Institutional analysis of irrigation management in Uzbekistan using Qualitative Comparative Analysis: Case studies of water consumers associations in Bukhara region

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Paper prepared for presentation at the Young Researchers' Forum of the International Conference- Natural Resource Use in Central Asia: Institutional Challenges and the Contribution of Capacity Building

September 30 to October 1, 2013
JLU, Giessen, Germany

Abstract

Given the fact that water consumers associations (WCAs) in Uzbekistan were established about a decade ago in a top-down fashion to maintain on-farm water facilities, using fuzzy set Qualitative Comparative Analysis tool this paper attempted at determining sets of conditions that are necessary and sufficient to achieve an outcome. The study followed the logic of abductive approach, where sets of theories were adjusted based on the empirical field stint. Institutional economics perspective was applied to identify rural farmers' behavior in the management of common pool resources (CPRs). The study took place in Bukhara region – southwestern part of Uzbekistan – and involved focus group discussions with members of fifteen WCAs using semi-structured interview format. Three sets of conditions (appropriate chairmanship skills [ACS], proper water allocation [PWA], and effective participatory governance [EPG]) were found to be important for explaining the outcome (improved maintenance of irrigation canals [IMC]). The analysis of necessary conditions indicated that neither condition ACS nor PWA nor EPG is necessary for IMC on its own. The same finding was apparent for the complements of the three conditions, ~ACS, ~PWA, ~EPG. In the meantime, the analysis of necessary conditions for unions of conditions (logical OR) revealed that the terms of PWA OR EPG (i.e. PWA+EPG) is necessary to achieve the outcome. However, their presence is not sufficient. The result for sufficiency analysis highlighted that no single condition alone is sufficient to achieve IMC. The results for combinations of conditions showed that the presence of ACS AND PWA AND EPG (i.e. ACS*PWA*EPG) is sufficient for achieving the outcome, IMC. Therefore, it is reasonable to believe that when these conditions are present simultaneously, there is a great chance of improving CPR use within WCA territories.

Keywords: Common pool resources, canal maintenance, institutional analysis, water consumers associations, qualitative comparative analysis.

1. Introduction

With the dissolution of the former Soviet Union, previous collective farming system (*kolkhozes* and *sovkhozes*) that was practiced in most former socialist countries also collapsed. Unlike some other neighboring Central Asian nations that followed Washington Consensus and quickly adopted land privatization policy, Uzbekistan has followed a cautious approach, by first sub-dividing the large collective farms into smaller family oriented cooperative farms (Noble et al., 2005). During this process, there was an ambiguity over who shall be responsible for on-farm water management, meaning water distribution among consumers, canal maintenance, and resolving potential conflicts over water allocation (Abdullaev et al., 2010). As a result, the Uzbek government faced a huge dilemma to figure out sustainable irrigation farming system and contracted Central Asian Research Institute of Irrigation (SANIIRI) to study the experience of other countries with regard to water allocation system. This is due to the fact that during 1990 and 2000, the government experienced significant downfall in providing adequate funding to invest in operation and maintenance of on-farm irrigation and drainage canals. Finally, SANIIRI completed its study in the beginning of 2000 and presented its recommendations to Uzbek government by advising to create a farmer-oriented water consumers association (WCA). As such, wide-scale establishment of WCA started in the country, mobilized by local governments and donor community. The main idea behind this reform was that WCA members would act collectively to operate and maintain their internal irrigation and drainage canals. The benefits that they would receive from this common pool resource (CPR – irrigation systems) can be shared across all members and those who do not contribute can be excluded. This theoretical idea did not materialize in practice as most of the WCAs currently experience institutional and financial constraints. WCAs have lack of autonomy and financial independence. As a result, canals are outdated and cooperation among members has diminished.

The main objective of this study is to find out appropriate conditions that can explain the improvement of canal maintenance within WCA territories. By using fuzzy set qualitative comparative analysis (fsQCA) technique, the study attempted at determining sets of conditions that are necessary and sufficient to achieve the outcome, improved

maintenance of irrigation canals.

Theoretical arguments and empirical evidences emphasize that in the context of transition, appropriate chairmanship skills is important to achieve successful management of CPRs. Therefore, the study hypothesize that current WCA chairmen have limited leadership skills to improve CPR condition. Additional hypothesize included that proper allocation of water resources within the territories of WCAs is important for members to invest into the improvement of the CPR (i.e. irrigation infrastructure) and receive benefits from it. Last but not least, effective participatory governance shall allow community members to influence in the design and implementation of everyday internal rules. Through members' participation it is possible to improve information flows about the CPR and get acquainted with members' preferences. These theoretical arguments are detailed in the next section.

2. Collective action for common pool resource use

After wide range of discourse that took place among scholars for sustainable CPR management, each set out conditions (factors) that they believed to be decisive in sustaining the CPR. These theoretical assumptions were derived from different research findings across the globe. For instance, Wade (1987) determined sets of factors - *the resources, the technology, relationship between resources and user group, user group, noticeability, relationship between users and the state group size, clear boundaries, and ease in monitoring and enforcement* – that may lead to successful management of shared natural systems.

Ostrom (1992) suggests the attributes of the resource (i.e. *feasible improvement, indicators, predictability, and spatial extern*) and of the appropriators (i.e. *salience, common understanding, low discount rate, trust and reciprocity, autonomy, and prior organizational experience and local leadership*) that can increase the likelihood that self-governing associations will form and survive for longer period. Achievement of sustainable resource use requires that one draws on cultural endowments and their knowledge of local resources to find innovative solutions that fit local conditions (*ibid*).

2.1 Leadership

There are number of examples of successful collective action in the context of CPR that is related to leadership skills of the person(s) within a community. Poteete et al. (2010) note that leadership is one the most well studied social factor, which contributes to sustained CPR regimes. Baland and Platteau (1996) synthesized number of empirically-driven literatures and asserted that good leaders are important to help people become aware of the real challenges that they confront with, mobilize users into a coordinated unit to manage the resources, and make sure that rules and enforcement mechanisms are fair. They further characterize good leader as being relatively young, literate person with vast experiences in the area of his/her expertise, and who is bounded into traditional societal structure (*ibid*.).

In fact, the very early discourse on leadership skills in the context of CPR comes from Ostrom's (1992) propositions on attributes of resources and of appropriators. She points out that when appropriators (resource users) have learned at least minimal skills of leadership through participation in other local groups, there is substantial chance that self-governing associations are formed and survived for longer period (*ibid.*).

In terms of characteristics of a leader, Meinzen-Dick et al. (2002) puts emphasize that leaders are seen to be important actor mediating the society and contributing to build trust among members. A leader should also be accountable to his/her employees, i.e. farmer groups (*ibid.*).

In her dissertation, Zavgorodnyaya (2006) studied performances of Uzbek WCAs employing collective action theory to determine factors that influence to the success or failure of WCA establishments. She concluded that when the chairman has water engineering background and connected to traditional societal structure, the success is most probable (*ibid.*). This was also confirmed by the research findings of Hamidov and Thiel (2011).

Taking into account these theoretical and empirical findings on the importance of leadership skills of WCA manager for successful collective action to govern CPR, the study hypothesized that when a WCA chairman has charismatic leadership skills, has high education background in the area of irrigated agriculture with vast experience in the irrigated farming practices, then there is a good chance to achieve successful collective action on irrigation canal maintenance.

2.2 Resource appropriation

In her paper, Ostrom (2000) further highlights the importance of benefit flows that irrigation systems provide. She emphasizes to the fact that the amount, timing, and technology used to withdraw a flow of resource units (i.e. water) is important to achieve sustainable CPR use (*ibid.*). Therefore, this study included an additional condition 'proper water allocation' that may influence to the improvement of CPR status.

In fact, Ostrom (1992) asserts that appropriation (water allocation) and provisions of resources (irrigation infrastructure) are intertwined. In this research, we concentrate on the provision issue as an action situation looking at this little nature-related puzzle acknowledging that it goes with an overall picture of water appropriation. In the meantime, appropriation issue is mapped as an exogenous (explanatory) factor to explain canal maintenance outcome. The issue of water allocation requires broader action arena where farm-level water allocation maybe influenced by the certain political decisions at the national and international levels, by climate change discourse, and involves various actors in the decision-making process. By contrast, the study believes that when this small piece of problem heals, i.e. infrastructure provision, it may improve general water allocation problem.

Theesfeld (2009) investigated the potential forms of collective action among Bulgarian villagers for managing their irrigation water during the process of transition. Her findings included that chaotic water appropriation rules associated with unreliable irrigation water allocation left little room for successful cooperation. She found that the absence of monitoring system for water appropriation increased transaction cost of guarding farmers' fields around the clock (Theesfeld, 2009: 18).

In addition, Abdullaev et al. (2010) studied collective action in the irrigation sector in Central Asia. They highlight the importance of water appropriation issue in the area due to the emergence of hundreds of individual farmers who cultivate different irrigation intensive crops. As a result, this situation has increased problems with water allocation particularly, during water scarcity season. There are cases where frequent clashes between appropriators are apparent (Abdullaev et al., 2010: 1035).

2.3 Theory on participatory governance

Additional condition that influences the action situation in the context of transition is active involvement of resource users in the decision-making process to manage and maintain CPRs, which was mainly empirically-driven contribution. The concept of participatory governance has actively been pursued by various donor agencies in developing countries to promote citizen participation and to involve them in public decisions (Speer, 2012: 2379). Anderson and van Laerhoven (2007: 1090) point out that participatory governance is defined as institutional arrangements that facilitate the participations of ordinary citizens in the public policy process. In this research, we use the term of participatory governance to provide an explanation of WCA members' participation during the decision making process on canal maintenance activities. Speer (2012: 2381) notes that explanatory factor for effective participatory governance includes allowing community members to influence the design and implementation of everyday rules. Through members' participation it is possible to improve information flows about the CPR status and get acquainted with members' preferences.

3. Methodological approach

The sequence of empirical process in this research follows the logic of abduction approach. The researcher, equipped with the theoretical tool of Collective Action, conducted the empirical investigation to identify conditions that influence cooperation among WCA members in managing the CPR, with particular focus on issues related to infrastructure provision. Additional theories that were applied during the empirical process included Shared Mental Models and the theory of Transition Economics. These combined theories provided some explanations about the research problem but did not provide full picture of the process. It was observed during the empirical field visits that some form of participatory governance together with the importance of water allocation were additional important conditions that afore-mentioned theories did not prevail. As a result, the observed phenomenon was able to explain with additional conditions, which led to an expansion or modification of the existing theories (Schlueter and Koch, 2011:385). This process is called an abductive approach to research (Reichertz, 2011).

In order to conduct qualitative interviews with WCA members, the field visit took place during 2011-2013. The study areas are located in *Vobkent, Romitan, Peshku, Shofirkon,* and *Gijduvon* districts of Bukhara region, southwestern part of Uzbekistan, in the lower reaches of Amudarya River, which is the major water source for all water sectors in Bukhara (Figure 1). The region covers an area of about 42,000 km^2 and approximately 400 km south of the remainders of the Aral Sea. Total irrigated area of the region is accounted at 275.1 thousand ha. Total population is about 1.4 million, of which about 60% live in rural areas and depend on irrigated agriculture. The region consists of 11 districts plus the city of Bukhara as an administrative center.

Bukhara is characterized with diverse ethnic population, frequent water shortage, severely salinised soil and groundwater, high waterlogging, and geographical proximity to the Aral Sea. The region has typical arid continental climate with cold dry winters and very hot summers. For instance, during summer period the temperature goes as high as $+47^0$C (e.g. observed in July, 2005) and during winter as low as -29^0C (e.g. noted in January, 2008). In some instances, due to the freezing of lower-layers of soil horizons, which happened in 1969, 1976, 1984 and 2008 years, it caused difficulties in conducting agro-technological activities in due time, which delayed starting of vegetation season (Jurayev and Khamidov, 2012). Annual precipitation in the region is determined at 120-140 mm, which falls mostly outside of growing season in autumn-winter period. Local potential evapotranspiration is about 2000 mm/year greatly exceeds precipitation. Thus, large scale irrigation for cultivated crops is essential to this area.

3.1 Case selection steps

Five steps were followed to figure out appropriate cases for this research and selected based on the following criteria: In the first step, the total number of WCAs functioning in Bukhara Region of Uzbekistan was obtained from the Amu-Bukhara Basin Irrigation System Authority (BISA), which consisted of 124 cases. Using the most similar cases design approach, two irrigation system authorities (ISAs) subordinated by the Amu-Bukhara BISA were randomly selected which share geographic borders with each other (*Kharkhur-Duoba* and *Toshrabod-Jilvon*) as well as share relatively similar climatic

characteristics. The interaction between ISAs and WCAs were also included in the selection criteria that may also influence the outcome. With this, we reduced the number of WCAs for 63 representing five districts of Bukhara. In the next step, we selected 45 WCAs that varied in their outcomes to ensure that cases with good and badly maintained irrigation systems are included. Since it is difficult to obtain such evaluation reports for individual WCAs, as the best indicator we relied on the fact of collection rate for irrigation services. In the fourth step, we eliminated WCAs that strongly differed from other WCAs in key characteristics (size of resource, number of members, and date of establishment). Thus, we left with only 26 WCAs in the selection that share similar characteristics that might affect the outcome. In the final step, we selected fifteen cases that included WCAs from each five districts that may serve as representatives for the entire Bukhara region. The list of selected cases is given in Appendix 1.

3.2 Empirical methods

The empirical work was based on the qualitative interviews. A semi-structured interview format was developed for conducting qualitative study. Selected WCAs were invited for focus group discussions (FGDs), a method used as part of the group interview. The unit of analysis of this study is the water consumers association, i.e. a group of farmers' legal organization. Since the main empirical data collection phase came to the fall season, where farmers were busy with cotton harvesting, in addition to FGDs the study conducted an in-depth interview with individual WCA members. During the selection of participants (i.e. WCA members), the following basic criteria was respected: i) the average number of participants in the group was between 4 and 6; ii) a moderator had an assistant for recording the discussions and keeping notes; and, iii) the group was relatively homogenous (age, education, profession).

Selection of participants was done prior to the field visit based on the secondary data received from Amu-Bukhara BISA. Apart from the above-mentioned criteria, representativeness of WCA members for the entire WCA operational area was also considered. As such, WCA chairmen was contacted by the researchers and requested to gather selected members into a WCA office for FGDs. In addition to WCA members, a separate individual expert interview was carried out with each WCA chairman to

acquaint with achievements and potential constraints for WCA success.

Audio recording was used to record interviews when respondents agreed. All recorded interviews and discussions were then transcribed, and similar to the field notes, entered in to a computer. Using fsQCA software, the researcher carried out qualitative data analysis.

It is important to note that the absence of access to quantitative data that was difficult to obtain from the Statistical Committee, and lack of resources and accessibility to carry out widespread survey with resource users prevented using quantitative data analysis (such as efficiency analysis using stochastic frontier, data envelop analysis, and distant function approaches). QCA may provide alternative analysis options when collection of such intensive and trustworthy quantitative data is not possible. Furthermore, QCA allows the impact of different institutional aspects on decision making where quantitative analysis has limitations. However, conclusions of the study could be compared with such quantitative approach when data becomes available, which may be considered as further research direction in the future.

3.3 Analytical tools for data analysis - fuzzy set QCA

Qualitative comparative analysis (QCA) method was used in order to compare the cases and determine necessary and sufficient conditions to achieve the high levels of canal maintenance within WCA territories in Bukhara region. QCA is a methodological tool, which was introduced by the American social scientist Charles Ragin in late 1980th (Wagemann and Schneider, 2010). It is a research approach and analytical tool that provides the possibility to compare intermediate number of cases and to examine conditions that are necessary and sufficient for a given outcome. This analytical technique offers the opportunity to better understand different cases and to capture accurately the characteristics of cases. QCA has been well-accepted by many social scientists since it builds upon certain theories to provide local explanations or interpretations of individual cases.

In this study, we believe that QCA is a useful instrument in the context of WCA comparisons in order to identify combinations of conditions for better maintenance. In particular, this study uses fsQCA as it provides different elements that can have differing degrees of membership in sets (Wagemann and Schneider, 2010). These degrees vary

between 0 (fully out) and 1 (fully in). This is the latest version of QCA developed by Ragin in response to much criticism for his initial crisp-set QCA (csQCA).

A crisp-set is Ragin's early developed tool that takes into account dichotomy, i.e. either fully in in the membership set or fully out. In political science sphere, there were many comparative cases on democratic membership of a country. When using the csQCA, the researcher selects conditions and outcomes either present or absent. However, the degree of vary in conditions and outcomes are not included in csQCA.

Recall that fsQCA was developed to overcome the issue of complexity in the real world. Wagemann and Schneider (2010) note the importance of fsQCA since its flexibility enables social scientists to make qualitative differences among membership sets.

3.3.1 Conditions and outcome

Prior to field visit this study had developed a list of independent variables (in QCA language, conditions) that may be necessary/sufficient to achieve the outcome. Accordingly, preliminary measures had been developed to test in the field condition. Schneider and Wagemann (2010) informed that the selection and definition of conditions and an outcome is subject to changes based on the preliminary findings throughout the research process. Therefore, new sets of conditions and measures have been developed after the extensive interviews with resource users. In the meantime, fuzzy set values (or membership scores) were assigned for each measure reflecting the degree of qualitative difference (Table 1).

Table 1: List of conditions and outcome with fuzzy-set value definitions

Conditions	Measures	Definitions of fuzzy-set values
Appropriate chairmanship skills (ACS)	Charismatic chairman	1: The chairman is able to communicate effectively with WCA members and gained their trusts
		0.5: The chairman has been appointed by external actors and WCA members respect him
		0: The chairman has gained no trust among the members and has no skills to effectively communicate with WCA members
	Educated chairman	1: The chairman had water management specialization with university degree

		0.75: The chairman had university degree but not specialized on water
		0.5: The chairman had a secondary degree with specialization on water/agriculture
		0.25: The chairman had a secondary degree with no water/ agriculture related
		0: The chairman completed primary education
	Experienced chairman	1: The chairman has vast experience in the area and is working since *kolkhoz* period
		0.67: The chairman has been working in the area since WCA establishment
		0.33: WCA chairmen have been changed frequently and the current one is the latest with little experience
		0: The chairman is new with no previous experience
Proper water allocation (PWA)	Access to irrigation water	1: Requested water amount fully received in due time during the study period
		0.5: Requested water amount was not received but it did not affect crop productivity
		0: Requested water was not received and farmers failed to fulfill the quota for strategic crops
	Dispute resolution mechanism	1: No major disputes within WCA territory over water allocation
		0.75: Emerged disputes are solved internally without any external interventions
		0.5: Emerged disputes are solved with the help of local authorities
		0.25: Courts are involved in solving/reviewing disputed situations
		0: Frequent disputes over water allocation are apparent and no clear mechanism exists
	External environment	1: Local authorities (such as: BISA and ISA directorates, local *khokimiyats*, or VCA officials) do not intervene in the decision-making process of irrigation water distribution at WCA-level
		0.5: External actors attempt at advising/advocating but their intentions never materialize

		0: Local authorities constantly interfere with WCA's internal water allocation decisions
Effective participatory water governance (EPG)	Frequency of meetings	1: Meetings with WCA members over CPR are held every day
		0.75: Meetings with WCA members over CPR are held once a week
		0.50: Group meetings for discussing CPR issues take place once a month
		0.25: Group meetings for discussing CPR issues take place few times a year
		0: No meetings happen at the WCA
	Participation of group members	1: All members attend frequent/regular meetings
		0.67: When members are unable to attend the meetings, they send their representatives
		0.33: Not all members/representatives are present during the meetings
		0: Very few members attend the meeting

Outcome	Measures	Definitions of fuzzy-set values
Improved maintenance of irrigation canals (IMC)	Nature-related transaction	1: Un-maintained canals have no major implications to other neighboring associations
		0: Un-maintained canals have negative externalities to other associations
	Engagement of external authorities	1: Local authorities do not intervene in WCA's canal maintenance activities
		0.5: Local authorities attempt at advising/advocating canal maintenance activities but their intentions never materialize
		0: Local authorities interfere with WCA's decision-making process on canal maintenance
	Mobilization of social activities	1: Members support mobilization of social activities (e.g. *khashars*) in canal maintenance and fully take part

		0.5: Not all WCA members are active in canal maintenance
		0: Members are reluctant to support and take part in collective canal maintenance activities
	Role of households	1: Local households provide their full support during canal maintenance activities
		0.5: Not all households are active in canal maintenance
		0: Local households do not provide full support during canal maintenance

3.3.2 Calibration of fuzzy sets

In fuzzy-set QCA, it is important that membership scores are assigned for the investigated cases (Schneider and Wagemann, 2010: 403). These membership scores are generated through calibration of sets (*ibid*.). During this process, a list of qualitative anchor points for each fuzzy set shall be developed to clarify how to distinguish a case that is more in than out in the membership score set (Ragin, 2000; Basurto and Speer, 2012). Three main thresholds in fuzzy set indicate the anchor points: 0 (full non-membership), 0.5 (cross-over point), and 1 (full membership). Theoretical arguments are required to determine whether the observed empirical evidences qualify for set membership scores above or below these anchor points (Schneider and Wagemann, 2010: 403). Since the calibration is crucial to fuzzy-set QCA, the researcher should be transparent, open, and replicable during the process of assigning membership scores (Ragin, 2006: 298).

The anchor points in this study were developed based on the theoretical considerations derived from Collective Action theory as well as empirical evidences supported by theoretical arguments of resource appropriation and participatory governance. This study followed Basurto and Speer (2012) technique to transform quantitative and qualitative data into membership scores. Accordingly, their technique of data calibration was employed, which includes the application of content analysis to the data in accordance with the series of criteria that are derived from both theory and case knowledge. Appendix 2 provides the list of conditions and the outcome with the final set membership scores.

4. Discussion of results

Once data matrix was developed for the study, fsQCA software was employed to run the analysis for determining necessary and sufficient conditions to achieve the high levels of outcome. Schneider and Wagemann (2010) inform researchers to carry out the analysis of necessary conditions first. The analysis of necessary conditions in fsQCA looks at which individual factors may be necessary for the outcome to take place (Kent, 2008). In an XY plot, all cases with high proportion of necessary conditions should be located around or below the bisecting line (*ibid.*).

The analysis of necessary conditions to achieve improved maintenance of irrigation canals within the territories of WCAs indicated that none of the three conditions alone, i.e. neither condition ACS nor PWA nor EPG is necessary for the outcome IMC on its own. The same finding was apparent for the complements of the three conditions, ~ACS, ~PWA, ~EPG. In this study, we use consistency score 0.90 as a threshold for accepting a condition to be necessary (Emmenegger, 2010: 12). As can be seen in Table 2, all consistency scores are below our threshold. Consistency and coverage were calculated using the fsQCA software (Rihoux and Ragin, 2009). According to Ragin (2006: 291), consistency assesses the degree to which the cases sharing a given condition agree in displaying the outcome under investigation. With another word, consistency indicates how closely the subset relation of cases is approximated. In the meantime, coverage assesses the empirical relevance or importance of a consistent subset (*ibid.*).

Table 2: Analysis of necessary conditions

Conditions tested	**Consistency**	**Coverage**
Appropriate Chairmanship Skills (ACS)	0.823	0.724
~ Appropriate Chairmanship Skills (~ACS)	0.593	0.627
Proper Water Allocation (PWA)	0.841	0.770
~ Proper Water Allocation (~PWA)	0.558	0.564
Effective Participatory Water Governance (EPG)	0.651	0.814

~ Effective Participatory Water Governance (~EPG)	0.779	0.607
Proper Water Allocation OR Effective Participatory Water Governance (PWA+EPG)	**0.904**	**0.730**
The tilde sign (~) refers to the negation of a condition (or absence)		

The analysis of necessary conditions can also be executed for unions of conditions (i.e. logical OR). Schneider and Wagemann (2007: 59) reiterate that good theoretical arguments are needed for combining the conditions. This procedure is called *functional equivalence* in QCA term. Therefore, we performed additional analysis to determine whether unions of conditions may be necessary to achieve improved maintenance of irrigation canals within WCA territories. The result shows that the term of PWA OR EPG (i.e. PWA + EPG) is necessary to achieve the outcome, meaning that PWA+EPG is a superset of IMC. At this combination, consistency score shows 0.904 with significantly high coverage. However, the presence of PWA OR EPG is not sufficient for attaining the presence of outcome.

In accordance with the result, one can summarize that the presence of proper water allocation or effective water participatory governance, or both is a necessary condition for having improved canal maintenance, but it may not be a sufficient condition. This finding corroborates our theoretical expectations that improved canal maintenance can not necessarily be attained with the presence of a single condition. Since the phenomenon under study is complex to explain, the result is also derived from causal complexity.

Graphical representation of the relationship of the necessary analysis is shown in Figure 2 below. As can be seen from this figure, most cases are around or even on the bisecting line. Recall, for necessity, each case's fuzzy membership score in A must be equal or greater than its fuzzy membership in outcome Y (i.e. $A \geq Y$). With another word, in XY plot, most cases shall be around or below the diagonal line. As we can see from Figure 2, most cases are indeed, around or below the diagonal line.

At the same time, however, there are few cases that are above the bisecting line. This means that while the presence of proper water allocation, effective participatory

governance, or both is a necessary condition for the outcome to take place, their presence is not sufficient. The clear contradicting the argument necessity is WCA 9 (*K.Murtazaev*). Ragin (2000) suggests that when such cases appear, the researcher may reflect this as the condition that is 'usually' necessary for the outcome. He further reiterates that in such instances, it is important to provide appropriate theoretical and substantive argumentation and auxiliary evidence. In the case of *K.Murtazaev* WCA, despite having a low fuzzy membership score in PWA or EPG, fuzzy membership score in the outcome of this case was significantly higher. As can be seen from data matrix in Appendix 2, the fuzzy membership score for a condition PWA was set at 0.34 and a score for a condition EPG at 0.00. Nevertheless, the outcome was set at 0.70. When we closely consulted with the case, it was obvious that despite frequent cut-off water resources for members and the absence of effective participatory governance, the WCA was able to improve its canal condition. Local households were effectively supporting canal maintenance. Since WCA was located in the desert zone with difficulty to access to water resources and was rather considered as a downstream of a water course, un-maintained canals did not have major implications to neighboring WCAs or other actors situated in the adjacent area.

The result for sufficiency analysis highlighted that no single condition alone is sufficient to achieve improved maintenance of irrigation canals within the territories of WCAs. Since the analysis of the presence as well as the absence (~) of individual conditions for sufficiency to achieve the outcome did not answer the question, we then turned to the investigation of the combinations of conditions (logical AND). The results pointed out that the presence of ACS AND PWA AND EPG (i.e. ACS*PWA*EPG) is sufficient for achieving the outcome, meaning that ACS*PWA*EPG is a subset of IMC (Table 3). The consistency score shows 0.916 and the coverage value is 0.575, which are high and satisfying, respectively. This means that simultaneous occurrence of appropriate chairmanship skills and proper water allocation and effective participatory governance is sufficient for improved maintenance of irrigation canals. This finding corroborates our theoretical expectations, where improved canal maintenance can happen in the presence of several conditions. Therefore, it is reasonable to believe that when these conditions

are present simultaneously, there is a great chance of improving CPR use within WCA territories. Truth table result is provided in Appendix 3.

Table 3. Sufficiency analysis

Solution	ACS*PWA*EPG	→	IMC
Single WCA coverage	WCA 3, WCA 6, WCA 10		
Consistency:	0.916		
Raw coverage:	0.575		
Unique coverage:	0.575		

The results of the sufficiency analysis are graphically displayed in Figure 3. Note that for a condition or a combination of conditions to be sufficient, all cases should be located around or above the bisecting line (i.e. $A \leq Y$). In another word, a case's score on the outcome should not be lower than the level set by its score on relevant sufficient conditions. Recall, the contrast here with necessity. In this figure, we may note that most cases are around or even on the bisecting line. As was the instance with the necessity analysis, there was only one case but different – WCA 15 (*Khavzak Guliston Jilosi*) – clearly below the bisecting line, which contradicts the argument of sufficiency. The case of WCA 6 (*Kumrabot Chrotuk Suvi*) is rather close to the bisecting line that supports sufficiency condition. Ragin (2000: 114) reaffirms that it is usually difficult to find perfect subset relations for fuzzy sets than for crisp sets. This means that some more flexibility is needed and perfect sufficiency cannot be the only goal of such an analysis (*ibid.*).

As for the WCA 15 case, the higher membership scores in all explanatory conditions in comparison to the membership score on the outcome did not produce positive outcome. In fact, the result showed that despite the fact of having high level of chairmanship skills of the WCA manager together with proper water allocation mechanism but the absence of effective participatory governance does not lead to improved canal maintenance.

When we looked at the case more closely, it was confirmed that WCA chairman has been working as the manager since its establishment – January 2007 – and had worked during the *kolkhoz* period as the main hydro-technician, but still, these characteristics did not help enforcing collective action among members to manage common pool resources in an effective way. Furthermore, proper water allocation for agricultural crops during the full vegetation season did neither improve nor lead to the positive outcome. During the discussion with resource users and personal observation, it was obvious that irrigation canals were in poor conditions. This is because WCA canals pass by many households who use water to irrigate their backyards but refuse participating in canal maintenance. There is no legal back-up to charge households and the WCA was incapable of addressing this constraint.

Overall, the results indicate that improved maintenance of irrigation canals is expected when high levels of three conditions are combined, i.e. appropriate chairmanship skills (ACS), proper water allocation (PWA) and effective participatory water governance (EPG). This is not a surprising finding as the theoretical arguments also highlight the importance of appropriate chairmanship skills, proper water allocation, and participatory governance that induce group of farmers to maintain their commonly owned canals in an effective manner. Through the analysis it was possible to prove that single condition alone is not sufficient but rather multiple conditions are involved in the management of CPRs. The combination of an appropriate chairman with charismatic leadership skills, high technocratic education and vast experience in the area, together with proper water allocation (uninterrupted access to irrigation water, clear dispute resolution mechanism over water allocation, and effective external environment) and effective participatory water governance (frequent WCA member meetings and full participation of the members) seem to motivate local resource users to effectively invest both financial and labor resources into canal maintenance. Combinations of these three conditions are found to be sufficient to ensure that group of farmers act collectively and achieve improved maintenance of canals.

According to the sufficiency analysis, WCA 3 (*Khalach Kalti*) had higher levels of canal maintenance in comparison to other neighboring WCAs. During the FGD, it was

noted that this WCA had 2073 hectare of irrigated land, of which 52% were devoted to cotton production and about 30% for cultivating wheat. According to the chairman, the WCA decided to charge ISFs per hectare basis. The total amount of expected costs to distribute water to individual farm's territories was divided into the total hectare that WCA serves. Since it was yet to install individual metering for each farm, the decision was made per hectare basis and amounted at UZS 25,000 per hectare. It is important to note that about 50 percent of the members use lift irrigation. Electricity costs are thus an additional burden to farmers. Most WCAs that use pumps have huge debts from electricity companies. In order to overcome these challenges, the general assembly of the WCA decided to calculate the whole expenses for the entire year including potential electricity costs and costs associated with pump maintenance. These costs were equally divided into all members. As a result, the amount charged for ISF reflects the costs for water distribution, electricity cost, and maintenance of pumps.

The initial hypothesis that derived from the theory included that the skills of a chairman is essential to improve the management of a CPR. In accordance with the *Khalach Kalti* WCA's formal papers, the WCA employed five workers: a chairman, a chief accountant, an agricultural machinery driver, and two *mirabs* (irrigators). In fact, the researcher was informed that the chairman was aware of water skills and did not employ *mirabs*. All activities related to water allocation within the territory was carried out by the chairman per se. The chairman was elected by the members during the WCA general assembly and has served since *kolkhoz* period. He was a head of *kolkhoz* during the socialism as well as the chairman during the post-*kolkhoz* period. The chairman acquired vast experience through working in the area and was 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 water scarcity.

Additional advantage of the chairman included that he was a farmer and the member of the WCA, simultaneously. Therefore, he was less dependent on the members' ISF contribution as a salary. This was the case with the accountant as well who was a part-time employer at the WCA and was a farmer with about 100 ha of irrigated land. The priority of the WCA was to collect ISF contributions to mainly pay-off electricity costs

and maintain irrigation facilities (including pumps). The salary was the least concern for both. Due to his own farm profits, the chairman was able to purchase a private car to monitor fields during the vegetation period for water allocation and organize collective action for maintaining irrigation facilities.

Despite the fact that the chairman was able to solve issues related to water allocation to his members, he was less optimistic about his future position. During the discussion, it was obvious that he was less enthusiastic to continue his job as he felt incompetence in water engineering. He obtained high degree with Agronomy specialization. Since he is not from water background, he seems to lack theoretical and empirical skills in water distribution and measurement. There were incidents when he was unable to verify the amount of water flowing to each member's field.

Another example that fulfilled sufficiency condition includes WCA 6 – *Kumrabot Chortuk Suvi.* This WCA is rather controversial case, where high levels of ACS, PWA, and EPG did not lead to the high levels of IMC (see Figure 3) but it was sufficiently adequate to achieve the outcome. Most interviewed WCA members reiterated that water delivery for farm gates have been sufficient and the chairman using his technocratic skills was able to establish a discipline among water consumers. The chairman had high degree from Irrigation University with the background of hydro-engineer. Using farmers' ISFs contributions, the chairman was able to install water metering to each member's gate and provided water according to the agreed amount. In the beginning of each vegetation period, it was noted that 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 in case consumers break measurement devices. He has been in this position since end-2006. Note that this WCA was established in April 2006.

Members of the *Kumrabot Chortuk Suvi* WCA reaffirmed that frequent meetings are held in the WCA to discuss issues related to maintenance, water availability, and ISF contributions. Most members seem to attend these meetings and raise the questions related to maintenance activities and water disturbances by external actors (such as local households). All consumers agreed that collective action is important to conserve water resources and improve crop productivity. The chairman was accepted by the group of

members as a competent leader to overcome various water-related challenges. There were some incidents that farmers attempted at free-riding and utilizing water without any payments for its service. However, the chairman was able to solve the issue, despite involving external actors, i.e. local prosecutors. At the end, the chairman was able to win the debate.

Last but not least, WCA 10 – *Labirut dehkonlari* – was also found as the positive case in our research. The head of the association graduated from Irrigation University with water engineering specialty. He has been as the head since its establishment. It is important to highlight that the head understands water issues very well and established a discipline among resource users. The WCA has 1138 ha total irrigated area and about 13 farmers are members of the association. According to the chief-accountant, ISF collection rate is also relatively high but most members contribute as an in-kind (e.g. hays, cotton stems, and wheat) because the state does not provide cash for strategic crops (cotton and wheat) in due time. According to the members, once a year General Assembly approves the chairman's candidacy and he continues his position. As of 2012, there were no major complaints about the chairman by the members. As for the access to irrigation water, in 2012 farmers received up to 6 times to irrigate cotton. This is a very good considering that in water shortage period, maximum 4 times of irrigation was allowed. When water is required to a farmer's field, he/she submits application to the WCA about 5 days prior to irrigation. Farmers believe that WCA is an important agency to take over water-related responsibilities. Without WCA, transaction cost of dealing with the state on water issues would have been extremely high. Members also noted that the WCA organizes meetings very often and the chairman seems to deal with external actors quite competently. If external actors intervene to WCA's decision-making process, the chairman would interfere and if distracting suggestions, oppose against their statements.

It is interesting to note that the result also provides some interesting regularities and crucial differences. Recall, despite higher levels of chairmanship skills and proper water allocation mechanisms, alone they are not sufficient conditions, as can be seen from WCA 15 (*Khavzak Guliston Jilosi*). Despite higher levels of ACS and PWA, this particular association has lower level of canal maintenance. The same phenomenon was found with WCA 1 (*Shohruhdaryo Sohili*), where the presence of appropriate

chairmanship skills of the manager and proper water allocation did not prevail to attain improved canal maintenance. The chairman has been in the position since February 2009 who had worked as an 'irrigator' in the area during the *kolkhoz* and follow-up *shirkat* eras. In fact, during the discussion it was clear that the reason why current head did not become the president of WCA at first was due to the family reason. He seemed to be involved in his daughter's medical check-ups. According to the members' statements, the chairman had a strict and nasty discussion with farmers from the beginning. He informed the members that he would do utmost to bring water to the territories of individual members and in return, farmers shall contribute towards ISF payments as well as canal maintenance activities. Otherwise, access to adequate amount of water would be cut-off. In the instance where WCA is unable to deliver water in due time with required amount, the WCA chairman accepted any penalties. As a result, mutual agreement with full of promises were agreed between the users and the WCA. The chairman and the members pointed to the fact that all parties have been fulfilling their promises. Unfortunately, the chairman as well as the members admitted that irrigation canals were in a poor state of the art. This is mainly due to the fact that WCA lacks agricultural machinery (i.e. excavator) to organize constant canal maintenance. On top of that, irrigation canals go through local households' backyards, where effective canal maintenance is difficult to organize. There were no appropriate mechanisms yet to involve vast number of local households into canal maintenance.

Another interesting and worth for exploration finding included that the presence of both proper water allocation and effective participatory governance simultaneously, do not lead to the presence of outcome either. This was the instance with WCA 13 – *Gishti Kavali Mirishkori* – where, the chairman with relatively low profile in regards to experience and education but assuring proper water allocation and having effective participatory governance within the WCA still could not support addressing the issue of canal maintenance. Focus group discussion with resource users indicated that irrigation canals were designed inappropriately, where WCA irrigated lands are located in a higher areas making water conveyance quite challenging. In short term, the WCA is able to solve but members seek long-term solution requiring huge investments for digging and reconstructing canals out of concrete. Additionally, maintenance seems to be very

difficult due to the reluctance of local households to involve in canal maintenance. Since the irrigated area is located in a densely populated zone, the negotiation with local households over canal maintenance or canal construction had been challenging. WCA members reiterated that the association has no capacity to invest into large-scale canal construction or maintenance. WCA seem to be very incompetent to deal with such issues.

5. Conclusions

This study employed a fuzzy set QCA analytical tool to compare number of WCA cases to determine sets of conditions to explain the outcome 'improved maintenance of irrigation canals'. Collective action theory along with the concept of resource appropriation and the theory of participatory governance were employed to identify potential sets of conditions that may affect the use of common pool resources. However, there are limited literatures out there exploring the combination of conditions, as was used in this paper. Furthermore, sufficient/necessary conditions to attain the CPR use have also been less explored by scholars in the area of institutional economics.

Based on this analysis, we may summarize that in the context of Uzbek water consumers associations, none of the three conditions - developed in accordance with theoretical and empirical knowledge - alone is necessary to achieve improved maintenance of canals. The results indicate that the presence of proper water allocation or effective water participatory governance, or both is a necessary condition to expect a high level of canal maintenance within investigated WCA territories. However, their presence is not sufficient.

In the meantime, the analysis of sufficient conditions point out that improved maintenance of irrigation canals is expected when high levels of three conditions are combined, i.e. appropriate chairmanship skills, proper water allocation and effective participatory water governance, the outcome showed relatively high consistency score. Thus, it is reasonable to conclude that improved maintenance of irrigation canals is expected when all three conditions are present, simultaneously.

Acknowledgements

Theoretical background was developed at the Division of Resource Economics, Humboldt-Universität zu (HU) Berlin. Financial assistance for the stay at HU Berlin was provided by the European Commission's Erasmus Mundus External Cooperation Window lot-8 scholarship program. Special gratitude goes to the coordinator of this program – Mr. Matthias Parske – for his kind support. An empirical field visit to fifteen WCAs in Bukhara region of Uzbekistan was supported by the Foundation fiat panis. Thus, the authors' sincere thanks go to the Foundation Committee.

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Appendix 1: List of selected cases in Bukhara region

WCA Name	Case	District
Shohruhdaryo Sohili	WCA 1	Vobkent
Komil Zilol Suvi	WCA 2	
Khalach-Kalti	WCA 3	
Utabek	WCA 4	Romitan
Kokishtuvon Suv Yullari	WCA 5	
Kumrabot Chortuk Suvi	WCA 6	
Omon Kudrat	WCA 7	Peshku
Zandani-Zilol Suvi	WCA 8	
K Murtazaev	WCA 9	Shofirkon
Labirut Dehkonlari	WCA 10	
Karvonboshi Tezguzaro	WCA 11	
Sarmjon Mirishkori	WCA 12	Gijduvon
Gishti Kavali Mirishkori	WCA 13	
Govshun Mazragan Sahovati	WCA 14	
Khavzak Guliston Jilosi	WCA 15	

Appendix 2: Assigning membership scores for selected cases

Case	Conditions	Outcome		
	ACS	PWA	EPG	IMC
WCA 1	0.87	0.67	0.46	0.75
WCA 2	0.27	0.10	0.30	0.30
WCA 3	0.93	0.83	0.59	1.00
WCA 4	0.40	0.67	0.25	0.75
WCA 5	0.67	0.00	0.13	0.00
WCA 6	1.00	0.67	1.00	0.60
WCA 7	0.43	0.75	0.30	0.60
WCA 8	0.15	0.15	0.54	0.40
WCA 9	0.40	0.34	0.00	0.70
WCA 10	0.90	0.75	0.59	0.60
WCA 11	0.25	0.34	0.30	0.30
WCA 12	0.43	0.34	0.00	0.15
WCA 13	0.40	0.60	0.54	0.45
WCA 14	0.46	1.00	0.30	0.45
WCA 15	0.63	0.67	0.46	0.15

Appendix 3: Truth table for the analysis of sufficient conditions for the outcome 'improved maintenance of irrigation canals'

ACS	PWA	EPG	Outcome	Consistency	Cases
0	0	0	0	0.646	WCA 2, WCA 9, WCA 11, WCA 12
1	**1**	**1**	**1**	**0.916**	**WCA 3, WCA 6, WCA 10**
0	1	0	0	0.867	WCA 4, WCA 7, WCA 14
1	1	0	0	0.877	WCA 1, WCA 15
0	0	1	0	0.840	WCA 8
0	1	1	0	0.881	WCA 13
1	0	0	0	0.733	WCA 5
1	0	1	0	0.898	No Cases