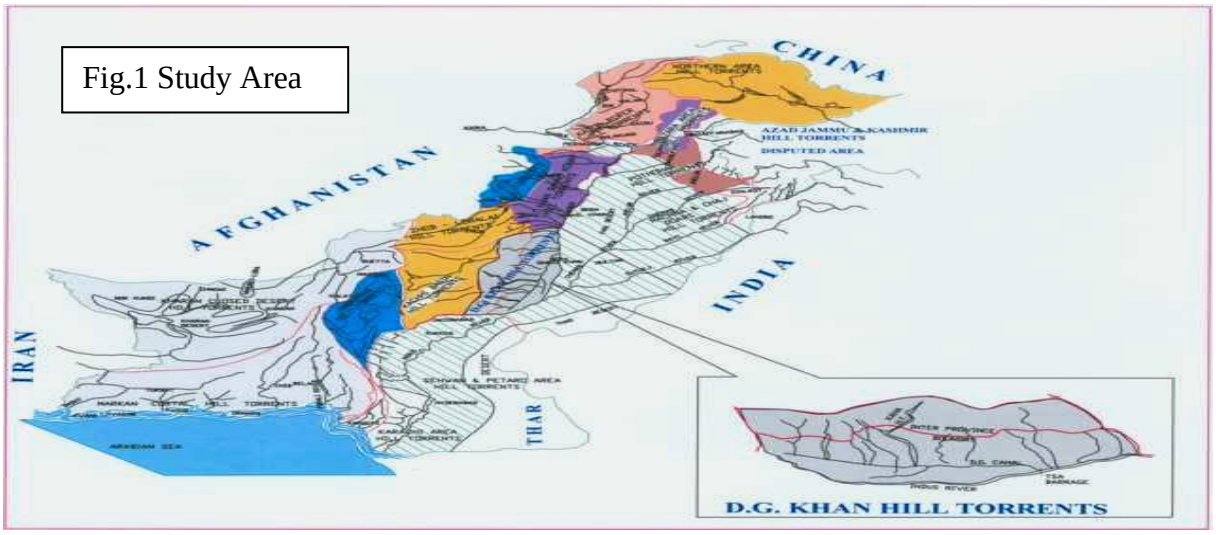

Fig.1 Study Area

Source: PARC, 1995

Community Homogeneity

Unlike other parts, the communities are homogenous in spate command areas in general and in the study site in particular. The communities have long history of tribal conflict surrounding them and in order to protect themselves they like to stay together in the forms of tribes. There are very few landless families as the land is believed to be distributed among families in a tribe with tribal chiefs holding comparatively larger share. The lands are classified on the basis of irrigation rights i.e. the one with traditional spate irrigation rights are valued higher than rainfed and or run-off farming. The majority of the people owning spate irrigated land also own rainfed irrigation land which shows equity in distribution considering land quality.

Most of the people of the study area speak Siraiki, while Balochi, Sindhi, Punjabi and Pushto are also spoken. The 'Jirga' system is the most common social phenomenon in the social setup. This is essentially needed to resolve the social disputes and acts amicably. The supreme local court and governing council, law and order is also maintained by the local police which is different from police of settled areas (the recruitment is done on the basis of previously determined quota allotted to different sub-tribes). ‘Sardars’ i.e Tribal Chief position is a hereditary status ascribed through ancestors and is a symbol of unity and power for tribes and play key role in conflicts resolution and other day to day matters. The mentioned tribal system still works in its true spirit in uplands (considered tribal belt by Law) while the most of the low lands are now treated as settled (non-tribal) areas.

The sample selection has been done by dividing systems into upland (perennial and non-perennial) and lowland (perennial and non-perennial) systems. The purposive

sampling technique was used to select the system. In all 280 households selected randomly were interviewed, comprising 70 households from each of the four selected system (with further division of 35 households from head and tail end of each system)

Historical evolution of spate irrigation systems

Historically there is a well defined community of irrigators at different levels of the system to keep the system working according to established rights. At main diversion structure the purpose is to make water flow to *Haqooq* lands and whole community of irrigators at a system gather to perform this operation. Similarly irrigators of different Channels and sub-channels with common interest join together for collective work. The *kamara* (in form of labor, bullock or cash) is levied on the basis of share in benefit i.e. proportionate land irrigated from respective channels. The *kamara* is expressed in terms of pair of oxen or unit of currency as the work was performed with the bullocks or with monetary contribution to pay for hired labor and it was easy for local people to remember their proportionate shares. Currently with introduction of machinery in the area bullocks are not used to perform collective work, the pair of oxen still reflects monetary or labor share in total cost.

The laterals and field channels were dug collectively centuries back and irrigation rights (*haqooqs*)are believed to be given to the contributing land owners, proportionate to their labor contribution. The irrigators, from the experience of centuries are familiar with the nature and behavior of water flows as well as their requirements to use it. Farmers divert water from the main spate bed by building earthen diversion structure (*Gandh*) to divert it into the field channel (*Kas or Wah*) through contribution in the form of labor and materials determined in units of pair of oxen **(***Jora***)** customarily determined

proportionate to *haqooq lands* (i.e. lands with irrigation rights); and then divert water into sub-channels by constructing earthen structure (*Wakra*); and further join together to install earthen diversion (*Wakree*) to raise water level to enter into the fields. The rights of fields to be irrigated from a particular *kas* or *kassi* are well codified. Once the fields from a particular *Wakra* are irrigated; it is breached to go to next diversion downstream and so on. The earthen structures build collectively are often washed away by severe floods and the farmers are required to join again to build them in order to capture next spate. The principle of *Saropa-paina* (Head to Tail) is followed while constructing all diversion structures from main channel to the field channel and then sequence of location of fields on it. In upland Systems, the water is conveyed to a *Kacchi* (the cultivable land along main stream) through water course (*Joo*). To divert water into "*Joo*" an earthen structure is installed to raise water level to make it flow in J*oo* and irrigate fields. Both *Bandha* and *Joo* are constructed by collective work at the similar pattern in lowland system. (The local terminologies denoting local practices and structures in these indigenous systems along with brief description are given in appendix-2).

Patterns of Change

During the last two decades a lot of changes have occurred in rural economies. As noted by Baker (2005) in his study on *Kuhls of Kangra*, increased non-farm labor opportunities has affected these systems by decreased participation in collective work, increased inequalities between head and tail farmers in terms of water availability and consumption and contribution in work, decline in water system manager's (i.e *Maimar*)authority.

The major factors influencing such changes are rise in non-farm and off-farm work opportunities, availability of farm machinery, declining land holding size with hierarchical division, weakened tribal system and government intervention (especially in lowlands), access to urban areas with better roads networks. However these effects are variably distributed spatially and are described separately:

i. Lowland Systems

In the pre-colonial era; mostly the spate areas were irrigated from natural flow and locally recognized water rights were followed. The colonial authorities structured all record and formulated a separate cell under revenue circle '*Rod-kohi'* and give the name to all prevailing customs as "*Haqooq-e-Aabpashi*" (also called as '*Riwajaat-e-Aabpashi*' i.e. Irrigation customs). The codification was on the basis of existing customs and with joint consultation of land owners at that time. The existing irrigated lands and existing gravity flow routes were recognized. The major objective of codification was revenue generation and legitimacy of their power in these previously considered tribal areas. The amount of collective work needed with oxen was estimated at all collective work sites and were distributed among all farmers proportionate to their haqooq-lands area. In this way it was made mandatory for all farmers on a spate to work collectively at these locations. For this *Darogha* (water master), an official from *Rod Kohi* department is assigned to convey to all farmers the date for repair and maintain attendance register to ensure participation of farmers with their determined number of oxen (through institution of *Maimar*). Mostly landowners owned bullocks for land preparation and therefore the work was distributed using unit of bullocks. In case some landowners don't have bullocks; then they were to provide labor and construction

material which mostly consisted of plant material (Brush-wood, small tree). In case of defaulters, the work was tendered to some farmers in auction and the price of that auction was paid back by the defaulters.

The D. G. Khan and Chashma Right Bank Canals widely changed the livelihood system of the areas. With canal networks development; the spate command downstream areas came under canal irrigation and resulted in more burden of water diversion work on remaining farmers at one hand and has provided with off-farm income opportunities in close vicinity on the other hand. The increased level of income from off-farm resources made spate farming attractive in the sense that they are able to make better livelihood living with their tribe and culture. However the younger ones have tendency to go non-farm jobs and avail recruitment preferential quota in military and Para-military forces. Currently the irrigation department has been given responsibility to construct structures without any supervision and maintenance responsibilities. During the survey and discussion with the official revealed a complete failure of most of engineering structures due to challenges in the form of sediment deposition and high speed of the flows compared to designs of structures. A survey in Baluchistan shows the fact that only 34% of 47 agency developed schemes are in functional form (Groundwater consultant, 1991 cited from Steenbergen, 1997) and the situation is not different in Punjab province where small number of government sponsored structures have already been partially or completely damaged (personal communication with irrigation department officials)

ii. Upland Systems

The Upland systems are mostly located in tribal or political area and are completely managed by community without interference from any specialized agency compared to

lowland systems. The institution of *maimar* is still functional which is supported by the authority of *jirga*. The selection of *maimar* is based on experience and good reputation among the irrigators. He commands others in all works including construction of bund (*Bandha*), Joo and its design and water distribution. To divert water into "*Joo*" a bund is developed to raise the water to make it flow in *Joo*. The tribal system has its own merits and drawbacks. Maintaining equity among tribe members is first priority of tribal culture. The land is distributed among family members without any land consolidation. Similarly water is distributed among owners through "*Draw or Lottery system*". Once the water is in the *Joo*, there are draws among farmers owning different parcels to sequence of irrigation rights in a given season. Similarly to ensure further equity among the members of particular parcels, there is a further lottery or draw among individual owners. This way the sequence to irrigate in whole command area is established. The person having prior irrigation rights will irrigate land (it may be in more than one places in a parcel at different corners). However the irrigators sometimes agree to exchange irrigation turns to irrigate adjacent lands. Monitoring and enforcement of all works is done communally. The monitoring is done by the farmers themselves and the one with next water turn will take care of *Joo* and his turn. However during peak water demand season; the farmers decide to cut their irrigation time slots to half to get their turns more frequently.

The institution of *Maimar*

The institution of *Maimar* (also termed as *Thalidaar* and *Mate* in certain locations at uplands and other districts) is an integral part of the spate irrigation systems in the area. The literal meaning of *Maimar* are *mason or somebody associated with construction*. The farmers collectively diverting and using water from a lateral select an experienced

person as *Maimar* (in some cases 2 persons are also selected based on size of lateral) with a responsibility to supervise and ensure smooth working of the system. His duties include estimating amount of work needed, the design of the structure, calling farmers about the date of collective work, keeping record of presence of farmers at work, information about flood as well as about any loss to the diversion structures. The *Maimar* is selected every year based on consensus among the farmers. However many times the same person is supposed to continue as long there are some strong allegations against him. Keeping in view the temporary status, *Maimar* is reported to maintain his impartiality through out the system. The *Maimar's* testimony in disputes, absence from work and imposing fine is highly valued.

In lowland, even after the deputation of revenue staff to look after the systems; the institution of *Maimar* is still operating. It works as a bridge between farmers and between farmers and revenue staff. *Maimar* still holds the responsibility to inform farmers about the *kamara* date, maintains attendance register, mediate conflicts and his witness has legal importance in case the disputes (Dastoor-ul-Amal Rodkohi, 1937). The *Maimar* is paid as a fixed proportion of produce by each irrigator which is also pre-determined and can vary from year to year and system to system.

Operational Rules and Management Systems:

The centuries old systems are working with some mutually understood rules and differ considerably with the type of system. The selected systems in this study are representative of the similar systems found in the area. This section is mainly focusing on geographic overview and rules evolved in different resource settings and later we will discuss the compatibility of rules with the physical and cultural context of the systems.

Table 3 Summary of operational rules in Lowland and Upland systems

Operational Rules	Lowland Systems	Upland Systems
Irrigation rights	The irrigation rights are fixed to the "Haqooq lands". The logic of getting status of haqooq land is stated to be contribution in communal systems development centuries back.	Irrigation rights are fixed for Haqooq lands. The non-haqooq lands in the command area are one which were either uncultivable previously or the owners did not participate in development work at the initial stages.
Transfer of rights	The water transfer rights are bound with the land and are transferred with sale or purchase of specific land.	The land and water has different legal transfer rights.
Work Distribution	The work is determined based on *kamara* system i.e. estimated on number of oxen needed to cultivate haqooq land.	*Kamara* system defining labor and money contribution proportionate to water haqooqs are followed based on traditionally calculated ratios.
Water Distribution system	*Saropa-paina* (head to tail) system is usually followed with head end have first right for irrigation. The non-perennial	Water distribution is based on the fixed time slots proportionate to haqooq lands in perennial systems and Head to Tail end in

	systems mostly irrigate as much as they need while perennial system follow fixed time slots	non-perennial systems. The irrigation turn is determined through 'lottery' in perennial system and one field in a sequence in non-perennial
Land-water relationship	Every share holder can only irrigate specific haqooq lands based on flexibility in quantity of irrigation. The land cannot be replaced with other land without irrigation rights without collective permission to do so.	The land and water have separate transfer rights in revenue records. Some member can sell their water share if the land is eroded and others with reclaimed land or non-haqooq land in the system can buy this right.
Community's response to distribute water	Tail end farmer can break diversion structure at main water course if the head end farmer's water is going to non-haqooq lands or going waste out of field.	The fixed sequence of irrigation is known to all members and *maimr*. The farmers with next turn can divert water to his fields at fixed time.
Codification of rules and legal recognition	All haqooqs are codified since British time (having thumb impressions of all land owners at that time) with details about	The irrigation customs/rules are not codified. The rules are well known and recognized by community members and tribal

	haqooq lands as well as work contributions	elders.
Enforcement	The *Rod-kohi* (spate) department is to help enforce rules if farmers and *Maimar* themselves can not resolve any problem	There is no specific government agency for the enforcement of rules. The tribal elders constituting 'Jirga' mediate if conflicts are not resolved by the irrigators and *Maimar*

In all case study systems, the farmers tend to use existing community based decision making structure to manage their systems. These existing structures are known to the water users and are also recognized by the state laws. The two sites differ widely in terms of governance arrangements and their effectiveness. Given these above mentioned background information, now we analyze the institutional settings of the case study sites using Ostrom's design principles

Design Principles and evaluation of Spate Irrigation Systems

Many studies have used these principles to confirm their existence in the long enduring forest institutions (Tucker *et al,*2007; Gautam and Shivakoti, 2005; Morrow and Hull, 1996) as well as irrigation systems (Trawick, 2001; Sarker and Itoh, 2000; Tang, 1992). This study seeks to use design principles as evaluative and theoretical framework to determine their existence as well as comparative robustness of the systems. The authors have used household perceptual data about existence of design principles (as

used by Wittayapak and Dearden, 1999) to come up comparison of institutional strength and policy implications.

1. Clearly defined boundaries

This principle has two parts i.e. the boundary of the resource itself and the resource users.

i. Resource Boundaries: The demarcation of physical boundaries of huge resources as spate irrigation systems (getting water from more than thousand square kilometers on average in the study sites) is almost impossible. However there is a specific location as well as traditionally developed system for water diversion from the main flood stream in each system. In this way the physical boundaries of each spate systems are not that vague as usually treated in literature.

ii. User Group: There is a well defined and predominantly fixed number of resource users owning haqooq lands. The rules for entry as restrictive as it is generally stated that non-members once allowed to get irrigation water from the system can claim to have permanent right in its use. The members may also own some plots without irrigation rights and are therefore used for rainfed farming.

The perception of resource users about acceptability of the rules as well as *de facto* situation of rules obeisance shows that except for lowland perennial system, majority of respondents in other three systems showed positive response about rules acceptance. However the level of satisfaction over the following of the rules is found to be lower than rules acceptability in lowland systems (as shown in table 4)

Table 4 Response regarding acceptance and obeyance of boundary rules

i. Perception about acceptance of rules

Figures in table are in %

Rules Acceptance	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
Reluctantly	24.3	17.1	55.7	18.6	28.9
Voluntarily	75.7	82.9	44.3	81.4	71.1
Total	100	100	100	100	100

Pearson Chi-Square = 33.543[a]

ii. Perception about obeying rules

No	30.0	24.3	58.6	18.6	32.9
Yes	70.0	75.7	41.4	81.4	67.1
Total	100	100	100	100	100

Pearson Chi-Square =30.046

2. Congruent rule: the proportionate equivalence between benefits and costs suitable to the local situations

This principle also has two parts i.e. first part describing congruence between the appropriation and provision rules and part two relates to the matching of appropriation rules to the local conditions.

i. The first part of this principle explains that every member gets benefits in proportion to their contribution. In all of these systems, the work (cost) and water share (benefits) are already decided based on proportionate contribution in work and water share. While some labor has been replaced by machinery use, the proportionate contributions are calculated keeping previously determined ratios. The survey results show that

comparatively higher level of disagreement over satisfaction in lowland systems compared to upland systems. One possible explanation of this can be that the upland system use equitable water distribution by *lottery or draws* to determine water turn (perennial systems) and *one plot in a sequence* irrigation practice (non-perennial systems) compared with the lowland systems where head to tail water distribution is followed. The results further reveal that most lowland tail-end farmers were not happy with the distribution rule where cost sharing was same through out the system. Some upland farmers also showed concern about *lottery* and *one plot is a sequence* water distribution on grounds that it result in less efficiency and water loss.

Table 5 Respondents perception of rules congruence to local conditions

Figures in table are in %

Rules Congruence	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
No	34.3	20.0	28.6	12.9	23.9
Yes	65.7	80.0	71.4	87.1	76.1
Total	100	100	100	100	100

Pearson Chi-Square =10.261[a]

ii. Rules and the local conditions:

The spate irrigation uses the locally available material including stones and brush-wood to divert water using indigenous wisdom and design parameters by constructing semi-circle diversion structures. There is a general agreement among the farmers that this labor intensive construction and distribution criteria is in harmony with the local conditions.

3. Collective choice arenas

The underlying theme of the principle is that participation in decision making meetings provides individuals to raise their voice in modifying operational rules. All members have right to participate in the meeting which are usually held several months before the on-set of monsoon with the main objective to asses the labor and machinery needs as well as collection of share from the members. The members usually send one senior member as their representative. *Maimar* is selected in one of such meetings on the basis of his expertise and is impartiality in day to day spate related activities.

Traditionally influential landlords and tribal heads dominate the meetings and decisions. Therefore the direct participation may not be a true measure of how people feel satisfied with the decisions. The design principle may be re-designed in a way to know about the community's satisfaction with the decisions whether they participate in person or not. As in case of the Lowland perennial system, the respondents from tail end of the system don't feel any positive outcome by going into these meetings. So the individual responses regarding participation in meeting don't provide much information as respondents are satisfied with the decisions made by their tribal representatives. It is therefore that the sampled respondents were asked about satisfaction about meetings and the decisions.

Table 6 Respondents satisfaction over participation in decision making

Figures in table are in %

Decision Making	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
No	31.4	12.9	58.6	22.9	31.4
Yes	68.6	87.1	41.4	77.1	68.6
Total	100	100	100	100	100

Pearson Chi-Square = 24.95

4. Monitoring

There is always a temptation in human nature to gain at the cost of others and it makes monitoring an important element of self-governed resource systems. Due to bigger size of the system and location of main diversion structures away from the settlements (characteristic of spate areas as settlements are usually away from the flood streams). in all systems, a monitor (*Maimar*) is appointed at main diversion structure who live there during entire season and inform members about the first and subsequent floods, the damage to the structure and to guard it against any breach by the lowland system members. The monitoring at the laterals and field level is on self-monitoring basis of each other. With the inclusion of guards in lowland system, farmers perceive it as their responsibility and avoid any conflicts with fellow farmers by monitoring and stopping them from some action. It is evident from the result that the perennial system where the revenue department has great influence and economic incentive, the perception of self-monitoring is low compare to non-perennial system in lowlands. However mutual monitoring is perceived as to be irrigator's responsibility in upland systems and is

perceived to be carried out by majority farmers while working on their fields and waiting for their turns.

Table 9 Respondents awareness about monitoring responsibility

Figures in table are in %

Participation in monitoring	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
No	44.3	34.3	62.9	22.9	41.1
Yes	55.7	65.7	37.1	77.1	58.9
Total	100	100	100	100	100

Pearson Chi-Square =24.953

5. Graduated Sanctions

The repeated violation of the rules by any member need to be dealt with heavier penalty at every repeated time and this is the central theme of this design principle. In the sampled systems with largely homogenous population, community pressure and loss of reputation on being caught are found to be major penalty for users followed by more strict economic sanctions of fixed amount of fine (in lowland systems) and one season ban on irrigation (both in upland and lowland systems). In upland system the *Maimar exercises* his authority to cancel one water turn during a season or impose some additional work for violating a rule (which is seldom reported to be exercised and verbal warnings is given in extreme cases). In lowland system, *Maimar* has no more authority to impose penalties. He can only report to officials from revenue department about any infractions that are thought to be corrupted in some cases. The survey reveals that most of the respondents in lowlands perceive sanctions to be fixed as they

are imposed at a fixed rate (while some also perceive verbal warnings from *darogha* before filing case with police as a smaller sanction or threat of loosing irrigation right during next season as a heavier sanction though both seldom exercised).

Table 10 Respondents perception about sanctions

Figures in table are in %

Gradual Sanctions	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
No	51.4	38.6	48.6	28.6	41.8
Yes	48.6	61.4	51.4	71.4	58.2
Total	100	100	100	100	100

Pearson Chi-Square = 9.323

6. Conflict resolution mechanism

This principle deals with the respondents' perception and preference on mechanism to resolve conflicts among the irrigators which may take several forms as in our case studies by the local irrigators themselves, *Jirga* (the collection of tribe elders), police cases (in lowland systems only), cases going up to courts even without consulting other channels (mostly lowlands but also uplands in some cases) are reported. Overall perception about conflicts resolution is at local level in presence of *Maimar* and some senior members in uplands while decisions by revenue officials and even increasingly courts is in lowland systems (especially lowland perennial case study respondents).

Table 11 Respondents perception about conflict resolution

Figures in table are in %

Conflict Resolution	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
Local irrigators	57.1	84.3	17.1	79.7	59.5
Officials	28.6	0	37.1	.0	16.5
Courts	14.3	5.7	45.7	5.8	17.9
Jirga	0	10.0	.0	14.5	6.1
Total	100	100	100	100	100

Pearson Chi-Square = 141.368

7. Minimal recognition of rights to organize

Historically the spate irrigation systems were known to be free to devise their own rules unchallenged by the government in terms of intervention in endogenously crafted institutions. The respondents in lowland perennial system has shown dissatisfaction (mostly affected tail end farmers) with the government making decisions neglecting local rules (some decisions where decisions are made according to minor canal act of 1906). Similarly some respondents in uplands showed their concern over the few decisions giving stay orders by court against community's decision. However the respondents overall response signifies the recognition of community institutions by government.

Table 12 Respondents perception about recognition of community rules

Figures in table are in %

Rules Recognition	Lowland non-perennial	Upland non-perennial	Lowland perennial	Upland perennial	Average
No	24.3	17.1	31.4	11.4	21.1
Yes	75.7	82.9	68.6	88.6	78.9
Total	100	100	100	100	100

Pearson Chi-Square = 9.513

Evaluating Institutional performance

The design principles put forward by Ostrom (1990) provide useful guidelines to evaluate the performance of common property resources against set criteria. As deduced from the results based on perceptual individual responses, the four systems have shown variation in performance. The criteria for existence of a principal are based on 50% or more responses in 'yes' for the questions being used to ask the respondents. Similarly the systems where all Design Principles on the basis of above laid down criteria existed were ranked to be *"robust"*, those with one of the principle absent as *"average"* and more than one principles absent as "weak". Of the four systems, the highly productive lowland perennial system was found to be the weakest in institutional performance. The researchers own observation and discussion with the communities showed that the vested interests by the revenue officials have paved way for temporary provision of irrigation rights for non-haqooq lands at head end areas. The absence of such interventions in the upland systems and strong community control combined with unchallenged authority of *Maimar* has maintained the systems in tact. The lowland non-perennial system showed better performance than its counterpart perennial system

because of high labor costs compared to benefits which needs head end tail end relationship tied and resultantly less interference by the revenue officials.

Table12: Comparison of Institutional performance in four community managed irrigation systems

Design Principles		**Lowland systems**		**Upland systems**	
		Lowland non-perennial	Lowland perennial	Upland non-perennial	Upland perennial
1.	Clearly defined Boundaries	Yes	No	Yes	Yes
2.	Congruent rules	Yes	Yes	Yes	Yes
3.	Collective Choice	Yes	No	Yes	Yes
4.	Monitoring	Yes	No	Yes	Yes
5.	Graduated Sanctions	No	Yes	Yes	Yes
6.	Conflict Resolution Mechanism	Yes	Yes	Yes	Yes
7.	*Rights to organize*	Yes	Yes	Yes	Yes
Overall assessment		*Average*	*Weak*	*Robust*	*Robust*

Conclusion and the way forward

The four community managed irrigation systems in the study share common history, rules, managed by homogeneous communities, a well defined body of user group and

access to off-farm employment opportunities in the nearby areas have endured over time. The evaluation of two resource system using design principles explains the overtime changes and current situation of institutional strength at two locations. The interference of revenue department in local decision making has weakened authority of traditional *maimar* institution for conflict resolution in lowland systems. Further the rent seeking behavior of public officials have negatively impacted the perennial system by introducing temporary permissions for irrigation of non-haqooq lands of some influential farmers at head end of the system. The dichotomous responses on institutional parameters given by Ostrom (1990) are used to compare institutional strength of the systems. Based on these responses and their aggregate responses against seven design principles, upland systems were found to be robust than the lowland systems. Whereas the lowland non-perennial systems were found to be stronger (than lowland perennial) where officials interventions are not so disturbing because farmers have no incentive to defect and demand for asymmetric rules for higher share in water because of high costs of operation and maintenance of systems. On the contrary, the lowland perennial systems have very less O&M costs compared to benefits and head end farmers have been able to get illegal permissions to irrigate *non-haqooq* lands by defecting from the traditional mutually agreed and codified rules. So the lowlands absolute weakened institutions compared to upland systems clearly indicate governmental interventions as major factor whereas comparative strength of lowland non-perennial systems than lowland perennial systems shows state interventions along with cost of maintenance and collective action paradox given by Ostrom (2008).

The design principle 3 describing participation in decision making and modifying operational rules doesn't quite fit to the study context. In highly homogeneous tribal societies with long history, participation by a member from each tribe is considered enough in making such decisions. It is therefore that despite of very few people participating in the meetings had no effect over satisfaction with the decisions.

The analysis has important policy implication as the system found weak or fragile can overcome their weakness and the system described as strong can be saved by avoiding factors responsible for weak or fragile systems. This is important in the context that government with the help of Asian Development Bank is planning to start a mega project for the development of spate irrigation systems. It is therefore pertinent to keep community based institutions in tact instead of state mechanisms of management.

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Appendix 1

Specimens of Legal documents under Revenue Department

1. Preparation of list of farmers and no. of bullocks owned (to be prepared by January each year)

Sr. No	Mouza (Revenue circle) and Tehsil	Name of Spate	Name of share holder	No. of fields/area owned	No. of bullocks owned (to estimate needs for additional work)

Source: Revenue records ("Dastoor-ul-Amal" Dera Ghazi Khan)

2. Attendance Register (Specimen translated into English from *"Dastoor-ul-Amal Rod-Kohi (1934)"*

Sr. No	Mouza (Revenue circle)	Name of Spate	Name of share holder	No. of bullocks/labor for work	Date(s)

Source: Revenue records ("Dastoor-ul-Amal" Dera Ghazi Khan)

3. Record of Fines

Sr. No	Reference No. of case	Mouza (Revenue circle)	Name of Spate	Name of person fines	Amount of fine

Source: Revenue records ("Dastoor-ul-Amal" Dera Ghazi Khan)

Appendix 2

Local Terminologies used in lowland spate irrigation systems with purpose and problems

Local Name	Definition	Labor Pattern	Purpose	Problems
Lowland Systems				
Gundh	It is a water diversion structures in the path of spate flow. It is the major point of action for farmers and *Kamara*. The spates are diverted to *Wahs*	Collective work on spate irrigated land holding basis	Customary it is the responsibility of command area farmers to construct and rehabilitate (with supervision from spate department in lowland since codification in British times.	-Breakage of Gudh in heavy floods even more than once in a season -Need heavy work and more than one time construction in a season -The permanent engineering structures almost flopped due to heavy flows and sediments -Huge amount of small trees and twigs needed every year for construction
Wah or Kas	It is a channel which leads to one or more than one sub-channels (*wahis*) and directly or indirectly irrigates	Collective share in work on the basis of land share in a particular wah	To divert water either directly to fields or through *Wahis* on the basis of *haqooqs*	-Silting up as the floods bring a lot of sediments and needs heavy labor for maintenance and cleaning every year

	fields.			
Wakra	It is an earthen (with brush-wood) obstacle across the *Wah* to raise and divert water into *Wahi* or field	----do---	To provide slope gradient needed for water delivery	-It needs to be constructed every year with brush-wood and mud -trees and bush-wood needed in large amounts -With raised field level due to silt, the location of *wakra* is keep on changing
Bund	The field irrigated by spate water is called a *Bund* and can be either irrigated by a wah or a wahi. Its size vary from 1 acre to 20 acres with average size of 5-10 acres	Individual farmers responsibility	The bund is with raised borders to store more water as the water availability is quite uncertain. Also water need to be stored for longer time to conserve moisture for subsequent crops	-Due to silting process; the level of *bund* is raised by few inched every year. -It becomes more and more difficult and costly to convey water at this level.
Mohaan	the convenient location from where water flows into field	Individual farmer's decision	It is designed in a way that water enters into field easily under gravity flow and is usually at higher level side	-Its place keep on changing due to sedimentation and increase in bund height -Need cost in terms labor, tree trunks, brush-wood and a piece of cloth to

				stop reverse flow of water from field into *Wah* or *Wahi*
Maqaasma	The points at Wah or Wahi where water is distributed among all water share holders	Every year decided collectively by measurement according to *Riwajaat* (customs)	To distribute water into *Wahi* or *Kassi* to equitably irrigate Haqooq lands as per *Riwajaat*	- Conflicts at location with earthen nature of structures -At certain locations decline in Haqooq lands due to canal and water go waste
Wandara	The distribution of water in different *wahs* at the time of spate flow from *Darrah*	Collective decision as mentioned in *Riwajaat*	To irrigate Haqooq lands as per *Riwajaat*	-Difficulty in diverting high foods -Breaching of diversion structures by flows
Lath or Banna	The embankment of a field	Individual farmers responsibility	It is mostly kept height to store more water	-With silting up of fields, the level of bunds is kept higher and higher
Sud	A small diversion wall or dam	Collectively made in order to make water flow in haqooq lands. Also financed by government as permanent walls in some cases	To make water flow to haqooq lands and avoid going waste or to non-haqooq lands	It is eroded by high floods and water tend to change route and either go to non-haqooq lands or go waste

Upland Systems (the above mentioned structures 'Gandh' and 'Wakra' have the same name and description in upland systems)				
Joo	Literal Meanings "Canal" The water course which convey water from perennial flow to the irrigated areas	Shared by all farmers in a an area	To convey water from main canal to fields	-Sometimes *Joo* is washed away with erosion as it runs parallel to foot-hill.
Kassi/Sub Joo	The water from main canal goes to *kassi* for further distribution	Shared by all command area farmers of a specific *kassi*	To convey water from main canal into sub-canals and field channels	Need to be adjusted with joo size every season and is labor intensive
Kacchi	The area irrigated by a certain "joo" in perennial flows	There are share holders mostly from same tribe	These are haqooq lands and have water rights since the system development	-With land fragmentation the system is becoming inefficient to convey water to different small parcels of same owner located distantly. There is a need for land consolidation.

Source: Field Survey, 2008