www.water-alternatives.org Volume 5 | Issue 1
Clarke-Sather, A. 2012. State development and the rescaling of agricultural hydrosocial governance in semi-arid Northwest China. Water Alternatives 5(1): 98-118

State Development and the Rescaling of Agricultural Hydrosocial Governance in Semi-Arid Northwest China

Afton Clarke-Sather
Department of Geography, University of Colorado Boulder, Boulder, CO, USA; afton.clarke-sather@colorado.edu

ABSTRACT: Over the past 20 years, agriculture in the semi-arid Zuli river valley in Northwest China has been transformed from subsistence to commercial production. Instead of spring wheat and millet, peasants now grow maize, potatoes, and cabbage for national markets. This transformation has been facilitated by a series of interventions that have rescaled agricultural hydrosocial relations in the valley. Many of these interventions, such as alternative cash crops, do not fall under what is traditionally considered water governance, but have altered peasants' relationship with agricultural water nonetheless. This article (1) calls for a broadening of our understanding of scale in hydrosocial relations that gives more attention to the socioeconomic interactions that facilitate human relationships with water in the absence of the biophysical resource of water; (2) illustrates that state-backed rescaling of hydrosocial relations comprises contingent processes, which may or may not be planned; and (3) examines how water governance can mean examining what people do without water, as well as what they do with water. This article illustrates that a diverse set of state actors govern farmers' relationships with agricultural water in often conflicting ways by rescaling both the biophysical resource of water, and socioeconomic institutions that affect agricultural water use.

KEYWORDS: Water governance, aridity, agriculture, climate, China

INTRODUCTION

Over the past 20 years, agriculture in the semi-arid Valley of the River of Ancestral Strength (*Zuli*) in Northwest China has been transformed by a series of state-backed changes in water management. For as long as anyone could remember peasants grew their own food, primarily spring wheat, pulses, and millet, with the region's sparse rainfall. Now peasants use water-mediating technologies and policies to grow primarily cash crops: maize, potatoes, and vegetables. None of these crops are among their primary foodstuffs.[1] This transition from subsistence to market agriculture was facilitated by a fundamental transformation in the hydrosocial relations of agricultural water in the Zuli river valley. The previously direct connection between rainfall and what people ate has been interrupted at several points by state backed development programmes that aim to change the way peasants relate to both agricultural water and food. These development programmes have rescaled the political, technical, and economic institutions that mediate the relationship between people and water. Building on previous work on agricultural hydrosocial relations (cf. Dubash, 2004; Budds, 2008; Birkenhotz, 2009) I argue that if we are attentive to the social in hydrosocial relations, we must consider questions of scale in hydrosocial governance beyond the biophysicality of water, and look to the rescaling of social, political, and economic institutions that have a direct bearing on the relationship between humans and water.

[1] The vegetables produced commercially in the area are, for the most part, not eaten by peasants in the area. Farmers generally have small vegetable gardens within their courtyard homes that provide vegetables for domestic consumption. The variation of cabbage grown in the region (western-style cabbage) is not a crop with a long history in the area. Similarly while potatoes are eaten (and have been for a long time), they have not become a staple source of carbohydrates in the area.

This article moves beyond the biophysicality of water by examining hydrosocial governance – which I define as the political mediation of human-water relations – through the lens of aridity (the shortage of water).[2] Three interventions have transformed how humans relate to agricultural water in the Zuli valley: irrigation; the introduction of climate appropriate cash crops, particularly potatoes; and the introduction of hybrid maize combined with plastic film mulches. Each of these interventions rescales agricultural hydrosocial relations in unique ways. While many of these interventions do not involve the biophysical allocation or distribution of water, they do involve governance that is explicitly directed towards altering humans' relationships with water. Moreover each of these interventions has changed the scale at which some facet of hydrosocial relations occurs. The introduction of potatoes, for example, does not alter the flow of the biophysical resource of water, nor does it change who has access to agricultural water. Instead, potato agriculture attunes crops to prevailing patterns in precipitation. However, the introduction of potatoes, which was framed as a solution to the problem of aridity, required state-backed interventions to create markets for potatoes that engender political economic processes at a national scale. Thus without altering biophysical water in any way, alternative cash crops became a form of hydrosocial governance that introduced new scalar relations to agricultural water.

This study proceeds as follows. The next section addresses existing studies of hydrosocial governance, scale, and the state in China. A third section introduces the research site and methods. The fourth section presents details of changes that have occurred in the Zuli valley in land dedicated to each type of crop. The fifth section details three hydrosocial interventions conducted in the Zuli valley. Finally, the sixth section presents some concluding remarks.

BACKGROUND

The biophysicality of water and hydrosocial governance

Studies of water politics and governance from across a variety of disciplines have often centred on the allocation and distribution of the biophysical resource of water (cf. Ostrom, 1990; Worster, 1992; Dubash, 2004; Moose and Sivan, 2005; Baker, 2008; Birkenholtz, 2009).[3] This focus on allocation and distribution has been quite productive. Within studies of water politics from the perspective of geography, scholars have revealed the role that control of water has played in the making of modern states (Worster, 1992; Swyngedouw, 1999, 2007), and illuminated social struggles over who has access to and control of water (Perreault, 2005; Dubash, 2004; Budds 2008). Many critical studies of water management take the social role of water seriously, emphasising social equity and struggles over water provision (Perreault, 2005; Swyngedouw, 2004). However, such social struggles over access to water are fundamentally questions of equitable water distribution and allocation. In a similar vein, the on-going debate of whether water is a public good or a commodity (Bakker, 2002; Perreault, 2005) asks by which ontological principles water should be allocated.

More recent scholarship has engaged with the literature on hybrid natures (Swyngedouw, 1999, 2009; Bakker, 2003; Linton 2010) to conceive of water through the rubric of the hydrosocial cycle (Swyngedouw, 2009). These studies show that water governance is more than the political aspects of hydraulic engineering by emphasising that nature and society are co-produced. Water does not exist, as we know it, without transformations undertaken by humans. For example, piped water relies upon technological, political, and economic organisation to flow from the tap. Early examples of this literature called for engaging with the materiality of water (cf. Swyngedouw, 1999), which has led this

[2] This is something of a departure from Swyngedouw's definition of hydro-social research: "in a sustained attempt to transcend the modernist nature – society binaries, hydro-social research envisions the circulation of water as a combined physical and social process, as a hybridised socio-natural flow that fuses together nature and society in inseparable manners" (Swyngedouw, 2009). I aim to build on the important contributions of hydro-social research to understand how we can conceptualise hydro-social relations in the absence of biophysical water.

[3] An important exception to this pattern is studies of social contestation of water quality (cf. Prudham, 2004).

vein of literature to focus on water as a biophysical resource. For example, Swyngedouw writes: "[w]ater is a 'hybrid' thing that captures and embodies processes that are simultaneously material, discursive, and symbolic" (Swyngedouw, 2004). Speaking of water as the *embodiment* of social process prioritises the biophysicality of water. While biophysical water may be an embodiment of material, discursive, and symbolic processes, these hydrosocial processes can also be analyzed independent of such embodiment. We can study the governance of humanity's relationship to water without focusing on the thing of biophysical water itself. That is to say, hydrosocial governance need not be limited to the governance of biophysical water. This is not merely an intellectual exercise. Conceptualising water governance as the manipulation of hydrosocial relations, rather than the political and social factors that affect the distribution and allocation of water, allows us to consider how human-water relationships may be governed under a broader set of circumstances, particularly situations of water scarcity. This article extends the hydrosocial paradigm by examining how humanity's relationships to water are co-constructed in the absence of the biophysical resource of water.[4] While most past studies have focused on what people do *with* water, by examining arid area agriculture, I, instead, examine hydrosocial relations from the perspective of what people do *without* water. Governance practices, such as drought-resistant crop varieties that obviate the distribution of biophysical water, nonetheless constitute hydrosocial governance.

Scale and hydrosocial governance

Scale has been a central, yet contested, concept in human geography over the past two decades (Marston, 2000; Marston and Smith, 2001; Brenner, 2001; Sheppard and McMaster, 2004). While it is beyond the scope of this paper to detail these debates, a central point of this discussion has been to illustrate that scale is not an ontologically pre-existing phenomenom, but is rather both socially and epistemologically constructed. This article takes as a point of intervention Moore's (2008) call to examine scale as a category of practice, rather than a category of analysis. This requires us to think through how political actors use scale, rather than considering what scale is. In understanding how political actors use scale, I seek to understand how political actors actively *rescale* hydrosocial governance. Such rescaling involves shifting the scale at which both biophysical and socioeconomic processes that mediate the connection between humans and water occur. I use scale here in three distinct ways. First, I examine alterations of hydrosocial relations across temporal scales. State-backed interventions that alter the timing of human interactions with water are treated as alterations of the temporal scale of water management. Second, the level of territorial state governance (e.g. county, prefecture, province) constitutes the scale of state institutions. A third use of scale in this article examines spatial extent of hydrosocial processes and relationships. This spatial extent may or may not be coincident with the territorial jusitiction of state actors whose policies have created them. As a concrete example, a river-basin scale irrigation project promoted by a county water bureau to rationalise water budgets within its territorial boundaries exemplifies a project where the level of state actor and scale of hydrosocial processes coincide. However, when a county government facilitates extra-local markets for cash crops to make its county a centre of potato marketing for the nation-state, the level of state intervention (county) and scale of hydrosocial processes (nation-state) are not coincident.

Discussions of how scale is used in the water governance literature have tended to take one of two approaches. The first involves various forms of scaling up, often as part of state-building projects. Often considered the "state hydraulic paradigm" (Bakker, 2003) associated with the high modernist ethos of the 20th century (Scott, 1998), such studies examine how water has been rescaled by state actors to be congruent with their own administrative extent (Sywngedouw, 1999, 2007; Kaika, 2006). The second approach involves the scaling down of governance; these have been both ballyhooed for their

[4] Questions of scarcity in hydro-social governance are not new. Birkenholtz (2009), for example shows how social arrangements of tubewell irrigation have led to produced scarcity.

empowerment of local communities, and critiqued as part and parcel of the devolutionary process of neoliberalisation (Perreault, 2005; Norman and Bakker, 2009; Cohen and Davidson, 2011). For both scaling-up and scaling-down governance, prior studies have illustrated changes to the management of the biophysical resource of water. This case study illustrates that when we conceive of hydrosocial governance broadly, rescaling may simultaneously move towards multiple scales through contingent processes.

Hydrosocial governance in China

The connection between control of water and state power has a long history in China dating to Wittfogel's (1957) theory of Oriental Despotism. While this theory has not been empirically sustained (c.f. Du and Woodworth, 2011), the role of the state in managing water resources in China has been central to the theory of fragmented authoritarianism (Lieberthal and Oksenberg, 1990; Mertha, 2008; Nickum, 2010). The fragmented authoritarian approach to the state in China argues that while the Chinese state is authoritarian in nature, it also is divided into competing bureaucracies organised both vertically by function (*tiao*) and territorially by administrative level (*kuai*). While the connection between authoritarianism and centralised water works has been identified in previous work on hydrosocial governance (Swyngedouw, 2009), such studies have tended to treat state actors in water projects as relatively cohesive.

In this study, state actors are considered to be numerous and sometimes in competition with one another. In China the biophysical resource of water is governed through the functional bureaucracy of the Ministry of Water Resources and its correlates at each level of government. However, other ministries often have significant influence over water management as well (Mertha, 2008). For example, the Ministry of Construction, which is charged with road building, has successfully opposed dam projects supported by the Ministry of Water Resources that would flood desirable bridge sites. Similarly, the Ministry of Environmental Protection, while considered weak, has at times been able to influence water projects. This study illustrates that when hydrosocial relations are broadly conceived, the Ministry of Agriculture, as well as poverty alleviation authorities, which play a central role in many of the interventions discussed in this paper, are similarly involved in hydrosocial governance. Thus, while state actors remain central agents in hydrosocial governance, the state's involvement is conceived differently in this study than in previous ones that focus on the allocation and distribution of water alone.

Agricultural hydrosocial relations in Northwest China

Water is not the only resource affecting how well peasants are fed in the Zuli valley, but it is the resource that is most limited and over which peasants have the least control. Academic researchers (Fei, 1985; Yang and Zehnder, 2001), policy analysts (Brown and Halweil, 1998), and state actors (Xinhua, 2009) both inside and outside of China have often linked food security with the aridity of the regions. Prominent Chinese anthropologist Fei Xiaotong (1985), for example, said of this region:

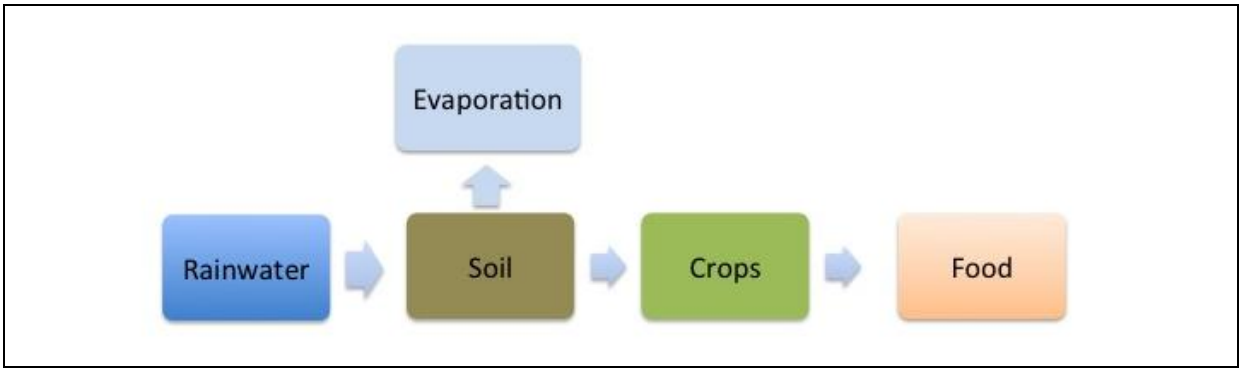
> Central Gansu's Dingxi is what has historically been known for the saying "Central Gansu's hardship is famous throughout the land". Where does this hardship come from? I have not fully verified. But poverty's origin clearly lies in its high altitude, cold climate, aridity, soil erosion, and vicious ecological cycle that have for long time caused Dingxi to experience repeated famines.

Poverty alleviation in this region of China has focused heavily on solving the dual problem of poverty and aridity (Fei, 1985; Shang, 2007; Xinhua, 2009). Efforts of the state to reshape the region are two-pronged: creating both equity among citizens by reducing poverty and an environment that is more conducive to agriculture. This transformation of the environment plays an important role in establishing state legitimacy: attempts to control the environment for the benefit of humans have long been a pillar of Chinese state legitimacy (Shapiro, 2001; Snyder-Reinke, 2009). While most attention to Chinese state

building through environmental modification has focused on symbolic mega-projects (Boland, 1998; Kaika, 2006), mini-projects of environmental management that reshape their subjects through the micro-politics of poverty reduction (Li, 2007) are similarly used to demonstrate state legitimacy.

While I seek to understand hydrosocial relations broadly by considering how the absence of water is managed, my focus on agricultural hydrosocial relations is rather limited: it is bounded on one end by rainwater, and on the other by food (figure 1).[5] I have taken 1990 as a base year for hydrosocial relationships prior to state intervention. I selected this time period because key informants reported that it was before major state interventions in agricultural water (with the exception of some irrigation), but peasants were still likely to remember the time period. Prior to state-backed interventions, the hydrosocial relationship of agricultural water in the Zuli valley was fairly straightforward. Rain fell. It was absorbed by the soil in place. Some of it evaporated. Some of it went to nourish the roots of crops. The volume and timing of rainfall were the primary determinants of success of crops.[6] Those crops fed the peasants who grew them. Interventions backed by a variety of state actors have, in the past decade, altered this chain. I use interventions in this case study to mean policies and technologies, generally state-backed, that are intended to solve the problem of limited agricultural water. However, these projects have functioned both by changing the allocation and distribution of water, and by switching to agricultural production that requires less water. Such policies and technologies are generally framed by state and academic actors in terms of broader discourses of development, and have included technologies to introduce other water sources, technologies to retain water, and policies to mediate the relationship between crops and food.

Figure 1. Agricultural hydrosocial relations in Eastern Gansu prior to recent state interventions.



RESEARCH SETTING AND METHODS

The Zuli river valley, located in Dingxi Prefecture in Eastern Gansu province, stretches approximately 80 km through the loess plateau of the upper Yellow river basin (figure 2). Most of the year the stream of the Zuli river is quite small, but swells to a muddy torrent when rainfall comes in late summer. Accumulated salts in the loess render groundwater in most of the valley saline, but the Zuli river's headwaters in the upper valley are underlain by metamorphic rock formations that contain fresh ground water (figure 3). These headwater areas are also located at a higher elevation, and receive up to 50 mm more rain than areas in the lower valley (Wei et al., 2005). As the river flows north towards the

[5] I do not consider the myriad of interactions farmers have with water outside of agriculture, nor do I consider surplus food sent outside of the countryside.

[6] Interestingly, farmers did not identify disease or insects as being major factors in determining yields in the past. The most common response when I asked farmers why they used more pesticides now than in the past was that there are more insects now (see methods in section 3 below). Although it is unclear why this may be, the more diverse cropping patterns used in the past possibly better protected against infestations.

Yellow river, it becomes saline from accumulated salts in the loess soils, and, in the lower reaches of the valley, is polluted by effluent from industrial food plants. Because of both the saline and organic pollution, the downstream river is considered unusable for most agricultural and household purposes.

Figure 2. Location of research site.

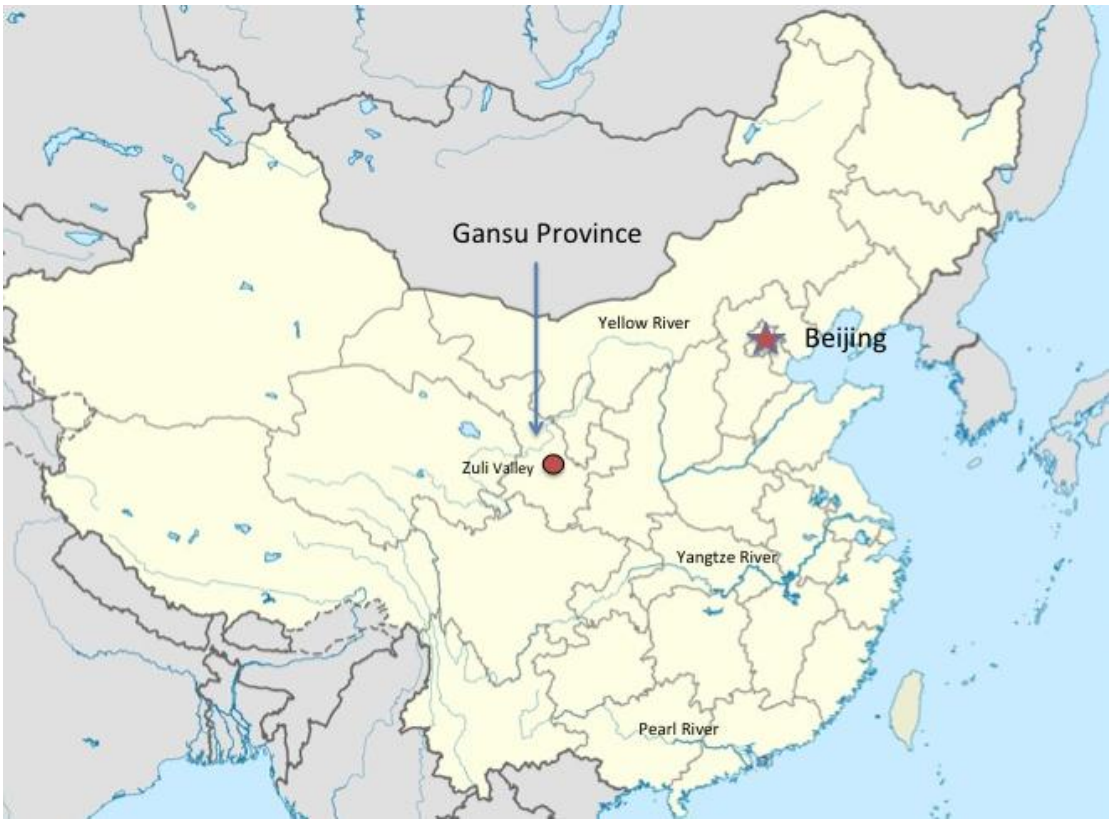
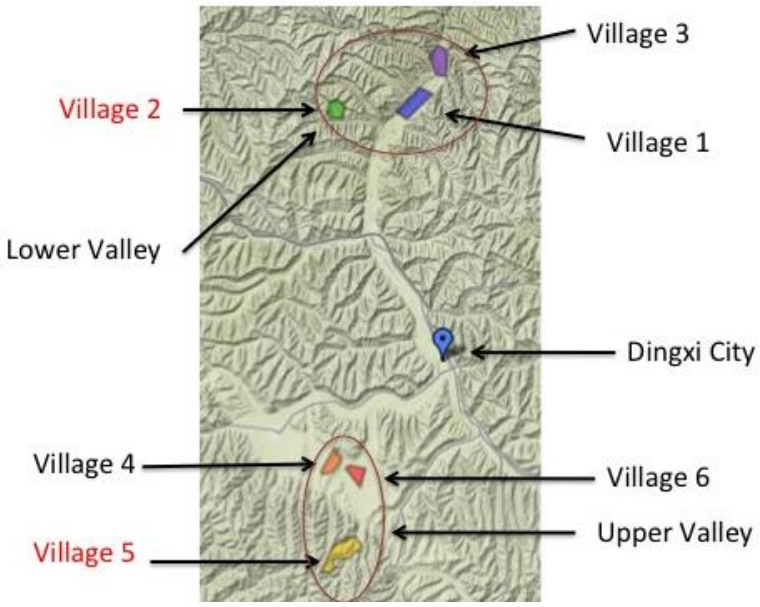


Figure 3. Map of study area.



The problem of aridity in the Zuli river valley has as much to do with timing as it does with quantity. The area is technically defined as being semi-arid rather than arid, and the 380 mm annual rainfall isopleth that divides rain-fed from irrigation agriculture in China bisects the valley (Wei et al., 2005). However, the region is influenced by the monsoon cycle of East Asia, and as a result 60% of precipitation in the area comes between July and September, leaving crops vulnerable to drought early in the growing season. A further temporal element of the hydrosocial relations of the region is that it experiences significant inter-annual variability in rainfall (Wei et al., 2005), making the success of crops unpredictable from one year to the next.

This research site was chosen for several reasons. The county water bureau has been particularly proactive in trying new technological approaches to address the problem of aridity. As a result, the county has been something of a showcase area for state actors interested in poverty alleviation. Finally, because of the variety of strategies tried in this region, it has also been more open to outsiders than other regions of China.

Methodologically, this research relied upon: review of academic, journalistic and policy documents; interviews with 165 farmers and 40 potato traders; and participant observation, including informal conversations with various government officials. Between April and October of 2010, I conducted 165 interviews representing 10% of households in each of six villages (16-37 households per village). Two villages were interviewed from each of three sub-areas in the Zuli river valley (figure 3): the lower valley (villages 1 and 3), which includes flat land, but saline ground and surface water; the upper valley (villages 4 and 6) with flat land and usable ground water for irrigation; and mountainous areas (villages 2 and 5) that feature sloped lands that make water management difficult. Although these interviews were part of a larger project, this paper relies upon questions asked about changes in agricultural water management, changes in agricultural inputs and marketing, and how much land was allocated to each crop at the time of the interview (summer/fall 2010), five years in the past, and 20 years in the past. While survey methodologies dependent on respondent recall are known to suffer from biases arising from poor memory (Scott and Amenuvegbe, 1990; Gibson and Kim, 2010), this was the best methodology available for understanding agricultural change at the household level. I controlled for lapses in memory of planting patterns by confirming whether farmers grew all of the most common crops, asking them to restate their estimates as a total, and converting all land allocation data to percentages, which both allowed us to understand land allocation decisions in comparison to one another, and controlled for changes in land tenure over the past 20 years.

AGRICULTURAL CHANGE IN THE ZULI VALLEY

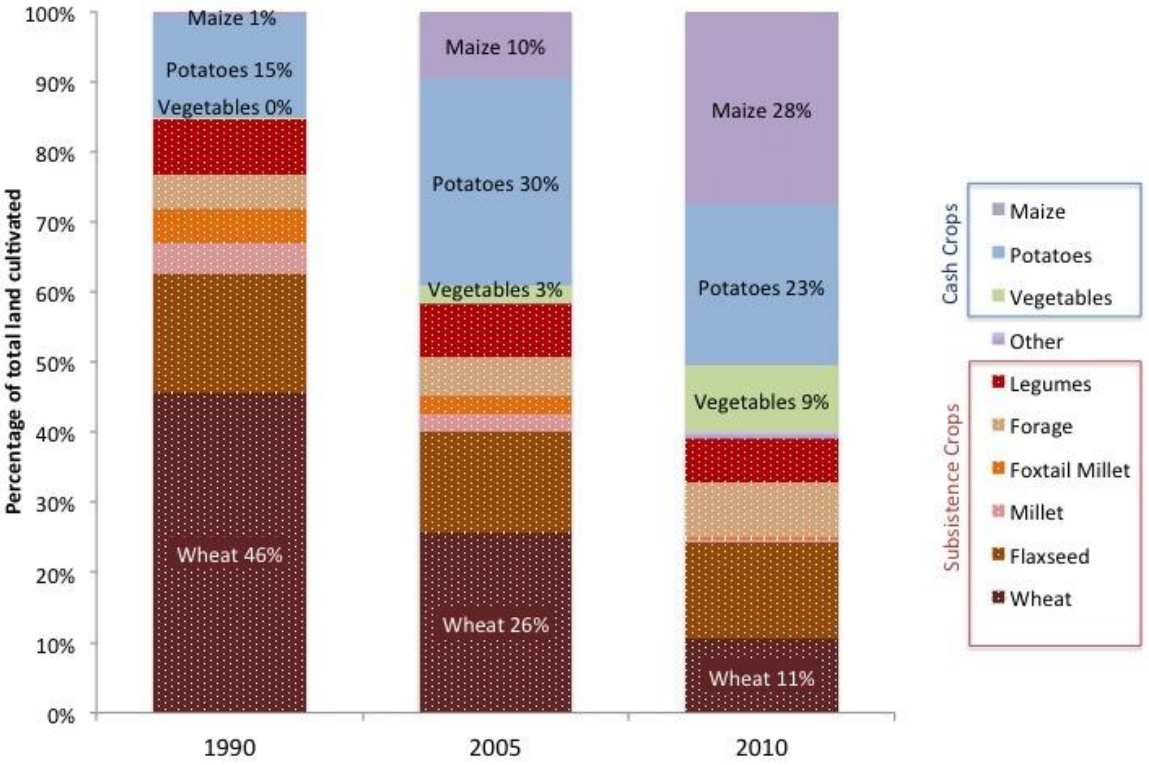
The change from rain-fed subsistence agriculture to market agriculture facilitated by hydrosocial interventions is quite clear from survey respondents' estimates of how much land they dedicated to each crop in the past and present. Figure 4 illustrates the changes in the average percentage of each farmer's land dedicated to each crop for the entire valley.[7] In 1990 the average household in the Zuli valley dedicated 85% of its land to subsistence crops (defined as anything except potatoes, maize and vegetables shown in solid colours) while 15% was dedicated to market crops (defined as potatoes, maize, and vegetables, shown with dotted pattern).[8] While national markets exist for some of the crops

[7] To control for differences in plot size, between smaller plots in valley farmland and larger plots in mountainous farmland, I converted units of land to percentages for each farmer. These data represent the allocation decisions that individual farmers make in light of changing policies and technologies for manage agricultural water, rather than as representative samples of the total area of each crop in the region.

[8] These averages are not weighted, however, because each village was sampled at a rate of 10%, they are approximately correct at the village level. A larger problem lies in differences in average acreage between upper valley, lower valley, and mountainous towns, which is far more difficult to approximate. The figure of 15% cash crops in 1990 probably somewhat overstates the prevalence of cash crops because these were primarily potatoes, which are used for subsistence when planted in to 1/12 of one hectare or less of land.

grown on a subsistence basis (particularly wheat and legumes) their cultivation in this particular region has historically been mostly limited to subsistence-level production.[9] By 2010, this allocation had changed to 60% market crops and 40% subsistence crops.

Figure 4. Percentage of land dedicated to crops in all villages.



This change in crop allocation has not taken place evenly in all areas of the valley. The hydrosocial relations of agrarian change have differed in the three sub-areas of the valley (mountain, upper valley, lower valley) due to differences in the availability of the biophysical resource of water.

Land allocation changes have had the least impact in the mountain villages where 60% of land remains dedicated to subsistence crops (figure 5). While maize has begun to be grown in the mountains, it has happened slowly for several reasons. First, in Northwest China maize requires land flat enough to use plastic mulches. While much of the land in these villages has been terraced, large portions remain sloping. Secondly, technology of all sorts arrives more slowly in the mountain villages where the organisational power of local government is somewhat weaker. Finally, some mountain regions in the study area are simply located at too high an elevation to grow maize successfully. Potatoes, on the other hand, have become more widely grown in mountain villages, and are the primary cash crops in those areas. However, a large percentage of land in these villages remains dedicated to spring wheat.

[9] The subsistence nature of crop production in small grains and legumes is substantiated two sources. First, no farmers reported having sold wheat in the past. A few farmers reported occasionally selling some legumes, but these sales have never been a significant source of income. Second, average plot sizes ranged from 2 ha in areas of more productive land, to 4 ha in mountainous land. These plot sizes coupled with average harvests leave little surplus crop that could be sold.

Figure 5. Percentage of land dedicated to crops in mountain villages.

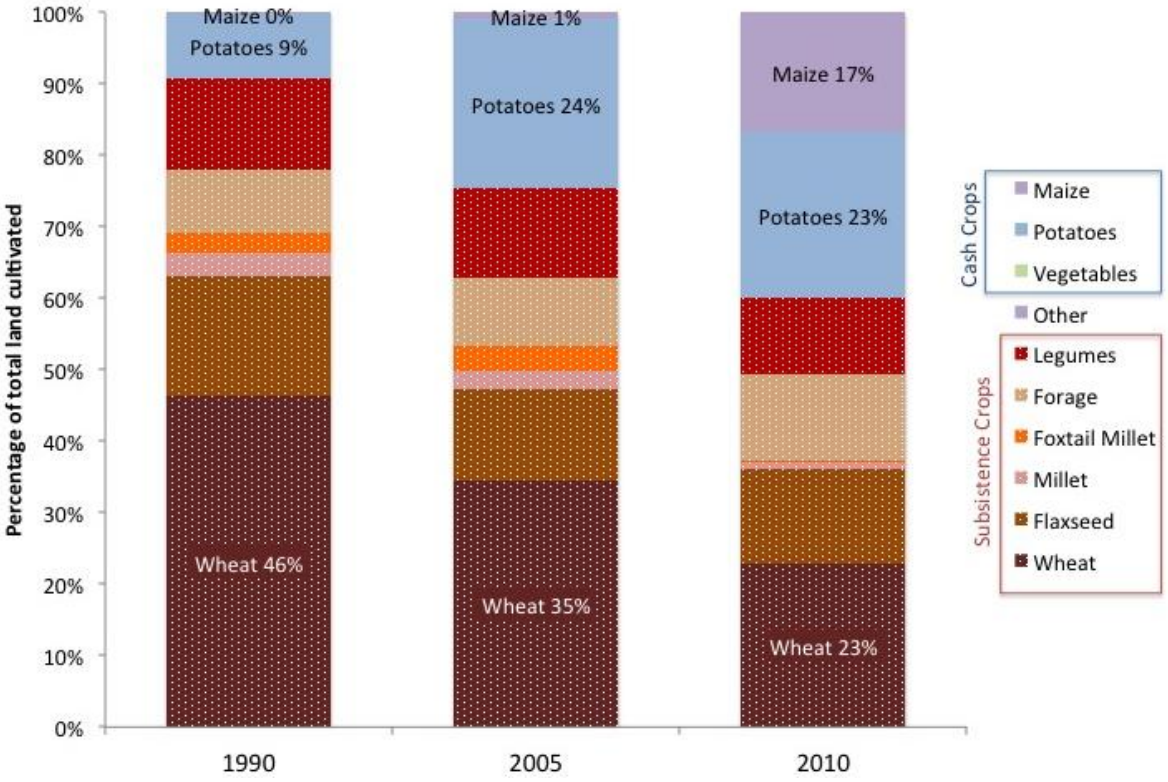
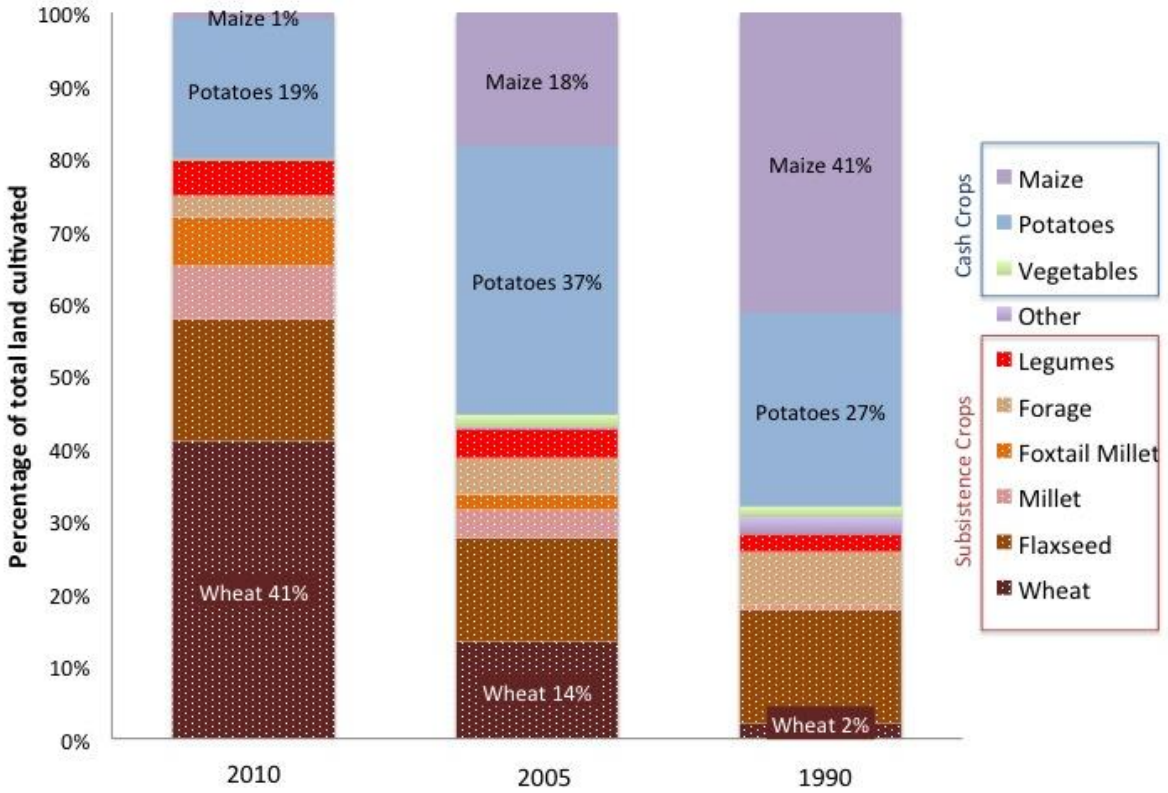


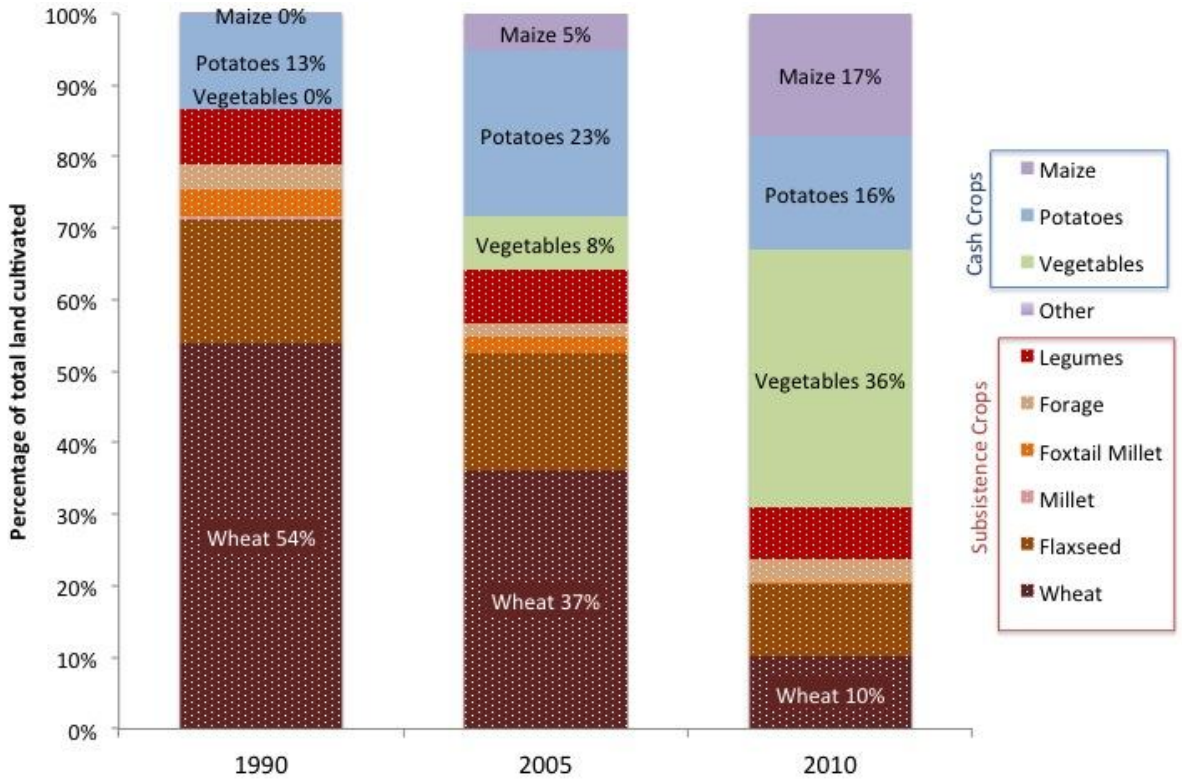
Figure 6. Percentage of land dedicated to primary crops in lower valley villages.



The lower valley experienced a more drastic increase in the cultivation of cash crops, which now equal roughly 70% of total acreage planted (figure 6). The initial increase in cash crops came from potatoes, which accounted for 37% of total land planted by 2005. However, by 2010, the land dedicated to potatoes had also begun to decrease, a trend that will be discussed in greater detail below.

Like the lower valley, the upper valley has seen the percentage of cultivated land dedicated to cash crops expand to roughly 70%, but the mix involved is far different (figure 7). The lower valley has transitioned primarily to growing potatoes and maize, while vegetables, primarily cabbage, are the largest crop in the upper valley.

Figure 7. Percentage of land dedicated to primary crops in upper valley villages.



The changes in cropping that have occurred in these three sub-areas of the Zuli river valley show that modernisation and marketisation of agriculture are reshaping the agricultural patterns of Northwest China. These changes are not simply changes in agriculture, but represent state-backed, hydrosocial interventions in agricultural water.

HYDROSOCIAL INTERVENTIONS

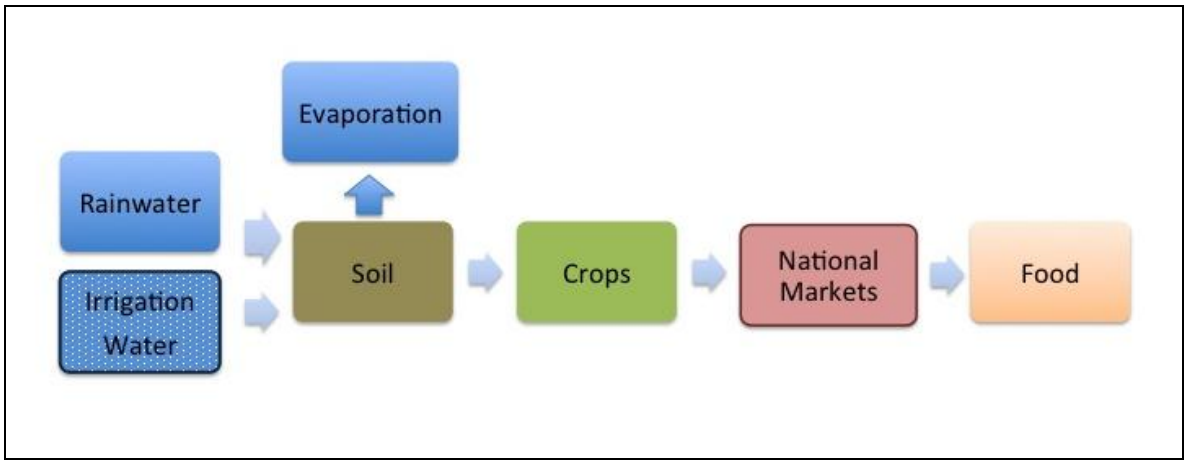
Three types of interventions have changed the hydrosocial relations in agricultural production in the Zuli valley: irrigation, the introduction of climate appropriate crops, and the introduction of maize.

Irrigation: Making water mobile

Agricultural water governance is most often associated with irrigation (c.f. Dubash, 2004; Mollinga et al., 2007; Budds, 2008; Perreault, 2008; Birkenholtz, 2009; Nickum, 2010), and the Zuli valley is no exception. Irrigation projects in the Zuli valley can be divided into three eras. First, in the late 1970s the county water bureau attempted a basin-scale irrigation project in the Zuli valley. Following the failure of

that project in the early 1990s, the county water bureau began a centralised tube well irrigation system in the upper valley. Finally, a major inter-basin transfer scheme, scheduled for completion in 2012 (Xinhua, 2009), has been promised as the panacea that will provide stable irrigation to the whole valley over the coming decades. Each of these irrigation systems aims to solve the problem of water scarcity in the Zuli valley's agricultural hydrosocial relationship by adding water from an outside source to the hydrosocial system, or regulating water availability across larger spatial and temporal extents (figure 8). In this case, the problem of water scarcity is met with the solution of water mobility. Such mobility also requires rescaling hydrosocial relations in either time or space.

Figure 8. Irrigation hydrosocial relations.



Basin-scale irrigation

The first era of irrigation in the Zuli valley was characterised by a basin-scale irrigation management programme. In the late 1970s and early 1980s, the county water bureau constructed eight dams and an extensive irrigation delivery system to irrigate valley-floor areas. Within my study area this project affected most of village 1 and a portion of village 3. All of the land irrigated by the project was relatively flat-bottom land that was used primarily to grow wheat, traditionally the dominant crop in the area. Farmers in the first and third villages reported that under such irrigation wheat yields did increase, often doubling, and yields became much more stable from year to year.

Basin-scale irrigation rescaled the biophysical resource of agricultural water both temporally and spatially. Temporally basin-scale irrigation rescaled the availability of water, making it available throughout the year. Because the Zuli river has its greatest water shortages in the early summer, basin-scale management allowed water to be stored over the course of a year and released when needed early in the growing season. The second form of rescaling associated with basin-scale irrigation was a spatial rescaling of water from being a distinctly local resource to one that was governed and managed at the scale of the river valley. Agricultural water was no longer limited to being used where it fell, instead mediating technologies – dams, canals, and sluices – made water mobile. Such rescaling required rethinking water as an abstract quantity (Linton, 2010), which could be predicted, measured, and allocated within the defined geographical area of the basin. Prior to the advent of basin-scale irrigation there was no centralised system of agricultural hydrosocial governance.[10] Primarily, individual farmers made hydrosocial decisions within the constraints of relying on rain-fed agriculture. When state actors introduced irrigation management it was at the scale of the medium-sized river basin. This

[10] Domestic water supplies were also governed by institutions that were quite small scale. Domestic water came from underground storage tanks or shallow wells, which were generally shared between several households in an extended family.

rescaling was in many ways an archetypal case of the high modernism discussed by Scott (1998), and this choice of scale for hydrosocial governance was driven by both political and technical constraints. Politically, the new scale was congruent with the territorial extent of the county water bureau. Thus, the level of state intervention and the scale of hydrosocial change were the same. Technically, this decision was limited by cost constraints that restricted development of the irrigation system to a river valley scale (an inter-basin transfer programme had been cancelled 20 years earlier when it was found to be infeasible (Xinhua, 2009).

The era of river-basin scale irrigated agriculture in the Zuli river valley proved remarkably short. By 1990, seven of the eight dams that initially provided water to the system had silted to the point of being unusable. Only one remaining reservoir is still active, and irrigates a relatively small area of the upper valley. In the lower valley, irrigation works remain, but they are mostly unused.[11] Ultimately the design of these dams proved too complex a means of mediating water for this region.[12] Yet, even at the time of their construction, such dams did not effect a change in the crops that were grown in the region. Instead, crops that had always been grown achieved higher yields with a steadier supply of water. There are several explanations for this. At the time, agricultural taxes were still paid in grain, specifically staple crops such as wheat. This system locked farmers into cropping patterns required to achieve a certain quota of grain each year. In the mid-1990s, these policies were relaxed by allowing payments of cash in lieu of grain, and, in 2004, the tax was eliminated (Kennedy, 2007). More importantly, there were not yet national-scale markets that would allow peasants to market cash crops. Agricultural trade remained a primarily local activity. Changes in the scale of markets and other socioeconomic factors of hydrosocial relations would later change agriculture in the region. By the late 1990s, it was clear that basin-scale irrigation had failed, and policy makers began looking for other ways to deal with the problem of aridity in the Zuli valley.

Groundwater irrigation

In the late 1990s, approximately ten years after the farmers in the lower valley could no longer reliably receive water to irrigate wheat, the county water bureau began installing tube wells for irrigation in the upper valley which, in contrast to the lower valley, has potable groundwater. This irrigation project is much smaller in scale; eight tube wells, each approximately 100 m deep have been dug since 2000. This water is routed through a centralised distribution system run by the county water bureau to individual households.[13] Although aquifers in the area are as shallow as 10 m below the surface, prior to the advent of tube wells there was no history of irrigation in the area. Until quite recently, this irrigation water was directed primarily towards wheat; however, in the last five years it has increasingly been used to grow vegetables, particularly cabbage, for the national market for reasons described below.

From the perspective of state actors, tubewell irrigation has the advantage of being quick to implement. Tube wells can be drilled in a season, and additional irrigation works built up slowly. Thus, local cadres can have projects completed in time for their review for promotion after two years (Cook, 2005). Indeed, the growth of tube wells in the upper valley has come at a rate of approximately one new well per year over a period of ten years. The hydrosocial governance regimes associated with

[11] Farmers reported that every few years they might be able to irrigate once if water is released, but it is not a reliable source of water. Indeed, when water does come now, it is available in late summer in wet years; in other words, at times when water is least needed.

[12] The dams in question may not have been built with the highest design quality. These dams were completed shortly after the end of the Cultural Revolution, a time when it was still widely believed that the sheer power of labour, rather than technical planning, could triumph over the natural world. See Shapiro, 2001, chapter 3.

[13] In each village, distribution is based on a first come, first served basis. Over most of the growing season there is about a one-week wait for water, longer in particularly dry spells, shorter during periods of rain. The challenge for producers then, is predicting when they will need water. Most producers in this area irrigate three times per year, approximately every four weeks between mid-April and early July. Each village has a community member, employed part-time by the water bureau, charged with opening valves to provide irrigation water for individual farmers.

groundwater irrigation (both wheat and cabbage) have engendered both biophysical and socioeconomic rescaling.

The rescaling of the biophysical resource of water in groundwater-based irrigation is primarily temporal since groundwater is water that has been stored for millennia in the rock formations below the upper valley. In the last ten years, water tables have fallen by approximately three meters, or about one foot per year. This fall, however, has varied from year to year, and appears to be accelerating as additional tube wells have been dug in the past five years.

Socioeconomic rescaling has also contributed to the shift in agricultural hydrosocial relations that accompanied groundwater irrigation in the upper Zuli valley. First, irrigation water used in the upper valley includes embodied energy, in the form of electricity used for pumping, which comes from national network power distribution. Rural electrification in the 1980s connected the Zuli valley to the Northwest China power grid, an essential input required to irrigate. Irrigation water is pumped from approximately 100 meters, requiring energy in quantities that were unavailable in the region before electrification in the 1980s. The second form of socioeconomic rescaling that has altered hydrosocial relations in the upper Zuli valley is the introduction of national vegetable markets. Figure 7 illustrates that irrigation water was initially (as recently as 2005) directed towards growing traditional crops, particularly wheat. By the late 2000s, this water came to be used instead for growing vegetables, particularly cabbage.[14] This shift to growing cabbage was a deliberate policy decision made by the township government of Neiguan, a township in the upper valley not included in this study, that realized that the relatively cool and dry climate of the upper valley is well-suited to cabbage growing. Creating successful markets for agricultural products requires, among other things, physical infrastructure to facilitate market processes (Garcia-Parpet, 2007). The township government of Neiguan initially built cold storage cellars, and private entrepreneurs have since also built storage cellars. This has made Neiguan a central point for marketing cabbage in Northwest China. Thus, although the state actor involved in promoting cabbage (Neiguan township) is at a lower level and has a limited territorial extent, its policies have engendered changes in hydrosocial processes that spill into other townships, and engage with national-scale socioeconomic actors.

Developing groundwater irrigation in the upper valley of the Zuli river has required both the temporal rescaling involved in accessing the biophysical resource of water, and perhaps more importantly, a rescaling of the socioeconomic aspects of hydrosocial relations. The national connections made for both inputs (e.g. electricity) and outputs (e.g. cabbage) have made irrigated vegetables a viable cash crop in the upper Zuli valley (figure 8). Until these national market institutions were introduced, the hydrosocial relations in this region were only partially altered. Each rescaling represented separate governance interventions undertaken by separate state actors. The scale of socio-ecological processes associated with these changes has not always been congruent with the level of the territorial state actor. While the county water bureau has engaged with hydrologic processes within the borders of its territorial unit of governance (the county), the Neiguan township government has engaged with national processes of market integration that have spilled over, changing the hydrosocial governance outside of its territorial boundaries.

Inter-basin irrigation

The third stage of irrigation in the Zuli river valley is based on the inter-basin transfer of water from the Tao river, which originates on the Tibetan Plateau in Qinghai province (Xinhua, 2009). The goal of the Tao river project is to provide sufficient irrigation water to all regions of the Zuli valley that have had water in the past, and open further areas to irrigation. This project is emblematic of technologically intensive mega-projects that have symbolised modernity and rescaled the state the world over (Kaika, 2006; Swyngedouw, 2007). Water, which was once a local resource, or at most a basin-wide resource,

[14] The cabbage in question is what is referred to in English as 'cabbage' *Brassica oleracea* (Capitata Group) (Chinese *baocai*) rather than 'Chinese cabbage' *Brassica rapa* subsp. *pekinensis* (Chinese *baicai*).

will be rescaled to become a provincial resource, managed and allocated at a scale congruent with the level of territorial governance charged with its administration. Modern water management has been based on the abstraction of water as an interchangeable and calculable object (Linton, 2010). Yet, it is specific actors, working at specific scales, whose measurements and calculations abstract water. In China the scale of at which water is abstracted has coincided with the level of territorial administration of the water bureaucracy charged with its management. Thus the provincial-based engineers of the Tao basin transfer project, conceptualised the water of the Tao River as a provincial resource that could be used to irrigate the Zuli basin as early as the 1950s. It was not until the 2000s that the provincial water ministry gained the technical and financial ability to materialise that abstraction. With the Tao river basin the abstraction and management of water has been rescaled from the watershed to the province and nation. County water bureau officials believe that this project will affect a massive shift of hydrosocial relations in the valley. Yet, many farmers in the lower valley are sceptical, having seen agricultural water projects fail before. Agricultural water made mobile has come to visit before, but it has never stayed long.

Potatoes: Obviating water

The second major change in the agricultural hydrosocial relations of the Zuli valley has been the expansion of potatoes as a cash crop. Growing potatoes does not require moving or altering biophysical water supplies in any way. Instead, potato agriculture solves the problem of water scarcity by changing when water is needed. Potatoes require water later in the growing season, making them more suitable to the local hydrological conditions than small grains (Shang, 2007; Yan, 2008). The introduction of potatoes must be understood as a deliberate intervention in peasants' relationship with agricultural water. Potatoes did not emerge autochthonously as a crop in this region. Rather, they were introduced by a variety of state-backed interventions that rescaled how peasants related to agricultural water. These interventions came in the form of policies that created national markets for agricultural products.

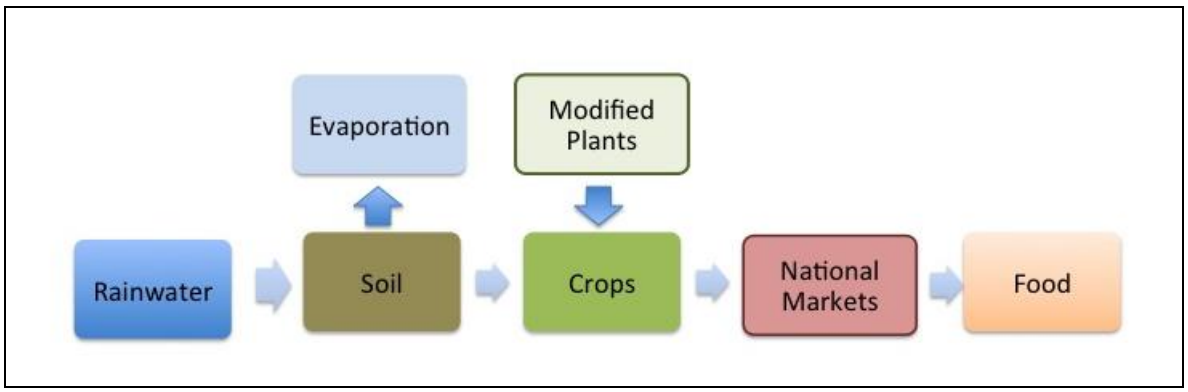
In the early 2000s the local government began to formulate a plan to promote growing potatoes as a way to alleviate poverty in the region (Shang, 2007, Yan, 2008). Because state actors view poverty and aridity as deeply intertwined, the promotion of potatoes was also seen as a way to solve the problem of aridity. The premise was that while summer grains required early season water (May-June), potatoes required water later in the summer (July and August) (Shang, 2007). With most precipitation in the area falling later in the summer (Wei et al., 2005), potatoes seemed a perfect fit. Local government and academics began pushing for potatoes as means to reduce poverty; local government framed the switch to potatoes as adapting to the local weather conditions or "going with nature and the seasons" (*shunying tianshi*) (Shang, 2007).

The introduction of climate-appropriate potato agriculture required rescaling how people related to food (figure 9). As with cabbage, the previously direct link between the crops farmers grew and the foods that they ate came to be mediated by national commodity markets. Rescaling of agricultural hydrosocial relations in potato cultivation occurs primarily after the harvest of the crops. The presence of markets at the scale of the nation, as well as direct policies to support those markets, allow potatoes to be a cash crop in the Zuli valley.[15] Potatoes are sold in national markets, and the wheat that peasants rely on for food is, in turn, purchased in a national market (most often actually coming from other areas of Gansu). The fact that the markets that convert potatoes to staple foods are national in scale is a direct outgrowth of state policies. While a global market for wheat exists, the Chinese state has made concerted efforts to ensure that it is self-sufficient in grain production (Boland, 2000), often with grave environmental consequences. While potatoes are not classified as a staple crop, potato traders and

[15] Though rich in carbohydrates, potatoes are not treated as a staple crop by the Chinese state or by peasants. Though peasants in the Zuli river valley eat potatoes often, they do not refer to them as staple food (*zhushi* 主食). In national markets potatoes are treated as a type of vegetable. The ability to pay grain taxes in cash, and their eventual elimination, in 2004, may have played a role in the expansion of potato cultivation.

representatives of local government told me that almost all of the potatoes grown in the region were used domestically, rather than sold for export.

Figure 9. Potato hydrosocial relations.



Integration with national markets was not an organic process, but rather the result of specific policies of the county and prefecture governments, the agricultural ministry, and national-scale poverty alleviation authorities that were intended to make potatoes a successful dry-land agricultural strategy. First, integrating potatoes in a national market requires extensive transport networks. In the case of Dingxi, potatoes are shipped by both truck and train to markets throughout China. The local government arranges several trains each year to send potatoes to cities in East China. Similarly, improved roads built over the last decade have made it economically feasible to ship potatoes to eastern cities by truck. Second, county and township governments have promoted storage and marketing. Several larger towns in the valley have built storage caves that are rented to vendors each fall, and the prefecture and county governments organise two large potato markets located at railheads. Third, with national support, the county has been involved in breeding programmes to increase the quality, and therefore price, of local potatoes. The product, a breed called 'New Big Harmony' (*xindaping*) commands higher prices (based on interviews in 2010, about 10% higher) on the national market. The local state has also become deeply involved in attempts to create 'potato industrialisation'. The central valley is already home to a large number of potato starch factories, as well as potato growing equipment companies. All of these efforts are part of the Dingxi county government's goal of becoming the 'Potato Capital' (*shu du*) of China.

Changing the agricultural hydrosocial relations of Northwest China to accommodate potatoes has not involved altering the hydrology of agricultural production (figure 9). Instead, state actors changed the way people and the economy in the Zuli river valley interact with its limited water resource by replacing staple crops, which were locally grown and consumed, with potatoes that are mediated by national institutions. To be clear, these policies were an attempt to deal with the problem of aridity in Dingxi, and thus can be read as state policies to change how people relate to water.

The active role of local state policy in promoting and regularising potatoes (a climate-appropriate cash crop) can be seen in the counterfactual case of Jerusalem artichokes, a similarly climate-appropriate cash crop that was briefly grown in the area. A local entrepreneur began encouraging farmers to plant Jerusalem artichokes in approximately 2004, and for a few years it was widely planted and quite profitable for farmers. However, a broader market never developed, and farmers remained reluctant to plant a crop that remained dependent on only one buyer. Similarly, lamb from the area is famous for its high quality within the province, and is widely sought out. Yet, without state support, neither lamb nor Jerusalem artichokes have taken off in a way similar to potatoes. The rescaling of the agricultural hydrosocial relations in the Zuli valley to support potato agriculture required specific policy

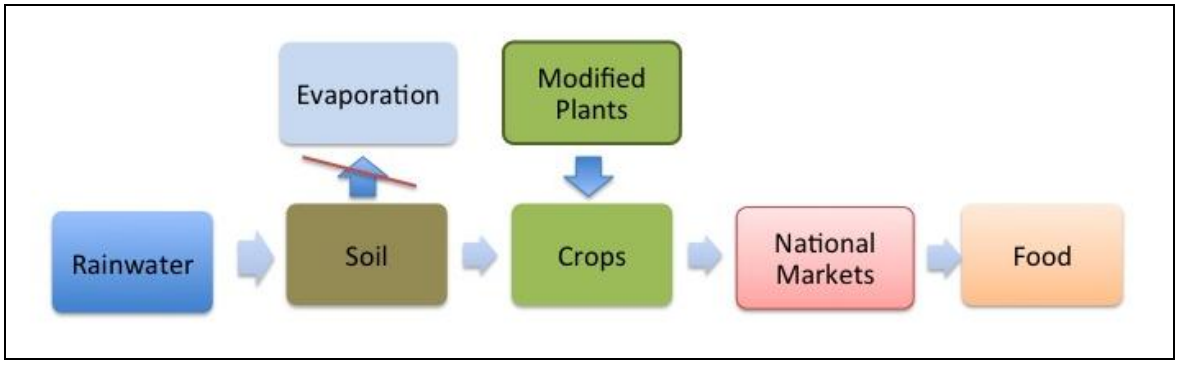
interventions by local state actors, including storage and marketing facilities. These interventions facilitated national-scale markets that have made potatoes a cash crop in the Zuli valley. If we are to consider hydrosocial relations broadly, we must include state-backed interventions in agricultural practices that not only manage biophysical water, but also reduce the need for biophysical water as forms of hydrosocial governance. These interventions have little to do with biophysical resource of water. Instead, these programmes represent ways of obviating water through the construction of storage caves and marketing facilities, plant breeding, and state-backed transportation initiatives. These policies were part of a deliberate and successful state policy to change the relationship of farmers to agricultural water in the Zuli valley.

However, several respondents reported that they are planting fewer potatoes today than in the past. There have been two major factors driving peasants away from potatoes. Potatoes are far more labour intensive than maize, which, at recent prices and with technological interventions, has become as profitable to grow, as discussed further, below. Second, there is simply less labour available than in the past. In past years, outmigration for labour, particularly from the mountain towns, was limited; however it is now a major trend in the region. The availability of maize as an agricultural strategy and pressures on labour have resulted in lower levels of potato planting in recent years. Despite the goal of the county government to become 'China's potato capital', maize is largely taking the potato's place.

Plastic films and maize

The final major change to the agricultural hydrosocial cycle has been the introduction of maize as an agricultural crop in the region. Maize is a new crop in the region, and its introduction required three hydrosocial interventions (figure 10). First, plastic film mulches were introduced to retain soil moisture. Second, new varieties of maize were bred to be drought resistant. Finally, the arrival of maize was dependent upon the introduction of national and international markets for the commodity.

Figure 10. Maize hydrosocial relations.



The first intervention biophysically intervenes in hydrosocial relations by preventing evaporation that would otherwise desiccate the soil. With this intervention crops that would otherwise wither can last through the dry early summer period (Li and Gong, 2002). This is a direct intervention in the hydrology of the region; however, by focusing on preventing the loss of water rather than on the provision of water it presents an alternative approach to agricultural water governance. Films for maize are currently subsidised by national poverty alleviation funds that are distributed by township governments. Maize has also been supported by agricultural extension efforts undertaken by the county agricultural bureau to teach peasants how to grow it. Maize is the latest in a string of crops for which films have been supported by the local government and agricultural extension programmes (Cook, 2005). However, this is the first crop that has been grown using this technology in a sustained manner. Even when films are not subsidised farmers continue to purchase them for maize. Thus while mulch-

supported maize has governed water movements at a micro-level, it has been supported by state-backed socioeconomic institutions at the county and provincial scales.

The second hydrosocial intervention involved in maize agriculture in the Zuli river valley was to change the very nature of the plants that were grown. The choice of plants and varieties is part of agricultural hydrosocial relations, and altering the biology of plants to be drought resistant is part of transforming agricultural hydrosocial relations. Until the past decade maize had been unable to tolerate the arid weather of the Zuli valley. Several drought-resistant maize varieties, the most prominent of which is called 'success ball' (*cheng dan*) made maize agriculture successful in eastern Gansu. Farmers had always planted potatoes in small quantities, but maize had never been planted until hybrid seeds and plastic mulches were introduced. I was told by several farmers that cheng dan maize was originally bred by the Chinese Academy of Sciences. However, the patent for this cultivar is held by the Sichuan Institute of Agricultural Sciences, while the actual seed used in the Zuli valley is produced by a seed company from Hebei province. Although the local understanding that these seeds were produced by the nation's preeminent scientific organisation is incorrect, these cultivars did arrive through a national infrastructure of seed breeding and extension. This has rescaled hydrosocial governance by introducing new seeds that enable new relationships between farmers and water.

Finally, expansion of maize agriculture in the Zuli river valley has depended upon the introduction of national, as well as local markets for maize. National markets for maize brought national-scale institutions to bear on the previous direct link between peasants and their staple foods, and facilitated the biophysical transformations in how agricultural water is used. Peasants in Northwest China do not eat maize.[16] Therefore, like potatoes and vegetables, maize must be exchanged in national markets and wheat flour purchased. The price of maize has been rising rapidly in recent years in China, due in large part to its role as an input in growing protein, both meat and eggs, which increasingly prosperous urban residents continue to demand. Indeed, many people said that most of the maize being grown in the lower valley did not leave the valley, but was used as chicken feed in village 3, which had dozens of small-scale confined poultry-farming operations that produce eggs for the provincial capital of Lanzhou. These farms too, were created through a specific state policy by the township government, supported by the national poverty alleviation office, which sought to raise peasant incomes by becoming a centre of egg production.[17] Thus the introduction of maize agriculture in the valley relied upon the introduction of a variety of socioeconomic interventions at both national and local scales to convert crops into usable foods for farmers.

The shift to growing maize in the Zuli river valley has involved changing how the biophysical resource of water interacts with plants, the very nature of plants, and the socioeconomic institutions that link agricultural water and food. Using plastic films has slowed the processes of evaporation and altered the physical hydrology of the soil. The very nature of the plants being grown has been altered by the introduction of seeds from a national infrastructure of plant breeding and extension, and the crops introduced have required the use of national as well as local commodity markets to mediate between crops and food. Each of these three changes was necessary to alter the agricultural hydrosocial relations of the Zuli valley. Yet these changes did not occur on their own or out of market conditions alone: various state actors, primarily township governments and the county agricultural bureau, have

[16] One interesting facet of this in the most maize-intense village (village 1) was the institution of 'exchanging flour'. When asked if they ate their maize, several people said that they did, and when we asked more thoroughly, they explained that they did not actually truly eat their maize; rather they traded it for. Although the exchanges took place at what were basically market prices, farmers conceived of this as not selling maize, but rather continuing to eat the grains that they had grown. Their market behaviour also expressed this. Those who exchanged maize would do so slowly over the course of the year, holding on to their stores of grain as a form of food security. Maize, even if people don't eat it, is a staple food. However, not everyone in this village exchanged flour. Many farmers did say directly that they sold their maize, and these farmers would often sell it all at once at harvest.

[17] This too has been facilitated by changes in water management. Such chicken farms were not possible until a piped rural drinking water supply lowered the price of water in the area.

backed each of these steps. Thus state actors whose policy portfolios do not include the management of the biophysical resource of water also engage in governance of hydrosocial relations.

CONCLUSIONS

These three state-backed interventions in the agricultural hydrosocial cycle – irrigation, climate-appropriate cash crops, and hybrid seeds and mulches – have effected a complete change in the relationship between agricultural water and food in the Zuli river valley. Each intervention has rescaled the hydrosocial relations through both the governance of the biophysical resource of water, and the social institutions that surround that water (table 1).[18] There are three key findings of this research that add to our understanding of the relationship between humans and water.

First, state-backed governance interventions that rescale hydrosocial relations are not unidirectional, and the scale of hydrosocial processes need not be congruent with the scale (level) of state interventions. Furthermore, many such processes of rescaling are contingent upon the opportunities available to political and policy actors. Previous studies linking state development programmes to scale in water governance have tended to view changes in the scale of water governance as deliberate processes undertaken by state actors to move the scale at which water is managed either upwards as part of a larger political process of modernisation (Kaika, 2006; Swyngedouw, 1999, 2007) or downwards as a process of political devolution (Perreault, 2005; Norman and Bakker, 2009; Cohen and Davidson, 2011).

Table 1. Interventions in agricultural hydrosocial relations in the Zuli river valley.

Intervention	Actor	Biophysical rescaling	Socioeconomic rescaling
Basin scale irrigation	County Water Bureau	Scaling water governance up to basin scale	Limited
Ground water irrigation	County Water Bureau Township Government	Use of past water resources	National commodity markets for crops National grid for energy
Inter-basin irrigation	Provincial Water Bureau	Scaling water up to national water resources	National level management
Climate-appropriate cash crops	County Government County Agriculture Ministry National Poverty Alleviation Office	None	National commodity markets for crops State investment in markets
Maize agriculture	County and Township governments	Controlling evaporation and the micro-scale	National commodity markets for crops State extension and research infrastructure

Some processes of rescaling in the Zuli valley have clearly embodied the modernist ethos of rescaling water governance upwards to be congruent with state based territorial units. For example, inter-basin water transfers rescaled water management to the national level, and basin-scale irrigation rescaled water as a basin-wide resource. In the case of the latter, the rescaling did not work, or in the language

[18] A final rescaling, which I have not explored in this paper, involves a large increase in the use of pesticides and fertilizers required to grow maize, purchased on the national market.

of Moore (2008) it was a failed attempt at 'scaleness'. Yet those state interventions that have most changed the scale of hydrosocial relations were not undertaken as a deliberate attempt to rescale. Becoming a centre of potato marketing was a strategy selected because the county government viewed national markets for potatoes as the most expedient scale for arid area agricultural development following the failure of basin-scale irrigation. Similarly, the introduction of maize cultivation was the product of several small technological changes that occurred at different scales. While these processes did change the scale of hydrosocial relations, and increased the role of the state in governing those relations, such changes to the scale of hydrosocial relations were not deliberate policy goals. Indeed state interventions backing maize and potatoes have competed with each other because different bureaucracies working at different scales have provided competing strategies for dealing with the problem of aridity. The prefectural government has promoted potatoes, while a township government has emphasised chicken farms that helped to drive maize production, and the county water bureau has built tube wells that irrigate vegetables which are sold at a marketplace built by yet another township government. A state actor made each of these policies, but each state actor has rescaled hydrosocial governance in a different way. By applying the fragmented authoritarianism framework which has been so productive in understanding the politics of large-scale water projects in China (Lieberthal and Oksenberg, 1990; Mertha, 2008) to small-scale changes in hydrosocial governance we see that state-backed rescaling of hydrosocial relations are not necessarily deliberate, and are often contingent upon what opportunities are available to state actors.

Second, studies of water governance linking rescaling of hydrosocial relations to projects of modernisation and state building often tend to emphasise processes of rescaling that are capital- and technology-intensive (Kaika, 2006; Swyngedouw, 1999, 2007). The case of the Zuli valley illustrates that rescaling governance of hydrosocial relations, even when associated with modernisation and the intensification of state power, may use low levels of both capital and technology. The interventions discussed in this paper, for the most part, used low levels of capital and technology. Indeed the only completed intervention in hydrosocial relations that was capital- and technology-intensive, namely basin-scale irrigation, was the least successful. Switching the crops that farmers grew in the Zuli valley used comparatively lower levels of both capital and technology, but nonetheless changed the scale of hydrosocial relations. Thus state-backed rescaling of hydrosocial governance is as likely to operate through the micro-politics of development (Li, 2007) as it is through the symbolic techno-natural remaking of waterscapes (Swyngedouw, 2007).

Finally, if we are to take seriously the socionatural construction of water, addressing hydrosocial governance need not be limited to studying the governance of the biophysical resource of water. Rather, we must examine the governance of other political and economic factors that affect human interactions with water. For example, creating markets for potatoes following the failure of basin scale irrigation governed how humans related to agricultural water, even if it did not govern the biophysical resource of water. This is not to say that changes in the management of biophysical water are unimportant; indeed many of the changes in agricultural hydrosocial relations in the Zuli valley demonstrate the importance of such changes. Rather, the case of the Zuli valley calls for thinking through hydrosocial governance more broadly in a way that takes the politics of what people do *without* water as seriously as the politics of what people do *with* water.

ACKNOWLEDGEMENTS

This research was supported by the U.S. National Science Foundation Award Number 092739, the Fulbright-Hays Doctoral Dissertation Research Abroad Program (US Dept. of Education Award Number P022A090013), the University of Colorado, Boulder Graduate School, and the Political Geography Specialty Group of the Association of American Geographers. The Lanzhou Branch of the Chinese Academy of Sciences provided important help in conducting fieldwork. Tim Oakes, Emily Yeh, and the

China group at the University of Colorado Geography Department provided comments on previous drafts of this article. Any remaining errors are mine alone.

REFERENCES

Baker, J.M. 2008. *The kuhls of Kangra: Community-managed irrigation in the western Himalaya*. Seattle: University of Washington Press.

Bakker, K.J. 2002. From state to market?: Water mercantilización in Spain. *Environment and Planning A* 34(5): 767-790.

Bakker, K.J. 2003. *An uncooperative commodity: Privatizing water in England and Wales*. New York: Oxford University Press.

Birkenholtz, T. 2009. Irrigated landscapes, produced scarcity, and adaptive social institutions in Rajasthan, India. *Annals of the Association of American Geographers* 99(1): 118-137.

Boland, A. 1998. The Three Gorges debate and scientific decision making in China. *China Information* 13(1): 25-42.

Boland, A. 2000. Feeding fears: Competing discourses of interdependency, sovereignty, and China's food security. *Political Geography* 19(1): 55-76.

Brenner, N. 2001. The limits to scale? Methodological reflections on scalar structuration. *Progress in Human Geography* 25(4): 591-614.

Brown, L. and Halweil, B. 1998. China's water shortage could shake world food security. *World Watch* 7(8): 10-21.

Budds, J. 2008. Whose scarcity? The hydrosocial cycle and the changing waterscape of La Ligua river basin, Chile. In Goodman, M.K.; Boykoff, M.T. and Evered K.T. (Eds), *Contentious geographies: Environmental knowledge, meaning, scale,* pp. 59-78. Hampshire: Ashgate Press.

Cohen, A. and Davidson, S. 2011. The watershed approach: Challenges, antecedents, and the transition from technical tool to governance unit. *Water Alternatives* 4(1): 1-14.

Cook, S. 2005. Rainwater harvesting in Gansu province, China: Development and modernity in a state sponsored rural water supply project. PhD thesis. Yale University, New Haven, CT.

Du, J. and Woodworth, M.D. 2011. Irrigation society in China's northern frontier, 1860s-1920s. *Cross-Currents: East Asian History and Culture Review* 1(1): 22. http://cross-currents.berkeley.edu/e-journal/inaugural-issue/irrigation-society-china-s-northern-frontier-1860s-1920s

Dubash, N. 2004. Water, markets, and embedded institutions in Western India. In Peet, R. and Watts, M. (Eds), *Liberation ecologies: Environment, development, social movements,* pp. 218-243. London: Routledge.

Fei, X.T. 1985. Borderland development: Dingxi edition (*bianqu kaifa: dingxi pian)*. *Development Strategy (kaifa zhanlue)* 1985(1): 7-15.

Garcia-Parpet, M.F. 2007. The social construction of a perfect market: The strawberry auction at Fontaines-en-Sologne. In MacKenzie, D.; Muniesa, F. and Siu, L. (Eds), *Do economists make markets?: On the performativity of economics,* pp. 20-53. Princeton, NJ: Princeton University Press.

Gibson, J. and Kim, B. 2010. Non-classical measurement error in long-term retrospective recall surveys. *Oxford Bulletin of Economics and Statistics* 72(5): 687-695.

Kaika, M. 2006. Dams as symbols of modernization: The urbanization of nature between geographical imagination and materiality. *Annals of the Association of American Geographers* 96(2): 276-301.

Kennedy, J.J. 2007. From the tax-for-fee reform to the abolition of agricultural taxes: The impact on township governments in North-West China. *The China Quarterly* 189(1): 43-59.

Li, T.M. 2007. *The will to improve: Governmentality, development, and the practice of politics*. Durham: Duke University Press.

Li, X.Y. and Gong, J.D. 2002. Effects of different ridge: Furrow ratios and supplemental irrigation on crop production in ridge and furrow rainfall harvesting system with mulches. *Agricultural Water Management* 54(3): 243-254.

Lieberthal, K. and Oksenberg, M. 1990. *Policy making in China: Leaders, structures, and processes*. Princeton NJ: Princeton University Press.

Linton, J. 2010. *What is water? The history of a modern abstraction.* Vancouver: University of British Columbia Press.

Marston, S.A. 2000. The social construction of scale. *Progress in Human Geography* 24(2): 219-242.

Marston, S.A. and Smith, N. 2001. States, scales and households: Limits to scale thinking? A response to Brenner. *Progress in Human Geography* 25(4): 615-619.

Mertha, A. 2008. *China's water warriors: Citizen action and policy change*. Ithaca NY: Cornell University Press.

Mollinga, P.P.; Meinzen-Dick, R.S. and Merrey, D.J. 2007. Politics, plurality and problemsheds: A strategic approach for reform of agricultural water resources management. *Development Policy Review* 25(6): 699-719.

Moore, A. 2008. Rethinking scale as a geographical category: From analysis to practice. *Progress in Human Geography* 32(2): 203-225.

Mosse, D. and Sivan, M. 2005. *The rule of water: Statecraft, ecology and collective action in south India*. Oxford: Oxford University Press.

Nickum, J. 2010. Water policy reform in China's fragmented hydraulic state: Focus on self-funded/managed irrigation and drainage districts. *Water Alternatives* 3(3): 537-551.

Norman, E.S. and Bakker, K.J. 2009. Transgressing scales: Water governance across the Canada-US borderland. *Annals of the Association of American Geographers* 99(1): 99-117.

Ostrom, E. 1990. *Governing the commons: The evolution of institutions for collective action*. New York: Cambridge University Press.

Perreault, T. 2005. State restructuring and the scale politics of rural water governance in Bolivia. *Environment and Planning A* 37(2): 263-284.

Perreault, T. 2008. Custom and contradiction: Rural water governance and the politics of usos y costumbres in Bolivia's irrigators' movement. *Annals of the Association of American Geographers* 98(4): 834-854.

Prudham, S. 2004. Poisoning the well: Neoliberalism and the contamination of municipal water in Walkerton, Ontario. *Geoforum* 35(3): 343-359.

Scott, C. and Amenuvegbe, B. 1990. *Effect of recall duration on reporting of household expenditures*. Washington, DC: World Bank.

Scott, J.C. 1998. *Seeing like a state: How certain schemes to improve the human condition have failed*. New Haven: Yale University Press.

Shang, B. 2007. Dingxi potatoes go out. *People's Daily Online*, 3 April 2007. www.cpad.gov.cn/data/2007/0403/article_333569.htm (accessed 29 February 2011)

Shapiro, J. 2001. *Mao's war against nature: Politics and the environment in revolutionary China*. Cambridge: Cambridge University Press.

Sheppard, E.S. and McMaster, R.B. 2004. Introduction. In Sheppard, E.S. and McMaster, R.B. (Eds), *Scale and geographic inquiry: Nature, society, and method,* pp. 1-22. Oxford: Wiley-Blackwell.

Snyder-Reinke, J. 2009. *Dry spells: State rainmaking and local governance in late imperial China*. Cambridge, MA: Harvard University Press.

Swyngedouw, E. 1999. Modernity and hybridity: Nature, regeneracionismo, and the production of the Spanish waterscape, 1890-1930. *Annals of the Association of American Geographers* 89(3): 443-465.

Swyngedouw, E. 2004. *Social power and the urbanization of water: Flows of power*. New York: Oxford University Press.

Swyngedouw, E. 2007. Technonatural revolutions: The scalar politics of Franco's hydro-social dream for Spain, 1939-1975. *Transactions of the Institute of British Geographers* 32(1): 9-28.

Swyngedouw, E. 2009. The political economy and political ecology of the hydro-social cycle. *Journal of Contemporary Water Research & Education* 142(1): 56-60.

Wei, H.; Li, J.L. and Liang, T.G. 2005. Study on the estimation of precipitation resources for rainwater harvesting agriculture in semi-arid land of China. *Agricultural Water Management* 71(1): 33-45.

Wittfogel, K.A. 1957. *Oriental despotism: A comparative study of total power*. New Haven: Yale University Press.

Worster, D. 1992. *Rivers of empire: Water, aridity, and the growth of the American west*. Oxford, England; New York : Oxford University Press.

Xinhua. 2009. The yin tao project: Gansu's dream of half a century. www.gs.xinhuanet.com/jdwt/yintaogc/ (accessed 29 February 2011)

Yan, Q.G. 2008. *Potato smiles (tudou de weixiao).* Lanzhou, China: Duzhe Press.

Yang, H. and Zehnder, A. 2001. China's regional water scarcity and implications for grain supply and trade. *Environment and Planning A* 33(1): 79-96.