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Institutional design in transformation: A comparative study of local irrigation governance in Uzbekistan

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ARTICLE INFO

Article history:
Received 30 June 2014
Received in revised form
5 June 2015
Accepted 10 June 2015
Available online 30 June 2015

Keywords:
Institutional design
Qualitative comparative analysis
Water Consumers Association
Common pool resources
Irrigation infrastructure
Uzbekistan

ABSTRACT

The irrigation sector constitutes the backbone of Uzbekistan's economy, providing social and economic stability in the region. The sector collapsed with the fall of the Soviet Union, due to worsening of infrastructure conditions causing tensions among resource users. Subsequent irrigation management reforms were implemented in a top-down manner. More than a decade after the initial reforms – which established local Water Consumers Association (WCA) and transferred operation and maintenance responsibilities for on-farm irrigation canals – the poor performance of these associations is still apparent, illustrating the heritage of the strong role of state agencies in Uzbek water management that still affects collective irrigation management today. This paper identifies the necessary and sufficient conditions for successfully managing common pool resources (CPRs) and, more specifically, irrigation canal maintenance in the rural Bukhara region of Uzbekistan. Fifteen WCAs were examined regarding conditions that may facilitate successful irrigation canal maintenance. Methods involved focus group discussions and in-depth interviews with the associations concerned. Data gathered was analyzed using fuzzy-set qualitative comparative analysis. The results indicate that two paths of local factors can lead to well-maintained irrigation canals: (1) the combination of appropriate chairmanship skills with sustainable resource appropriation or (2) the combination of appropriate chairmanship skills with the presence of effective participatory governance. The results also illustrate the role of path-dependence and traditional co-production of irrigation management in Uzbekistan.

1. Introduction

Since the break-up of the Soviet Union in 1991, the management of common pool resources (CPRs) such as irrigation systems has undergone substantial reforms in Central Asia. As a result, new institutions and governance structures (e.g. user associations) were introduced. It is striking that these reforms hardly took into account local knowledge and experiences in regard to the management of CPRs. Instead, these policies drew on blueprint models with little consideration for the specific Central Asian socio-political context and

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http://dx.doi.org/10.1016/j.envsci.2015.06.012
1462-9011/

the existing institutional capacities. Moreover, implementation mostly followed a top-down approach, allowing little space for the active involvement of resource users and the civil society.

In order to change, however, the complex ways institutions regulate interactions between social and ecological systems, what we call "multifaceted institutional change", needs to unfold (Zikos and Thiel, 2013: 357; cf. North, 1990; Bromley, 2008). To reconstruct how such a process works, we employ here a qualitative comparative analysis (QCA) to analyze processes of top down intended institutional design for institutional change in Uzbekistan (Goodin, 1996; Alexander, 2005). In the country's agricultural sector, irrigation management was reformed in a top-down fashion in the 2000s, without engagement of local resource users. This was particularly the case with the implementation of Water Consumers Associations (WCA),[1] which were externally designed with the support of the international community (Zavgorodnyaya, 2006; Veldwisch, 2008; Abdullaev et al., 2010). It needs to be mentioned that, without any initial financial, technical, legal or administrative support, some of the associations have fallen into a state of collapse. Previous studies have reiterated that the infrastructure needs to be improved to an acceptable level before it can be successfully transferred to local farmers (Hamidov 2007). The particularly weak link here is the institutional one, as rules are still unclear and a law on WCAs that could protect their rights has yet to be issued.

The impact of climate change is expected to aggravate the situation, resulting in reduced snow and glacial reserves in the mountains – virtually the only source of water for most of the irrigated croplands throughout Central Asia (Hagg et al., 2007; Aleksandrova et al., 2014). Along with changing climates, transboundary water management conflicts have further resulted in a decline of crop production in the region (Rakhmatullaev et al., 2010). We propose that QCA is particularly useful for identifying conditions that promise successful top down institutional design because it can help us to generalize from individual cases. Thus, in this paper we evaluate institutional design for the Bukhara region of Uzbekistan, where the top-down implementation of WCA establishment required significant changes in irrigation management practices.

Departing from an institutional economics perspective and various discussions on institutional change, we aim to investigate purposeful institutional change or institutional design, understood as the deliberate replacement of existing, formal institutions or the creation of new institutions in a socially desired way (Thiel et al., 2015), in the irrigation sector of Uzbekistan. More specifically, and in relation to this special issue, we set out to explore the scoping conditions of intended institutional change in natural resource governance and to derive lessons from the QCA method applied so as to inform purposeful institutional change in comparable situations of post-socialist transition in the future. To achieve this, we identify the necessary and sufficient conditions for successfully managing CPRs and, in particular, irrigation infrastructure in the rural Bukhara region of Uzbekistan. Following an iterative research process, where theories are gradually adjusted based on empirical findings, we construct arguments around the theories of collective action (particularly the concept of leadership), resource appropriation and participatory governance, as influential concepts for the outcomes of designed institutional change. In this context, we focus on the operations of the WCA itself. As a result of our theoretical framing, we do not explicitly address more aggregate explanations that relate to the broader cultural context and local politics concerning irrigation management, which no doubt also shape irrigation management in significant ways. For example, it should be noted that the social fabric in the post-socialist transition suffers from a low degree of social capital, a deficit which tends to hamper cooperation and trust. Such a setting does not seem to support bottom-up initiatives that could effectively incentivize collective action and lead to the development of local institutions overcoming challenges of CPR management. Also, during land reforms, there were incidents where good relations with district authorities allowed some farmers to obtain land licenses while others could not (Kandiyoti, 2003). This caused a deterioration of trust that possibly hindered successful collective action.

Our contribution to this special issue explores what conditions at the level of the WCA might determine the success of top-down institutional design in post-socialist Uzbekistan as a means towards proposing sets of conditions for future successful institutional design. We employ QCA as a method that appears particularly valuable for science–policy interfaces and informing different kinds of intended institutional change because it enables the formulation of general statements regarding specific types of settings. Therefore, we scope the conditions for applying QCA for assessing intended institutional change in governance of CPRs. Because of its specific theoretical grounding and the limitations of the research design and method, the analysis focusses specifically on local collective action and cannot address the role of cultural factors or dynamics induced by power and micro-politics. To attain this aim, the paper is structured as follows: Section 2 provides background on irrigation reforms in Uzbekistan, with a specific focus on the historical role of the state in collective action; Section 3 outlines theoretical concepts regarding successful cooperation that we have developed through an iterative process; Section 4 describes the method and tools employed in this study as well as the analytical steps followed; meanwhile, Section 5 presents our findings and discusses the findings with reference to canal maintenance. The final section (Section 6) concludes the paper by proposing potential policy implications.

2. The irrigation sector of Uzbekistan

Irrigated agriculture remains one of the most important sectors of the Uzbek economy, contributing to 19% of the

[1] Note that, in December 2009, the Water and Water Use law of Uzbekistan was revised, and the previously used Water Users Association (WUA) term was changed to water consumers association (WCA). Distinctions between these two terms were clarified as follows: water users do not affect the actual amount of available water for processes such as fisheries and hydropower, whereas water consumers do reduce the actual amount of available water through irrigation, drinking and the like. Therefore, we use the term of Water Consumers Association throughout this paper.

Table 1 – Historical reform of land and water management in Uzbekistan.

Periods	Institutions for water management	Irrigation system development	Land use farming system	Total irrigated area (per farm in hectare)
Pre-Soviet occupation	*Mirab*[a] system: communities play important role	Small-scale irrigation canals	Smallholder land ownership: subsistence farming	Less than 1 ha
Early Soviet period (1920–1950)	Some elements of old system plus increase of state role	Construction of new irrigation canals	Collectivization of land use	300–500
Late Soviet period (1950–1990)	State controlled water management (WM)	Large-scale irrigation canal system	Collective (*kolkhoz*) and state (*sovkhoz*) farming	1500–2000
Early post-Soviet era (1990–2000)	State-controlled WM until farm level. Unclear rules at the former *kolkhoz*[b] and *sovkhoz*[c] levels.	No major construction works	Slow transformation from collective farms to individual family renting (*shirkat*[d])	1500–2000
Mid post-Soviet era (2000–2008)	Creation of WCAs (with Decree No. 8 in 2002) to manage water at farm level	Hydrographic (canal) principles	Individualization of irrigated land parcels	1–50
Late post-Soviet era (since 2008)	Completion of on-farm irrigation system transfer to local WCAs	Hydrographic (canal) principles	Land optimization reforms	40–100

Source: Modified from Abdullaev and Rakhmatullaev (2015: 851–856).

[a] The word Mirab (or Mirob) comes from an Arabic word meaning ''mir'' as in ''Amir'', or head, and ''ob'', meaning ''water'', with Mirob translating into ''head of water''.

[b] Kolkhoz: A large collective farm comprising several agricultural experts and farm labourers responsible for the collective management of the production system and delivery of targeted outputs to the state.

[c] Sovkhoz: They were entirely financed by the state budget and their entire output had to be delivered to the state.

[d] Shirkat: A cooperative large farm enterprise, oriented to family-based production, established to replace the former kolkhoz and sovkhoz. The shirkat's production output had to be delivered to the state.

country's GDP and, most importantly, providing almost 40% of the rural population with employment (World Bank, 2013). Uzbekistan is considered one of the oldest regions in the world that practices irrigated agriculture. According to research conducted by nationally famous historians and archaeologists, construction of canals in the country began as early as the middle of the 2nd millennium BC (Bartold, 1965). The historical development of reforms in Uzbek irrigated agriculture can largely be categorized into three major periods: pre-Soviet irrigation management during feudalist and colonialist periods, irrigation development after the accession of Uzbekistan to the Soviet Union, and the post-Soviet transformation process. Table 1 provides an overview of reforms in the history of irrigated agriculture in Uzbekistan.

In this brief sketch, we specifically focus upon historical variations in the role of the state in Uzbek irrigation management because of its relevance for the rest of the study. Prior to Soviet occupation in 1920, about 1.3 million ha of agricultural land was irrigated and all canals and ditches were owned and collectively controlled by local communities (Abdullaev et al., 2006). Irrigation was mainly carried out in the foothills, floodplains or deltas of large rivers such as in the Amudarya, Syrdarya, Zarafshan and Ferghana valleys (Bedrintsev and Korzhavin, 1975). However, absence of advanced engineering technology meant that local *mirabs* (irrigators) could not manage river flows or convey water from main canals to smaller canal structures (Sharov, 1968). As a result, small irrigation networks were relatively rare, and the main canals were of enormous size and length, with large flows of water. The state had a relatively marginal role in decisions on water allocation at the farm level, as local *mirabs* were responsible for water distribution to *dehkan* (peasant) farmers and operation of on-farm (secondary and tertiary) irrigation canals (Rakhmatullaev et al., 2011).

Since the late 1920s and early 1930s, due to the overarching political objective of boosting the Soviet Union's economy, the Ministry of Land Reclamation and Water Resources of the Union of Soviet Socialist Republics (USSR) became involved in the expansion of irrigated areas, concentrating on more effective use of agricultural machinery and the engineering or rebuilding of different types of irrigation systems. As a result of this expansive policy, an additional 3 million ha of land came under irrigation. The state water management authorities, based on administrative districts, were responsible for the delivery of water to the borders of collective (*kolkhozes*) and state (*sovkhozes*) farms, which then became responsible for on-farm water distribution and maintenance of irrigation systems (Wegerich, 2005). The managers of these farms would appoint the head hydro-technician to be in charge of irrigation water and maintenance-related activities at the production units (or *brigades*[2]). Due to the fact that the production of cotton became a leading industry, making a significant contribution to the national economy (Bedrintsev and Korzhavin, 1975), the Uzbek state played a very significant role in the allocation of water for irrigation within the collective/state farms and in the maintenance of irrigation infrastructure.

After the dissolution of the USSR, a slow transformation from *kolkhozes* and *sovkhozes* to family-oriented production

[2] The *kolkhoz* field workers were organized into brigades, which were assigned to specific plots of land. The head of a *brigade*, working under the leadership of a *kolkhoz* chairman, was responsible for farm administration and held accountable for fulfilling planned harvest targets (Trevisani, 2010).

units (i.e. *shirkats*) took place. The independent Uzbek Ministry of Agriculture and Water Resources (MAWR) was put in charge of managing water from the country's main canals. However, there was a huge vacuum of responsibility regarding who should manage and maintain on-farm irrigation canals, which had previously been managed and maintained by collective and state farms (Jumaboev et al., 2013). With its Decree No. 8, in 2002 the Cabinet of Ministers addressed "[m]easures for the reorganization of agricultural enterprises into individual farms" by introducing new institutions and governance structures – namely, an irrigation service fee (ISF) and the WCA – to shift the rights of managing irrigation canals at the on-farm level from government agencies to local resource users (i.e. farmers). The rationale behind this reform was that water consumers would act collectively to manage and maintain irrigation systems on which they depended but which they were not able to maintain by themselves at the level of individual farms. At the next highest level, Basin Irrigation Systems Authority (BISA) and Irrigation Systems Authority (ISA) state water organizations were established to manage water resources at the level of the main canal. The main task of an ISA, for example, was to ensure timely and fair distribution of water resources to local WCAs. Each WCA is responsible for developing a water use plan for its farmer members. Once annual water use plans were prepared and the ISA distributed water to a WCA's territory, it became the latter's responsibility to ensure reliable and equitable distribution of that water among the farmers. So, according to the 2002 reform, within the constraints of the relatively predictable water allocations from the ISA, which controlled the source of water in the main canal, the WCAs were to organize collective action for the management of CPRs (e.g. infrastructure) and the allocation of water (i.e. in the secondary and tertiary canals). Although overall water allocation by higher levels obviously affects operations within each WCA, we consider it legitimate to study here the degrees of success of collective action organized by WCAs separately, at the level of associations.

3. Theoretical concepts regarding successful irrigation management

The literature on institutions offers a great number of perspectives regarding the possibilities for changing institutions and the underlying methods that can be applied for this purpose (cf. Brousseau, 2011; Vatn, 2005; Lin, 1989). For example, top down institutional design implicitly presumes that theories can enable agents to determine how to effect intentional institutional change by creating new institutions aimed at affecting existing practices with predictable outcomes. Zikos and Thiel (2013) associate this with the kinds of understanding of institutional change propagated by rational choice orientations. In contrast, according to Alexander (2005), what has also been called subjective-dialogic institutional design exhibits a lack of conclusive understanding about how institutional change unfolds, making it essential to understand transformations that are unleashed by intended institutional change and descriptive-explanatory knowledge based on reflexive experience. Empirical observation and analysis are, thus, required in order to formulate adequate proposals for guiding development of institutions into intended directions. From this perspective, outcomes are presumed to be to a large extent unintended and unpredictable. This understanding would be associated with theories that emphasize the endogenous, cognitive dimension of institutions, as in learning- and evolution-oriented theories of institutional change (Zikos and Thiel, 2013).

Institutional change, aiming to steer social–ecological systems onto desirable pathways via successful CPR management, constitutes an underlying motivation of the work of a number of renowned academics, such as Ostrom (2000, 2005, 2007) and is here called intended institutional change or, synonymously, institutional design. Many scholars conducting research on CPRs from an institutional perspective suggest that there are different conditions for improving cooperation amongst groups of users that may form a vital element of success (Wade, 1987; Ostrom, 2000; Meinzen-Dick et al., 2002; Theesfeld, 2005; Zavgorodnyaya, 2006; Abdullaev et al., 2010). To different degrees, conditions could be considered to be either necessary or sufficient for helping to achieve successful CPR management. However, very few studies have investigated combinations of conditions in terms of their necessity and sufficiency and the possibility of their absence under certain constellations, especially in post-socialist Central Asia, where attempted top-down institutional design resulted in unexpected "failures" (Zavgorodnyaya, 2006; Abdullaev et al., 2010). Through testing existing theoretical concepts derived from collective action theory in the context of post-socialist transition, this research proposes certain conditions or their combinations under which successful cooperation in local CPR management is likely to occur.

Ostrom (1990) has emphasized that irrigation systems (water and infrastructure) can be classified as CPRs due to having the characteristic of difficulty of exclusion while, at the same time, being subject to a high degree of rivalry among actors over access to them. Thus, employing CPR theory is likely to help us advance our understanding of how the system in question functions. Ostrom (1990) further highlights that CPRs are subject to overuse if no suitable *institutions* (understood as rules of the game) are in place against rule-breaking individuals and also proposes collective action to overcome social dilemmas. Based on these ideas, we employ carefully and iteratively selected theoretical concepts regarding collective action, resource appropriation and participatory governance to try to explain the social dilemmas associated with unmaintained irrigation canals. We hold that the irrigation canals and the water that farmers share, and which is allocated to them by the ISA, are CPRs. Among the various CPRs at stake in irrigation systems, we are interested in the factors that determine the degrees of success that WCAs have in managing and maintaining irrigation canals.

Specifically, we focus on the following factors. First, we distinguish the **chairmanship skills** of the head of a WCA as the key condition for the success of community management, as posited by several researchers (e.g., Zavgorodnyaya, 2006; Theesfeld, 2009). Poteete et al. (2010) note that leadership is one the most well-studied social factors that contribute to sustaining CPR regimes. Baland and Platteau (1996) synthesized various studies and asserted that good leaders are

important to help people become aware of the real challenges that they confront to mobilize users into a coordinated unit to manage the resources, and to ensure that rules and enforcement mechanisms are fair. Meinzen-Dick et al. (2002) put emphasis on leaders who are perceived as being important social actors and, thereby, contribute towards trust-building among members. In the context of Uzbekistan, Zavgorodnyaya (2006) distinguishes three co-existing groups of leaders – WCA, Machinery Tractor Park (MTP)[3] and Village Citizens' Assembly (VCA)[4] – that may influence the WCAs performance. She studied the performance of Uzbek WCAs by employing collective action theory to determine factors that influence the success or failure of the establishment of WCAs. She identified having a water-engineering background and being connected to traditional societal structures as vital requirements for chairmen to increase the probability of success of their WCAs. Yalcin and Mollinga (2007) have also investigated the conditions which led to the establishment of WCAs in Uzbekistan. Their findings reveal that the **charismatic leaders** who were well-connected to state authorities were able to influence structural changes and mobilize support for their new ideas. These findings concern the role of the state as well as traditional structures both of which apparently remained important in irrigation management, a finding that we confirm below.

Further, the literature identifies **resource appropriation** (or allocation of irrigation water) as an explanatory condition for improved CPR management (Theesfeld, 2009; Abdullaev et al., 2010). Generally, the issue of water allocation is negotiated within a broad action arena comprising multiple levels of governance. Farm-level water allocation may be influenced by political decisions at the national and international levels, by climate-change discourses, types of crops grown as well as biophysical characteristics of the system, and they may involve various actors in decision-making process. This study, however, focuses on investigating infrastructure provision. We view this as being an appropriate indicator of successful water allocation in general. We include ''sustainable resource appropriation'' as an explanatory condition for having irrigation canals maintained. Theesfeld (2009) investigated collective action among Bulgarian villagers to manage water for irrigation during the country's post-Soviet transition, finding that unorganized water appropriation rules, associated with unreliable irrigation water allocation, left little room for successful cooperation. She also found that the absence of a monitoring system for water appropriation increased transaction costs for guarding farmers' fields 24 h/day. Abdullaev et al. (2010) have studied collective action in the irrigation sector in Central Asia, highlighting the importance of water appropriation in the area due to competition between many farmers who cultivate different but water-intensive crops. As a result, frequent clashes between appropriators might occur.

Finally, effective **participatory governance** may improve cooperation among resource users, as some studies have indicated (Speer, 2012). Andersson and van Laerhoven (2007) define participatory governance as institutional arrangements that facilitate the participation of citizens in public policy processes. In the present paper, the concept of participatory governance is used to examine WCA members' participation[5] in decision-making processes regarding canal maintenance as well as their frequency of participation in meetings. Speer (2012) notes that allowing community members to influence the design and implementation of everyday rules constitutes a determining factor of the effectiveness of participatory governance. Mukhtarov et al. (2014) point to the fact that it is questionable whether successful implementation of participatory approaches in semi or non-democratic countries is possible, because they may be confronted by a series of challenges during the process, which require careful consideration for effective institutional design. Participation, in this context, should not be confused with directly affecting decision making, although they are related. Various ''ladders'' of participatory governance as tools for analyzing issues involved in improving participation in water-resource management have been proposed, especially with reference to less-developed countries (cf. Mostert, 2006; Choguill, 1996). From this perspective, the authors recognize that what is often considered common practice in the ''Western World'' might be a real participatory achievement elsewhere, for instance, informing and consulting the public before reaching a decision. In our study, we deal with participatory issues, both in terms of scope and analytical purposes as well as concerning new processes leading to decision making, by involving resource users in different ways other than it had been the case in the past.

4. Methodological approach

Throughout the data-gathering phase of this study, we carried out focus group discussions (FGDs) with resource users – farmers who are members of WCAs – in the Bukhara region of southwestern Uzbekistan, using a semi-structured interview format. Some relevant characteristics of these FGDs have been that: (i) the average number of participants in each group was between 3 and 5, (ii) the on-site researcher had an assistant for recording the discussions and keeping notes,[6] and (iii) the participant pool was relatively homogenous in terms of age, education, profession and socio-economic status. Selection of FGD participants was done prior to the field visit, based on secondary data received from local district *khokimiyats* (governor's offices) and the Amu-Bukhara BISA. Representativeness from the WCA membership for the entire territory (i.e. participants representing the target population) was also

[3] MTPs were part of collective and state farms. They were reorganized into joint stock companies in 1997. Their main mission, among others, is to provide agricultural machinery services to WCA members and local households.

[4] VCA is a self-governance organization representing the interests of its members. The resident citizens over the age of eighteen are entitled to participate in the assembly.

[5] They are large farmers who are registered at local district *khokimiyat* (governor's office) and have a legal status with farm stamp. They or their representatives attend WCA meetings normally.

[6] A PhD student from the Bukhara branch of the Tashkent Institute of Irrigation and Melioration (BB TIIM) supported this study during its empirical phase.

sought out. WCA chairmen were contacted by the on-site researcher. They were requested to gather pre-selected members into a WCA office or local VCA office for the FGDs to be conducted, which took place when at least three farmers were present. Conditions derived from a variety of theoretical concepts were taken into consideration in designing the semi-structured interview format. Answers were coded, summarized into spreadsheets and analyzed with the qualitative software package fuzzy-set Qualitative Comparative Analysis (fsQCA).

4.1. *Case study region and selection of WCA cases*

The Bukhara region contains a diverse ethnic population (e.g., Uzbeks, Tajiks and Turkmens) and suffers from frequent water shortages, severely salinized soil and groundwater, extensive waterlogging, and close geographical proximity to an ecologically catastrophic zone: the Aral Sea (Fig. 1). We selected the Bukhara region for our study because little international research has been conducted in the region thus far, particularly from an institutional economics perspective. Total irrigated area of the region is accounted at 279.6 thousand ha. Total population is about 1.4 million, of which about 70% live in rural areas and depend on irrigated agriculture. Bukhara's local economy is based on tourism, agriculture, oil and natural gas, raw materials for construction and light industry. The region has relatively high costs for distributing water among users, since the Bukharians primarily use costly-to-operate electrical pumps to lift water 50–100 m above the level of the Amudarya river to release it into the Amu-Bukhara Main Canal (ABMK). ABMK is the main water conveyance canal of the Amu-Bukhara Basin, which supplies water to almost the entire irrigated lands of Bukhara and parts of Navoiy regions (ADB, 2013). The total area supplied by the ABMK is 315,000 ha. It was built in the 1960s and 1970s and currently, requires huge investment for rehabilitation and reconstruction.

Most notably, the problem of outdated irrigation canals has become a serious issue in the region. This is due to the fact that severely salinized soils require large-scale application of freshwater to leach agricultural fields during non-vegetation periods, leaving almost no time or resources to carry out canal maintenance activities. Bucknall et al. (2003) have reported that the problem of soil salinity is particularly acute in the areas closest to the Aral Sea, meaning that about 90–94% of the land in the Karakalpakistan, Khorezm and Bukhara regions of Uzbekistan is salinized to varying degrees. Furthermore, high silt content in the Amudarya river (up to 6 kg of silt and sand per 1 m^3 of water) requires the investment of relatively huge financial and labour resources to carry out maintenance of secondary and tertiary canals. As a result, many water facilities in the basin are currently silted-up and, thus, canals require maintenance by WCAs three to four times a year in the

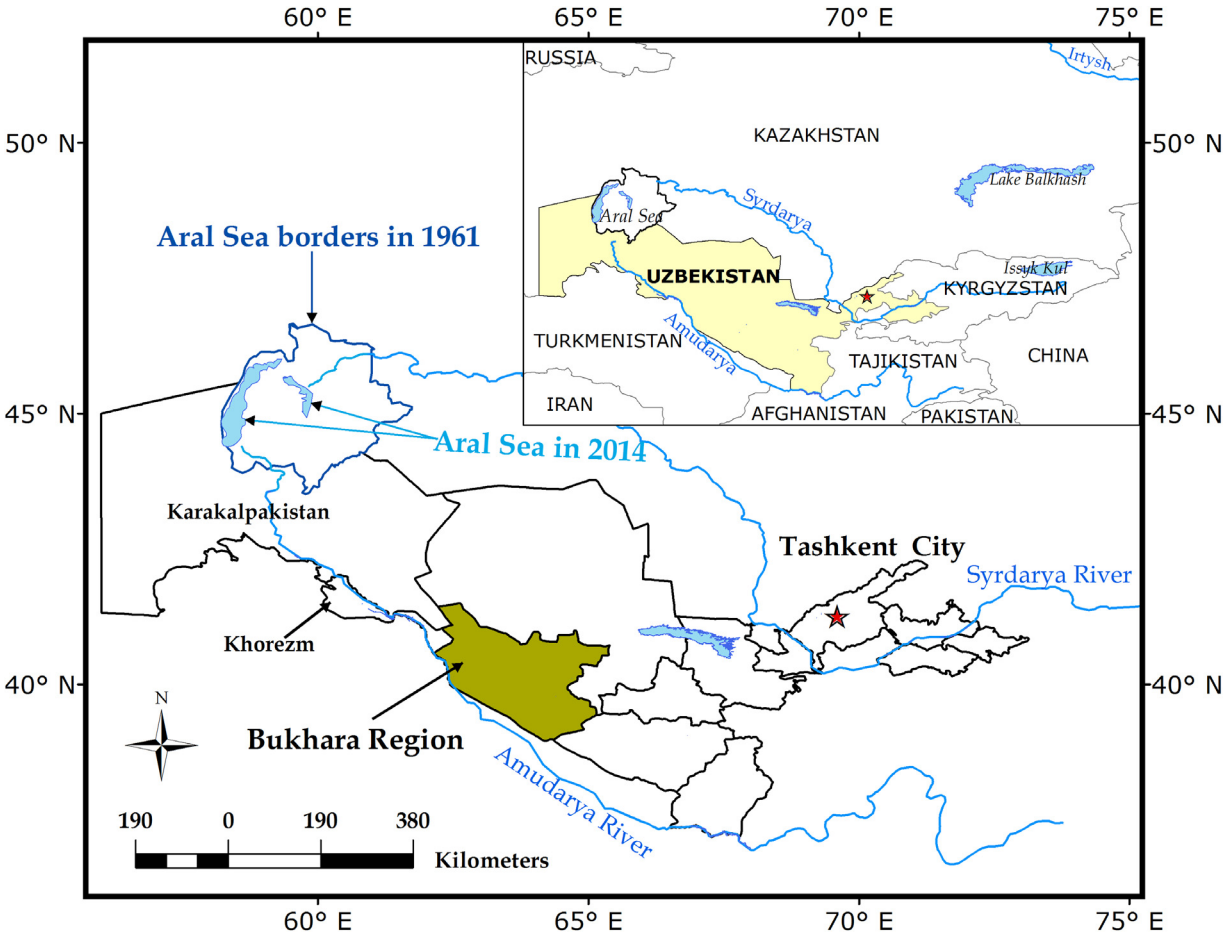

Fig. 1 – Location of the study region.

Amu-Bukhara Basin, compared to one to two times a year in other parts of the country (interview with officials from the Amu-Bukhara BISA). We consider this a specifically challenging environment for the organization of collective action for canal maintenance in a region where proper maintenance is of great importance. According to information received from the Bukhara regional department of agriculture and water resources (i.e. *Obselvodkhoz*) in 2011, about 20% of water in the main canals and 35% of water in secondary and tertiary canals (WCA level) is lost, mainly due to poorly functioning irrigation facilities.

In terms of case selection within the Bukhara region, we relied on Mill's (1872) most similar cases design approach. In the beginning, WCAs functioning in two neighbouring ISAs – Kharkhur-Duoba and Toshrabod-Jilvon – were selected (i.e. 63 WCAs that represent five districts of Bukhara), which share relatively similar climatic characteristics (Fig. 2). The following primary criteria were considered to select cases: existence of information on "well" and "badly" maintained irrigation canals, obtained through secondary data from MAWR; the education and experience of WCA chairmen; and representation of the different districts of the region within the two ISAs. As a result, fifteen WCA cases were selected – eight from Kharkhur-Duoba and seven from Toshrabod-Jilvon – to compare and analyze the effectiveness of irrigation canal maintenance in the region. We attempted to conduct FGDs with members from all fifteen WCAs. In some instances, however, mainly for practical reasons, we found it difficult to bring together groups of farmers. Note that Uzbekistan has retained its state order for cotton and the extended period of empirical data collection took place during the cotton-harvesting season (i.e. autumn 2012). Thus, in some WCAs it was challenging to gather farmers together for FGDs. In such instances, we consequently visited individual member's fields to conduct in-depth interviews. We are aware that results of FGD and in-depth interviews usually cannot be equated. However, given the practical constraints indicated, we had to opt for interviews where FGDs where not possible. The way FGDs developed makes us confident that our use of different qualitative methods biased results only in insignificant ways. This is due to the fact that we used the same semi-structured interview format developed for FGDs and where possible, invited neighbouring farmers to participate in a rather small FGD in their farm territories. Appendix A provides general characteristics of all selected WCAs.

4.2. *Qualitative comparative analysis*

Qualitative comparative analysis (QCA) was employed to explore conditions determining the success of institutional design in Uzbekistan and, based on findings, propose sets of

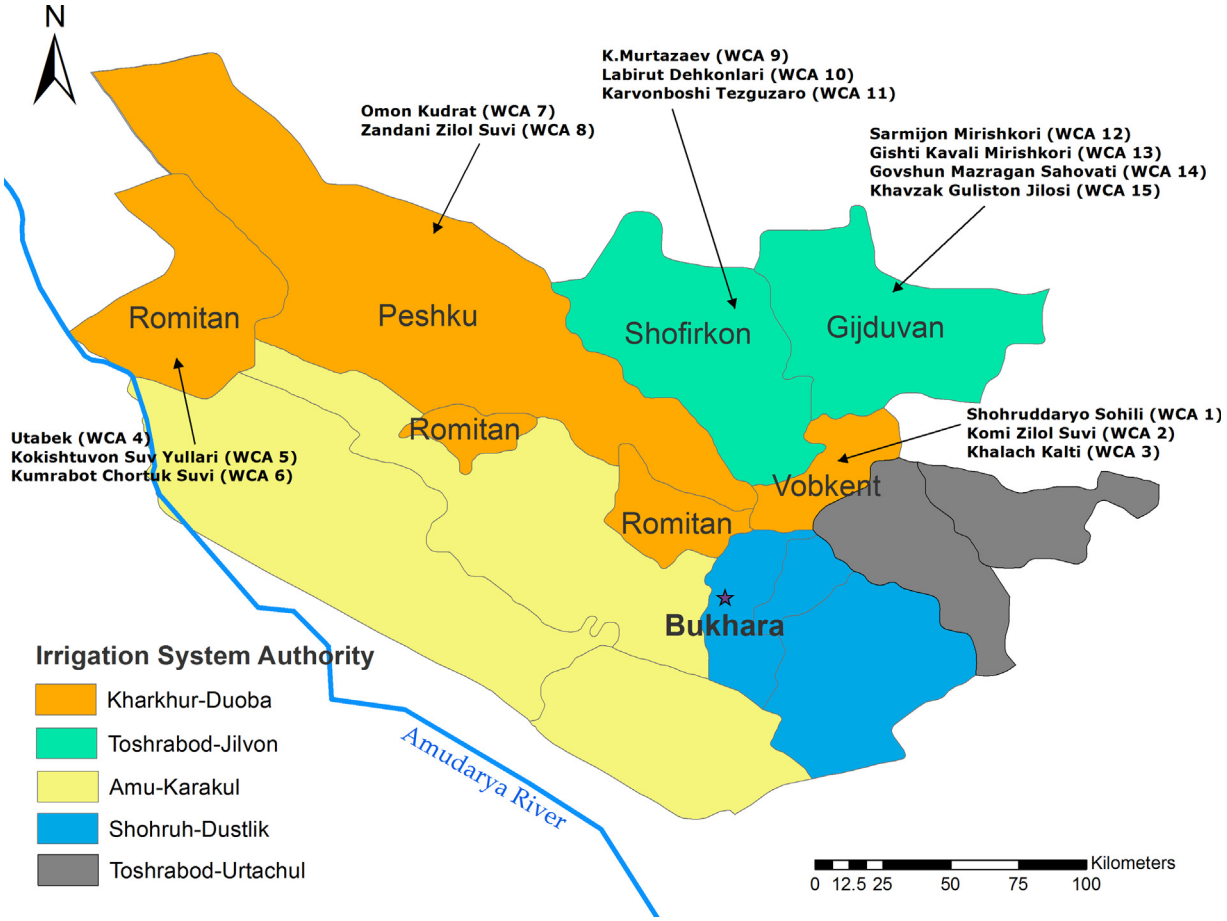

Fig. 2 – Territories of Irrigation System Authority and Water Consumers Association in study area.

conditions for future successful institutional design. This research method was first introduced by Charles Ragin in 1987 and, since then, has become popular among social scientists for analyzing intermediate numbers of cases (Thiem and Duşa, 2013). It is also widely used by a variety of other disciplines – including the political sciences, international relations, business and economics, management and organization, and legal studies – and is recognized as the most influential and innovative social science method of the past two decades. The initial version used binary-value crisp-set data, whereas Ragin's (2000) follow-up version, fsQCA, has become increasingly popular because it permits continuous base variables within a membership interval. For the present study, we employed fuzzy-set[7] QCA in order to compile factors – known as ''conditions'' in QCA terminology – that seem to be necessary and/or sufficient for a given outcome.

Schneider and Wagemann (2012) argue that the rationale behind the use of QCA cannot be solely the availability of only an intermediate number of cases; rather, the phenomena to be explained needs to be the result of a specific kind of causal complexity, making QCA a suitable methodological choice regardless of the number of cases at hand. Consequently, our study adopted this method because it is aimed at understanding the maintenance of irrigation canals within WCA territories due to the causal complexity of conditions, which seemed to require use of such a set theoretic approach. Additionally, QCA allows for combination of conditions to achieve an outcome; we saw this as an advantage for better understanding whether certain conditions, either individually or in combination, or their absence (i.e. complements), is sufficient for facilitating successful CPR (irrigation infrastructure) management in the given institutional design setting in Uzbekistan. This, we reasoned, could also aid us in making a contribution towards the literature on successful institutional change in transformation.

4.2.1. *Selection of conditions and the outcome of interest*

When employing QCA, it is important that sets of conditions and outcome are selected and conceptualized based on prior theoretical knowledge and empirical insights gained through the research process (Schneider and Wagemann, 2010). It is also advisable to keep the number of conditions at a moderate level, since high numbers of conditions are dysfunctional for QCA and may lead to an increase of logical remainders, meaning logically possible ''cases'' that are not observed empirically. There are different approaches concerning how to select conditions that can explain a given social phenomenon. Through an iterative process, we identified what appear to be three key determinants (or conditions) affecting our outcome of interest; that is maintenance of irrigation canals (MIC) in Bukhara: appropriate chairmanship skills (ACS), sustainable resource appropriation (SRA) and effective participatory governance (EPG). Appendix B provides a list of conditions and their outcomes with fuzzy-set value definitions that were identified during the study process.

4.2.2. *Calibration of fuzzy-sets*

Calibration is crucial to fsQCA and should be transparent, open and replicable during the process of assigning membership scores (Ragin, 2006). A qualitative calibration method was used to develop anchor points and identify cases that were more in a particular set's membership or out. Theoretical knowledge as well as empirical insights was used to assign cases according to the categories of full membership, full-non membership, and crossover point.[8] In order to assign a single membership score for a condition and an outcome, the following calibration method was employed for each condition and outcome:

- Condition (ACS): Appropriate chairmanship skills (ACS) are characterized as being when a chairman is either charismatic (CC) OR educated (EdC) AND experienced (ExC). In Boolean algebra, it is expressed as ACS = CC + (EC*EC). It is important to note that whenever there is an expression of OR, then maximum value was selected from the expression. In contrast, whenever there is an expression of AND, then the minimum value was chosen;
- Condition (SRA): Sustainable resource appropriation (SRA) means that farmers have access to irrigation water in due time (AIW) OR that a dispute-resolution mechanism (DRM) is in place AND the external environment (EE) for water allocation is suitable; expressed as SRA = AIW + (DRM*EE);
- Condition (EPG): According to the literature (Speer, 2011), effective participatory governance (EPG) can be defined as the frequency of group meetings (FM) AND the participation of group members (PM) in meetings; expressed as EPG = FM*PM;
- Outcome (MIC): Maintained irrigation canals (MIC) refers to when mobilization and participation of farmers in community action (MPC) AND involvement of local households (ILH)[9] who benefit from using irrigation canals managed by respective WCAs OR contributions for delivered irrigation services by farmers (ISF) is effectively undertaken; expressed as MIC = (MPC*ILH) + ISF.

Fuzzy-set values (membership scores) were assigned for each condition, with the outcomes reflecting degrees of qualitative difference being summarized in Appendix C.

[7] The term ''fuzzy-set'' is relatively new to the social sciences, but the basic idea behind it is relatively simple and straightforward: by allowing for partial membership in addition to full membership and full non-membership in sets (Ragin, 2008), it enables researchers to establish differences in degree among qualitatively similar cases (Schneider and Wagemann, 2012).

[8] As an example, we refer to Ragin's study on Protestant religion, where he proposes that in fsQCA, an individual could be scored as 1.0 (fully Protestant), 0.0 (fully non-Protestant) or 0.5 crossover point (neither Protestant nor non-Protestant, see Hopkin, 2010: 304).

[9] A unit of the analysis is the WCA and its members (i.e. large-scale farmers) and thus, the study initially excluded local households from the analysis. Moreover, exploratory field visits as well as initial discussions with experts indicated that WCAs first prioritize water allocation to its members due to state order for cotton and wheat. However, during the FGD and in-depth interviews, we found out that local households are also one of the key actors that influence in WCA performances with regards to irrigation infrastructure maintenance. Since some irrigation canals pass by households' territories, their contribution to voluntary community action was found to be vital. Thus, we included this indicator in the outcome measures.

5. Results and discussion

Fuzzy-sets were calibrated on the basis of the above theoretical reasoning as well as on the basis of substantive knowledge of the cases. Once the data matrix was developed through incorporating quantitative numbers, fsQCA software was run to analyze the determinants of necessary and sufficient conditions to achieve the desired outcome. Schneider and Wagemann (2010) advise researchers to carry out the analysis of necessary conditions first; here, fsQCA seeks to determine which individual conditions may be necessary or mostly necessary for a specific outcome to take place (Kent, 2008).

The analysis of necessary conditions to achieve maintained irrigation canals within the territories of the WCAs studied indicated that none of the three conditions – ACS, SRA or EPG – were necessary for the outcome MIC on their own. The same finding was seen for the complements of the three conditions (i.e. their absence): ~ACS, ~SRA, ~EPG. For this study, we used a consistency score of 0.90 as a threshold for accepting a condition as being necessary (Emmenegger, 2010). As can be seen from Table 2, however, all consistency scores are below that threshold. Consistency and coverage were calculated using the fsQCA software (Rihoux and Ragin, 2009). According to Ragin (2006), consistency assesses the degree to which cases sharing a given condition agree in displaying the outcome under investigation. In other words, consistency indicates how closely the subset relation of cases is approximated. Meanwhile, coverage assesses the empirical relevance or importance of a consistent subset (Ragin, 2006).

By performing a sufficiency analysis using fsQCA, we sought to find out which individual conditions (in this example ACS, SRA, and/or EPG) would be sufficient for achieving the outcome MIC. Would the appropriate chairmanship skills of a WCA chairman, for example, be sufficient to achieve maintained irrigation canals in the WCA territories? When no single condition on its own is sufficient for achieving an outcome, Schneider and Wagemann (2012) suggest carrying out an analysis of combinations of conditions (logical AND or * symbol), as it is possible that the simultaneous occurrence of different conditions might be sufficient for the presence of an outcome.

Table 2 – Analysis of necessary conditions.

Conditions tested	Consistency	Coverage
Appropriate Chairmanship Skills (ACS)	0.812265	0.787621
~Appropriate Chairmanship Skills (~ACS)	0.498123	0.588757
Sustainable Resource Appropriation (SRA)	0.876095	0.723140
~Sustainable Resource Appropriation (~SRA)	0.413016	0.620301
Effective Participatory Water Governance (EPG)	0.458073	0.783726
~Effective Participatory Water Governance (~EPG)	0.707134	0.546951

The tilde symbol (~) refers to the negation of a condition (or absence).

Table 3 – Sufficiency analysis.

Solution	ACS*SRA	+	ACS*EPG	→ MIC
Covered cases	WCA 1, WCA 3, WCA 6, WCA 7, WCA 10		WCA 3, WCA 6, WCA 10, WCA 13	
Consistency	0.9342		0.8423	
Raw coverage	0.7296		0.4480	
Unique coverage	0.2816		–0.0000	
Solution coverage		*0.7296*		
Solution consistency		*0.8437*		

The results of our sufficiency analysis indicated that no single condition alone would be sufficient for achieving a high degree of maintained irrigation canals within the WCA territories studied. Since the individual analysis of the presence or absence of single conditions did not generate any sufficient condition by itself, combinations of conditions were assessed, with the results revealing combinations of different paths that can lead to the same outcome. In fact, three paths were identified, with the Boolean expression of all sufficient rows for outcome MIC being expressed as follows:

$$ACS * SRA * EPG + ACS * SRA * \sim EPG + \sim ACS * SRA * EPG \rightarrow MIC$$

which can be minimized to

$$ACS * SRA + ACS * EPG \rightarrow MIC.$$

As such, two sufficient paths for successfully maintaining irrigation canals were found: (1) combining appropriate chairmanship skills with sustainable resource appropriation and (2) combining appropriate chairmanship skills with effective participatory governance. This means that properly maintained irrigation canals can be expected from the occurrence of either of these two paths. The values of sufficiency for this solution are provided in Table 3.

Superset relations can also be visualized through an XY plot (Schneider and Wagemann, 2012). Accordingly, the results of our sufficiency analysis are graphically displayed in Fig. 3. For a condition or a combination of conditions to be sufficient, all cases need to be located around or above the bisecting line. In other words, a case's score related to the desired outcome should not be lower than the level set by its score for relevant sufficient conditions. It is notable that, in this figure, most cases are around or even on the bisecting line. We also observe, however, that Kumrabot Chortuk Suvi (WCA 6), Labirut Dehkonlari (WCA 10) and Gishti Kavali Mirishkori (WCA 13) are clearly below the bisecting line, which runs counter to the argument of sufficiency. The case of Omon Kudrat (WCA 7) is rather close to the bisecting line, which would consequently support the sufficiency condition. Ragin (2000) reaffirms that it is usually more difficult to find perfect subset relations for fuzzy sets than for crisp ones. This means that greater flexibility is needed in terms of accepting the condition to be sufficient, and

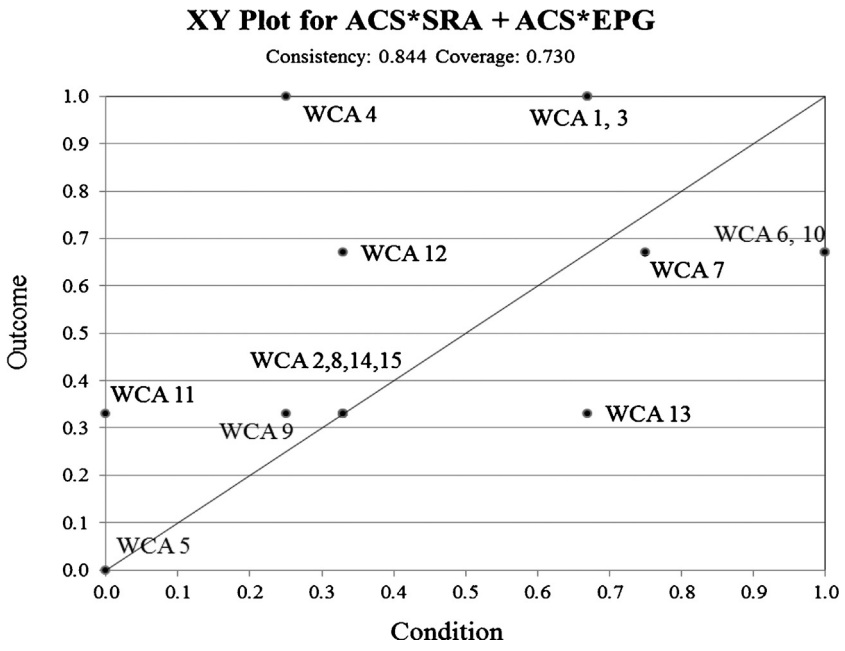

Fig. 3 – Plot of outcome MIC against conditions ACS*SRA + ACS*EPG for 15 WCAs in Bukhara.

thus, perfect sufficiency cannot be the only goal of such an analysis.

5.1. *Combination of leadership and resource appropriation*

According to the fsQCA results, five associations (WCA 1, WCA 3, WCA 6, WCA 7 and WCA 10) have high levels of chairman leadership skills and sustainable resource appropriation, which together led to well-maintained irrigation canals as an outcome. Below we elaborate on specific aspects of these five cases.

According to the sufficiency analysis, Khalach Kalti (WCA 3) had higher levels of canal maintenance in comparison to other neighbouring WCAs. During the FGD, it was noted that this WCA had 2073 ha of irrigated land, of which 52% were devoted to cotton production and about 30% to cultivating wheat. According to the chairman, since it had yet to install individual metering for each farm, the WCA decided to charge ISF on a per-hectare basis rather than a volumetric one.[10] The total amount of expected costs for distributing water to individual farm's territories is divided into the total hectares that the WCA serves, resulting in a cost of UZS[11] 25,000/ha.[12] It is important to note that about 50% of the members use lift irrigation, so electricity costs are an additional burden to farmers. Most WCAs that use pumps usually have huge debts from electricity companies. In order to overcome these challenges, the General Assembly[13] of WCA 3 decided to calculate all expenses for the entire year, including potential electricity costs and costs associated with pump maintenance. These costs were then equally shared by all members. As a result, the amount charged for ISF reflects the costs for water distribution, electricity costs and maintenance of pumps coordinated and carried out by the WCA staff.

In accordance with Khalach Kalti WCA's bylaws, the WCA has five workers: a chairman, a chief accountant, an agricultural machinery driver and two *mirabs*. However, we were informed that the chairman had good water management skills and, consequently, did not actually employ *mirabs*. All activities related to water allocation within the territorial border were thus carried out by the chairman together with other workers. The chairman was elected by the members during a WCA General Assembly and has been working in the area since the Soviet era, when he was the head of a *kolkhoz*. According to local water officials and the WCA members, the chairman was able to overcome conflicts related to water scarcity by using his reputation and networking abilities. For example, the present regional governor and the Deputy Minister at MAWR had previously been working in this district's *khokimiyat*. According to the chairman, he is still in a powerful position and has good relations with these officials (networking skills), and in case of water shortages or violation of water allocations, he may consult with them.

[10] According to Decree No. 8, as the central body for decision making the General Assembly can decide an ISF amount based on a volumetric basis, per farmer basis, per hectare basis or per types of crop grown.

[11] The local currency in Uzbekistan is called the *Soum* (or UZS). As of November 2011, 1 Euro = 2500 UZS.

[12] The ISF amount for the Khalach Kalti WCA was obtained from the WCA accountant in November 2011.

[13] The supreme governing body of a WCA is the General Assembly, which meets once a year, with all members of the WCA being invited and encouraged to actively participate during the meeting. The main topics of discussion include electing a chairman, setting up irrigation service fees, evaluating the performances of the WCA management team and identifying dates for maintaining on-farm irrigation canals.

Another example that fulfilled the sufficiency condition for the combination of leadership skills and resource appropriation was Kumrabot Chortuk Suvi (WCA 6). Most interviewed WCA members there reiterated that water delivery to farm gates had been adequate and that the chairman, using his technocratic skills, was able to establish discipline among water consumers. The chairman has a higher education degree from the Irrigation University in Uzbekistan. Using farmers' ISF contributions, he was able to install water metres at member gates and has since then been able to provide water according to agreed amounts. At the beginning of each vegetation period, the chairman sits together with each farmer and determines the amount of water he/she needs. Unlike other WCAs, this chairman seems to know different approaches for calculating water amounts. Therefore, deliberate vandalism of measurement devices would not inhibit more or less accurate charges for water consumption from being calculated in this association.

Labirut Dehkonlari (WCA 10) was also found to be a case with a positive outcome. As is the case with WCA 6, the head of this association also graduated from the Irrigation University and has been the WCA head since its establishment. It is important to highlight that the chairman understands water issues very well and has established discipline among resource users. According to the members, once a year the General Assembly approves the chairman's candidacy and he continues holding the position.

As for access to irrigation water, in 2012 farmers from WCA 10 received water to irrigate their cotton fields up to six times. This is very good, considering that, in periods of water shortage, irrigation is usually permitted only up to four times a year. Farmers believed that the WCA was an important agency to take over water-related responsibilities and, without it, transaction costs for dealing with the state on water issues would have become extremely high.

Additional cases that had a higher level of chairmanship skills and sustainable resource appropriation include Shohruddaryo Sohili (WCA 1) and Omon Kudrat (WCA 7), both of which also had higher outcome values. In the case of WCA 1 the chairman's charismatic leadership skills (which we equate with the ability to effectively communicate with group members and to gain trust) have proven to be important for enforcing rules on collective action; also, the vast experience of WCA 7's chairman has shown to be an important indicator for achieving good maintenance of the irrigation canals in his area. Despite being located in the desert, WCA 7's chairman was able to provide an adequate amount of water to farmers and maintain its canals well. In the case of WCA 1, the chairman had been in the position since February 2009. Similar to another chairman discussed in this section, he had vast experience, because he had worked as an irrigator in the area during the *kolkhoz* and the following *shirkat* eras.

5.2. *Combination of leadership and participatory governance*

Our analysis showed that good maintenance of irrigation canals can also be expected in the presence of both appropriate chairmanship skills and effective participatory governance. Khalach Kalti (WCA 3), Kumrabot Chortuk Suvi (WCA 6), Labirut Dehkonlari (WCA 10) and Gishti Kavali Mirishkori (WCA 13) revealed that, when these two conditions are combined, then there is a great likelihood of having canals that are well-maintained. The first three WCAs in this section have already been discussed above, as they exhibited both appropriate chairmanship skills and sustainable resource appropriation characteristics. In contrast, at WCA 13 we found a skilful chairman and effective participatory governance, but we did not see sustainable resource appropriation. Nonetheless, the first two characteristics appear to have been sufficient to achieve well-maintained irrigation canals.

A detailed review of the Gishti Kavali Mirishkori (WCA 13) reveals interesting insights. The chairman completed his education in a vocational school with a specialization in construction and had been working in the association since 2007. Overall, he has extensive experience in the field, with significant leadership skills. Simultaneously, he had been managing the local MTP. According to members, the chairman was elected by farmers, was accepted by local authorities, and was now considered to be a well-accepted leader. Although there had been some difficulties in communicating with certain members who did not want to contribute with ISF, he has generally been able to gain their confidence. Thus, the qualifications and track record of the chairman of this association can apparently account for the positive performance of the WCA.

Effective participatory governance was also in place in WCA 13, meaning that the association organized frequent campaigns regarding water use, electricity issues and canal maintenance. Through workshops, the WCA encouraged farmers and local households to use less water, increase productivity and keep irrigation canals running. Overall, participation levels in this particular case were rather high because WCA meetings were organized in parallel with local VCA meetings, attracting greater farmer participation. Despite the analysis pointing towards a positive outcome in canal maintenance in this particular WCA, there were some instances of canals being broken-down, silt clogged or blocked by dumped trash. No machinery or financing has been available, however, to address these issues. In addition, due to poor canal design inherited from the Soviet Union, it has been difficult to get access to water resources.

In the case of Kumrabot Chortuk Suvi (WCA 6), members reaffirmed that frequent meetings are held in the association to discuss issues related to maintenance, water availability and ISF contributions. Most members seem to attend these meetings and raise questions related to maintenance activities and regular water disturbances that affect local households. All consumers agreed that collective action was important for conserving water, increasing crop productivity and improving irrigation canals.

At Labirut Dehkonlari (WCA 10), members also noted that the WCA organizes meetings very often, and the chairman seems to deal with external actors quite competently. If external actors seek to intervene into the WCA's decision-making processes, the chairman would interfere and, if distracting suggestions are made, would oppose them. Due to these regular meetings, members acknowledged that a good amount of information is available with respect to canal maintenance status. In addition, there is a General Assembly

once a year attended by WCA members to approve water and canal maintenance plans as well as to assess the chairman's performance.

Khalach Kalti (WCA 3) is another example where combination of appropriate chairmanship skills and effective participatory governance has produced a positive outcome with regard to canal maintenance. Here, the chairman organizes regular meetings with farmers to discuss and take informed decisions about water shortages and canal maintenance work.

The overall results indicate that three of the cases (WCA 3, WCA 6, WCA 10) occurred in two pathways of the sufficiency analysis. All three conditions seem to be important but are not sufficient individually. This presents us with the seemingly commonsense idea that the presence of higher levels of all conditions simultaneously may lead to greater overall improvement of collective canal maintenance in the Bukharian region of Uzbekistan.

5.3. *Specificities of Water Consumers Associations in post-socialist Uzbekistan*

Most researchers who have studied successful cooperation in the use of CPRs have concluded that the role of external actors should be minimal and that decisions are best taken by group members themselves (Ostrom, 1990; Agrawal, 2001; Wade, 1987). In the case of post-socialist Uzbekistan, the WCA can be considered an organization for the purpose of managing a CPR because it is seen as ''a voluntary, non-governmental, non-profit entity established and managed by groups of farmers located along one or several watercourse canals'' (Winrock International, 2007, cited in Gunchinmaa and Yakubov, 2010: 166). They are constituted by groups of water consumers (i.e. farmers) to collectively manage, operate and maintain irrigation systems that they all depend on and, within the constraints of water allocated to a WCA by the ISA, there is scope for autonomous decision-making and collective action among WCA members. In this sense, our case compares well to the settings that other authors have extensively studied (cf. Ostrom, 1990). However, at the same time, we have found that the role of external actors in collective decisions regarding canal maintenance has been greater than in conventional cases of irrigation management by the WCAs and that, in general, networking abilities of WCA chairmen (establishing trust and facilitating information flow and coordinated action) in combination with strong connections to state authorities (that help mobilizing resource at the disposal of state agents) had a positive influence on the performances of some WCAs in the region (e.g. the Khalach Kalti and Gishti Kavali Mirishkori WCAs). Although we did not specifically test for this factor, because traditionally CPR theory has not addressed it, it clearly emerged from some of the cases we studied.

In our view, this can be explained by the fact that the dominance of state engagement in irrigation management decisions during the Soviet era has left the state with an important role in irrigation management today in terms of, for example its provision of machinery and know-how and overall allocation of water to the WCAs, which surely have an impact on overall levels of satisfaction among WCA members. This seems to indicate a form of path dependency regarding the role of state actors, based on the fact that smoothly running irrigation systems in the country have traditionally required state support. Consequently, despite the relative independence of the WCAs in Uzbekistan, we need to underline that maintenance of irrigation canals in the kind of post-socialist context we encountered there is rather a case of co-production (Ostrom, 1996), where the state and users need to cooperate, than one of collective action solely among water users. Thus, and also for reasons of path dependence and mutual resource dependence, in such contexts the specificities of the relation between the state and users seem to be an important object of study for determining the factors that can lead to successful collective action. However, in this paper we have not been able to address this further but point to the need for future research on this relationship. Both of the paths that have led to successful collective action regarding canal maintenance – that is, combination of appropriate chairmanship skills with sustainable resource appropriation or combination of appropriate chairmanship skills with the presence of effective participatory governance – suggest that selecting WCA leadership carefully is of utmost importance. Yet, such leaders need to not only be accountable to their members but also have good collaborative relations with local and overarching sectoral state authorities, particularly during the transformation process.

6. Conclusions

There are always challenges related to the use of CPRs, and this is particularly the case with collective maintenance of physical infrastructure within irrigation systems, especially in the transition contexts of post-socialist countries. Overcoming such dilemmas requires careful institutional design. Since declaring its independence from the Soviet Union in 1991, Uzbekistan has undergone substantial reforms in the area of irrigated agriculture through exogenously imposed institutional change in the form of top-down implementation of the local WCAs. However, this top-down intended institutional change or design has not produced the expected results of successful cooperation in CPR management, and most associations have been undergoing a difficult transformation. More than a decade has passed since the initial reform establishing local WCAs and the transfer of operation and maintenance responsibilities for on-farm irrigation canals to them, but the pervasively poor performance of these associations is still apparent. This is particularly noticeable in the case of irrigation canal maintenance, as broken-down and silt-clogged canals as well as some blocked by deliberately dumped trash can be observed.

In this study, we have argued that the ambitions of top-down institutional design can in fact only be implemented if institutional design was accompanied by processes that help revealing detailed knowledge of the settings which are addressed. Obviously, this specifically holds for settings where outcomes are expected to be particularly unpredictable. The endogenous, cognitive dimension of the effects of such processes on institutions therefore needs to be recognized. At the same time it requires further research. Using QCA, we have explored conditions that may determine the degree of success of institutional design to enhance local collective

action in WCA in Uzbekistan. These aspects leave out broader cultural or political features of the settings into which they were embedded. Nevertheless, we are aware of the co-productive nature of relations between the state and WCA which, therefore, open up the need to further study the relation between the state and users. An fsQCA was applied to compare fifteen WCA cases in order to determine necessary and sufficient conditions that may explain the target outcome of collective action among users and in the frame of the WCA to successfully maintain local irrigation canals. Through an iterative process, where theories were adjusted based on empirical findings, we have formulated several arguments positing the theory of collective action (in particular the ''leadership'' condition), resource appropriation and participatory governance as influential concepts in relation to the outcomes of designed institutional change. The contribution of our approach can be identified as the testing of combinations of theoretical conditions to better understand local level cooperation among WCA members in post-socialist transition, especially given the limited literature exploring such combinations.

Based on our analysis, we hold that, in the context of Uzbek WCAs, none of the three explored conditions by themselves are necessary for achieving good canal maintenance. Meanwhile, our analysis of sufficient conditions also indicates that no single condition alone is sufficient for achieving high levels of canal maintenance in the territories of the Bukharian WCAs. However, analyzing combinations of these conditions has shown that there appear to be two paths leading to well-maintained irrigation canals: (a) combination of appropriate chairmanship skills with sustainable resource appropriation and (b) combination of appropriate chairmanship skills with effective participatory governance. As well-maintained irrigation canals can be expected when either of these two paths is present, we feel that it is reasonable to believe that there will be a great chance for successful institutional design when preliminary analyses found that these two paths are present simultaneously. From our perspective, these results point towards the importance of embedding intended institutional design into processes of knowledge creation for two reasons: (a) we confirmed that presence of these conditions facilitates successful intended institutional design. It, therefore, needs to be considered desirable to verify their presence in specific empirical settings before intended institutional design is being implemented. A way to accomplish this is to embed top-down institutional design into processes that enable revealing in-depth knowledge about context conditions throughout which idiosyncratic knowledge about the presence of combinations of conditions is deliberately acquired. (b) Among the conditions we identified leadership, sustainable resource appropriation, and participatory governance; the latter being especially indicative of the relevance of processes and methods that help uncovering detailed knowledge in regard to the settings which are addressed throughout processes such as for example action research (Zikos and Thiel, 2013). It is worth mentioning that a significant finding of our study is that, although the institutional arrangements of the WCAs were set in a top-down manner – contradicting to an extent the very notion of participatory governance – their charismatic chairmen have through their networking backgrounds been able to challenge, to the point of resolving, the inherited conflict between top-down control and the setting of rules via effective participation, and even been able to influence the decision of resource users.

Leadership, resource appropriation and participatory governance with reference to irrigation management in the context of transformation have been well documented (Zavgorodnyaya, 2006; Yalcin and Mollinga, 2007; Theesfeld, 2009; Abdullaev et al., 2010) but, as we have mentioned, their combination has been less explored. In this respect, future research focusing on the combination of factors to explain cooperation for irrigation management could be particularly useful. Furthermore, it appears that the specificities of the relationships between the state and local users also require attention in the future. In sum, the findings of this study have indicated ways of effectively contributing towards good performance of irrigation canal maintenance at the level of WCAs in the context of transformative and transitional settings as well as pointing towards pathways for future research. Moreover, in the future, the conditions found using fsQCA method, need to be embedded into studies that address causal chains and include higher levels as well as cultural and political features and the role of power in shaping WCAs. Such extensions of the findings of this study would probably best be achieved through multiple comparative case studies, in contrast to the use of fsQCA, because research of the role of dynamics involving higher levels requires a considerably more differentiated understanding than we established throughout this study. Such work would allow for a more contextualized understanding of the factors that cause dilemmas in Uzbek, local CPR management and their change. Thus far, it seems that institutional design, following the findings of this study, can indeed only be successful where it is embedded into an in-depth understanding of the settings which are addressed. All in all, our paper indicates that fsQCA, despite its discussed limitations, can contribute significantly as a complementary method for collective action research, with the aim of corroborating the role of specific factors determining success or failure of collective action in different cultural and socio-economic settings. This also makes such work valuable for informing also context-specific intended institutional change.

Acknowledgements

The authors are indebted to Matteo Roggero and Sergio Villamayor-Tomas for their comments on earlier version of this paper, which was initially presented at the International Conference and Young Researchers' Forum at the Justus Liebig University Giessen, Germany (October 1, 2013). Financial assistance was provided by the Volkswagen Foundation within the framework of the InDeCA project (Designing Social Institutions in Transition: Promotion of Institutional Development for Common Pool Resources Management in Central Asia). Empirical field visits to each of the fifteen Water Consumers Associations were supported by the Fiat Panis Foundation. The authors gratefully

acknowledge these funding agencies. Additionally, Andreas Thiel's and Dimitrios Zikos's research for this paper benefited from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme (under REA agreement No. 289374: ENTITLE). Andreas Thiel also benefited from grants from the Einstein Foundation Berlin (EJF-2011-57) and the Deutsche Forschungsgemeinschaft (DFG) (TH 1459/2-1).

Appendix A: General characteristics of selected WCAs

Case	WCA name	Date of formation	No. of members	Irrigated area (ha)				Chairman's background	Total no. of interviewees	ISF rate (%)
				Total	Cotton	Wheat	Other crops			
WCA 1	Shohruddaryo Sohili	25.01.2007	30	1940	911	512	517	Vocational school	3	66
WCA 2	Komi Zilol Suvi	25.01.2007	22	1656	678	437	541	University degree (Mechanical engineer)	4	28
WCA 3	Khalach Kalti	30.09.2006	34	2073	1069	627	377	University degree (Agronomist)	3	39
WCA 4	Utabek	01.04.2006	63	3234	1793	825	616	Vocational school	5	48
WCA 5	Kokishtuvon Suv Yullari	01.04.2006	22	1897	940	503	454	University degree (Hydro-technician)	4	22
WCA 6	Kumrabot Chortuk Suvi	01.04.2006	47	2582	1349	542	691	University degree (Hydro-technician)	3	39
WCA 7	Omon Kudrat	01.02.2004	30	2206	959	488	759	University degree (Zoo engineer)	3	36
WCA 8	Zandani Zilol Suvi	01.02.2004	29	2259	953	607	699	Vocational school	3	47
WCA 9	K. Murtazaev	01.04.2002	63	4553	1591	2110	852	Vocational school	4	12
WCA 10	Labirut Dehkonlari	01.06.2004	13	1138	298	180	660	University degree (Hydro-technician)	4	41
WCA 11	Karvonboshi Tezguzaro	01.04.2005	18	542	305	163	74	Primary school	5	22
WCA 12	Sarmijon Mirishkori	01.01.2005	17	2085	991	267	827	University degree (Agronomy)	4	31
WCA 13	Gishti Kavali Mirishkori	01.01.2006	18	1859	925	205	729	Vocational school	3	32
WCA 14	Govshun Mazragan Sahovati	01.01.2007	19	1973	985	371	617	Vocational school	5	42
WCA 15	Khavzak Guliston Jilosi	01.01.2007	18	1786	812	294	680	Vocational school	4	49

Source: Data was obtained from the Amu-Bukhara BISA (2013) as well as derived from interviews with WCA employees.

Appendix B: Final conditions and outcomes with fuzzy-set value definitions

Conditions	Measures	Definitions of fuzzy-set values
Appropriate chairmanship skills (ACS)	Charismatic chairman (CC)	1: The current chairman is able to effectively communicate with group members and has gained their trust to a high degree. 0.67: The chairman has gained a high degree of trust among the members but with limited communication skills. 0.33: The chairman shows his/her competence in effectively communicating with group members but must work to gain their trust. 0: The current chairman has gained a low degree of trust among the members and lacks skills to effectively communicate with them.
	Educated chairman (EdC)	1: The chairman has a university degree with a water management specialization. 0.75: The chairman has a university degree but not specialized in water. 0.5: The chairman has a secondary degree with specialization in water. 0.25: The chairman has a secondary degree with no water-related specialization. 0: The chairman completed primary education.

(Continued)

Conditions	Measures	Definitions of fuzzy-set values
	Experienced chairman (ExC)	1: The chairman had ample previous experience in irrigated agriculture and has been working in the position since the establishment of the association. 0.67: The chairman had little previous experience in the subject but has been working in the position since the establishment of the association. 0.33: The chairman had extensive previous experience in the subject but has only been working in the position since after the establishment of the association. 0: The chairman has no previous experience in the subject and is new to the association.
Sustainable Resource Appropriation (SRA)	Access to & timeliness of irrigated water (AIW)	1: Requested water amount fully received in due time during the study period. 0.67: Requested water amount was fully received but not in time, although this did not affect crop productivity. 0.33: The amount requested for the agreed season was not received but available water was provided in due time; nonetheless, this did not help for obtaining harvest as planned. 0: Requested water amount was not received, and farmers failed to deliver the quota for strategic crops.
	Dispute resolution mechanism (DRM)	1: No major disputes have emerged within the WCA territory over water allocation. 0.67: Emerging disputes are solved internally. 0.33: Emerging disputes are solved with the help of local authorities and with the support of prosecutors. 0: Frequent disputes emerge over water allocation due to the absence of a clear resolution mechanism.
Effective participatory governance (EPG)	External environment (EE)	1: Local authorities (including BISA and ISA directorates, local *khokimiyats*, or VCA officials) do not intervene in the decision-making process of irrigated water distribution. 0.5: Local authorities attempt to advise/advocate but their intentions never materialize. 0: Local authorities constantly intervening in association's internal water allocation decisions.
	Frequency of meetings (FM)	1: Meetings with WCA members about CPR status are held every day. 0.67: Meetings with WCA members about CPR status are held once a week. 0.33: Group meetings for discussing CPR issues take place once a month. 0: Group meetings for discussing CPR issues take place a few times a year.
	Participation of members in meetings (PM)	1: All members/representatives (e.g. neighbours, farm heads, relatives) attend group meetings. 0: Not all members/representatives attend group meetings.
Outcome	**Measures**	**Definitions of fuzzy-set values**
Maintained irrigation canals (MIC)	Mobilization & participation in community action (MPC)	1: Members support mobilization of community action (i.e. *khashar*) in canal maintenance and fully take part. 0.67: Despite some members not being supportive of the community action concept for canal maintenance, they fully take part in this voluntary unpaid work nonetheless. 0.33: Members support the community action concept for canal maintenance but are reluctant to actually take part in collective canal maintenance activities. 0: Members are not supportive of collective community canal maintenance and are reluctant to participate.
	Involvement of local households in community action (ILH)	1: Local households (HHs) provide their full support during canal maintenance activities. 0.67: Despite some HHs not being supportive of the community action concept for canal maintenance, they fully take part in this voluntary unpaid work nonetheless. 0.33: HHs support the community action concept for canal maintenance but are generally reluctant to take part in collective canal maintenance activities. 0: Local households never contribute to collective action for canal maintenance.

(Continued)		
Outcome	Measures	Definitions of fuzzy-set values
	Payment for delivered services (ISF)	1: Actual collection rate for the association's water delivery services during the study period was more than 50%. 0: Actual collection rate for the association's water delivery services during the study period was less than 50%.

Appendix C: Assigning membership scores for selected cases (Fuzzy data matrix)

Case	Conditions			Outcome
	ACS	SRA	EPG	MIC
WCA 1	1.00	0.67	0.33	1.00
WCA 2	0.33	0.67	0.00	0.33
WCA 3	1.00	0.67	0.67	1.00
WCA 4	0.25	0.67	0.33	1.00
WCA 5	0.67	0.00	0.00	0.00
WCA 6	1.00	0.67	1.00	0.67
WCA 7	0.75	1.00	0.00	0.67
WCA 8	0.33	0.33	0.67	0.33
WCA 9	0.25	0.67	0.00	0.33
WCA 10	1.00	1.00	0.67	0.67
WCA 11	0.00	0.33	0.00	0.33
WCA 12	0.33	0.67	0.00	0.67
WCA 13	0.67	0.33	0.67	0.33
WCA 14	0.33	1.00	0.00	0.33
WCA 15	0.33	1.00	0.33	0.33

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