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Comparative Analysis of Nature-Related Transactions and Governance Structures in Pasture Use and Irrigation Water in Central Asia

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Abstract: Central Asian countries have experienced a transition from a centralized state-managed economy to a decentralized market-oriented one, and gained valuable experience in designing institutions involving common-pool resource (CPR) management. Top-down policy interventions have affected natural resource usage practices and had environmental, social and economic consequences. On the other hand, in a bottom-up transformation process, many informal practices for using local resources and many forms of cooperation have emerged and become institutionalized, adapting to the changing socio-economic context. This paper demonstrates an empirical application of the Institutions of Sustainability (IoS) framework, analyzing these emerged institutions, and governance structures in pasture and irrigation management. It studies how the physical nature-related transactions are institutionalized through the operationalization of a discriminative alignment principle. The research results show that actors' interdependencies caused by the attributes of nature-related transactions play a decisive role in institutional development in CPR management in Central Asia. The authors argue that differences in the properties of physical nature-related transactions in pasture and irrigation water use can be linked and explained through differences in the key characteristics of governance structures.

Keywords: common-pool resource; governance structure; institutions; pasture; irrigation; sustainability; Kyrgyzstan; Uzbekistan

1. Introduction

After the breakup of the Soviet Union in 1991, the independent Central Asian countries implemented reforms and policies in the transition to a market economy, including in the agricultural sector. Policy interventions in common-pool resource (CPR) management affected resource use practices and agricultural production methods and techniques [1,2]. The consequences of pastoral and irrigation water reforms in Kyrgyzstan and in Uzbekistan, respectively, have been extensively discussed in different papers (for pasture use in Kyrgyzstan, see [3–6]; and for irrigation water use in Uzbekistan, see [7–9]).

In pasture management, most authors identify a massive reduction in pastoral mobility after 1991 in Central Asia due to the privatization of livestock, the dissolution of large organizational structures such as former kolkhozes (collective farms) and sovkhozes (state farms) and the deterioration of infrastructure. Reduced mobility has environmental and economic consequences: it caused the

degradation of rangeland due to the overuse of pastures near villages and the underuse of remote summer pastures [6,10–14], leading to a decrease in livestock productivity [15]. After the dissolution of the kolkhozes and sovkhozes, the traditional institutions and practices started adapting to the new realities and many different institutional arrangements were developed. A major characteristic of the transition process in Kyrgyzstan is the ongoing institutional reform of pasture management, which is conducted to make the sector more efficient, market-oriented and democratic through decentralization and user participation. The World Bank and other international agencies supported the Kyrgyz government in developing and implementing the new pasture law, which introduces radical changes to the pasture management system: (1) it abolishes the three-level system of pasture management based on spatial pasture characteristics; (2) it creates Pasture User Unions (PUUs) and Pasture Committees (PCs); (3) it transfers the competence for pasture management to local municipalities; (4) it abolishes the area-based long-term pasture lease system and introduces an annual livestock-based pasture fee (pasture ticket); and, finally, (5) the new law introduces a planning and monitoring system for pasture use and management. After intensive discussion among experts and responsible organizations at the national level, the new law “On Pasture” was adopted in February 2009 by the Kyrgyz Parliament and came into force by government resolution in June 2009. By 2011, PUUs and PCs had already been created in 454 municipalities (Ayil Okmotys) in Kyrgyzstan. The World Bank’s Agricultural Investment and Services Project and Community Development and Investment Agency supported the creation of these new governance structures.

Meanwhile, with the breakdown of the Soviet system where agricultural production was well-organized and each entity or individual had clear responsibility over who had rights for land use and who managed irrigation canals, this system was no longer functional in Central Asian countries, particularly in Uzbekistan. This was most noticeable in the irrigation sector [16]. There was a huge vacuum over who was to manage and maintain on-farm (secondary and tertiary) irrigation and drainage canals, which had been managed and maintained by former collective farms during the Soviet era [17]. As a result, there was a need for social interaction among irrigation water stakeholders to assign responsibility for the ownership of these assets [18–20]. The deterioration of irrigation canals was apparent. Most canals were built during the Soviet era but needed regular investments in maintenance. This lack of attention put much of the infrastructure in a critical situation. The dilapidated infrastructure has led to a reduction in crop yields, an expansion of weeds and silt in the farm canals [1,21]. It has hindered the timely allocation of water to users and caused farmers’ dissatisfaction. Additionally, though there are clear formal rules on what individual resource users must or are supposed to do, there are still practices where people follow their own traditional customs. For instance, farmers formally agree to and sign the agreement with local Water Consumer Associations (WCAs) to financially contribute for irrigation services, but in most cases, they either do not fulfill their promises or contribute through in-kind services to certain WCA employers [16,22,23].

This paper aims to reconstruct and theorize how the institutions and governance structures have been shaped by nature-related transactions in CPR management, contributing to an understanding of what determines the bottom-up transformation processes of CPR management in Central Asia.

We follow the conceptual framework of Institutions of Sustainability (IoS) developed by Hagedorn [24]. In line with Hagedorn [24,25], we define institutions as sets of rules, which shape social relationships, and governance structures as forms, modes and processes of organization to make institutions effective. We employ a discriminative alignment principle by which “transactions are aligned with governance structures” [26] by incorporating the perspective of the physical transaction of resources and the concept of hybrid governance structures. Lastly, we interpret our findings in the context of how institutions, governance structures and institutional change are understood in CPR management in Central Asia.

2. Conceptual Framework

This study applies the IoS conceptual framework developed by Hagedorn et al. [27]. The authors assume that institutions regulate relationships among individuals and between social and ecological systems, i.e., rights and duties as well as costs and benefits of actions. Therefore, institutions are the essential linkage between the social and ecological systems [28].

To place the analysis of transformation and institutional change in a more specific pastoral and irrigation system management context, the concept of nature-related transaction is applied.

Commons [29] was the first who highlighted the importance of the transaction as the main unit for institutional analysis. Individual actions and transactions create conflicts of interest over scarce resources and institutions are an effort to mitigate conflict, create order and realize mutual gains. The transaction is defined as “alienation and acquisition, between individuals, of the right of property and liberty created by society, which must therefore be negotiated between the parties concerned . . . ” [29]. Commons underlines the institutional dimension of transactions; for him a transaction is a “unit of transfer of legal control” or “transfer of property rights” [30]. He differentiates between bargaining transactions, managerial and rationing transactions. Four economic issues are related to the bargaining transaction: competition (fair or unfair), discrimination (equal or unequal opportunity), economic power (equality or inequality) and working rules, which change along with changes in custom, class dominance and so on. These “relations of possible conflict of interest” are institutionalized in four classes of working rules [29].

Williamson [31,32] followed the central idea of Commons [29] placing the transaction in the center of his analysis of economic governance. He stressed the physical aspect of the transaction. In his understanding a “transaction occurs when a good or service is transferred across a technological separable interface. One stage of activity terminates and another begins” [32]. Beckmann [33] illustrates the transaction with the following example: “If the activity a_i produces a good x_i and that is necessary to perform activity x_{i+1} , the question arises to how this transaction is completed and what makes the good and services move?” Answering to this question Hagedorn [25] explains the need for coordination of the transaction by governance structures and institutions in terms of frictions between activities. The transaction is mutually beneficial for partners and the governance structures are designed to coordinate its move and make it easier [33].

Hagedorn [24] assumes that the social world and characteristics of actors, as well as the physical world and related characteristics of physical transactions are important for institutional analysis in agriculture. He stresses the importance of linkages—interrelations between activities, actors and natural systems. Actions and transactions cause interdependence between actors, affect their opportunities to access goods and to use resources, and may result in conflict or cooperation. Institutions and governance structures are understood as regularizing the interactions between these actors. Physical transactions can include physical flows and movement of natural resource between actors or they can also be social transactions, which have some physical implications for other actors. A transaction is “a physical phenomenon that is induced by a decision of one or more actors and affects one or more actors” [30]. Hagedorn [30] suggests that properties of nature-related transactions resulting from the attributes of the production system (asset specificity, frequency and uncertainty) as well as the ecological system (modularity and functional interdependence, excludability, rivalry, separability, complexity, measurability, irreversibility, legitimacy, heterogeneity and variability) have to be taken into account for an institutional analysis.

A definition of the individual properties of nature-related transactions, operationalized in this paper, is based on Hagedorn [24] and Thiel et al. [34].

Meanwhile, it is important to understand how physical transactions can become institutionalized. Hagedorn [25] argues that institutions arise or change due to nature-related transactions, which cause or reveal interdependence between actors. To analyze the interdependence between transactions, institutions and governance structures, Hagedorn [25] suggests employing discriminative alignment—an analytical process by which “ . . . transactions are aligned with governance structures . . . ” in “ . . . the ex post

stage of contract” [26]. The theoretical assumption is that “... transactions, which differ in their attributes, are aligned with governance structures, which differ in their costs and competence, in a discriminating—mainly, transaction-cost economizing—way” [35] (p. 17).

The concept of hybrids governing CPR resource use is employed differentiating between three core elements of this type of institutional arrangement: pooling, contracting and competition. Resource users pool their resources, retaining their rights to make individual decisions; they have a contractual relationship (often incomplete), and they compete between themselves and with other hybrids. Two main types of cooperatives can be distinguished here: users pool natural resources (e.g., common pastures) or human-made resources (e.g., irrigation infrastructure) [24,25,36].

The physical transactions under study are the provision of fodder to livestock on pasture in Kyrgyzstan and an activity of removing weeds and silt from the canal (i.e., maintaining irrigation canals) in Uzbekistan. The transaction implies the social dilemma, when social rationality may lead to social sub-optimality. For instance, herders’ decision for or against seasonal migration has an impact on pasture conditions and affects other pasture users. In the irrigation sector, carrying out irrigation canal maintenance may improve the overall water flow for users located downstream of the canal. By contrast, leaving removed trash by the side of the canals, which is a regular practice in Uzbekistan, may have a negative consequence for local residents.

3. Methods

Qualitative data for the empirical study have been gathered from two case studies in Central Asia—Kyrgyzstan and Uzbekistan (Figure 1), implemented within the InDeCA project (Designing Social Institutions in Transition: Promotion of Institutional Development for Common Pool Resources Management in Central Asia). Central Asia is geopolitically and strategically important because of its geographic position in the heart of the Eurasian continent, where CPR resources such as pastures and irrigated water are crucial for wellbeing and livelihoods of the country’s sizeable/overwhelmingly rural population [37]. In Kyrgyzstan, with its 9.1 million hectare (ha) of natural pasture, the agricultural sector is largely dominated by transhumant pasture use. Livestock production consists of 43.5% of agricultural production. The agricultural sector in Uzbekistan, in contrast, is much more strongly focused on irrigated crop production since 97% of crop production is carried out on irrigated land [1]. The case studies investigate both formal and informal, undocumented arrangements for regulating natural resource use and analyzes the causes and different factors which determine the development of rules in use and governance structures. Our case selection strategy has the objective of achieving maximum variance along relevant dimensions [38]. We have included two communities, each from Kyrgyzstan and Uzbekistan, in order to compare the two different local institutional contexts in the management of two different resource systems (pasture use and irrigation infrastructure), and also to explore each of them in detail. The main unit of our analysis is the nature-related transaction.

The empirical work was based on interviews with local experts in the region, discussion with resource users, as well as empirical observation during the study period. Data collection took place during 2013–2014. Table 1 provides general characteristics of the selected case studies in Kyrgyzstan (Pasture User Union) and Uzbekistan (Water Consumer Association).

Table 1. General characteristics of the selected case studies in Central Asia.

Characteristics	Jergetal (Pasture User Union)	Khalach Kalti (Water Consumer Association)
Date of establishment of user organizations	March 2011, re-registered in April 2012	October 2006
Number of organization members	104	34
Total land area (ha)	85,100	2073

Table 1. Cont.

Characteristics	Jergetal (Pasture User Union)	Khalach Kalti (Water Consumer Association)
Resource units	Livestock (heads): Horses (2440) Sheep and Goats (27,706) Cattles (2857) Camels (41) Poultry (2084)	Crops (ha): Cotton (1069) Wheat (627) Other crops (377)
Infrastructure	146 (bars)	56 km (length of irrigation canals)
Total budget (Euro)	6130	14,300 (with electricity cost included)
Collected amount (Euro)	1800	5530
Pasture fee collection rate (%)	30	39

Source: own compilation.

Figure 1. Map of Central Asia (Retrieved from: <http://origins.osu.edu/article/69/maps>).

4. Results and Discussion

To operationalize the IoS framework, we carried out empirical research in two rural communities in Kyrgyzstan and Uzbekistan, applying the concept of nature-related transactions. In this section, we first outline the two empirical cases we have selected and illustrate the challenges and opportunities facing the selected cases, presenting a detailed review of rules in use and the performance of pasture use in the Jergetal community in Kyrgyzstan and the irrigation water management in the Khalach Kalti WCA in Uzbekistan based on information collected during the qualitative interviews.

This is followed by a detailed analysis of the physical nature-related transactions (their similarities and differences). The analysis addresses the questions of how properties of the physical nature-related transactions in pasture use and irrigated water management are institutionalized, considering the costs (transaction costs) of coordinating actors and organizing them as well as the benefits from cooperation

and preventing/solving social dilemmas in the use of resources, and how the properties of this transaction are related to key elements of governance structures found in the empirical study regions.

4.1. Pasture Use in Kyrgyzstan

4.1.1. Jergetal Community

After the dissolution of the Jangy Talap kolkhoz and the privatization of livestock, machinery and agricultural land, the Jergetal municipality in Naryn was formally established in the mid-1990s [5]. Today, about 1164 households reside in the community, with a total population of 5225 inhabitants (communal statistics 2013).

Most arable land (1650 ha) is used as hay meadows and for the cultivation of fodder crops (sainfoin and clover). The rest is used for wheat and barley production. The Jergetal municipality has about 91,597 ha of pastureland. Most winter pastures located near the village are overgrazed. Some accessible spring/autumn pastures are also overused. Herders from the community do not use the most distant summer pasture, Aksay. Large and medium livestock owners own about 146 bars on winter and spring/autumn pastures.

Livestock is the core of Kyrgyz nomadic culture and is an important economic basis for securing people's livelihoods in Jergetal. Livestock has become important as financial capital. The value of livestock is increasing and livestock can easily be sold for cash. Livestock numbers have increased strongly in recent years. An average household owner has livestock, which comprises about 80% goats and sheep, and 5–10% horses and cows [5]. There is a growing asymmetry in livestock ownership in Jergetal. While 1% of households own 16.8% of livestock, 61% of households own only 39% [39]. Wealthy households keep more horses and cows, while small and medium livestock owners prefer goats and sheep.

4.1.2. Rules in Use and Governance Structures

The PUU and its executive body PC were officially registered in March 2011 as a Territorial Public Self-governance Organization. The PC is responsible for pasture use planning and implementation, monitoring pasture status, defining and collecting pasture fees, pasture-use-related conflict management, and managing funds collected from pasture use for pasture improvement and management.

The PC develops an annual pasture use plan allocating pasture to herders taking into account pasture capacity, the aim being to have a more balanced distribution of livestock on pasture. The capacity and condition of the pasture has to be monitored and accessed annually as a basis for the next year's pasture use plan.

One of the difficult tasks for the newly established PC is the collection of pasture fees. The collected pasture fees are supposed to finance the overhead costs of the PC and to be invested in pasture infrastructure and pasture improvement. The pasture fee is defined annually by the PC for each type of livestock and eventually for each type of pasture. It cannot be lower than the basic tax for using the pasture. The pasture fee is calculated according to the annual budget of the PC and collected according to the annual pasture use plan. The collection of pasture fees is quite a difficult task as livestock reporting is a problem. The head of the municipality in Jergetal complains: "it is difficult to collect the pasture fees as people do not report truthfully about their livestock". Nevertheless, the PC in Jergetal managed to collect 30% of its pasture fee in 2012, spending 50% of the money on overhead costs (salaries, transport costs, etc.) and investing the rest in the improvement of pasture infrastructure (e.g., repairing roads).

4.1.3. Informal Institutions in Pasture Use

Many small and medium livestock owners also pool their livestock to collectively use common pastures. Herders have the same costs if they move with their own livestock, but the benefit for the

herder may increase greatly if they collect livestock and provide herding services to clients. Providing herding services has become a popular business. Wealthy herders and livestock owners herd their livestock individually, but many provided herding services in the past, stopping as soon as their own livestock increased and they could no longer manage to take care of others' livestock.

Mal koshuu is traditionally practiced in many communities. For instance, more than 70% of herders in Jergetal provide services for livestock owners, collecting livestock and moving to pastures. Herders have their own livestock and may collect some additionally from clients.

Herding is risky work. Livestock can be lost, eaten by wolves or succumb to extreme weather conditions on high pastures. Herders have to pay the price of lost livestock to the owner in such cases. Herders offering this service therefore have to have certain professional experience and assets.

Rules differ regionally and cooperating parties may have specific individual arrangements, but certain rules are generally accepted. The herder is responsible for herding on spring, summer and autumn pastures and protecting livestock. If wolves eat livestock, then the herder has to show the evidence (head and skin of the animal) and if there is nothing left, he pays the price of the livestock. Likewise, if livestock is lost, the herder pays the price. The payment can be made in kind by replacing the animal with another one or by providing services for free in future. The livestock owner is responsible for his livestock in case of illness. In such cases, he has to come to the pasture with medicine and treat the animal. The herder is responsible only for informing the owner and, if requested, for sending livestock back to the village; the herder takes care of mares for free (bee baylap); in turn, the herder may have milk products for himself.

There is no signed contract and the conditions are agreed verbally. Each writes on his own paper the agreed price for the herder's service and how many heads of livestock are being given for pasturing. They also write down the age and marks of the livestock. Based on these documents, livestock are returned. Each livestock owner has to remember his/her animals and their marks in the autumn. There is a certain trust between herder and livestock owner during their cooperation every year.

Livestock owners prepare winter fodder and get their livestock in the autumn. Livestock owners sell some of the livestock at this point as livestock have their highest value at this time.

In Jergetal, small and medium livestock owners also cooperate by taking part in mal kesüü and bada—a neighborhood-based rotational herding scheme (Figure 2). Each participating household appoints a herder to collect livestock in the morning and, after herding on pastures near the village, bring it back to the owners in the evening. Respected people and elders coordinate the cooperation. For instance, they define the starting day and when to stop. It may stop by the end of April in Naryn, when work in the field starts. They discuss and decide together with the community about the rules and conditions.



Figure 2. Mal kesüü herding in Jergetal.

4.1.4. Properties of Nature-Related Transactions

Herders and livestock owners are involved in complex interactions between different actors at the local, regional and national level and related to informal and formal institutions and organizations.

The actions of pasture users may have consequences for others. Some of their actions become nature-related transactions when they have desired or undesired consequences and are mediated through biophysical processes in the pastoral system. Such transactions may result in conflict or cooperation and require coordination by institutions and governance structures [24].

The physical transaction under study is the provision of fodder to livestock on the pasture. This transaction implies a social dilemma, when social rationality may lead to social sub-optimality. Herders' decision for or against seasonal migration has an impact on pasture conditions and affects other pasture users. This transaction may be affected by other transactions. For instance, herders' decisions to build and use bars on pastures and to fence pastureland for fodder production, or sell pastoral products and livestock, affect the transactions examined in the study as they may change the pastoral migration pattern.

The following characteristics of nature-related transactions for the provision of fodder to livestock on pasture and their changes have been identified:

Modularity and functional interdependence are related to types of transactions. The transaction is complex; it occurs physically within structures with low modularity and decomposability and highly interconnected with other transactions. Providing fodder to livestock is an individual transaction within a module as a pastoral production system. It is functionally interdependent with, e.g., pastoral product markets.

Exclusion is related to the mechanism and costs of exclusion in pasture use. It is difficult and costly (e.g., fencing) in pasture use. There is a difference in their characteristics between different types of pasture. The exclusion is very low on remote summer pastures, higher on winter, spring/autumn pastures and very high on pastures near villages, where herders own bars, fence small plots for fodder production and transform the use of pastureland (e.g., building irrigation systems for wheat production). The enforcement of the new law by the PC decreases the excludability within the community by not prolonging long-term pasture rent contracts. The transfer of the management competence to the community level has increased the excludability between communities and external pasture users.

Rivalry is again different depending on the pasture location and quality. It may be high on accessible winter, spring/autumn pastures, close to the community and local markets, and low on remote pasture or less productive pasture. The increase in livestock, their value and the number of herders leads to higher rivalry for all types of pasture, intensifying the social dilemma in pasture use.

Asset specificity (capital and knowledge) is moderate; the transaction requires a certain specificity of site capital (livestock adapted to local conditions, bars on pastures, prepared winter fodder) and herders who have knowledge about livestock management as well as about pasture conditions. There is an increase in asset specificity as many herders build bars on spring/autumn pastures, change the herd structure (more cattle than sheep) and transform winter pastures and underproductive pastures into rain-fed or irrigated land.

Separability is low and is decreasing even further as many herders diversify their income-generating activities, combining herding livestock with selling livestock products, producing fodder and working for the mining company in Jergetal or working in the capital in Tösh-Bulak. For instance, the strategy of combining herding with selling livestock products leads to the overuse of pastures near local markets.

Frequency (seasonal use) is high as this transaction is related to the seasonal variation of pasture productivity. Herders and livestock migrate from winter to spring/autumn and summer pastures following the life cycle of pasture plants (fodder). The migration has decreased compared to the pre-Soviet and Soviet period, but is increasing again as more herders provide herding services and move to summer pastures.

Uncertainty is high. This is related to the difficulties and costs of measuring pasture degradation, and gathering real information on livestock. This can be decreased with the enforcement of new pasture legislation, specifically monitoring and planning.

Complexity is high as the causal relationship between pasture use and related problems, such as overgrazing and degradation, is complex. For instance, the impact of overgrazing on pasture soil and vegetation may be different on winter pasture, which is more resistant to shocks compared with the sensitive ecological system on summer pastures [39].

Heterogeneity and variability (or site situation specificity) is high as the transaction depends on many factors: the seasonal productivity of a pasture, the distance, location and exposure of pastures, weather and precipitation, etc. The uncertainty related to this characteristic may be partly reduced if the PC plans annual pasture use based on the monitoring of pasture conditions and information on livestock. However, the cost of collecting such information is high.

Legitimacy of the transaction is high in Jergetal as herding is important for securing the livelihood of the community, and is highly respected as a traditional practice strongly related to social life (e.g., celebrating lifecycle events). For instance, punishing herders for not moving to summer pastures by the PC is well supported in the community.

Measurability is low. For example, the statistics on livestock are not only reduced by rich and medium livestock owners in order to pay lower pasture fees, but also increased by poor herders in order to get loans from micro-financing organizations and banks. However, there is a decrease in uncertainty with the implementation of monitoring pasture conditions and planning of pasture use by the PC.

Reversibility is low as a limited amount of irrigated and rain-fed land is available for fodder production. The irreversibility decreases further with increases in the demand and fodder price.

4.2. Irrigation Water Management in Uzbekistan

4.2.1. Khalach Kalti Water Consumer Association

The Khalach Kalti WCA is located in the Vobkent district of the Bukhara province and was established in October 2006 in the territories of former Ruzi-Khusenov shirkat (cooperative farm). Currently, the WCA has 34 members. Of these, 30 members cultivate cotton-wheat; three members are oriented to livestock production, and one member towards orchard production. It employs three people: a chairman, a chief accountant and an agricultural machinery driver. The name Khalach Kalti came from the combination of two irrigation canals—Khalach and Kalti. The general characteristics of this WCA are presented in Table 1. The WCA has 2073 ha of irrigated land, of which 52% is devoted to cotton production and about 30% to cultivating wheat. According to the chairman, the WCA decided to charge Irrigation Service Fees (ISFs) on a per-hectare basis. The total amount of expected costs to distribute water to individual farm territories is divided among the total hectares that the WCA serves. Since it is yet to install individual metering for each farm gate, the decision is made on a per-hectare basis and amounts to UZS 25,000 per ha (the exchange rate is approximately 3200 UZS to 1 Euro). It is important to note that about 50% of the members lift water using electrical pumps. Electricity costs are thus an additional burden to farmers. Most WCAs that use pumps have huge debts from electricity companies. To overcome these challenges, the WCA general assembly decided to calculate the whole expenses for the entire year including potential electricity costs and costs associated with pump maintenance. These costs are equally divided into all members. As a result, the amount charged for ISF reflects the costs for water distribution, electricity costs and the maintenance of pumps.

4.2.2. Rules in Use and Governance Structures

Khalach Kalti WCA is located downstream of the main canal in the middle of two drainage canals. Whenever water is abundant or unused, the upstream WCAs let water into the drainage system. Apparently, this WCA enjoys being downstream. Five WCAs are located in the same canal upstream, before water reaches this WCA.

Despite there being a water-scarce season in 2012, the WCA used its pumps to lift water from drainage systems and achieved full delivery of water to its clients. In general, it does not experience much water scarcity. Since it is located in the middle of two major drainage canals, where WCA installed electrical pumps to lift water for irrigation, water shortage is not a major problem. Water may not be a scarce resource but the electricity cost can be an additional burden to most farmers.

Due to his long-standing managerial skills, the chairman was able to overcome any disputes without involving external actors. Moreover, the local authorities are in a weak position to intervene on the WCA's internal decision-making process with regards to irrigation water allocation.

In spite of a lack of appropriate facilities to held major meetings, WCA workers acknowledged that at least there are meetings once per week to discuss various issues related to water allocation and canal maintenance, particularly during the vegetation period (April to September). Some meetings are held in the conference room of local irrigation systems authority (ISA) or in the territories of the WCA farm. Discussion with farmers demonstrated that all members were actively participating in these meetings or, at least, their farm managers attend these meetings.

Although the Khalach Kalti WCA employs five people *de jure*—a chairman, a chief accountant, two mirabs (water master), and an agricultural machinery driver—*de facto* the chairman was aware of water skills and thus, did not employ mirabs. All activities related to water allocation within the WCA was carried out by the chairman together with his fellow employees. An additional reason of leaving the mirabs' positions vacant is due to the absence of an adequate amount of money to pay their salaries.

The chairman was elected by the members during the WCA's general assembly and has served since its establishment. He was the head of a *kolkhoz* during the Soviet era as well as the chairman during the *shirkat* period. The chairman acquired vast experience through working in the area and is well-accepted by the community and local authorities. According to local water officials and the WCA members, using his reputation and networking abilities the chairman was able to overcome issues related to internal conflicts as well as water availability.

Concurrently, the chairman is a farmer and a member of the WCA. This is also true of the chief accountant, who is a part-time employee at the WCA, responsible for financial management and is a farmer with about 100 ha of irrigated land. The priority of the WCA is to collect ISF contributions, mainly to pay off electricity costs and maintain irrigation facilities (including pumps). Due to his own farm profits, the chairman was able to purchase a private car to monitor the fields during the vegetation period for water allocation and organize collective canal maintenance.

Using his knowledge and networks, he has established a discipline in the group where farmers receive their water shares in accordance with agreed schedules. It is important to note that when the chairman of this WCA was contacted through local ISAs who provide water, the chairman informed them that his WCA had a non-governmental organization status and could not be hierarchically approached by external actors. It is striking to see that the WCA manager was fully aware of his rights and duties.

WCA charges farmers extra to cover canal maintenance, electricity cost, taxes and salaries for the employers. When canal maintenance is required, the WCA requests local ISA to provide an excavator and the WCA covers all expenses from its budget. They do not charge farmers for the maintenance, separately. This is the case when large canals are maintained. In the case of smaller farm-level canals, farmers hire seasonal workers to clean these canals (Figure 3). According to the WCA chairman, farmers support the mobilization of community action in canal maintenance and fully participate. Additionally, WCA plans to invest in changing the earth canals to concrete-lined canals.

Households, meanwhile, are exempt from paying for irrigation services and instead help maintain irrigation canals through community action. According to the WCA, some households refuse cooperation, but, overall, local households provide their support through public community action for canal maintenance.



Figure 3. Canal maintenance in Khalach Kalti Water Consumer Association.

4.2.3. Properties of Nature-Related Transactions

The main focus of the analysis is to understand how canal maintenance (a nature-related physical transaction or action) is organized to address collective action dilemmas in the territories of WCAs. In particular, an activity of removing weeds and silt from the canal (i.e., maintaining irrigation canals) is taken as a transaction, as conceptually it may have some positive or negative effects on other actors. For example, carrying out irrigation canal maintenance may improve the overall water flow for users located downstream of the canal. By contrast, leaving removed trash by the side of the canals, which is a regular practice in Uzbekistan, may have a negative consequence for local residents. Furthermore, odor and noise may cause environmental problems as well as disturbances to locals residing in the vicinity. Specifically, this transaction may directly or indirectly affect actors such as farmers, households, and the state. Ostrom [40] classifies irrigation systems as a CPR, where the physical characteristics of the resource (in this example, an irrigation canal) make it difficult for communities to exclude someone from using it but, at the same time, depending on canal capacity there is a strong rivalry among the users of irrigation canals. An empirical case from the study corroborates this theoretical assumption. It shows the difficulty of excluding non-payers or non-contributors involved in canal maintenance due to the social and natural structure of the canal. The canal belongs to society, with each household or farmer able to withdraw the resource unit (i.e., water) and benefit from consumption. However, it is feasible to sanction these free riders, but it involves huge transaction costs, such as coordinating and monitoring individuals who do not comply with the community rules. Since the infrastructure capacity is finite, there is a strong rivalry among different resource users to benefit from its use. Naturally, the transaction of cleaning the irrigation canal requires some knowledge, site and capially fixed asset-specific investments (machinery). It is important to underline that cleaning irrigation canals, in this association, is moderate in frequency because of the recurrence and seasonality of the transaction.

It is relatively certain that carrying out canal maintenance as a form of collective action results in improved cooperation in the association. This particular transaction is separable as the transaction can be separated from other transactions in order to establish transaction-outcome relationship.

Traditionally, elderly and respected people would call for community labor mobilization (khashar) to collectively remove weeds and silt using gardening tools, such as hoes, shovels, spades, rakes and trowels. The research stay in the association revealed that most canals in the associations were not made of cement, so require physical capital (such as an excavator or bulldozers) to remove weeds and silt, which leads to the high complexity of the system. It is generally difficult to identify transacting partners, which leads to opportunistic behavior requiring coordination. The WCA management team informed us that when canal maintenance is required, the association rents the agricultural machinery from the local ISA and the cost is covered from the budget. The timing of canal maintenance is determined by the association and depends less on human mobilization. As such, variability in terms of the timing of the transaction is low. However, this does not mean that the association undertakes canal maintenance on its own. It is important to note that bigger canals are cleaned by the WCA, whereas farm-level canals are cleaned with the help of local households. Nonetheless, the WCA is in charge of coordinating and monitoring this entire canal cleaning process. This particular transaction is non-heterogeneous in terms of spatial variation, meaning that irrigation canal maintenance has no major implications for wider ecosystems. Consequently, the costs and benefits emerging from canal maintenance are measurable, i.e., can be identified and evaluated. The WCA chairman highlighted the fact that the association is located downstream of the main canal and between two drainage canals. During water scarcity, water is lifted using electrical pumps for irrigation using drainage water. As a result, this particular transaction is reversible, but bears certain costs, as the users can benefit from alternative sources, such as drainage canals. Since the resource scarcity is not so apparent in this case in comparison with cases located in desert areas with frequent water scarcity problems, there is a relatively moderate degree of modularity and decomposability. Finally, due to the chairman's competence in leadership skills, the association has more legitimacy to sanction different actors who do not participate in the canal maintenance or comply with community rules with regard to the transaction.

4.3. Exploring Interdependence between Properties of Transactions and Governance Structures

In this subsection, we analyze the relationship between transactions, institutions and governance structures by employing the discriminative alignment principle Williamson [26]. We take the following analytical steps: (1) describe and define the differences between properties of physical nature-related transactions in pasture use and irrigation water management; (2) describe and define the differences between core elements of the governance structures; (3) align the difference of transactions to the core elements of the governance structures; and (4) draw conclusions about key characteristics of the governance structures.

4.3.1. Comparing Nature-Related Transactions

The characteristics of the transactions we study show some similar properties (Table 2). Resource users face difficulties in excluding others from appreciating the resources. Both transactions are highly respected as a traditional practice and important for securing the livelihood of the communities. In addition, both transactions share the feature of the complexity of the causal relationship of pastoral and irrigation systems.

We found that most of the properties are substantially different. We explain the differences by relating them with the three core elements of the governance structures.

Table 2. Comparing properties of physical nature-related transactions.

Properties of Transaction	Provision of Fodder to Livestock (A)	Difference	Maintaining Irrigation Canals (B)
Modularity and functional interdependence	Low modularity and high functional interdependence	$A < B$	Moderate modularity and high functional interdependence
Excludability	Difficult, costly, but feasible (e.g., constructing bars and fencing)	$A = B$	Difficult but feasible (non-payers/non-contributors can be excluded)
Rivalry	Moderate, rivalry depends on pasture location and quality	$A < B$	Strong rivalry (finite resource)
Asset specificity	Moderate—requires asset-specific investments (livestock, bars, winter fodder and experienced herders)	$A < B$	High—canal maintenance requires knowledge, site and physically fixed, asset-specific investments
Frequency	High—this transaction is related to the seasonal variation of pasture productivity.	$A > B$	Moderate (recurrent and seasonal but not regular)
Uncertainty	High as many factors may affect outcome	$A > B$	Relatively certain (action-outcome linkage)
Separability /Jointness in production	Low due to diversification of income-generating activities	$A < B$	Separable—transaction related to the outcome
Complexity	High—the causal relationship between pasture use and related problems, such as overgrazing and degradation, is complex	$A = B$	High—due to complex relationship between human-designed and natural system
Heterogeneity /Variability	High—transaction depends on many factors: the seasonal productivity of a pasture, the distance, location and exposure of pastures, weather and precipitation etc.	$A > B$	Non-heterogeneous—irrigation canal maintenance has no spatial implications.
Measurability	Low (e.g., unreliable statistics on livestock)	$A < B$	Measurable—cost and benefit streams emerging from canal maintenance can be identified and assessed
Reversibility and irreversibility	Low as a limited amount of irrigated and rain-fed land is available for fodder production	$A < B$	Reversible—drainage canals provide alternative source of resources
Legitimacy	High—highly respected as a traditional practice and important for securing the livelihood of the community	$A = B$	Highly legitimate—association sanctions actors who do not participate in canal maintenance

4.3.2. Aligning the Difference in Nature-Related Transactions with Institutions and Governance Structures

In line with Williamson [35], we assume that institutions and governance structures are shaped by contracting out to economic actors for coordinating the transaction, considering the costs of coordinating actors and organizing the transaction (transaction costs). To align the transactions with institutions and governance structures, we refer to the concept of hybrid governance structures [24,25] and relate transactions with three core elements of this type of institutional arrangement: pooling, contracting and competition (Table 3).

Resource users pool some of their resources: in case of pasture management, it is common pastureland, and in case of irrigation systems, it is human-made irrigation infrastructure. This difference can be related to the difference of the modularity of transactions. For instance, high modularity of the transaction provision fodder to livestock reflects the high coherence of the non-designed pastoral system that is pooled in this type of hybrid institutional arrangement. This also means that this transaction is relatively more complex and more difficult to coordinate.

Individual choices of resource users are coordinated by contracts (usually incomplete). For example, in pasture use, we observe informal contractual arrangements between herders and livestock owners as well as formal agreements between livestock owners and PCs. In irrigation water management, there are informal and formal agreements between water users and WCAs. High uncertainty, high frequency and moderate asset specificity of the properties in pasture use require the flexibility of institutional arrangements and need less protective governance than in the case of irrigation water management, where we observe moderate uncertainty, moderate frequency and high asset specificity.

Resource users compete between themselves and other hybrids (other WCAs and pastoral communities). In the case of irrigation water management, we observe low excludability and high rivalry between water users within WCA, which may lead to high competition and social dilemmas. Low excludability and moderate rivalry between pasture users within and between communities create relatively moderate competition.

Table 3. Aligning physical transactions with governance structures in common-pool resource management.

List	Mal Koshuu and Pasture Use Plan	Difference	Khashar and Water Use Plan
Pooling	Low modularity, measurability, reversibility and high variability of the transaction reflects the high coherence of the non-designed natural system that is pooled in this type of hybrid institutional arrangement	Human designed vs. natural systems	Moderate modularity, measurability, reversibility and variability of the transaction is related to the fact that the human designed system is pooled in this type of institutional arrangement
Contracting (coordination of individual choices)	High uncertainty, high frequency and moderate asset specificity require flexibility of institutional arrangements and need less protective governance	Need for protective governance	Moderate uncertainty, moderate frequency and high asset specificity require more protective governance
Competition (rules for benefit sharing and dispute resolution)	Low excludability and medium rivalry within and between communities create relatively high competition and social dilemma	Level and scale of social dilemma	Low excludability and high rivalry within WCA leads to high competition and social dilemma

Thus, we can conclude that the differences in the properties of physical nature-related transactions in pasture and irrigation water use can be related, and explain the differences in the key characteristics of hybrid structures: the type of the resources pooled, level and scale of social dilemmas, and need for protective government.

5. Conclusions

In this paper, we describe and analyze informal and formal institutions and governance structures in pasture and irrigation water management within the process of transformation in Central Asia. Our analysis relied on the heuristic framework that is detailed in Hagedorn's [24] IoS framework, which underlines the importance of physical nature-related transactions to better understand institutions and governance structures.

In our research approach, we followed the recommendation made by Hagedorn [25], starting with the analysis of actors' actions, nature-related transactions and rules in use as well as formal institutions and governance structures, drawing conclusions about the relationship between physical nature-related transactions and governance structures in pasture and irrigation water use.

The study presents an empirical application of the nature-related transaction concept. The research results show that there is a high interdependence among actors in the use of CPRs, and the resource users are involved in multiple interactions with different actors at local, regional and national levels. Institutions, governance structures and properties of nature-related transactions have shaped these interactions.

Therefore, we argue that the differences in the properties of physical nature-related transactions in pasture and irrigation water use can be aligned with the governance structures in the ex post stage of contract. The differences in the key characteristics of hybrid governance structures—the type of the resources pooled, the level and scale of social dilemmas, and the need for protective governance—explain the institutional choice.

We have also observed an increase in asset specificity in both transactions. Herders/livestock owners fence pastureland to produce fodder, build bars on pastureland. In the irrigation system, WCA invests in changing earth canals to concrete canals and installing water pumps. We can probably predict that this might affect other properties of transactions—decreasing frequency and uncertainty, but increasing excludability.

How might this affect the level and scale of social dilemmas and the need for protective governance? Can we expect social dilemmas to increase, more protective governance to be required in pasture and irrigation water management, and formal governance structures such as PCs and WCAs to play a greater role in the future?

We believe that our research findings are highly relevant for CPR management beyond Central Asian region. Many states worldwide are implementing decentralization reforms in agriculture, policy makers, experts and scholars have been searching for answers to questions such as how government can design and supply appropriate institutions and governance for ensuring more sustainable resource use. In this article we suggest a shift from merely supplying institutions, which may be difficult and costly to enforce later, to identifying factors behind institutional choice. We hope that better understanding of actors' decisions and choice whether the selected governance structures solve social dilemmas (e.g., depletion of natural resources and conflicts among resource users) created by the transactions, and provide benefits and quality of coordination of the transactions may be helpful to support institutions that can coordinate resource use more effectively.

Further research is required into how the properties of transactions interplay with actors' characteristics during the institutionalization process; for example, how a change in the properties of transactions can affect power relations in pasture use, or how the leadership skills of a WCA head can affect or be affected by a change in the properties of transactions. Moreover, the interrelation between properties of transactions needs to be specifically addressed, with particular attention paid to how different individual transactions, types of transactions and modules of transactions are related.

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