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Concepts and Recommendations

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Abstract

Khorezm region is located in the northwest of Uzbekistan, approximately 350 km from the current shore of the Aral Sea. It comprises a large-scale irrigation system which conveys water from the river Amudarya to agricultural land cropped mainly with cotton, wheat, and rice. Khorezm's water resources are vulnerable because they depend on upstream developments and are indispensable for rural livelihoods and state budgets. Since water scarcity is expected to increase in the future, sustainable water management is a necessity. Hence the objectives of the paper are to (1) conceptualise the distinctive features of water management in Khorezm, (2) provide an integrated analysis of water management by establishing linkages between society, technical infrastructure, and the bio-physical environment, and (3) make policy and technology recommendations for improved water management. To conceptualise water management in Khorezm, the paper distinguishes three types of practices: formal practices, strategic practices, and discursive practices. Based on these, it presents an analysis of water management on the state water management level, the water user association level, and the farmer and field level. For each level, recommendations are given. The paper concludes that elements of IWRM such as transparency, accountability, participation, and technical efficiency are relevant to improve water management in Khorezm as elsewhere. In addition, it suggests for Khorezm in particular, to create legal space for agency and innovation. Technical tools such as models acquire additional importance in this context for facilitating transparency and enabling agents across the management hierarchy to access and make use of information.

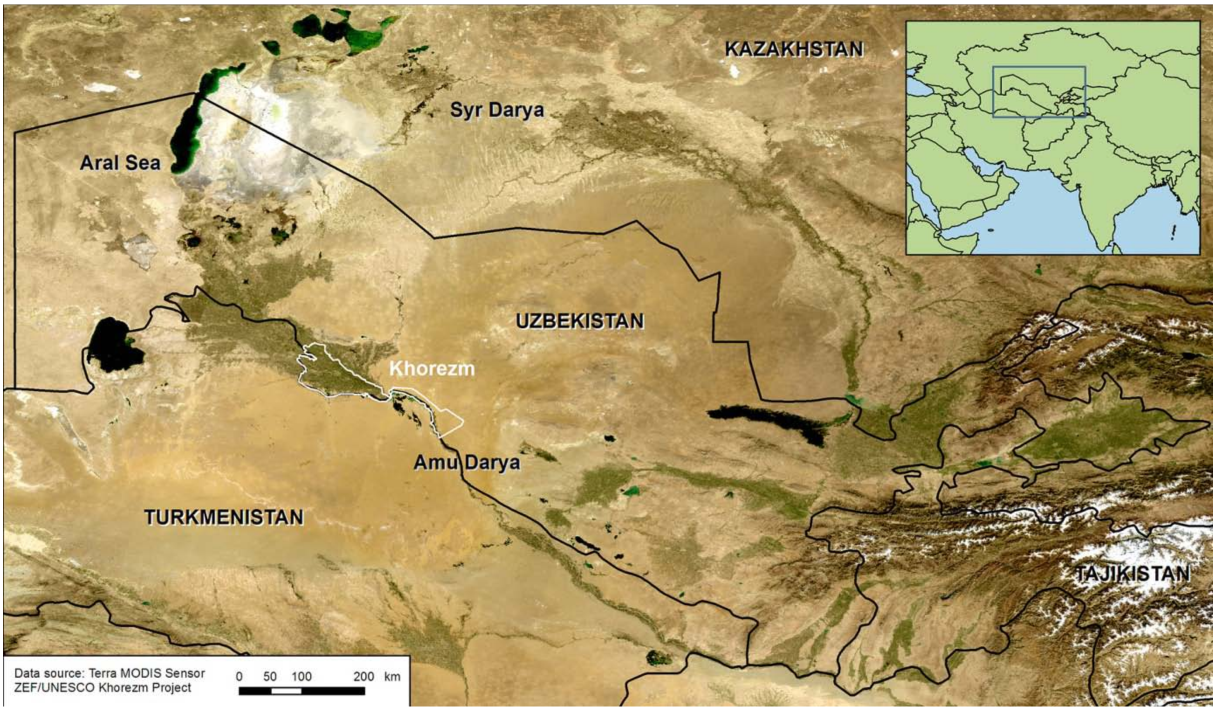
Keywords:

Irrigation water management, IWRM, interdisciplinary research, transparency, agency, participation, social construction, Uzbekistan, Central Asia

1. Introduction

The Aral Sea crisis in Central Asia is a well-known example for unsustainable use of water resources. The diversion of large quantities of water from the tributaries of the Aral Sea into the irrigation of cotton, wheat and rice has led to the desiccation of major parts of the Sea. This continues to threaten ecosystems and livelihoods, particularly in the circum-Aral region.

Figure 1: Location of Khorezm Province



The province Khorezm, located in the northwest of Uzbekistan, comprises a large-scale irrigation system that allows for intensive agricultural production (figure 1). Considering the degree to which the livelihoods of its approximately 1.5 million inhabitants depend on water for irrigation, inefficient water management and decreasing water availability pose a direct threat to the region. Efficient and sustainable water management in Khorezm is therefore a necessity. Hence the objectives of this paper are to:

(1) conceptualise the distinctive features of water management in Khorezm, i.e. the practices of the actors involved and the roles and rules that shape them,

(2) provide an integrated analysis of water management by establishing linkages between society, technical infrastructure, and the bio-physical environment, and

(3) make policy and technology recommendations for improved water management in Khorezm.

This paper is directed at water researchers from different disciplines and particularly researchers who engage in interdisciplinary water research. We are further addressing organisations and researchers who are dealing with water management in similar regions in Central Asia and who are looking for ways to improve it.

In the subsequent section we will describe key regional characteristics and conclude with a problem definition of water management in Khorezm (section 2). Section 3 will discuss the desired state of water management according to IWRM principles and present three types of practices of actors involved in water management in Khorezm. We will conclude this section by summarising our conceptual understanding of water management in Khorezm. Sections 4 to 6 will then discuss water management on different scales, namely the state water management level, the water user association level and the farmer and field level. Each of these sections contains recommendations for water management improvements.

2. Key characteristics of Khorezm and problem definition

The Amudarya is one of the two (now intermittent) tributaries of the Aral Sea. Khorezm is situated in the river's lowlands in a distance of approximately 350 km from the current shore (figure 1). It encompasses an area of 5,060 km² and was inhabited by 1,517,500 people as of 2008 (UzStat, 2009). The majority of the Khorezmian population lives in villages working in agriculture either as private farmers (fermers), peasants (dehqons), workers on private farms, or a combination of the latter two. Unemployment rates are high and about 28% of the population live below the poverty line (1 US$ per day) (Mueller, 2006). Boxes 1 and 2 summarise the key regional characteristics of the bio-physical and socio-political system.

Box 1: The bio-physical system

- Precipitation approx. 90 mm, annual average potential evapotranspiration approx. 1,500 mm, shallow groundwater levels approx. 1.2 m below ground during peak irrigation period (July) leading to secondary soil salinisation but also contributing to crop development
- Average annual temperature increase in Central Asia between 1950-2000 above the global average (Giese and Mossig, 2004), glacier-melt runoff predicted to bring gains in water availability in short or mid-term perspective, but long-term water availability expected to become lower, average annual temperature increase of 1-2°C predicted for 2010-2039 (Cruz et al., 2007), long-term evapotranspiration increases
- Medium and heavy loam soil textures prevailing, clayey light loam and sandy loam soils less widespread (Forkutsa, 2006), approx. 50% of soils moderately or strongly saline (GME, 2007 quoted in Ibrakhimov, 2004)
- Main crops: cotton, winter wheat and rice with frequent double cropping of plots to wheat (winter, spring) and rice (summer)
- Between 3.5 and 4.0 km³ of water during vegetation period and 1.0 to 1.5 km³ during winter period diverted from the Amudarya (Conrad, 2006); irrigated area in Khorezm is around 275,000 ha
- Canal system length of 16,233 km (Conrad, 2006) reaching from the Amudarya to the borders of Turkmenistan and Karakalpakistan, only 11% of the canals lined (Ibrakhimov, 2004), on local level no discharge measurement structures
- Irrigation water pumped or diverted by gravity from canals, applied as furrow irrigation for cotton and some vegetables, basin irrigation for wheat, rice, maize and sorghum
- Drainage system of 9,255 km length (open ditches and collectors) (Ibrakhimov, 2004), main collector Ozerny conveys drainage water into the desert of Turkmenistan (Sarykamish depression); drains frequently blocked by farmers to secure water availability for crops

Water reaching Khorezm from the Amudarya's catchment area in Afghanistan and Tajikistan is ample in the majority of years (Veldwisch, 2008). If efficiently used, the available amount exceeds Khorezm's crop requirements. Within Khorezm the finiteness of water resources becomes apparent mainly in the large differences between the head and the tail end areas of the irrigation system as well as during drought years such as 2000, 2001 and 2008. That very little water is allocated to the environment within or downstream of Khorezm is another characteristic of the region – the most prominent consequence being the desiccation of the Aral Sea. In the long run, water resources are predicted to become scarcer in Khorezm (Sehring and Giese, 2009; Martius et al., 2009; Giese and Sehring, 2007).

Figure 2: Trends of water supply and demand in Khorezm

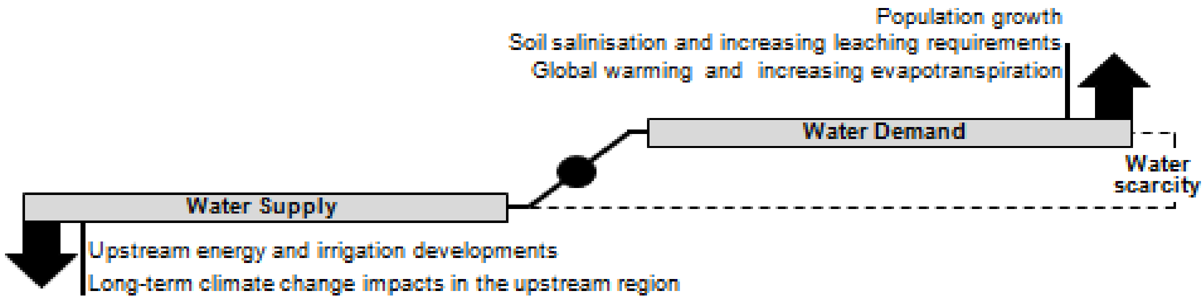


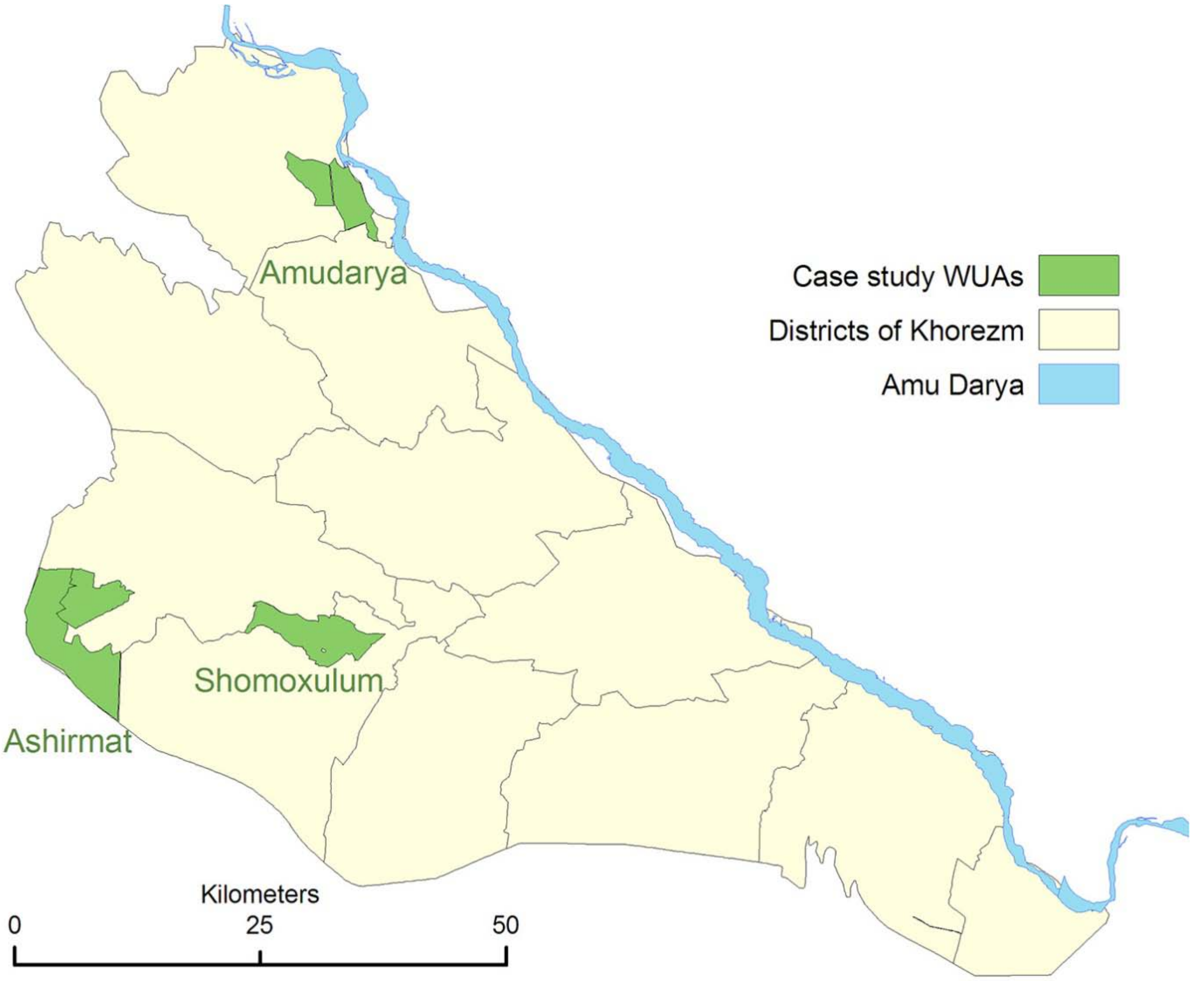
Figure 2 shows five trends which are likely to influence this process either by increasing demand or by decreasing supply. The upstream irrigation and energy developments mentioned in the figure highlight the significance of the Amudarya watershed being a trans-boundary management unit. Water allocations within the watershed as well as the operation of the Amudarya's many hydraulic structures are negotiated in fragile political processes between and within the riparian nations.

Box 2: The socio-political system

- State-centric, top-down governance approach with little public participation; accountability and transparency upwards
- Strong hierarchical organisation of society with distinction between katta (big) and kichkina (small) Uzbeks and a complex system of coercive reciprocity (Turaeva-Hoehne, 2007), limiting the individual's flexibility and risk-proclivity
- Since independence in 1991 partial transition from planned economy into market economy; market regulations with regard to agricultural production of cotton and wheat still in place (Mueller 2006)
- After independence in 1991, state farms (sovkhozes) turned into collective farms (kolkhozes), then into joint-stock companies (shirkats, literally 'associations'), in the early 2000s completely dismantled and divided into ferms (private farms) (Veldwisch, 2008).
- Ferm land (usually > 80 ha) is state property and leased to fermers in lease contracts for up to 50 years; tomorqa plots for household production (approx. 0.25 ha) are owned by dehqons (peasant farmers) and inherited
- Despite ongoing lease contracts, ferm land consolidation in 2008 with land redistribution into bigger plots and approx. ¾ of fermers losing their land
- Three forms of production: state-ordered production of cotton and wheat, state-order freed commercial production of the cash crop rice (and less vegetables, sunflower and fodder) and dehqon (peasant) production for home consumption and petty trade (Veldwisch, 2008); almost every rural household is engaged in dehqon production
- Area- and production-based yield quota for state-ordered crops; compulsory sale to the state at fixed prices; subsidised inputs; agricultural norms to regulate cropping patterns and agricultural practices, norm compliance monitored and enforced

In summary, this paper deals with a region, in which water resources are currently abundant in the majority of years, but are vulnerable because they depend on upstream developments and are indispensable for state budgets and livelihoods. Water scarcity currently only occurs with regard to temporal and spatial distribution and ecosystem demands, but will increase in the future. Water management in the region will have to cope with the changed situation. Options to ensure this and improve water management in Khorezm have to fit into the local context, which can be summed up as (1) an arid climate with global warming above average, (2) a downstream location within a trans-boundary watershed, (3) a state-centric governance system with agriculture under state-order, (4) a changing land tenure system, (5) a cropping pattern of cotton, rice and wheat, and (6) shallow groundwater levels and saline soils.

Figure 3: Location of the case study WUAs



The findings presented in the paper are based on field work in different locations within the districts Qo'shkopir, Gurlen, Xiva, and Xonka. Case studies for water management practices and institutions were three water user associations, namely Amudarya (Gurlen) at the head of the irrigation system, Shomoxulum (Xiva) in the middle, and Ashirmat (Qo'shkopir) at the tail of the irrigation system (figure 3), as well as the state water management organisation Shavat-Kulabat UIS (sub-basin organisation). Research on bio-physical and technical aspects was conducted on different field trial sites in Xiva and Xonka district and in the water user association Shomoxulum (Xiva).

3. Conceptualising water management in Khorezm

The concept of IWRM has gained wide-spread acceptance in the last decades for improving water management. The Global Water Partnership defines IWRM as "a process which promotes the co-ordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (GWP, 2000). IWRM has attracted special attention through international conferences in the 1990s, the most important being the International Conference on Water and the Environment (ICWE) in Dublin (1992) which led to the formulation of the Dublin Principles (Box 3). Basic ideas of IWRM are empowerment and participation of water users, transparency of governance and accountability of actors involved in water management, the integration of ecosystem needs and human needs, and the idea of management units based on hydrographic boundaries. The three "E"s, efficiency, equity and ecosystem vitality, are what IWRM strives for.

Box 3: IWRM – The Dublin principles

1. Water is a finite, vulnerable and essential resource which should be managed in an integrated manner
2. Water resources development and management should be based on a participatory approach, involving all relevant stakeholders
3. Women play a central role in the provision, management and safeguarding of water
4. Water has an economic value and should be recognized as an economic good, taking into account affordability and equity criteria (GWP, 2000).

Improved water management as we aim for in Khorezm is well represented by the principles and objectives of IWRM. They reflect our understanding that it is necessary to bridge the gap between sectoral management approaches as well as livelihood and conservation needs by integrating management tools with an enabling institutional setting. While we thus see IWRM as the desired process for Khorezm and the objective of the recommendations presented in the subsequent section, we do not consider IWRM sufficient as a concept to analyse water management processes and to base our recommendations on.

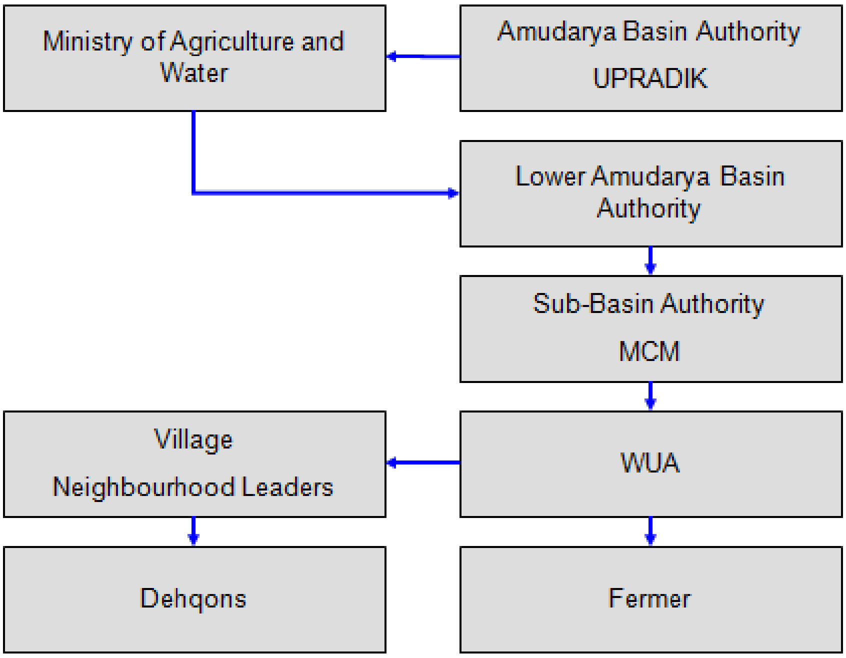
Our concerns are well represented by three groups of critics of IWRM. The first group has argued that IWRM lacks a clear and precise definition on which its implementation could be based, that it remains elusive and fuzzy (van der Zaag, 2005) and creates unnecessary misunderstandings. Thus preventing a core idea of IWRM: to bring different perspectives together (Jønch-Clausen and Fugl, 2001). A second type of argument against IWRM has been brought forth by Biswas (2004) who states that one single concept is unlikely to be applicable in different contexts, i.e. in different cultures, economies and climatic regions. The third type of criticism refers to the absence of power in the conceptual approach of IWRM. Authors such as Mollinga (2008), Allan (2006), Mehta (2005), Mosse and Sivan (2003) argue that water management is inherently political. IWRM can thus be seen as too simplistic and uninformed of the strategic practices and power struggles of different actors and agents involved in water management. In addition, our research supports Mehta (2005) in stressing that there are social construction processes taking place around water resources and their management. The IWRM concept fails to reflect this.

In light of both the normative and integrative strength of IWRM as well as the mentioned criticism, we apply two concepts in this paper. Firstly, we use IWRM as a benchmark of what we aim for in Khorezm, and secondly, develop our own conceptual understanding of water management as it takes place on the ground. We do this based on Khorezm-specific water management practices. This section therefore identifies three types of practices common in Khorezm, assesses their guiding institutions and underlying rationales and discusses their relevance as drivers or barriers of change; change here being an unquestioned part of improving water management along the lines of IWRM.

a. Formal practices

Once water is diverted from the Amudarya into Khorezm's irrigation system, a number of state organisations on different administrational levels (figure 4) are formally responsible for the allocation and delivery of water from the off-takes along the river to the entrance of the water user associations (WUAs). Allocation hereby refers to the assignment of so called water limits to different units within the irrigation network. These limits are determined through water requests based on irrigated area, planted crops and the respective irrigation state norms, which are passed on and aggregated on various organisational levels from the dehqon (peasant) and fermer (private farmer) via the WUA, UIS (sub-basin irrigation system authority) and BUIS (lower Amudarya basin irrigation system authority) to the Ministry of Agriculture and Water Resources on province level. The allocation of limits is done vice-versa from the Ministry of Agriculture downwards and water quantities are allocated among different water management units on each level (Veldwisch, 2008).

Figure 4: Water allocation through *limits*



On the level of the former kolkhozes, water allocation is formally in the hands of WUAs, which were introduced between 2000 and 2005 in Khorezm. The (donor-driven) WUA design is based on Western ideas of participation and democracy, WUAs are supposed to consist of water users (fermers and dehqons) and their elected representatives. They do not receive a state budget, but are meant to recover their costs via fee collection from water users.

b. Strategic practices

The physical delivery of water, i.e. the operation of technical structures, is done only by some of the water management organisations, mainly the Main Canal Management (MCM) units of UIS, the WUAs, and the water users themselves (Veldwisch, 2008). Formally, water delivery should match the water allocations. In reality, however, delivered water quantities depend on many factors, only one of them being the official limits. Veldwisch (2008) has shown for Khorezm that water management in averagely water abundant years reacts rather effectively to water users' demands and shows considerable flexibility. He explains this on the basis of different strategies which water users apply to get access to water outside the formal functioning of the water management organisations. Such strategic practices are a deviation from the formal rules of water management in Khorezm, reveal a strong agency of the actors involved and follow their own set of informal institutions.

One example is the use of small, mobile pumps to lift water into field canals, which is formally considered illegal theft of water, but is informally a wide-spread practice (Oberkircher and Ismailova, in prep.). At pumps which are shared between fermers and sometimes dehqons, pump management is a negotiation process in which social relations play a large role for determining the rules of water use. Using social relations strategically becomes even more important when actors aim to influence decisions on water delivery. Oberkircher and Ismailova argue that the pursuit of individual (water) interests as a social activity derives its legitimisation from the role of an individual within a network of patron-client relationships. It is accepted by the clients and sanctioning can be expected only from superior or competing patrons. By catering to individuals' water demands, this delivery according to strategic practice (both with the help of technical means as well as social relations) is a deviation from the formal water management institutions but at the same time effectively compensates inadequacies of the formal water management organisations – at least for influential agents.

c. Discursive practices

Water management in Khorezm is thus shaped by two parallel systems of practices: (1) the official system with its practices that reflect clearly formulated formal institutions and (2) the strategic practices that individual agents apply to pursue their interests and that follow informal institutions. As the strategic practices are no exceptions, but were found to be wide-spread in the case study locations on different levels of the water management system, it is surprising that they are not more clearly sedimented in the formal body of water management. It should be expected that such practices would in the long-run result in a contestation of the formal water management structure leading to (formal) institutional change. Despite change taking place based on deviation, it is not as prominent as one could expect. On the contrary, change seems to be taking place slowly and sporadically, and in the midst of frequent malfunctioning of water management and widespread deviation, the formal structure appears to be surprisingly resilient.

We would like to explain this high level of resilience of the formal water management system towards change by pointing to continuous processes of strengthening and reproducing the system through discursive practices of the actors involved. While deviation is commonly taking place, the actors involved spend considerable effort and resources on the discursive compensation of these deviations. When fermers diverge from the rule that cotton as a state crop should be irrigated before the cash crop rice, observations in the case study WUAs have shown that they are very likely to state in any official conversation that cotton needs to be irrigated first. At the same time as individuals take water management actively into their own hands and pursue their own interest, their statements suggest that 'water management is up to the state'.

Certainly, this behaviour to some extent reflects the political risk that any openly admitted deviation carries in an authoritative state with severe repressions threatening contesters. It is also understandable that many actors have multiple roles of being individual agents with a distinct role in the patron-client network on the one hand and state representatives on the other, the latter creating a stake for them to preserve the status-quo of the formal water management institutions. But the very prominence of these discursive practices on all levels of the hierarchy down to the peasant farmers suggests that there is a meaning of such practices that goes beyond these motivations. It is argued here that the discursive compensation essentially reflects the extent to which the formal rules and roles of water management have been institutionalised in the sense of Berger and Luckmann (1966). According to Berger and Luckmann, reality is a social construct, produced by humans through their social practices and reproduced in and through discourses. Institutions which we encounter in Khorezmian water management have been constructed in their historical context as rules of conduct and specifically defined roles for actors involved. These institutions and their roles are 'reified' (Berger and Luckmann, 1966), unquestioned, accepted and passed on in society as social facts.

Box 4: Three types of practices

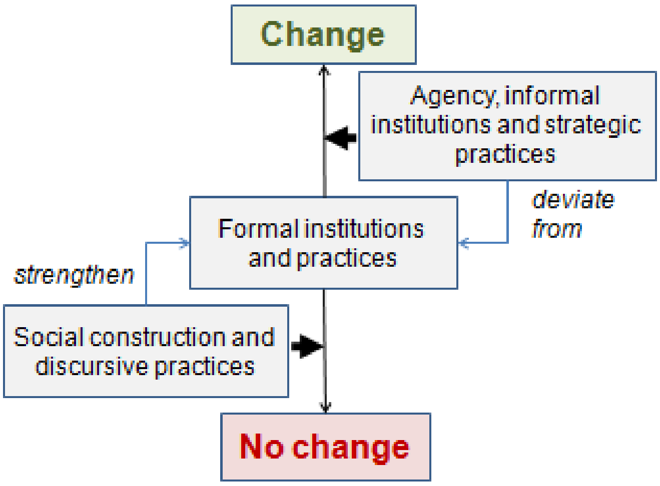
Formal practices: Reflect the formal rules of water management

Strategic practices: Are applied due to the agency of individuals to pursue their (water) interests; follow informal institutions

Discursive practices: Are applied to compensate deviations from formal rules and by doing so discursively reproduce the formal rather than the informal institutions of water management

Verbal reference to the formal institutions can be understood as a way to actively reproduce the formal water management discourse instead of formalising informal practices. Acts of deviation, such as the strategic practices discussed above, are thus compensated by means of discursive practices. They acquire the character of exceptions, special acts in a particular situation – no matter how frequently they occur. They are accepted and applied but do not challenge the formal water management discourse. But what makes the reified institutions so inviolable and resilient – although deviation is even habitualised, sedimented in informal institutions and little sanctioned? We argue here, that a collective aspiration of stability motivates this resilience. It was observed that change in Khorezm since the independence of Uzbekistan was perceived as having occurred largely towards the worse, particularly within agriculture. The population in the case study WUAs portrays Soviet times as golden times of order and abundance, followed by a process of decay and chaos since independence. The path of Uzbekistan after independence has been described as a process of 'thirdworldisation' by Trevisani (2008), which reflects this understanding that change may be considered as highly undesirable.

Figure 5:
Types of practices and their relation to change



Box 4 summarises the three types of practices and figure 5 illustrates their interrelation. Formal institutions, while influential, are nevertheless frequently side-stepped and replaced by informal institutions. Even though this deviation from the formal rules may be necessary to reach individual goals or cope with malfunctions of the formal institutions, the resulting display of agency and the strategic practices are of a rather applied and situational nature. They are used as coping strategies in struggles over power and water, but are not followed easily by change and innovation in the discourse. Formal water management thus shows a very strong continuity which is the result of an equilibrium of deviation and agency on the one hand and discursive practices, strengthening the formal institutions, on the other hand.

Figure 6: Conceptual understanding of water management in Khorezm

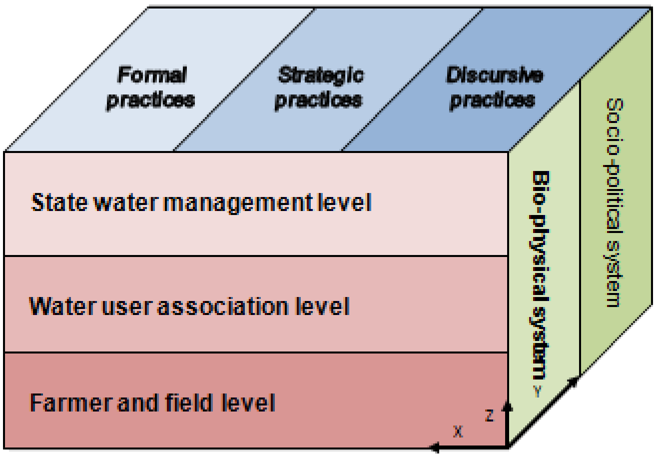


Figure 6 summarises the conceptual perspective on water management in Khorezm which underlies our analysis and recommendations. On the x axis we distinguish the three types of practices that actors in water management apply, the y-axis shows the bio-physical and socio-political system that characterise the region, and the z-axis reflects the different scales of water management in Khorezm, namely the state water management level, the WUA level, and the farmer and field level. Questions that arise based on this understanding are: How do formal, strategic and discursive practices of actors shape the bio-physical and socio-political system on the different levels of water management and vice-versa, how do the bio-physical and socio-political systems interact on these levels and how can these systems be improved to change practices towards IWRM in Khorezm? We will address these questions in the context of different water management levels in the following sections.

4. State water management level

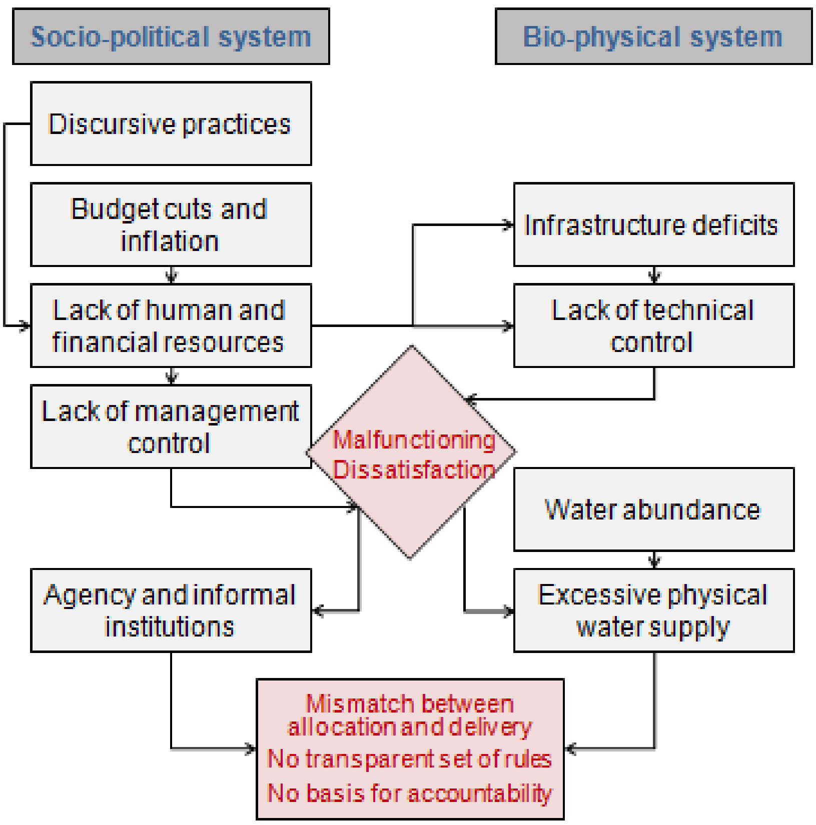
Deficits in human and financial resources of the state water management organisations (WMOs) have resulted in poor functioning of the irrigation and drainage network and are leading to problems with the provision of measurement and communication equipment and the maintenance of the irrigation and drainage infrastructure (Wegerich, 2010). Many bureaucratic routines discursively strengthen the formal institutions, but are often bare of an actual function for water management. These practices block human resources which could be used differently. Together with the lack of financial resources, this has led to a situation where the WMOs cannot effectively control the water delivery process.

In most years, Khorezm is (still) receiving ample water supplies. Under this abundance, the WMOs are able to distribute more water than theoretically required by the crops to compensate for institutional malfunctioning. This is facilitated by the technical path-dependency of a system which was originally designed for the conveyance of large quantities of water to collective farms, as common during Soviet times. The water needed for such excessive water use delivery is used at the cost of the environment both within Khorezm as well as in downstream regions. Considering a likely decrease of water resources in the future, this practice can certainly not be considered sustainable.

Particularly (but not only) in times and places of water scarcity, the institutional deficiencies of the WMOs furthermore create a necessity and the space for water users to show agency and take matters into their own hands. Formal institutions are then almost entirely replaced by informal institutions and strategic practices of actors who struggle over resources using their patron-client networks to support their claims. This is facilitated by the fact that like land, as described by Trevisani (2008), water is used as an asset by the water management staff who thus builds up and maintains patron-client relationships and creates extra incomes on the side (e.g. in the form of bribes) – one of the reasons why water allocation and delivered quantities mostly do not match. Individual agents, such as district governors (hokims), state water managers, WUA chairmen or influential fermers, pursue their own interest in water, either for commercial agriculture, for satisfying the demands of clients or for fulfilling the state production targets and thereby accumulating social capital and stabilising their position within the state hierarchy. It was thus observed that water was frequently distributed based on social relations and social capital instead of based on official limits.

In addition, there are structural reasons for the mismatch of water allocation and actual water delivery. The official water requests and limits are calculated based on the state orders of wheat, cotton and other cultivated crops and on the official data on tomorqa plots cropped by dehqons. Rice on fermer land which is mostly cropped on areas freed from state order or as second crop after wheat is not included in the official water allocations (Veldwisch, 2008). Consequently, almost all WUAs regularly exceed their limits and pay fines generally recovered from rice growing fermers. This gap in the official water planning facilitates individual agents to pursue their interests, with rice cropping being both the most profitable as well as the most secretively handled business of fermers.

Figure 7: Links between the socio-political and the bio-physical system on the state water management level



In conclusion, the pluralism of formal and informal institutions results frequently in a mismatch between official water allocations and the actual delivery of water. It is thus the main reason for the lack of clearly defined, transparent and enforced rules of water management according to which people are held accountable. Particularly in times of water scarcity, as expected for the future, such rules will become increasingly relevant. Figure 7 summarises the problems at the state water management level and highlights the links between the socio-political and the bio-physical system.

Transparency and Accountability

Information for and about water management decisions need to be transparently accessible for all involved in order to allow for the active participation of different actors aiming at collective rather than individual benefits. Furthermore, decision-makers need to be held accountable for their practices.

Options to create and improve transparency and accountability are the following:

- Introducing a WUA chairmen board: Abdullaev et al. (2009) have observed representatives of different WUAs to assemble in so called Unions of Water Users (UWU) in Ferghana valley in Uzbekistan. They suggest to implement such UWUs also in other regions and to introduce 'joint governance boards' between the UWUs and state water managers. By bundling the influence of the individual chairmen, the UWUs will form an important counterbalance to the state in water management and be able to hold the state water managers accountable for their practices.
- Integrating rice irrigation into water planning: To be able to keep track of water in the irrigation system and make decision-making on rice irrigation water more transparent, we suggest that rice on fermer land which is freed from the state order should be included in the formal water allocations and in the water fees of the WUAs as separate position.

Technical tools

As improvement for the technical performance of water management we suggest the use of a remote sensing toolbox (box 5) which has been developed for the region.

Box 5 : Remote sensing toolbox for the state water management level

Monitoring	Assessment & modelling	Capacity building
• reliable and consistent datasets • regional processing and calculation of biophysical parameters, agriculture and climate variables • long-term time series and up to date data	• assessing the status of a WUA based on a combination of monitoring with secondary data • toolbox for modelling land and water parameters and water distribution at WUA scale • indicator package at WUA and province level	• visualisation of land and water recommendations in terms of maps and tables • knowledge transfer among researchers and stakeholders • transparent information for policy makers

Equity indicator	Productivity indicator	Sustainability indicator	Efficiency indicator
Water consumption	Yield & biomass	Crop types	Crop water deficit

TOOLBOX

Scale	Input data		Outcome / Benefit
Province level	Moderate resolution satellite data on 259m to 1km per image pixel (e.g. MODIS, freely available and validated)	GIS database Secondary data Ground truth	Land use mapping Actual and potential evapotranspiration Yield and biomass modelling
WUA level	High resolution satellite data on 15m to 60m per image pixel (ASTER and Landsat)		Land use mapping Actual and potential evapotranspiration Water distribution modelling
Field level	Very high resolution satellite data on m to 6.5m per image pixel and temporal resolution of 14 days (SPOT and RapidEye)		Modelling biophysical parameters (fraction of photosynthetically active radiation) Updating cadastre maps Field based land use maps Identifying crop rotations

5. Water user association level

In 2000, non-governmental, participatory WUAs have taken over the responsibility for water management from the dismantled sovkhozes, kolkhozes and shirkats. But research in the three case study WUAs Ashirmat, Shomoxulum and Amudarya has shown that the WUAs have immense problems recovering their costs. Fermers are unwilling to pay their water service fees, the only revenue of WUAs, thereby pushing the WUAs to the verge of insolvency. The vicious circle of fermers not paying fees and WUAs consequently not being able to provide good and timely services has been described by Veldwisch (2008) and Abdullayev et al. (2008).

The malfunctioning of WUAs is reflected also in the technical deficiencies at this level. Maintenance deficits reduce the hydraulic capacity of canals especially of low hierarchy and drainage is impacted by severe outlet problems of drains and main collectors. Insufficient coordination of irrigation activities between the field and the network level and between different network hierarchies causes high operational losses (Veldwisch, 2008). Infrastructural deficits such as missing or non-appropriate diversion and measurement structures prevail and make spatially and temporally precise water distribution difficult. Furthermore, today´s rather small ferm units with diversified demand have significantly different requirements on the canal system than the larger uniform production units of the Soviet times. Canals are therefore mostly over-sized which increases water losses. Altogether, the technical performance of water management on WUA level is unsatisfying. Results of our study in an irrigation sub-unit (850 ha) revealed that the gross water input, including pre-season leaching, amounted to 2640 mm and 2810 mm in 2004 and 2005, respectively. However, an overall technical efficiency of approx. 30% and a field application efficiency in the range of 45% reflect that a high share of these quantities do not reach the crops. Instead, a reduction of actual evapotranspiration to 80% to 90% of potential evapotranspiration even in water rich years shows that the water demand of crops is not satisfied. For tail-end locations, Conrad (2006) shows an even less satisfactory situation with actual evapotranspiration reduced to 75% of the potential level in 2005, although gross water withdrawals were high averaging to 2240 mm for the whole Khorezm region in the vegetation period 2005.

Research in the three case study WUAs shows that the feeling of ownership regarding the WUA amongst fermers is very limited. This holds true even more for dehqon farmers, who often are not aware of the WUA's existence (Ul Hassan et al., 2010). Veldwisch (2008) states that dehqon water use is prioritised in comparison with water for state cropping and commercial cropping, but research from the water scarce year 2008 shows that this does not always hold true. In the case of water scarcity and conflicts over water, dehqons are highly disadvantaged. They are excluded from governance processes, from water management and information on water availability. Since many of the dehqons are women, who are generally granted less authority than men, they are further excluded (a problem acknowledged also in the IWRM Dublin principles (box 3)).

Research on social mobilisation in WUA Ashirmat has shown that even if water users are granted the possibility and space to get involved, they are very hesitant to do so. The common governance structures people are used to are based on a top-down approach with centralised command and control mechanisms. WUAs rely on good relations with state representatives to represent water users upwards and lobby for water. In return, interference into WUA-activities from the WMO-level, district and regional governors can be observed regularly. How to govern water in a participatory way does not come natural to fermers, dehqons or the local elites. Experience and knowledge on how to conduct elections and meetings or how to ensure transparency are often not available. Instead of using the WUA as platform to show agency, farmers rely on their patron-and-client networks as described above. This leads to a side-stepping of the WUA and further weakens its possibilities to function adequately.

Figure 8: Links between the socio-political and the bio-physical system on the WUA level

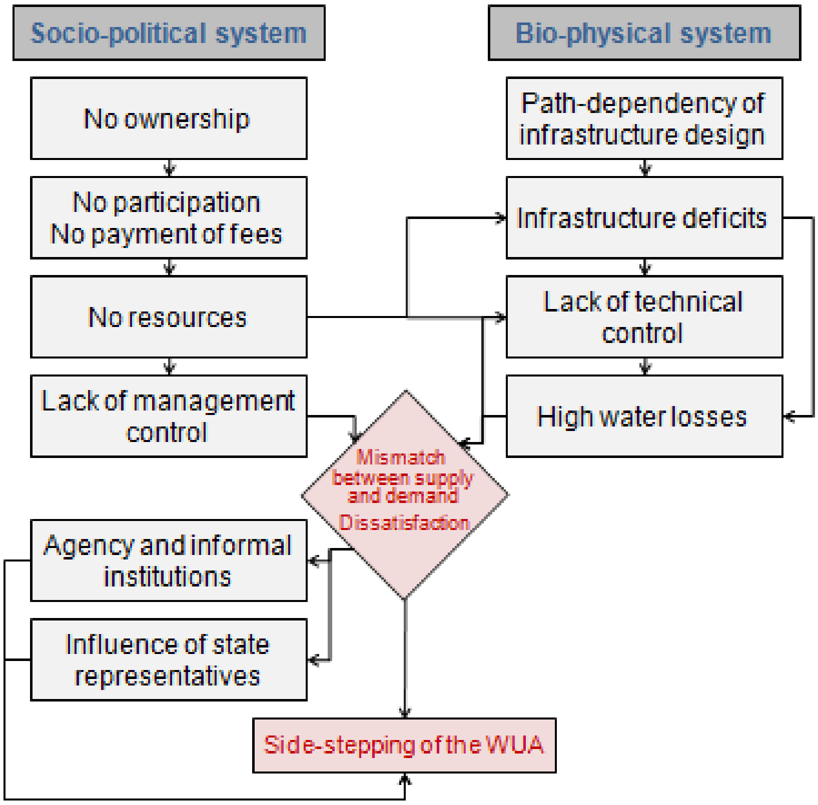


Figure 8 summarises the problems at WUA level. They have led to a situation in which neither the water users, nor the WUA staff, nor the state water management staff are satisfied with the resulting water management. During the water scarce year of 2008, dissatisfaction of all involved led to incessant complaints with the WMOs. Their overstraining was certainly one of the drivers for consolidating farm land in 2008 reducing the number of water users substantially and thereby easing water management on this level. In case of a second round of consolidating farm land, the future role of WUAs is unclear. Possible seems the abolishment of WUAs and replacement with differently shaped state or non-state organisations.

WUAs or their future replacements will be faced with similar challenges. The different rationales of decision-making, finance, communication as well as operation between the WMOs and the water users meet at this level and have to converge to allow for efficient coordination, a matching of supply and demand. The technical infrastructure is outdated, responsibilities for rehabilitation and maintenance need to be clarified and funds mobilised. To accomplish this, participation of all water users and their representatives in decision-making processes, operation and maintenance is necessary. This can take place within WUAs or within any other organisation which might be created on this level during the reform process. While we are discussing improvement strategies for WUAs in the following paragraphs, we thus suggest these likewise for any successor organisation which may follow in the course of further reform processes.

Raising funds: Development of WUAs as business units

Even the currently low water fees are not paid without a reform of the incentive structures for water users to cover the costs of the WUA. As shown above, the principal functions of WUAs include water distribution, cost-recovery, governance and representation. However, a WUA may work as a business unit and have a range of ancillary function such as the provision of management services, training, insurance or short term credit to rural communities or farmers. Such additional functions can benefit the farmers to increase agricultural production. It will decrease the marginal cost of the production and will motivate them to pay for water. Once fees are regularly paid, the WUA can provide additional functions for societal benefits using the resources raised. If the users perceive benefits generated from such function, they will be further motivated to pay the fees. The WUA and its water users should follow reciprocal accountability, i.e. if a water user does not pay for services he does not receive water, and, in turn, the WUA is not paid if it fails to provide required services.

Increasing participation: Empowerment and social mobilisation

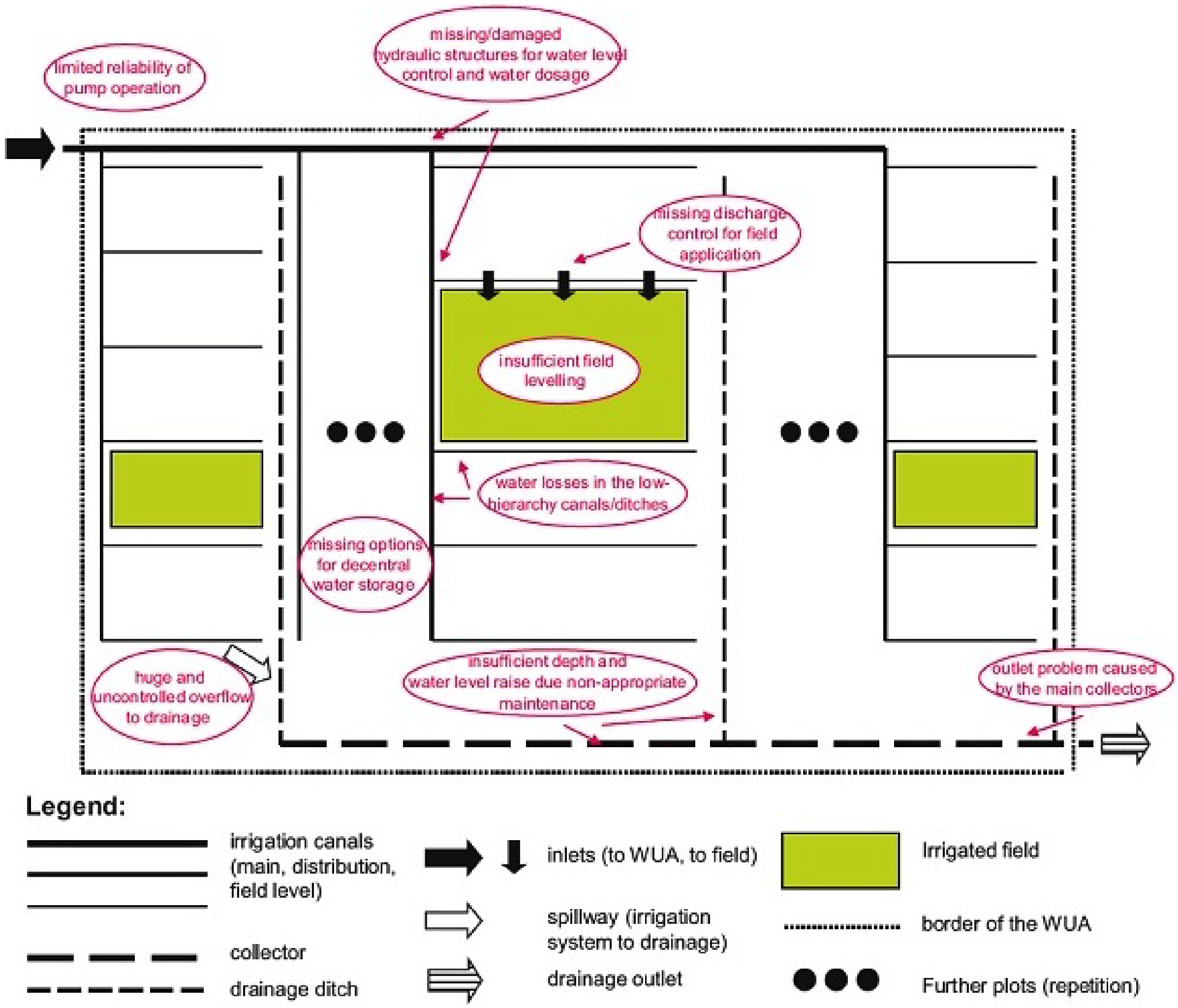
A joint experiment of researchers, fermers and WUA staff in WUA Ashirmat has shown that social mobilisation implemented by well-known and accepted people can increase awareness of water users about the WUA's existence and work (Hornidge et al., 2009). However, this is only the first step towards higher participation in the WUA's activities. To create room for water users to communicate their needs and represent their interests, it is necessary for the WUA to conduct regular meetings, so that water users' needs are acknowledged and ownership of the WUA is developed. Stratification among the water users which is related to geographical location should be reduced by introducing canal managers for different parts of canals so e.g. tail-enders have representation mechanisms to secure their water access.

WUAs need to improve their functions as arena of participation particularly for dehqons who are currently excluded from information and decision-making processes. This can be done by making the neighbourhood leaders (elatqoms) active members of WUA meetings and by introducing an election system in which dehqons can participate in WUA decision-making processes through their representatives. To empower dehqons further, practical measures can help formalise the dehqons' influence in water management. In WUA Amudarya, it was observed in 2009 that pumps were explicitly allocated to dehqons instead of the common allocation to fermers who then share the pumps with dehqons. The dehqons managed the operation of the pumps through the neighbourhood leaders and were granted explicit water limits for the pumps. Contrary to the situation around pumps, which are shared between dehqons and fermers, it was thus not possible to exclude the dehqons from water access. This practice should be introduced also in other WUAs.

Improving the technical performance: Infrastructure rehabilitation and modelling tools

The technical performance at the WUA level is currently largely impaired by a missing or not functioning hydraulic infrastructure. Figure 9 gives an overview over the infrastructure which needs to be rehabilitated as a basis for technical improvements.

Figure 9: Infrastructure deficiencies



Once the necessary infrastructure is in place, the results of modelling tools can be utilised to implement optimal water distribution within sub-systems. Tools that we have developed for improved irrigation management are shown in the boxes 6 and 7. The water distribution model deals with a larger sub-system (developed for an area of 11 WUAs), the integrated flexible irrigation scheduling and groundwater model with the area of one WUA.

Box 6: Water distribution model

Location and Aim

- Modelling the water distribution process within a sub-system covering 11 WUAs and approximately 3000 fields
- Modelling water demand, water distribution and management including locally used practices and infrastructure

Innovation

- Within season model update concerning water demand based on remote sensing products on different scales
- Province scale modelling of improvements achieved through water saving innovations

Outcome

- Comparison and collaboration with locally used water distribution management and policy makers
- Water management optimisation during times of water shortage

Box 7: Integrated flexible irrigation scheduling model

Location and Aim

- Developing irrigation schedules based on flexible models for water balancing and integrating the interface to the groundwater system
- Modelling irrigation scheduling processes taking the groundwater system into account with respect to a WUA covering around 1900 ha irrigated area

Innovation

- Linking irrigation scheduling and groundwater models for integrated use of surface and groundwater resources
- Use of detailed models (CROPWAT, SEBAL, HYDRUS, FEFLOW) enabling to react to changing environments

Outcome

- Optimised irrigation schedules taking surface and groundwater resources into account
- Strategies for controlled deficit irrigation to minimise the impact of water stress on yield
- Assessing the impact of irrigation strategies on groundwater resources

In addition to difference in scale, the two presented models differ with regard to the principles according to which they determine the distribution. In general, water can be allocated to water users according to the size of the water user's unit, the crops, the soil and groundwater characteristics, a combination of them or according to modelled crop demands – all reflecting different understandings of equity. Current water distribution in Khorezm following the norms considers crop, area, soil and groundwater conditions in a generalized way. This is reflected in the water distribution model as described in box 6. To cope with changing situations (diversified cropping plans; increasing variability of water supply), however, the relevance for water distribution according to flexible modelling taking site-specific conditions into account increases. The flexible irrigation scheduling and groundwater model (box 7) realises this approach and allows for determining temporal and spatial demand. Furthermore, the model enables the integration of groundwater use into irrigation strategies. While the water distribution model is thus closer to the currently practiced way of distributing water and more likely to be adopted for use by local water managers, the flexible irrigation scheduling and groundwater model allows for a further optimisation of the distribution. To implement it, infrastructure rehabilitation and the availability of site-specific information are prerequisites.

6. Farmer and field level

The technical situation at the farmer and field level can be characterised by a non-appropriateness of water supply indicated by reduced actual evapotranspiration. According to monitoring at the level of an irrigated field carried out in the vegetation period 2003 (Forkutsa, 2006), the actual evapotranspiration was reduced to 70% of the potential level mainly caused by inadequate irrigation timing, which did not match the time-depending crop water requirements especially in the beginning/middle of the vegetation period. Water is usually delivered to ferms in water rotations, roughly coordinated according to the demands indicated by fermers. However, the management problems discussed for the WUA level make on-time water delivery highly uncertain. This unreliability of supply is reflected in practices of tail-end fermers who tend to over-irrigate once water is available and block drains and collectors to raise the groundwater level so groundwater can contribute by increased capillary rise to crop water requirements. While this beneficial effect makes sense in the fermers' situation of uncertainty and in the short-term perspective, it also has negative impacts, such as secondary soil salinisation. Using hydrological measurements at two field sites, an analysis revealed, that salt input in the root zone by capillary rise exceeded the input by irrigation water by around 40% (Ibrakhimov et al., 2007).

Groundwater, canal water and salinity are in general strongly linked on the farmer and field level through the process of irrigation and leaching. Besides seepage from the irrigation canals, high application losses are the major source of groundwater recharge in Khorezm. At the end of the winter period without irrigation, the groundwater level drops to 2.3 m below ground, reaches after leaching 1.4 m in April and approaches the highest level of 1.2 m in August, consistent with the most intensive irrigation period in July and August (Ibrakhimov, 2004). This groundwater dynamics reflects a low application efficiency which is a result mainly of irregular micro-topography due to poor land levelling, insufficient information on the site-specific as well as the temporally appropriate irrigation depths, lacking optimization of application discharge according to field characteristics and missing infrastructure for proper handling of the application discharge.

The technical deficiencies on farmer and field level are thus caused by an outdated or missing technical infrastructure, technology and information and are further exacerbated by the institutional setting in which the irrigators act. Irrigation scheduling in Khorezm is based on norms which were developed in the 1960s. Since then, water user units have decreased in size, cropping patterns have diversified (particularly on ferm-land freed from state plans), awareness for limiting water withdrawals have increased and modelling tools to calculate evapotranspiration, determine capillary rise and estimate irrigation efficiencies have improved. Consequently, these norms, while remaining helpful tools for estimating large-scale water requirements for irrigation seasons, fail to provide insight into water management requirements under changing situations.

The high degree of state regulation of agriculture is furthermore reflected in area- and production-based state quota on cotton and wheat on the one side and a high level of

Box 8: Land consolidation 2008

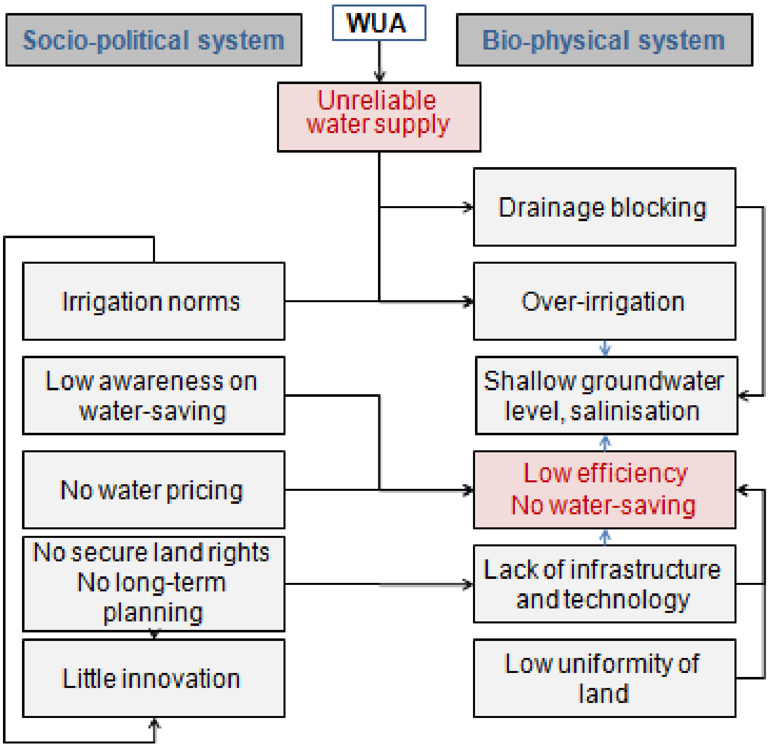
At the end of 2008, ferm land was recollected and redistributed in bigger plots to roughly one fourth of the former fermers. In WUA Ashirmat (2,116 ha of irrigated land) for example, ferm land had been leased to 93 fermers from 2000 onwards. In October/ November 2008, these 93 fermers – after being asked to do so by the government – returned their land lease contracts to the state and the land was redistributed to currently 21 remaining fermers, many of whom consider a second round of land consolidation as likely to take place.

uncertainty regarding land use rights on the other. Land is state property leased to fermers in up to 50 years contracts (Trevisani, 2008). Despite these contracts, leases remain subject to state will as illustrated by the event of land consolidation in 2008 (Box 8). The combination of a reliable state plan and unreliable land lease contracts absolutely increases the dependence of fermers on the fulfilment of the state plan, proportionately weakens their potential to independently plan, invest or innovate and lowers their interest to take the path of longer term planning and risk-taking. For water management on the farmer and field level, this means that water-saving techniques which come with investments on field level are not practiced (Oberkircher and Ismailova, in prep.).

Furthermore, little economic incentives exist to encourage water saving. Water is priced only by electricity costs for pumping and highly subsidised (often not paid) WUA fees, resulting in observable water wastage. Despite considering it a bad practice to let water run from the canal to the drain, it happens frequently. The state organisation Uzsuvnazorat (Department of Water Inspection), responsible for preventing water wastage and promoting water-saving, has one inspector per district checking on water wasting as well as illegal rice cropping. Considering the large areas of appointment, Uzsuvnazorat is understaffed, not able to prevent water wastage or to sanction it accordingly.

In conclusion, technical efficiency at farm and field level is low and cannot be balanced by the institutional setting (figure 10). Awareness on water-saving is low and water wastage is little sanctioned. There is no planning security and water supply is unreliable while at the same time highly subsidised, which steers farmers' behaviour towards risk minimisation rather than towards efficiency and water saving. To improve the efficiency at farm and field level, technical options should go alongside changes in the institutional setting that create awareness on water-saving, lower the risk and disincentives of farmers to apply water-saving practices and create space for innovation. The following paragraphs discuss our suggestions for accomplishing this.

Figure 10: Links between the socio-political and the bio-physical system on the farmer and field level



Technical aspects

- Adequate irrigation amount and timing: Modelling soil water and salt dynamics proved to be an appropriate tool to provide the irrigator with reliable information regarding amount and timing of irrigation and leaching events answering spatially and temporal changes of requirements. Matching the timing of irrigation events to actual crop water demand, instead of norm-based irrigation scheduling, allows to avoid water stress (with current level of field water input) or to enable a water saving potential of 20% (without changing the current level of water stress). Forkutsa et al. (2009) showed in a simulation with the HYDRUS model that 25% of the leaching water can be saved without reducing the leaching effect. Combining simulation models (HYDRUS) with refined monitoring techniques considering spatial distribution of soil salinity (electromagnetic induction device EM-38) is a promising tool to raise leaching efficiency.

Akramkhanov et al. (2008) showed that EM38 can provide timely and site-specific information on the current level of soil salinity as a reliable input for salt dynamics modelling.

- Optimizing the water application process: Due to the flat topography double-sided irrigation is a promising approach in Khorezm. Field tests resulted in a more uniform water distribution along the furrows, resulting in a 15% saving of the seasonal gross irrigation water input to the field (Paluasheva, 2005). Furthermore, the increase in salt accumulation at the end of the furrows due to low irrigation water application and high capillary rise could be halved (compared to 300 m furrows) and as a consequence cotton yield increased by 0.5 t/ha (Paluasheva, 2005). Improvement in operation and design of the furrow technique (optimizing application discharge; introducing surge flow; laser land levelling) allows to raise the application efficiency from currently 45% to 65%.

Institutional aspects

- Strengthening water inspection: In 2009, WUA Ashirmat introduced local water inspectors (Ul Hassan et al., 2010) – a promising innovation which is here suggested also for other WUAs. Local water inspectors should cooperate with the district inspectors of Uzsuvnazorat and make use of its formal sanctioning mechanisms. It can be expected that the local inspectors will feel more bound to their fellow villagers than to the state organisation Uzsuvnazorat and would try to avoid a control function with sanctioning mechanism. However, the mere existence of water inspection on local level and social sanctioning mechanisms would have a strong impact on water-saving awareness on the local level, as suggested by Veldwisch (2008).
- Build capacity and promote water-saving: In addition to these control mechanisms, Uzsuvnazorat together with local water inspectors should widen their functions and adopt a more prominent role in the education of water users on water wastage and water-saving. Concrete water-saving measures are currently only promoted through the annual Pakaz meetings of fermers in which state representatives communicate agricultural norms and regulations, which occasionally also relate to water-saving (i.e. shorter furrows). Awareness-raising campaigns as well as capacity building during and in addition to the state trainings should be conducted more systematically and frequently. By continuously being adverted to water-saving and by acquiring the skills to practice it, water users would be able to develop an ownership for water-saving instead of referring to a discourse in which water management and water-saving are 'up to the state' only.
- Loosen norms for irrigation: As mentioned above, irrigation practices in Khorezm are subject to norms which prescribe to fermers the amount of irrigation and the application technique. These norms are monitored throughout the season and if fermers do not apply them they may get into difficulties with state representatives with the possibility of land loss (Oberkircher and Ismailova, in prep.). To be able to improve the adequacy and efficiency of irrigation and to react on changing environments (especially on increasing variability of water supply in the future), changes are necessary which may contradict the norms (e.g. with regard to ploughing when practicing conservation agriculture). To allow fermers to practice water-saving, the norms therefore need to be loosened and presented as benchmarks and justified non-compliance with them be possible without sanctioning.

The technical and institutional options suggested above have to go hand in hand as they rely on each other to improve water management on farmer and field level. Table 1 gives an overview of the linkages between the measures and the overall improvement that can be expected from a joint implementation.

Table 1: Linkages between technical and institutional recommendations on the farmer and field level

	Technical measures	Institutional measures	Expected improvement
Adequacy of irrigation and leaching amounts and timing	• Determine spatial and temporal crop water and leaching requirements through – Soil water and salt modelling – Salinity measurements with EM-38 • Apply the necessary water amounts	• Loosen irrigation *norms* regarding irrigation amount • Raise awareness on water-saving and sanction water wastage through a strengthened Uzsuvnazorat	20% water-saving during vegetation season and 25% water-saving during leaching which can be used to reduce early season water stress
Application efficiency	Practice • Laser land levelling • Optimising discharge • Double-sided furrow irrigation • Surge flow irrigation	• Loosen irrigation *norms* regarding application process • Provide information and training on water-saving techniques	Increase of application efficiency from 50% to 65%

Agency and Innovation

Anticipated changes in water availability make it necessary that Khorezm does not only rely on state planning and responsibility but uses all its human capacity and resources to improve its resilience and adaptability. Farmers as fundamental agricultural actors should get the chance to increase and use their knowledge and show agency in being active innovators (Röling, 2009). To facilitate this, we suggest the following measures.

- Assure land rights: Ferm land is state property and land use rights are not secured. Events such as consolidating ferm-land in 2008 negatively affect risk proclivity and innovateness. Many fermers perceive another round of land consolidation as likely, which even in the current form of a rumour, further hampers individual investments into the land. Assuring land rights and leases therewith is crucial for increasing the ability and willingness of fermers to implement long-term land- and water-use planning.
- Improving the quota system: Abolishing area-based production quota, while maintaining production-based quota, is assumed to foster fermers' innovativeness to identify ways to increase yields; therewith fulfilling production quota with less land and input used. This could later be developed into a system of tradable cotton quota, allowing the specialization of some for cotton farming and others for alternative crops.
- Introduce innovation plots: Assigning specific plots of land for fermer innovation would give fermers the physical and legal space to experiment and improve their farming practices. Additionally it could strengthen the individual's feeling of responsibility to be active not merely as implementer of state norms but furthermore as conceptual driver, knowledgeable person and local innovator. It would thus open up room for agency to move from the domain of deviation to areas within the legal system where it can spur flexibility and innovation.

7. Conclusions

The previous sections of this paper have analysed water management in the province Khorezm of Uzbekistan and presented recommendations on how water management can be improved towards IWRM. The analysis takes into account the local context of water management as described in section 2 and derives its results from a joint analysis of socio-political and bio-physical aspects. While IWRM was presented as the framework which our recommendations are meant to create, we base our conceptual understanding of water management in Khorezm on additional insights. In section 3 we have described three different types of practices, which actors involved in water management apply: formal practices, strategic practices, and discursive practices. We have concluded that all three types of practices shape water management in Khorezm and furthermore keep the institutional setting in a state of equilibrium with strategic practices pushing for a change and discursive practices strengthening the formal practices and preventing change. Sections 4 to 6 have analysed water management on the different levels from the state water management level to the farmer and field level. Table 2 summarises the problems and recommendations for the different levels as well as the benefits that can be expected from the implementation of the recommendations.

Table 2: Summary of recommendations for different water management levels in Khorezm

	State water management level	WUA level	Farmer and field level
Main problems	Mismatch between water allocation and delivery No transparent set of rules No basis for accountability	Mismatch between supply and demand (spatial and temporal) No ownership and participation Side-stepping of the WUA	No water-saving practiced Little farmer innovation
Recommendations ***Institutional setting***	Creation of transparency and accountability through • Introduction of a WUA chairman board • Use of remote sensing toolbox for transparent communication • Integration of rice irrigation into formal water allocation	Development of WUAs as business units with ancillary functions Empowerment and social mobilisation of water users through • Activity of social mobilisers • Regular WUA meetings • Introduction of canal managers for different geographical parts of the WUA • Integration of neighbourhood leaders (***elatqoms***) in WUA activities and decision-making • Introduction of ***dehqon*** pumps	Strengthening of Uzsuvnazorat Promotion of water-saving Abolition of norm-based irrigation directives Land tenure reform Abolition of area-based quota Introduction of innovation plots

Recommendations ***Infrastructure and technical management tools***	Remote sensing toolbox	Infrastructure rehabilitation Introduction of monitoring infrastructure (e.g. discharge measurement devices) Water distribution model Irrigation scheduling and groundwater model	Soil water and salt dynamics model Soil salinity measurement tool Improved furrow application techniques through • Laser land levelling • Double-sided furrow irrigation • Surge-flow irrigation • Optimising discharge
Expected benefit	Clearly defined rules, rights and responsibilities which are transparently communicated and according to which actors are held accountable More balanced influence of state and water users respectively Higher technical efficiency	Increased representation and participation of water users in water management Better financing and technical functioning of WUA water management More adequate water distribution according to demand	Higher application efficiencies and practice of water-saving Agency as driver of innovation and adaptability to future water scarcity

Some of the results presented in the table reflect the general discussion of IWRM in other countries and agricultural systems. An example is that transparency, accountability and participation matter and need to be improved to create an enabling environment for IWRM. Furthermore considerations on infrastructure, the bio-physical system and technical efficiency are relevant to develop and use technical management tools to improve water management. These technical aspects need to be understood in the wider institutional setting – an IWRM principle which clearly applies to Khorezm as well as elsewhere. There are, however, also elements which reflect a special situation of Khorezm and Uzbekistan and which call for specific improvement measures.

What we have shown above is that the way human agency is currently displayed in Khorezm and compensated again through discursive practices, is a barrier to change and limits the human capacity to innovate. This occurs in addition to formal restrictions, through which state control pushes agency towards the domain of illegality. The two processes together prevent human capacity from unfolding in favour of improvements. They constrain the participation of knowledgeable actors for a collective benefit and make the region less flexible to adapt to future water scarcity. Specific for Khorezm are thus all those recommendations which aim at creating legal space for agency and innovation. Furthermore, tools such as models acquire additional importance in this context besides their technical function. They facilitate transparency and enable agents across the management hierarchy to access and make use of information. Once agency can enfold openly and strategic practices of actors are better integrated into water management, they do not consist of a deviation from the formal rules anymore and compensation through discursive practices will occur less frequently. We believe that such a positive feedback loop for change is what is needed to improve water management in Khorezm and prepare the region for future water scarcity.

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