The importance of institutions to address water scarcity within large-scale irrigation systems

An evaluation of the Indus Basin Irrigation System in Pakistan

Mark Oelmann & Jonathan Schulze[1]

Institutions, irrigation, agriculture, common pool resource, irrigation management, water access, Pakistan, participation, water users associations, Ostrom

This article is looking at the problem of water scarcity in large irrigation systems[2],and how this scarcity is mostly a problem of inadequate institutions that are unable to allocate water in an efficient, as well as in an equitable way. In order to explain the overall vulnerability of irrigation systems to become overused by their irrigators, they are defined as a common pool resource. As a potential solution to deal with this vulnerability, Elinor Ostrom has introduced eight design principles that can be applied to create considerate management rules for common pool resources. An example of a common pool resource with frail institutions is the Indus Basin Irrigation System in Pakistan. In this region, weak management rules translate into the so-called head-tail problem, which means irrigators at the head of the system take advantage of their privileged geographic position and irrigate beyond their designated water share at the expense of those irrigators further downstream. To address this head-tail issue the province of Punjab, among other provinces in Pakistan, had introduced a new reform concept referred to as Irrigation Management Transfer (IMT). Essentially, this reform process tried to decentralize irrigation management to enhance the participation and self-reliance of farmers and to create new and more responsive organizations to settle water disputes and water usage disparities between different regions. To a large degree this reform process has been in accordance with Ostrom's widely acknowledged design principles. However, much of the reform still needs to be implemented and therefore only very limited progress has been made.

1. Introduction

Irrigated agriculture now occupies 18 % of the total arable land in the world and produces more than 33 % of its total agricultural production. The agricultural sector is by far the largest user of water, accounting for 70 % of global withdrawals of water in low-income countries [1].

This article discusses the importance of functioning institutions to address the problem of water scarcity in large irrigation systems illustrated by the Indus Basin Irrigation System in Pakistan. Primarily, this water scarcity is an allocation problem that is the result of weak and inadequate management rules. Consequently, farmers with privileged access to water over-abstract water from the canals at the expense of the other farmers further downstream, also known as the head-tail problem. Not only does this head-tail problem lead to an inefficient use of those precious water sources, it also threatens the livelihoods of the tail farmers. Thus,

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2 There is no universally accepted classification of large irrigation systems. They can be defined in terms of their physical characteristics as well as in terms of their organizational characteristics. However, size of the command area alone is not the distinguishing feature, since a 500 ha scheme may be classified as a "major" or "large-scale" scheme in one country, but be regarded as "minor" or "small-scale" in another. In the context of this article, irrigation systems are defined as large irrigation systems if they have: (1) formal hierarchies of open channels for controlled delivery of irrigation water and for removal of drainage water; (2) formal organizational structures with a legally constituted management institution responsible for control of water allocation and delivery.

effective rules must be created to prevent farmers at the head to withdraw water beyond their designated share as well as to give them incentives to invest in more water efficient irrigation practices. Furthermore, this also includes a stronger involvement of farmers in the operation and maintenance of the canal network in addition to implementing a functioning monitoring and sanctioning system. As a potential solution, this research introduces Ostrom's eight design principles for managing common pool resources and attempts to identify possible areas of intervention where those design principles could be helpful within the institutional framework of the Indus Basin Irrigation System. The article is structured as follows: chapter two gives an introduction into common problems of large irrigation systems; chapter three provides some conceptual background on the nature of water institutions as common pool resources; chapter four discusses how institutional deficiencies contribute to the head-tail problem in Pakistan; chapter five analyzes whether the implemented irrigation reform sufficiently addressed those institutional deficiencies; and chapter six sums up the previous results.

2. Management problems of large irrigation systems

In the midst of the Cold War, governments in many developing countries invested in the construction of large-scale irrigation schemes to foster economic development and growth.[3] At the time, investing in large-scale irrigation schemes was viewed as a silver bullet for economic and social development. In the decades between 1950 and 1980 an almost threefold increase in the total area of irrigated agriculture throughout the world had been witnessed [2]. Overall, irrigated agriculture contributed to a massive increase of 50 % to 60 % in agricultural output [3].

Even though the massive investments in irrigation have generated substantially higher agricultural yields, many large-scale irrigation systems could not operate in a sustainable way [4]. First of all, this has to do with the fact that those irrigation systems were often oversized and therefore very costly to operate. Consequently, after the irrigation schemes were completed, the net flow of costs exceeded the net benefits [5].[4] Beyond that, those irrigation systems were usually run by huge and underfunded bureaucracies, which operated their system by imposing rigid and uniform management rules. Those top-down management rules left no or little room for regional disparities in terms of their varying water demands and did not take into consideration that many communities already had established their own local rules and norms to manage their scarce water resources.[5]

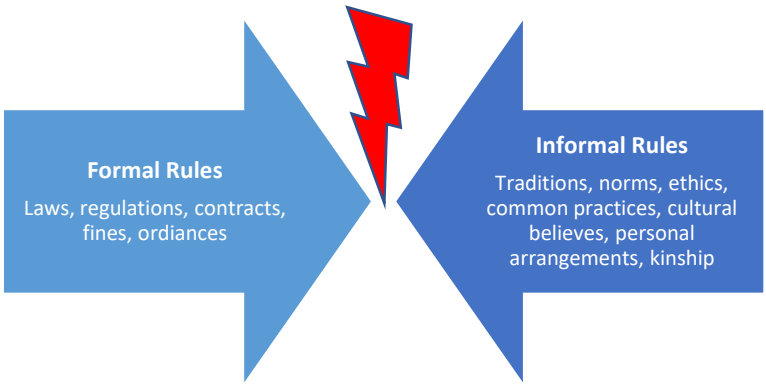

***Figure 1**: Formal & Informal rules in many instances do not match and are contradicting each other. When that happens, there is a great chance that formal rules are undermined by informal rules*

3. Theoretical insights

In order to understand the complexity of finding appropriate institutions to successfully manage large irrigation systems, it is helpful to provide some theoretical background. Thus, a definition on the term institutions will be given, and irrigation systems will be defined as common pool resources to provide a conceptual framework for analyzing the institutional gaps in the Indus Basin Irrigation System (IBIS) in Punjab, Pakistan in the subsequent chapters.

3.1 What are institutions?

In this article, a sharp distinction between institutions and organizations will be made: "institutions" refer only to formal and informal working rules, whereas "organizations" refer to the actors who are either shaping those rules or more passively are enforcing them. Formal rules are laws, regulations, and ordinances; informal rules are norms, cultural beliefs, ethics, and traditions as well as unofficial agreements and practices (See **Figure 1**). This is an important distinction to make because those two types of rules do not necessarily correlate and sometimes even contradict each other. This especially holds true in countries which do not have a long history with their governance and legal systems [6]. In those countries formal rules are often too frail to be enforced

3 However, such massive financial investments were only possible through the assistance of Western and Soviet development aid (See Barker and Molle (2004): Evolution of irrigation in South and Southeast Asia).

4 Thus, national governments had to subsidize heavily public irrigation utilities, which posed an enormous financial burden on their already constrained budgets.

5 This is also known as supply-oriented irrigation systems.

and therefore informal rules take over [7]. Informal institutions reflect a certain pattern of interaction and collective behaviour among groups and individuals. They are motivated by a broad range of social factors such as local hierarchies, loyalty to specific individuals, but also personal motivations such as political ambitions, pride and reputation, family ties, etc., as well as by material incentives [8]. Informal rules can create collective benefits like sharing a watercourse; or they can result in opportunistic behaviour where individuals or groups follow their self-interest at the expense of others [9].[6] Whether farmers engage in socially constructive or rather destructive informal institutions depends on the question, which option will generate a greater personal benefit for them, in addition to the question whether they will get away with such self-serving behaviour. Hence, the overall institutional framework will determine which kind of informal institutions will prevail.

3.2 Irrigation systems can be defined as common pool resources

Large-scale irrigation systems – like fisheries or grazing land – can be defined as common pool resources (CPRs). The most crucial feature of CPRs is that their core resource – in case of irrigation systems the water – is scarce and subtractable.[7] Thus, they are vulnerable to face problems of congestion and overuse because their scarcity creates a strong rivalry among its users. To keep the fierce competition among its users under control, an effective monitoring and sanctioning system is essential to enforce unambiguous abstraction rights. However, their great size makes it very costly to monitor the use of the CPR as well as to exclude unauthorized beneficiaries from its use [10]. The situation in which the use of a CPR is not regulated or monitored is described in Hardin's famous "tragedy of the commons" allegory, where herders let their sheep graze a free pasture. Within a short time period the pasture is so overgrazed by their animals that it can no longer feed anyone's livestock since each herder tried to exploit the pasture to his maximum benefit.[8] Essentially, Hardin describes in the tragedy of the commons a perversion of an unregulated competition that elicits a destructive form of egoistic behaviour. According to Hardin, the tragedy of commons can only be solved through an external power who enforces strong rules on the users of the commons [11]. This rather pessimistic view of Hardin on the capacity of human beings to deal with scarce resources in a sustainable way is challenged by Elinor Ostrom. Contrary to Hardin, Ostrom does not think people are inevitable trapped in a pattern of opportunistic behaviour but that people can overcome this dilemma through organizing themselves collectively. As a matter of fact, Ostrom offers real life evidence from a broad range of common pool resources that are successfully managed by communities. There are plenty of examples where common pool resources are managed in a sustainable way to the benefit of all, from mountain meadows and forests in Switzerland to commonly managed irrigation systems in Spain and the Philippines, just to provide a few examples [12].

Ostrom has investigated those successful examples and deducted eight design principles for creating long-enduring and self-organized common pool resources. Contrary to the still dominant, centrally operated management approach, the objective of Ostrom's design principles is to assist local communities to create their own rules within their jurisdiction. The notion here is that e.g. farmers in an irrigation system know considerably more on how to manage their scarce water resources in their villages. From a fair and equitable allocation of water to a fair and equitable share of costs, to appropriate monitoring and sanctioning rules, each of these aspects can – according to Ostrom – be dealt with more efficiently and at much lower costs at a local level. Furthermore, Ostrom introduces some concepts on how communities should cooperate with each other to organize all management aspects that go beyond the local realm. However, Ostrom's design principles should not be understood as a strict management blueprint on how to manage a CPR but instead as some broader guidelines that must always be adapted to their specific local environment [13].

4. Institutional deficiencies in irrigation management shown by Indus Basin Irrigation System in Punjab, Pakistan: The head-tail problem

An example of a common pool resource that has been mismanaged is the Indus Basin irrigation System (IBIS) in Pakistan – the largest and most complex irrigation system in the world. The network irrigates almost 34.5 million acres and consists of 44 canal systems. The length of the canals is over 56,000 km while the length of the watercourses is above 1.6 km (See **Figure 2**). Water is diverted into the main canals through a series of barrages and twelve inter-link river canals. These

6 For example, through bribes, free-riding, and rent seeking strategies.

7 Subtractable means that once somebody has used the resource it is gone.

8 It is called tragedy of the commons because the users respectively the wrongdoers are in the end the victims of their own excessive behavior.

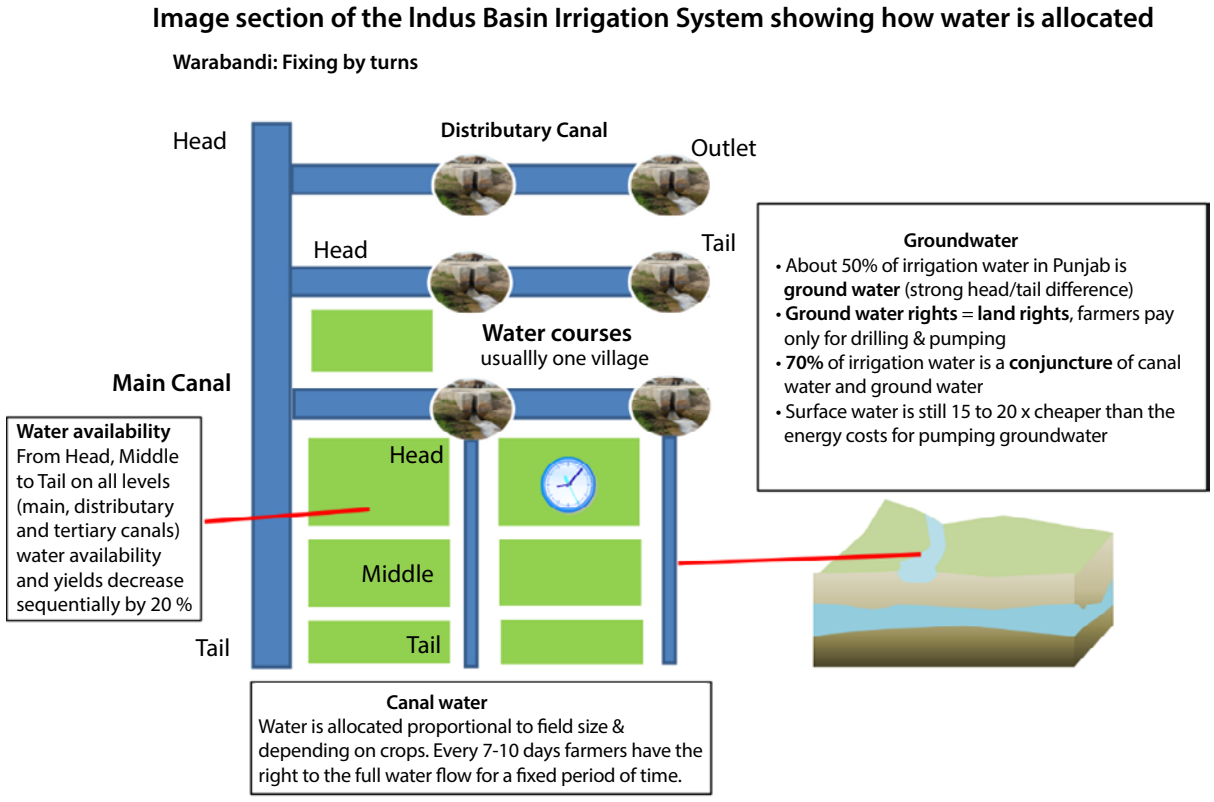

***Figure 2**: This figure explains the water allocation through the Warabandi as well as the head-tail problem of IBIS*

canals in turn deliver water to branch canals, distributaries, minors and eventually watercourses [14]. Historically, IBIS was built by the British as a centrally run supply-based system to supply as many people as possible. When it was built, it was planned as a hierarchically run system that was complemented by the strong inclusion and promotion of traditional local authorities (panchayats). After independence in 1947, many responsibilities were then transferred from local communities and traditional authorities to the formalized local branches of the central bureaucracy. This was justified on the grounds of the increasing complexity of technological change and growing concerns of irrigation engineers about the efficacy of decentralized water management.[9] At the same time the immense population growth in hand with a rising food demand and new cropping intensities from originally 75 % to 125 % had led to an increased water demand that went beyond the originally designed water capacities of the system [15]. Additionally, the parceling of land in addition to the democratization process that enhanced clientism had destabilized the existing formal water rights and the ability of the irrigation department to enforce them [16]. In the late 1980s the centralized management scheme gradually lost acceptance among local farmers, which they expressed through their unwillingness to pay their water fees and to provide labor for the maintenance work. Consequently, the irrigation infrastructure deteriorated, which resulted in an uncoordinated and unfair distribution of water resources among farmers as well as escalating conflicts among farmers and irrigation officials [17]. Moreover, the frail formal institutions in combination with the overburdened irrigation department encouraged farmers at the head of the canal system to over-extract water at the expense of farmers at the tail. Throughout the irrigation system, water theft and bribing irrigation officers to enhance the water share became endemic. Consequently, less and less canal water is reaching the farmers at the tail, therefore farmers are increasingly dependent on the lower-quality groundwater, which they have to pump at higher energy costs.[10] Altogether, the head-tail problem can best be described as a vicious cycle in which each of the just mentioned factors is aggravating the other.

9 Panchayats continued to play an important role but their influence was effectively restricted without any formal legal cover and based on local informal authority only.

10 Despite energy subsidies, the pumping costs for groundwater are about 15 to 20 times the canal irrigation (the exact price difference depends on the diesel or electricity price and inflation). Physically, this misallocation of water has given rise to in water logging and soil salinization in head areas as well as ground water depletion and deteriorating ground water quality at tail areas.

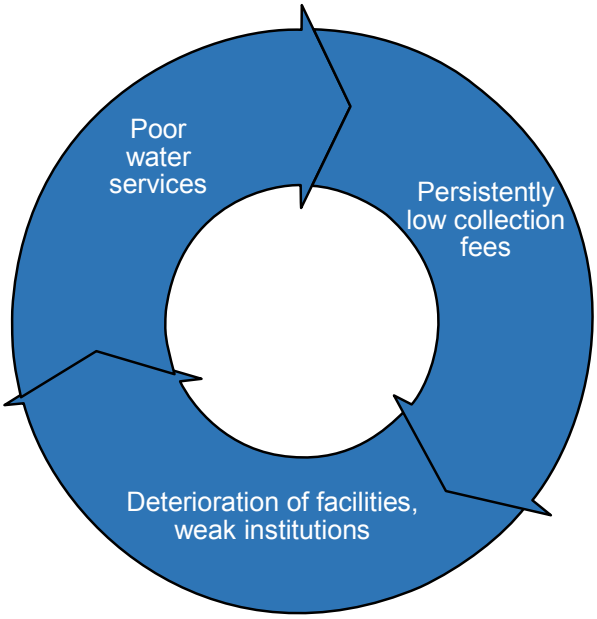

***Figure 3**: The vicious cycle of reinforcing factors that translate to an inadequate irrigation supply*

In many tail areas this head-tail problem has become so severe that it meets the description of a tragedy of the commons situation with no canal water reaching the outlets [18] (See **Figure 3**).

5. The Irrigation Reform evaluated by the Ostrom criteria

In 1997 there was a reform of the Punjab irrigation system. The Punjab Irrigation and Drainage Act was introduced by the government of Punjab with support of the World Bank. The following chapter explains this reform and analyzes how the Ostrom principles with regard to managing a common pool resource in a sustainable way have been applied to the irrigation reform of 1997.

The central question is whether the reform has put in place some effective policies to enable farmers to take over the irrigation management to allocate water more efficiently or whether it rather has introduced some paper tigers[11]. In this context, a particular focus is on the question of how the irrigation reform attempts to solve the earlier described head-tail problem.

In compliance with Ostrom's design principles, which will be explained in the following sub-chapter, the intention of the reform was to delegate the responsibilities of provincial irrigation departments to local irrigators. The reasoning behind the empowerment of farmers was to a large extent founded on Ostrom's and other researchers' observation that water users themselves can carry out the maintenance, allocation of water abstraction, monitoring and sanctioning, as well as water fee collection of their water courses more promptly and at much lower costs [19]. Consequently, the basic idea of the Irrigation and Drainage Act (PIDA) of 1997 was to decentralize water governance and to include farmers in the management of the irrigation system. In Punjab this reform process – called Irrigation Management Transfer (IMT) – was initially tested in five pilot regions and was intended to be expanded to the entire province. The IMT process restructured the former Punjab Irrigation Department into three new organizations with specific tasks for each of them. Provincial irrigation departments would become financially autonomous authorities, with responsibility from barrages to canal headworks. Area Water Boards would be established around all canal commands to take over and manage the irrigation and drainage system from canal headwork to distributaries and minors; and farmer organizations (FOs) would take over the operation and maintenance of distributaries, minors, and lower level drainage infrastructure. Essentially, FOs are a federation of the smallest hydraulic organizations within IBIS, which are located at watercourse level and referred to as Water User Associations (WUAs). Hence, in a farmer's organization each WUA – from head, middle, and tail reaches along a distributary canal – nominates one member to represent their watercourse in the federation [20]. Even though WUAs take up a central role within the newly formed farmer organizations, they themselves were not part of the formal IMT process. Instead, WUAs continued to operate under an earlier provincial ordinance. However, the original purpose of this Water Users' Ordinance had been primarily to introduce a temporary law for the rehabilitation of field channels, and only to a very limited degree was the purpose of the ordinance the empowerment of farmers [21]. In other words, in Punjab the reorganization of the irrigation management as defined by the irrigation reform did not include the tertiary level.

In order to evaluate the PIDA Act along the eight Ostrom principles they have been grouped in three different categories. Each category deals with an essential aspect of organizing an irrigation system in a sustainable way. Thus, it will be investigated how each category has been addressed in the reform.

Ostrom's eight design principles arranged in three categories:

1. Rules that define a local governance framework: watercourse level
2. Rules that define how this governance framework should be enforced: all levels
3. Rules that define how the different governance scales can work together: FOs, AWBs, PIDAs

(See **Table 1**)

11 „Paper tiger" is a literal English translation of the Chinese phrase zhilaohu.

Table 1: *Summary of the basic categories of Ostrom's eight design principles for a sustainable water management*

Elinor Ostrom's 8 design principles at a glance
Principle 1-3: **Defining a governance framework**
Basic framework for rules defining: the **boundaries** of the service area, the **water rights**, the **sharing of costs** for maintenance and operation, the **collective decision-making process**
Principle 4-6: **Enforcement rules**
Those principles define rules for: **monitoring**, **sanctioning**, and **conflict resolution** mechanisms
Principles 7-8: **Rules for nesting different levels of organization**
Those principles define rules for: **legal recognition of organization** & **synchronizing governance rules** with higher level governance entities

5.1 Rules that define a local governance framework

Ostrom suggests that a community that wants to govern itself must first draw a clear boundary of the area that belongs to its jurisdiction as well as draw a clear boundary of who is entitled to be a member. Without defining the boundaries of a system and closing it to outsiders, any collective benefit they produce – like for example rebuilding an irrigation channel – can be reaped by others who did not contribute.[12] In addition to closing the boundaries, a community needs rules limiting the use of the CPR whenever scarcity is present [22]. The second principle says that, for each member, the amount of resources he can withdraw must be proportional to his contribution to cover the costs for providing that resource – either by a payment or by providing labor. Simply put, those farmers who contribute most should be rewarded with the greatest share of water. The third principle underlines the need for community members to be included in the decision making of the allocation of water as well as in the operation and maintenance of the irrigation system. This goes in hand with principle seven, which says that governments grant local users a minimum of rights to set their own rules.

5.1.1 How a governance system with boundaries has been implemented at the local level

In the five pilot areas, Water User Associations (WUAs) had been established by the ordinance. In accordance with Ostrom, the legislation had established clear boundaries both in terms of the physical area as well as in terms of who belongs to the WUA. Farmers are eligible to vote for five board members that in turn take care of irrigation management. The board members also elect a chairman who represents them in the federation of WUAs. The physical border of the WUA is determined by the physical shape of the system – from the outlet of the distributary to last field channel of the watercourse. The principle of fairness with regard to how the share of benefits and costs are organized is not explicitly addressed in the ordinance. Instead, farmers are requested to participate on demand in rehabilitation campaigns of the field channels. The only way farmers can influence a satisfactory level of fairness is through the election of their representatives. Theoretically, the water fees (abiana), which are proportional to the size of the individual landholdings, reflect to some extend the proportion equivalence of benefits and costs. However, in reality this is not the case for a number of reasons. First, water supply is unreliable with notorious downtimes of the canals; second, there is hardly any data on the actual water use of the irrigators available; and third, many farmers even refuse to pay their fees. With regard to principle seven, the ordinance also deviates from Ostrom by impairing the decision-making ability of WUAs through installing a Field Officer. The Field Officer is hired by the Department of Agriculture and has the right to overrule all decisions of the WUA. Additionally, up until now relatively few WUAs have been implemented beyond the five pilot areas [23].

5.2 Rules that define how this governance framework should be enforced

Ostrom's principles four, five and six deal with the question of how this newly created governance framework should be enforced in practice. Principle four advocates a transparent and accountable monitoring system to make sure all farmers are in compliance with the collectively adopted rules. Principle five advocates a gradu-

12 The behavior of taking advantage of a benefit without contributing to its cost is called free riding.

ated sanction policy. Sanctions start at a low level but are exacerbated in case of repeated violations of the commonly agreed rules. The notion here is that sanctions based on coercion and deterrence are counterproductive to the identification with the rules of the community. Principle six introduces local arenas for the resolution of conflicts between users as well as between users and authorities. For irrigation systems, disputes over the precious water can never be fully abandoned no matter how considerate local institutions are, it is therefore vital to have an arena where conflicts can be discussed and mediated locally in some kind of formalized way [24].

5.2.1 How enforcement rules have been implemented and enforced at the local level

The WUAs Ordinance does not explicitly mention any rules regarding how the allocation of water and provision of resources for maintenance are to be monitored and enforced. Instead, it only mentions that the board members are responsible to deal with those issues. With regard to sanctioning, elected farmer representatives have no legal authority to sanction farmers who steal water or refuse to pay their water fees. As interviews by the University of Applied Sciences in Muelheim (HRW) have revealed, farmers' representatives regard this lack of legal recognition as one of the most severe problems because it considerably limits their capacity to sanction rule violators. In summary, in terms of monitoring and sanctioning the WUA Ordinance makes for very weak water user association [25]. Still many WUAs have been successful to moderate conflicts amongst farmers of their watercourse [26].

5.2.2 How enforcement rules have been implemented at secondary and primary level

At distributary and main canal level, according to the PIDA Act, Farmer Organizations and AWBs have the mandate to oversee an equitable allocation of water along their respective hydraulic units and are responsible for the maintenance of the canal as well as the collection of water fees by the WUAs. However, the PIDA Act has been too vague to define how these responsibilities should be carried out specifically and left many legal loopholes for the Province government to intervene. Still the reason why a functioning monitoring system at primary and secondary level within the five pilot areas is nonexistent is primarily that none of the farmers organizations or Area Water Boards have taken up their work after a few constituting meetings had taken place.

5.3 Rules that define how the different governance scales can work together

The last principle deals with the question of how self-organized groups should cooperate with other self-organized groups as well as with higher-level organizations. A large CPR is basically a comprehensive system that consists of many subsystems. According to Ostrom, the entire system functions better if the rules are organized on many nested levels rather than hierarchically top down. Ostrom's idea of nested enterprises takes up the idea of subsidiarity, which means each management responsibility should be assigned to the most immediate and appropriate level. For example, a village at watercourse level can do minor repair works and regular maintenance work at much lower costs and more quickly than a large irrigation department. On the other hand, an irrigation agency is doing better at running large infrastructure facilities such as a headwork or a main canal where it can take advantage of its superior financial and technical capacities [27]. However, it is not only important that each governance unit is able to carry out its specific tasks, it is equally important that all governance units synchronize their management tasks. The interdependent nature makes an effective and balanced cooperation between all levels imperative. For example, in a large irrigation system, each hydraulic unit must have clear agreements among each other on the availability of water and their specific water rights, as well as how the costs to maintain the irrigation system are to be shared. Furthermore, those horizontally shaped institutions between different governance units can vary substantially between regions resulting in a diverse institutional pattern, which Ostrom refers to as polycentric governance system. The advantage of such a polycentric system is that it can better consider regional variations in terms of their specific features and incentives.

5.3.1 How rules for nested organizations have been implemented

With regard to Ostrom's principle of nesting different levels of organizations this has been addressed in the reform. Theoretically, the notion of elected farmers that represent the interests of their constituents in the next higher organization as defined by the PIDA Act has a great potential to fulfill Ostrom's idea of a polycentric governance. However, the fact that neither Farmers' Organizations nor Area Water Boards have taken up their work to carry out their assigned responsibilities and functions make any further elaboration on this matter pointless.

5.4 Summary on how Ostrom's principles have been implemented

The analysis showed the reform has some clear deficiencies that prevent an improved allocation of water and a more responsive governance system. At the tertiary level, the PIDA Act did not even mention the foundation of Water User Associations. Instead, the

legal basis for WUAs is a provisional and in many ways very flawed ordinance. Consequently, farmers have very limited opportunities to manage their watercourses independently, since their rights are impaired by a Field Officer and have no legal mandate to impose sanctions on rule breakers. This has led to a significant decline in water fee collection in comparison to the pre-reform era [28]. With regard to the head-tail problem, the Farmer Organizations and Area Water Boards are crucial to address the head-tail problem, their solutions include better system-wide monitoring, a more reliable water delivery, as well as an increased water fee collection. Both arenas would theoretically be predestinated as arenas to negotiate new institutions that enable the disadvantaged tail-end farmers to mitigate their weak position and lobby for a more equitable allocation of water. Thus, it is imperative that both organizations carry out their assigned responsibilities in addition to the PIDA Act will be scaled up to the entire irrigation system as it was originally planned. Additionally, solving the head-tail problem would also require precise data on the water flow for each canal in order to gain reliable information available on the water quantities that enter and leave the main, distributary, and tertiary canals.

6. Conclusion

This article stresses the specific characteristics of large irrigation systems as common pool resources and how they are vulnerable to be subject to the tragedy of the commons fate. In this regard, Elinor Ostrom has defined some broad design principles to create long-enduring and self-organized irrigation systems that are meant to prevent such a tragedy of the commons fate to occur. These principles have been applied as a reference to analyze the Punjab Irrigation Reform of 1997. While most of Ostrom's principles deal with the question how local communities can organize themselves, only the last principle deals with governance aspects that go beyond the local boundaries. However, in a large irrigation system, farmers are to a large extent subject to many exogenous factors, which are outside of their local boundaries. In other words, without looking at a bigger management scope watercourses within the vast area of the IBIS irrigation system will continue to be spread along distributaries and main canals like isolated islands, and farmers at the head reaches can continue to exploit their favorable position at the expense of the farmers further downstream. Thus, a functioning monitoring system that enforces generally respected water rights and allocation principles must be implemented and coordinated at all hydraulic levels. The reform has drawn the right conclusions and introduced – in accordance with Ostrom's principle of nested enterprises – a multi-layered governance structure that can be instrumental to end those practices. This polycentric system in theory ensures that smaller hydraulic units are represented in the subsequent higher decision-making arenas in which they can articulate their interests. Moreover, those arenas serve as a platform where ultimately some common rules that overcome the given water access asymmetries can be negotiated. However, in order to find comprehensive management rules that transcend regional access asymmetries the appropriate organizations such as Farmer Organizations, Area Water Boards and the Punjab Irrigation and Drainage Authority have to finally commit to their designated work.

Check the references:

www.water-solutions.info

Authors:

Prof. Dr Mark Oelmann
mark.oelmann@hs-ruhrwest.de

Jonathan Schulze
Jonathan.schulze@hs-ruhrwest.de

Hochschule Ruhr West
Water and Energy Economics
Duisburger Straße 100
45479 Mülheim an der Ruhr