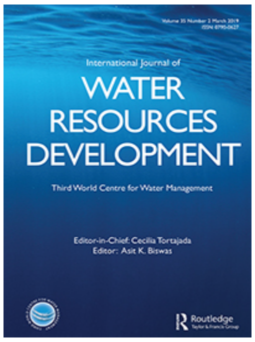

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Groundwater regulation in case of overdraft: national groundwater policy implementation in north-west China

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ABSTRACT

This article analyzes why China's national groundwater policy is implemented in a fragmented way. The question is addressed through a comparative case-study analysis of groundwater management in north-west China. The analysis focuses on the institutional context in which local government agencies responsible for groundwater management operate. It was found that direct pressure from the central government promotes policy implementation. Yet, the distribution of surface and groundwater management responsibilities over different government agencies also influences the importance attached to groundwater regulation. In a conjunctive-use setting the integration of surface water and groundwater management facilitates effective groundwater regulation.

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Groundwater regulation; local policy implementation; water policy reforms; comparative case study; China

Introduction

China has seen a tremendous increase in groundwater use over the last few decades. In the 1950s the country's groundwater use was insignificant, yet groundwater abstraction was estimated to have reached 100 km^3/y by around 2000 (Wada et al., 2010). In northern China, where rainfall is scarce and concentrated in the summer months, around 70% of the irrigated area relies on groundwater abstraction (Wang, Huang, Rozelle, Huang, & Zhang, 2009). Currently at least five million wells are in use for irrigation purposes, mainly in northern China (Qu, Kuyvenhoven, Shi, & Heerink, 2011). China's early development of groundwater use took off in the 1970s (Wang, Huang, Blanke, Huang, & Rozelle, 2007). After the redistribution of land-use rights to individual households and liberalization of the Chinese market in the late 1970s, groundwater use continued to rise. Intensified groundwater pumping led to agricultural intensification and increased income for smallholders (Shah et al., 2007; Wang, Huang, Huang, & Rozelle, 2006). Originally, well drilling developed without much regulation by the state (Wang, Huang, Rozelle, Huang, & Blanke, 2007). Like elsewhere in the world, the

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essentially 'open access' to groundwater allowed farmers to increase their water security and shift to high-value crops (Llamas & Martínez-Santos, 2005; Shah, Roy, Qureshi, & Wang, 2003). To a certain extent groundwater has also been used to enlarge the irrigated area, but in many cases pumping activities developed inside or at the fringes of existing canal command areas.

Although at first the increase in groundwater use meant a substantial improvement in farmers' livelihoods, problems of overdraft soon appeared. Overdraft is generally defined as groundwater withdrawal exceeding groundwater recharge (Lopez-Gunn, Llamas, Garrido, & Sanz, 2011). While there are instances where groundwater pumping sets off a new equilibrium of discharge and recharge (Aeschbach-Hertig & Gleeson, 2012), groundwater overdraft is characterized by a continuous drop of groundwater tables. Continuously falling groundwater tables have been reported in areas of intensive groundwater use in China, leading to multiple problems, such as reduced groundwater availability for natural ecosystems, groundwater saline intrusion in coastal areas, and land subsidence (Currell, Han, Chen, & Cartwright, 2012; Kendy, Zhang, Liu, Wang, & Steenhuis, 2004; Liu, Yu, & Kendy, 2001; Lohmar, Wang, Rozelle, Huang, & Dawe, 2003). These negative effects eventually render intensive groundwater use environmentally and socio-economically unsustainable.

In recent years problems associated with intensive groundwater use have received growing attention in China. The revised Water Law of 2002 for the first time stipulates that groundwater use has to be strictly regulated in regions of overdraft (Shen, 2015). Yet, national directives on how to implement this policy are non-existent. Policy instruments are designed locally where intensive groundwater use poses an acute problem. Worldwide it has turned out to be a daunting challenge to implement effective groundwater regulations, i.e. policies that actually curb farmers' groundwater use and stop or at least slow falling groundwater tables (Kemper, 2007). Two major constraints are discussed in the literature. First, implementation is hindered by difficulties in monitoring and controlling the use of groundwater because it is an invisible resource used by a large number of individuals (Giordano, 2009; Hoogesteger & Wester, 2015; Moench, 2004). Second, policy implementation by local authorities faces substantial opposition due to the short-term economic benefits of intensive groundwater irrigation (De Stefano & Lopez-Gunn, 2012; Hoogesteger & Wester, 2015; Molle & Alvard, 2015; Mukherji & Shah, 2005). Some scholars argue that groundwater regulation by the state is likely to be feasible in China because its hierarchical government structures reach out to agricultural groundwater users (Aarnoudse, Bluemling, Wester, & Qu, 2012; Shah, 2005). Moreover, China has had substantial economic growth over the last decades, which would provide the financial means to implement groundwater regulation measures (Villholth, 2006). Nevertheless, the few cases of groundwater regulation in China discussed in the English literature show varying results (Aarnoudse, Qu, Bluemling, & Herzfeld, 2016; Bluemling, Pahl-Wostl, Yang, & Mosler, 2010; van Steenbergen, Radstake, Fan & Zhang, 2016). Though it is obvious that national policies without clear policy directives will not lead to streamlined implementation, the question remains why, under the same national policy, groundwater regulation is implemented effectively in some cases and not in others. This article addresses this question by analyzing the institutional context in which local government agencies responsible for groundwater management operate and how this context impacts national policy implementation.

The institutional context is analyzed through a comparative study of three cases of local groundwater management in north-west China. In all three cases local authorities started to engage in groundwater regulation over the last decade. Yet, the outcomes in terms of policy instruments and effective regulation diverge. In the next section the theoretical considerations relevant for this study are outlined. Then, the study area and research methodology are introduced. After that, the three cases are presented in more detail. For each case, the article describes how the administrative structure affects the decision making of local authorities with regard to groundwater regulation (i.e. what policy instruments are selected). Finally, the results are discussed and conclusions are drawn on national groundwater policy implementation at the local level in the Chinese context.

Theoretical considerations

To understand why national policies are implemented in a fragmented way, this article looks at the institutional context in which local authorities, i.e. the actual policy implementers, operate. In this article the term 'local authorities' refers to all government agencies that operate below the province level, because these are the ones directly in charge of groundwater policy implementation at the local level. The institutional context is understood as a set of 'arrangements between people which are reproduced and regularized across time and space' (Cleaver, 2012, p. 8). Formal institutions, like administrative structures, play an important role in assigning responsibilities and advancing strategies for national policy implementation. Institutional barriers inherent in China's administrative structure are identified as a critical factor contributing to the environmental policy implementation gap in China (Kostka, 2014). Therefore, this article focuses on three dimensions of the administrative structure related to local groundwater management: the official and contextual goals of local water authorities; the designation of groundwater management responsibilities; and instruments of political control.

China's administrative structure is very complex, with responsibilities assigned over a range of vertically and horizontally interlinked government agencies (Bluemling, 2018; Tsang & Kolk, 2010). The hierarchical order defines who can issue binding orders to the government agency in charge of policy implementation (Tsang & Kolk, 2010). In this context it is important to identify what are the primary goals of the local government agencies responsible for policy implementation and what are the goals of the directly superior agencies who can issue binding orders. Van Rooij (2006) argues that policy implementation is often undermined because the implementing government agencies have conflicting goals. Local authorities may also shift from official goals to so-called 'contextual goals'. These are goals hidden behind the official goals, such as producing formal statistical outcomes or under certain circumstances also generating revenue.

The second dimension this article looks at, i.e. the distribution of surface water and groundwater management responsibilities over different government agencies, is particularly relevant given the specific situation of groundwater management in China. Historically, the designation of groundwater management responsibilities in China was extremely unclear and dispersed across various ministries and government agencies (J. Liu & Zheng, 2016). The government agencies headed by the Ministry of Water Resources (MWR) used to be primarily concerned with surface water, as surface irrigation infrastructure is operated and managed by the state. However, over the past decades China has undergone far-reaching reforms in the organizational structure of its water administration. One of the main purposes of the reforms was to bring different water management responsibilities together under the

MWR (Shen, 2014). The reforms have been inspired by the concept of Integrated Water Resources Management, which promotes a holistic approach to water issues and coordinated management at the river basin level. Consequently, groundwater quantity management and surface water management were both placed under the MWR in 1998. But the integration was only partial. Groundwater quality monitoring remained the responsibility of the Ministry of Land Resources, and the Ministry of Environmental Protection is responsible for groundwater pollution control (J. Liu & Zheng, 2016). Subsequent reforms, such as the establishment of river basin organizations (RBOs), again shuffled the allocation of responsibilities over different lower-level government agencies. For example, the mandate of RBOs tends to concentrate on surface water issues alone (Liu & Zheng, 2016). Hence, divergent arrangements for surface water and groundwater management continue to exist at the local level (Shen, 2015). Cases in Australia and the US illustrate that the coordination of surface water and groundwater management institutions is crucial for the implementation of conjunctive management solutions (Blomquist, Schlager, & Heikkila, 2004; Ross, 2017). Against this background, this article examines how the distribution of surface water and groundwater management responsibilities over different government agencies affects an effective groundwater policy implementation.

The third aspect, instruments of political control, relates to the argument of Andersson (2003) that the level of political control exercised by the central government also has an important impact on local policy implementation. In their study on forest policy implementation in Indonesia, they found that the likelihood of effective implementation was highest in municipalities where mayors perceived strong monitoring from the central government. In the realm of groundwater policy, different pressures by national and local actors are considered to have an important impact on effective policy implementation. In India, the world's largest groundwater user, the pressure by local constituencies against groundwater regulation is viewed as one of the main obstacles to effective groundwater policy implementation at sub-national levels (Mukherji & Shah, 2005). Though long-term environmental costs are accounted for in national policy making, the short-term economic benefits of uncontrolled groundwater use are often prioritized at the local level (De Stefano & Lopez-Gunn, 2012). Mukherji and Shah (2005) expect better results in China due to its hierarchical, 'hard' state, with government structures reaching to water users. However, Kostka and Mol (2013, p. 4) argue that even in China 'national policies without sufficient local support and legitimacy are only implemented strictly when there is direct and constant attention from the centre'. Mertha (2009) calls this 'fragmented authoritarianism'.

In summary, this article looks at the institutional context of local government agencies responsible for groundwater management, with a focus on the institutional dimensions related to China's hierarchical government structure, to explain how water policy implementation outcomes differ despite highly centralized policy making. Though this article focuses on institutions, this does not imply that politics played out between different layers of authority does not matter (Bartley, Andersson, Jagger, & Laerhoven, 2008). But understanding how the present institutional setting is shaped by such interactions would require in-depth insights into the power relations between national and local-level authorities (Bowornwathana & Poocharoen, 2010), which is outside the scope of this research.

Methodology

Comparative case-study analysis

This article employs a comparative case-study analysis. For a comparative case-study analysis the researcher purposefully selects multiple cases. These can be cases showing a similar outcome with respect to the research topic but appearing in different contexts (e.g. Scott & Shah, 2004), or the researcher can select cases within a similar context which expose different outcomes with respect to the research topic (e.g. Blomquist et al., 2004). The latter allows the researcher to understand why seemingly similar circumstances can lead to different results. In this research the second type of comparative case-study analysis was opted for. Three cases were selected with relatively similar hydro-geologic and climatic conditions, but varying groundwater development and management situations.

Data collection

In this article each case is described primarily based on data from in-depth, semi-structured interviews with multiple stakeholders backed up by data from a large-scale survey (including 30 village leader questionnaires, 27 well operator questionnaires and 312 farm household questionnaires). Relevant literature and available policy documents have also been consulted, mainly to provide technical information. Most information on the institutional context were gathered through the interviews. Data from multiple sources have been triangulated to provide the best evidence-based information at hand. The primary data were collected in 2013 and 2014. All in all, 26 in-depth interviews were carried out with water managers, village leaders and ordinary farmers (i.e. farmers who do not have a leadership position), more or less evenly distributed over the three case-study areas.

The interview partners were purposefully selected based on a preliminary analysis of the survey data. It was sought to select interview partners in villages with diverse groundwater development and management situations representative of the surveyed area. The survey gathered standardized data on village and household-level surface water and groundwater use and management activities (see the Appendix in the online supplemental data at https://doi.org/10.1080/07900627.2017.1417115 and Aarnoudse et al., 2016, for more detail). Hence, in the subsequent in-depth interviews questions could be formulated based on the survey data. The interviews with the village leaders and farmers loosely followed three main topics: cropping activities, surface water and groundwater use, and surface water and groundwater management activities at the field level. The interviews with water management staff concentrated on the implementation of groundwater policies and their coordination with surface water management. All interviews focused on the development over the last 10 years. The interviews were carried out in Chinese and transcribed into English notes by the researcher.

Study area

The three areas considered in this article are in the Hexi Corridor, in Gansu Province (Figure 1). The Hexi Corridor belongs to north-west China, a region characterized by a semi-arid to arid climate and inland river basins. From a hydrologic point of view the Hexi Corridor can be considered as one unit, with multiple streams flowing down the Qilian Mountains, through

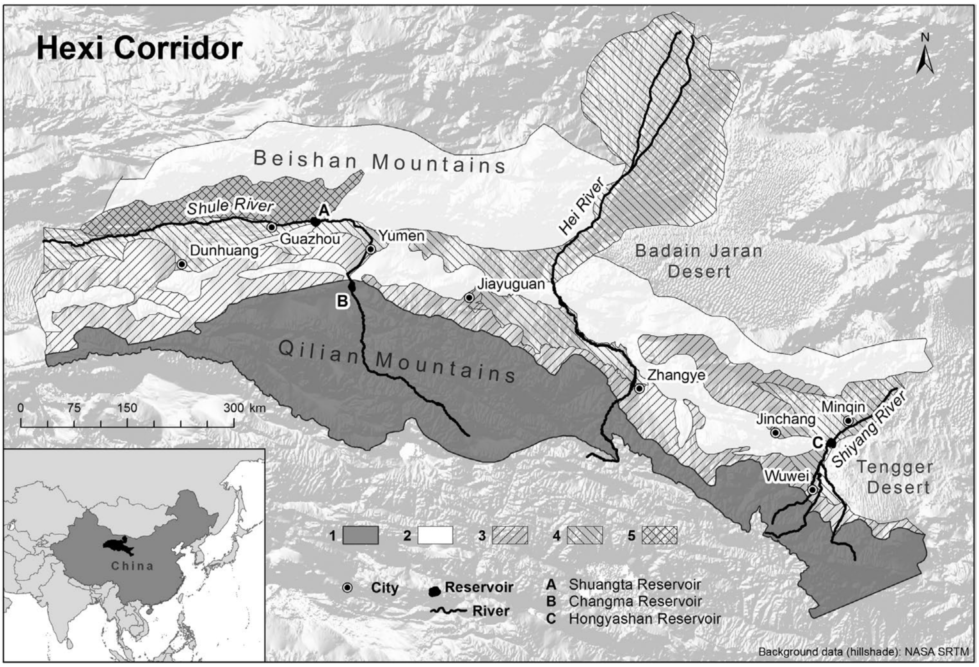

Figure 1. Map of the Hexi Corridor (1 = high rock mountains, 2 = low rock hills, 3 = alluvial fans, 4 = alluvial plains, 5 = foothill plains) , adapted from Zhou et al. (2007).

the plains, into the desert (Zhou, Nonner, & Li, 2007). Amongst the multitude of streams, three major inland rivers can be distinguished: the Shiyang, Hei and Shule. Annual river runoff reaches 1500, 2100 and 2100 Mm^3, respectively (Gansu Province Water Resources Bureau, 2008). The runoff varies inter-annually depending on snowfall in the Qilian Mountains. The findings presented in this article describe the local groundwater management situation on the alluvial plains of each of these three river basins. The alluvial plains are flat, with a mean slope of 5°, and are underlain by both shallow and deep aquifers. The shallow aquifers are shaped by unconsolidated sediments and are directly connected to the river flow (Ji et al., 2006). Naturally, the alluvial plains have high groundwater levels and springs. The salinity of the groundwater increases with intensive use (Wang, Ding, Shen, & Lai, 2003). Annual rainfall on the plains is 50–200 mm; most rain occurs in the summer months (Xiao, Li, Xiao, & Liu, 2008). Annual evaporation is 2000–3500 mm (Xiao et al., 2008).

Because of the relatively abundant meltwater from the Qilian Mountains and its plentiful sunshine, the plains of the Hexi Corridor are regarded as the most productive agricultural region in Gansu Province. The survey found that the influence of agri-businesses and land consolidation is on the rise. In one of the surveyed villages, farmers' land had been consolidated and was being cultivated by an agri-business company which employed the local villagers to work on the land. In another village, similar projects were under discussion. But the area is still mostly characterized by small-scale family farms. Around 70% of the people in the Hexi Corridor live in rural areas and rely on agriculture for their livelihood. The population density drops from east to west, with 2.2 million people living in the Shiyang River basin, 2.0 million in the Hei River basin, and only 0.5 million in the Shule River basin (Gansu Province Water Resources Bureau, 2008).

Due to the meagre rainfall, agriculture in the area is fully reliant on irrigation. In the absence of mega-cities and extractive industries, agriculture is the single largest water-using sector in the study area. As elsewhere in China, large-scale canal irrigation systems relying on dams and river diversions have been developed by the state since the 1950s. Local water bureaucracies, which used to be structured along administrative boundaries, were in charge of managing those irrigation systems. Recent water reforms in China have led to the establishment of RBOs (known as River Basin Management Bureaus) in each of the three river basins, which restructured the existing bureaucracies. Although the three RBOs are nominally the same, their hierarchical ranking and mandates differ (for an overview see Figure 2; a detailed description is given in the next section).

China's administration is divided into six hierarchical levels: national, province, prefecture (or city), county, township and village. At the village level surface water irrigation is managed by water user associations (WUAs). In the study area WUA boundaries are identical with village boundaries. Day-to-day management tasks, such as surface water allocation at the village level, organization of canal maintenance and collection of surface water fees, are taken up by the WUA board, which is made up of the same people as the village committee. Village committees had already been in charge of irrigation system operation and maintenance at the field level before the existence of WUAs. Therefore, the establishment of WUAs has in most places been a nominal change rather than an actual change in water management practices. At present the use of groundwater in conjunction with surface water for irrigation is common on the alluvial plains throughout the Hexi Corridor. Yet, the history and pace of this development differs significantly from river basin to river basin. Accordingly,

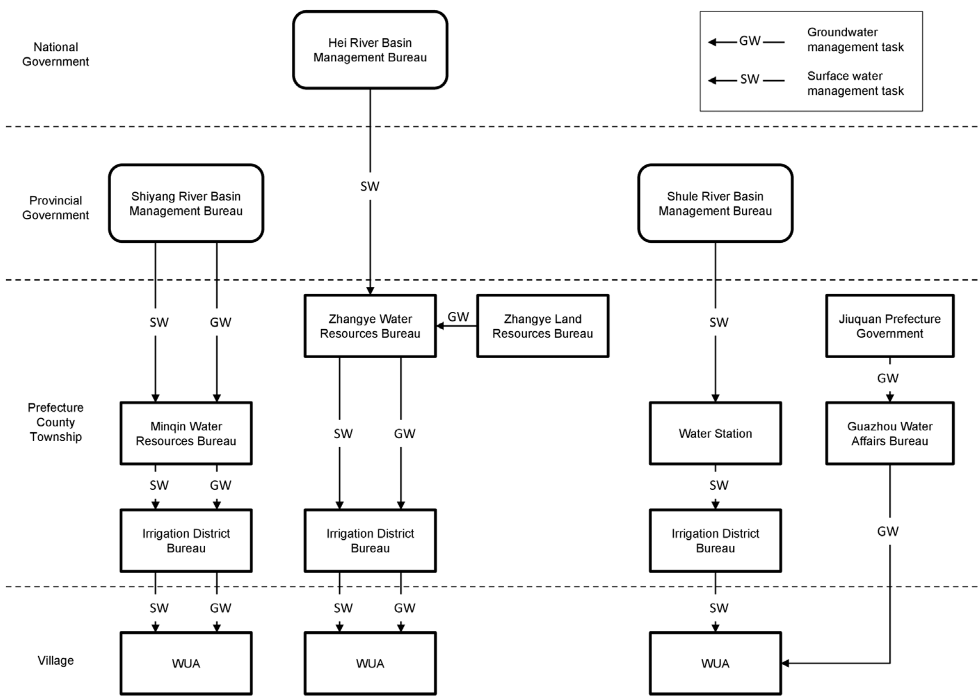

Figure 2. Administrative structure of surface water and groundwater management in the Shiyang, Hei and Shule River basins. Source: own compilation.

local authorities have followed different pathways with regard to groundwater regulation. The development of groundwater irrigation and regulation is described in more detail for each case in the following section.

Three cases of local groundwater management

Minqin, in the Shiyang River basin

Local groundwater management responsibilities

At the river basin level, the Shiyang River Basin Management Bureau is responsible for both surface and groundwater allocation and management. The RBO was established in 2002 and stands under direct jurisdiction of the Gansu Province Water Resources Bureau. In downstream Minqin County, the local government agency responsible for surface water and groundwater management is the Minqin County Water Resources Bureau, overseen by the RBO (Figure 2). The Minqin County Water Resources Bureau supervises the Irrigation District Bureaus (IDBs), which have their offices in local townships and are in charge of day-to-day surface water and groundwater management activities in cooperation with the WUAs at the village level.

Groundwater development

Groundwater irrigation in the Shiyang River basin developed most prominently in its downstream sub-basin, which belongs to Minqin County. During the 1950s and 1960s many small dams were built in the upstream reaches of the Shiyang River, which drastically reduced the river inflow to Minqin County. In response to the reduced access to surface water, farmers in Minqin started to pump groundwater on their own account in the 1970s. Within a short time, around 10,000 wells were drilled in the area (Ma, Wang, & Edmunds, 2005). With the use of groundwater the inhabitants of Minqin were able to expand their cropping area and intensify their agricultural production. By the end of the 1990s groundwater use for agriculture was estimated to reach 600 Mm^3/y, though the river inflow was only 100 Mm^3/y. Groundwater levels were reported to have dropped from 3–6 m in 1980 to 10–20 m in 2002 (0.3–0.6 m/y) (Sun, Kang, Li, & Zhang, 2009). The lower groundwater allowed the desert to encroach on irrigated areas and brought increasingly saline groundwater to the surface (Ma et al., 2005).

Groundwater policy implementation

The consequences of intensive groundwater use in Minqin became apparent in the 1980s and 1990s. However, early attempts to curb farmers' groundwater use in Minqin failed (Aarnoudse et al., 2012). Only after the implementation of the Shiyang River Basin Management Plan in 2007 did groundwater regulation effectively restrict farmers' groundwater use (Hao, Xie, Ma, & Zhang, 2017). The plan foresaw comprehensive reallocation of the surface water and groundwater resources within the river basin. The main goal was to prevent further desertification and salinization in Minqin County. The most important targets were to increase surface water inflow to the downstream sub-basin in Minqin from 100 to 200 Mm^3 and reduce groundwater pumping from 600 to 200 Mm^3 by 2010 (Gansu Province Water Resources Bureau, 2007). The plan was promoted and financially supported with around USD 600 million by the central government. In 2007 Prime Minister Wen Jiabao paid a visit to Minqin County to launch the Shiyang River Basin Management Plan. The Minqin Water Resources Bureau became responsible for reaching the target for reduced groundwater abstraction. The groundwater management targets were taken up in local officials' performance evaluation. Through the performance evaluation system higher-level authorities can steer promotion decisions on lower-level officials. The evaluation system is widely applied in Chinese policy implementation and usually has a bias towards economic development targets. Only recently have environmental objectives been included in the performance indicators (Tsang & Kolk, 2010).

The most important policy instruments to restrict farmers' groundwater use in Minqin were the closure of wells and the allocation of per capita groundwater quotas (Aarnoudse et al., 2012; Yu, 2016). Officially, 3000 out of 7000 wells were closed between 2007 and 2010 (water management staff SH1). Particularly wells which irrigated previously uncultivated land at the edge of the desert were forced to be taken out of use. In addition, so-called smart card machines with built-in water meters were installed on the remaining wells to monitor and control farmers' groundwater use. These machines enabled the enforcement of the per capita groundwater quotas (Aarnoudse et al., 2016; Wang, Shao, van Steenbergen, & Zhang, 2017). The groundwater quota was based on an irrigated area of 0.17 ha per person, which meant cutting the average cropping area per person by half (water management staff SH1). The water volume equivalent was set at 1200 m^3/y based on the irrigation requirements of relatively low-water-demand crops under local farming conditions. Village heads reported an 8–23% reduction in cropping area since the implementation of the groundwater restriction policies. Moreover, 80% of the farmers confirmed having reduced their groundwater use per unit of land over the respective period of time. In response to the new policies, groundwater levels have been reported to stabilize or even rise between 2005 and 2011 (Hao et al., 2017; Xue, Liao, Hsing, Huang, & Liu, 2015).

Zhangye, in the Hei River basin

Local groundwater management responsibilities

In the middle reaches of the Hei River basin, the Zhangye Prefecture Water Resources Bureau is the local government agency responsible for surface water and groundwater management (Figure 2). It is overseen by the Hei River Basin Management Bureau, founded in 2005. Because the Hei River crosses three Chinese provinces (Qinghai, Gansu and Inner Mongolia), the RBO is under direct jurisdiction of the Yellow River Conservancy Commission, headed by the MWR. The RBO is only responsible for the allocation of surface water between the three provinces and not in charge of local surface water management issues or groundwater allocation and management. These are handled by the Zhangye Prefecture Water Resources Bureau, which is the supervisory body of the IDBs. The IDBs deal with day-to-day surface water and groundwater management in cooperation with the WUAs at the village level.

Groundwater development

Irrigated agriculture on the alluvial plains of the Hei River basin is mainly located at the river's middle reaches, which belong to three different counties of Zhangye Prefecture. Here, groundwater use for irrigation intensified only recently. In 2002, the central government launched a pilot project in Zhangye to promote water saving. The associated policy measures focused primarily on reducing farmers' surface water use and triggered intensified groundwater use (Zhang, Zhang, Zhang, & Wang, 2009). Zhangye counted around 4,500 groundwater wells for irrigation in 2002 (Zhang & Zhang, 2008). Reliable figures on the current number of groundwater wells and estimates on the amount of groundwater pumped are not publicly available (staff water management H1). Village heads reported between 30 to 70 wells per village in the more downstream areas. All reported wells were drilled in the 1990s and 2000s by farmers. Despite spatially heterogeneous groundwater level developments, the groundwater level dropped continuously at the outer edges of the Zhangye sub-basin by 0.1–0.5 m/y from 1986 to 2007 (Nian, Li, Zhou, & Hu, 2014). Recently Zhangye is increasingly facing severe sand storms and desertification, which is associated with (among other things) land clearing for agriculture, often enabled by groundwater pumping (Luo, Qi, & Xiao, 2005; Nian et al., 2014).

Groundwater policy implementation

The RBO is not responsible for setting any target for groundwater abstraction for Zhangye; instead it has set strict surface water allocation targets to ensure increased inflow to the river's downstream reaches. In fact, the main task of the RBO since its foundation has been to secure sufficient water for the Erjina Terminal Lake in Inner Mongolia, which was at the brink of disappearance in the early 2000s. The river discharge flowing out of Zhangye was to increase from around 500 Mm^3/y to 950 Mm^3/y in 2010 (Deng & Zhao, 2015). Indeed, a significant upward trend was observed from 2000 to 2012 (Zhang, Zheng, Wang, & Yao, 2015).

As groundwater irrigation had long played a negligible role in Zhangye, the Zhangye Prefecture Water Resources Bureau hardly developed any active groundwater management. According to local water officials, the prefecture should be divided into different groundwater development zones (including restricted and forbidden groundwater development zones), but corresponding policy instruments had not been developed so far (staff water management H1). The designation of such zones was also mentioned in the 2002 Water Law (Shen, 2015). Farmers were required to apply for well permits, but until 2014, these had been issued by their local IDB without preconditions (village leader H1, village leader H2). A different signal was given by a complete ban on the drilling of new wells issued in 2014. The well-drilling ban was pushed forward by the Zhangye Prefecture Land Resources Bureau (Figure 2), which is responsible for countering the rising threat of sand storms and desertification in the area (staff water management H1). This motivated them to restrict the illegal appropriation of previously uncultivated land with the help of newly drilled wells. Because the ban was implemented in 2014, which was the year of survey, enforcement of the ban could not be verified within the framework of this study.

Guazhou, in the Shule River basin

Local groundwater management responsibilities

In the Shule River basin, two parallel government structures are in charge of surface water and groundwater management (Figure 2). The Guazhou County Water Affairs Bureau is the local government agency responsible for groundwater management. The bureau is supervised by the Jiuquan Prefecture Government and not ultimately headed by the MWR. The Shule River Basin Management Bureau was founded in 2005 and stands under direct jurisdiction of the Gansu Province Water Resources Bureau. It only has the mandate to allocate and manage surface water in the river basin. At its foundation the RBO took over the supervision of the IDBs from the Guazhou County Water Affairs Bureau. At the irrigation system level, so-called water stations coordinate the IDBs. These water stations were basically founded to replace the sub-basin coordination previously carried out by the RBO's predecessor, the Guazhou County Water Affairs Bureau. The IDBs are in charge of day-to-day surface water management activities in cooperation with the WUAs at the village level. For groundwater management issues, the Guazhou County Water Affairs Bureau remains responsible and is in direct contact with the water users at the village level. Although groundwater management is officially not the responsibility of WUAs, groundwater management tasks are often assumed by WUA board members in their role as village committee members.

Groundwater development

Groundwater use developed in the Shule River basin in the 1990s when rural inhabitants from impoverished mountainous areas in central Gansu were resettled to the Shule River basin. In the newly established villages, migrants were provided groundwater wells to cultivate previously uncultivated land. The government-supported groundwater development probably triggered privately financed well drilling in the neighbouring villages, which took off around the same time. In 2006 a new dam was constructed in the upstream part of the Shule River basin. The dam significantly increased the surface water supply to the upstream irrigation system in Yumen County, but reduced the surface water supply to the downstream irrigation system in Guazhou County. Consequently, farmers' groundwater use upstream decreased over the last decade, while it intensified further in Guazhou County. In 2014, 2300 wells were in use in the two irrigation systems, of which the large majority were located in Guazhou (staff water management SL2). In the Shule River basin, groundwater pumping is estimated to reach 180 Mm^3/y, while recharge does not exceed 70 Mm^3/y (Shule River Basin Management Bureau, 2013). Guazhou has been confronted with groundwater tables falling 0.34 m per year (Liu & Feng, 2015).

Groundwater policy implementation

After the foundation of the RBO in 2005, surface water and groundwater management mandates were split between two separate administrative structures. Surface water management was transferred to the newly established RBO, directly supervised by the water resources department at the provincial level, while groundwater management stayed with the municipal government at the prefecture and county levels. Cooperation between the two administrations is weak. The RBO claims that the Guazhou County Water Affairs Bureau should hand over the mandate for groundwater management. Though groundwater management had long played a minor role for the local water authorities, new groundwater management strategies were developed after the reforms. In 2007 the prefecture government of Jiuquan issued a new policy on volumetric groundwater pricing (staff water management SL2). Until then, a land-based groundwater price had existed on paper, but farmers had not been aware of paying such a fee. The volumetric groundwater price has officially been implemented to regulate farmers' groundwater use and avoid overexploitation (Government of Guazhou, 2015). Without this official goal, based on the 2002 Water Law, the local government agency would not have the right to collect a groundwater fee. After all, since 2000 the Chinese government has tried to reduce the income gap between the rural and urban population by abolishing agricultural taxes (Nickum & Mollinga, 2016). In China, fee collection for surface water is well established by now and generally accepted as a means of cost recovery and to increase use efficiency (Che & Shang, 2015). In contrast, groundwater irrigation is generally paid for by farmers themselves and in principle does not bear any costs for the state, and so does not justify levying fees.

To implement the new volumetric groundwater fee, the Gauzhou County Water Affairs Bureau installed 'smart card' machines on all groundwater wells in the county. Tiered prices were set per well, which means that farmers pay CNY 0.01/m^3 (USD 0.0016/m^3) for the first 100,000 m^3 pumped per season per well and CNY 0.02/m^3 (USD 0.0032/m^3) above this limit (village leader SL1, village leader SL2). The tiered pricing is intended to stimulate users to save water, while securing a limited amount of water at affordable levels for all users. Though the pricing system is enforced, and farmers confirmed that they are paying the new groundwater fee, it does not seem to affect their groundwater use decisions (Aarnoudse et al., 2016). In fact, 80% of the surveyed farmers stated that they had intensified their groundwater use over the last 10 years despite the pricing policy. It is often argued that water fees in China are too low to affect farmers' water use behaviour (Q. Zhou, Wu, & Zhang, 2015). In Guazhou, farmers do not perceive the groundwater fee to be that expensive. Hence, the current groundwater pricing mechanism raises the question of whether the groundwater fee was really implemented to reduce farmers' groundwater use, or whether revenue generation played a more important role (Aarnoudse et al., 2016).

Discussion

This article shows how local groundwater regulations can differ under the same national policy. To understand these differences, this article focuses on analyzing the distribution of responsibilities for surface water and groundwater management; water authorities' 'official' and 'contextual' goals; and how far instruments of political control are used for policy implementation (Table 1).

In the Shiyang River basin, the RBO – responsible for both surface and groundwater management – has set coherent surface and groundwater abstraction targets for farmers. Lower-level agencies are also prompted not to allow groundwater abstraction beyond the assigned target, as the reduction in groundwater abstraction forms part of their performance evaluation. While the agencies' official goal will be to implement the national water policy, their abidance with the groundwater abstraction target is likely to relate to the contextual goal of getting promoted. Under these conditions the local government agency responsible for groundwater management has opted for strict regulation measures through the closing of wells and allocation of water quotas. For farmers, the allocation of the water quota means a significant reduction in their cropping area. While these policy measures at least partly mitigate groundwater depletion and its long-term socio-economic and environmental impacts, they also affect the local livelihoods of farmers today.

In the case of the Hei River basin, the negative impact on farmers' livelihoods is likely to have been one of the motivations for the local government agency responsible for groundwater management to turn a blind eye to farmers' increasing groundwater abstraction. Intensified groundwater pumping has been triggered by the recent implementation of strict surface water targets set by the RBO – whose responsibility concerns surface water only. The goals of the two agencies hence differ considerably: on the level of the RBO, the goal is to secure surface water for the Erijna Terminal Lake; on the sub-basin level, the goal is to reduce surface water use and regulated groundwater use in case of overdraft. The emphasis on

Table 1. A comparison of the main institutional aspects analyzed for the three case studies.

	Minqin in the Shiyang River Basin	Zhangye in the Hei River Basin	Guazhou in the Shule River Basin
Distribution of surface water and groundwater management responsibilities	Completely integrated administrative structure for surface water and groundwater management from RBO to WUA	RBO only responsible for surface water management Lower-level agencies responsible for both surface water and groundwater management	Completely separate administrative structures for surface water and groundwater from river basin to village level
Goals of RBO	Increase surface water inflow to Minqin Reduce groundwater abstraction in Minqin	Increase surface water outflow from Zhangye	Surface water allocation (no special targets at least until 2014)
Goals of local government agency responsible for groundwater management	Surface water allocation Regulate groundwater use in case of overdraft *Contextual:* reach groundwater abstraction target in order to pass performance evaluation	Reduce surface water use Regulate groundwater use in case of overdraft *Contextual:* support the development of groundwater abstraction to substitute reduction in surface water use	Regulate groundwater use in case of overdraft *Contextual:* secure own existence despite loss of surface water management tasks and related surface water fees to RBO
Instruments of political control for groundwater management	Groundwater abstraction target included as indicator in officials' performance evaluation	–	–

Source: own compilation.

surface water management at the river basin level has probably led to possibly deliberate and continued neglect of groundwater management at the sub-basin level, to allow farmers to compensate for surface water loss and mitigate short-term socio-economic impacts. In this situation of conflicting goals, a third agent entered the policy arena: the local land resources department pushed for a ban on well drilling to mitigate the desertification effects of illegal land cultivation and falling groundwater tables.

The case of the Shule River basin shows that the split of responsibilities between surface water and groundwater management may aggravate intensive groundwater use. Here, two separate administrative structures are responsible for surface water and groundwater management. With the establishment of the RBO, the local government agency – currently solely responsible for groundwater management – had to hand over its previous responsibility for surface water management and was also deprived of its revenues from surface water fees. Hence, revenue generation through groundwater pricing probably became a more important contextual goal than the official goal of regulating farmers' groundwater use (Aarnoudse et al., 2016). Pricing for revenue generation does not necessarily coincide with optimal pricing to reduce groundwater overdraft (Yang, Zhang, & Zehnder, 2003). This would explain why farmers' groundwater use has not decreased in response to the pricing policy.

In China, local government agencies responsible for groundwater management have the power to issue groundwater regulations as long as they are consistent with higher-level policies (Foster et al., 2004). The cases presented in this article demonstrate that the official and contextual goals of such local government agencies are influenced by the management responsibilities and goals of the higher-level RBOs. Despite efforts at the national level to integrate surface water and groundwater management, this has not led to integrated approaches at all management levels (J. Liu & Zheng, 2016). All in all, the fragmented distribution of surface water and groundwater management responsibilities tends to lead to conflicting goals between upper-level and lower-level agencies or the prioritization of contextual goals, which undermines the enforcement of national policies (van Rooij, 2006).

These insights into the institutional context help explain why different groundwater policy instruments have been chosen in the different cases. Based on a study of empirical cases worldwide, Molle (2009) argues that government agencies that genuinely want to reduce irrigation water use in response to acute water scarcity opt for quotas instead of pricing as a policy instrument. The same can be observed in the cases here. In the Shiyang River basin, the pressure on the local government agency to actually reduce groundwater use was the highest. Here, well closure and groundwater quotas were chosen as adequate means to achieve this. The selection of wells for closure and the calculation of the quota were based on criteria which targeted actual reduction of farmers' groundwater use. However, in the Shule River basin the selection and design of groundwater policy instruments seem not to have been guided by the goal of reducing farmers' groundwater use. Here, groundwater pricing was selected as policy instrument. The prices were set low enough to secure payment and avoid protest from the farmers – and too low to actually affect farmers' groundwater use. In the Hei River basin, where the groundwater regulation goal was not prioritized, groundwater policy instruments mainly consisted of 'on paper' measures such as the demarcation of groundwater development zones and the distribution of well drilling permits. No clear criteria were set to implement those policies; hence, they stayed policies without teeth, as can be observed in many other countries facing similar problems (Molle & Alvard, 2015).

Moreover, the pressure from the central government and the use of instruments of political control on the issue of groundwater regulation varied across the three cases. Out of the three cases, the central government only directly intervened and provided additional funding for groundwater polices in the Shiyang River basin. It was only after the increased attention from the central government that effective groundwater policies were implemented, as also argued by Kostka and Mol (2013). Though the central government in China may play such an active role in a few outstanding cases, Shen (2015) argues that related costs are too high to pursue this strategy nation-wide. In the Hei and Shule River basins there was no active monitoring by the central government to implement national groundwater policies. Kotska and Mol (2013) argue that under such circumstances national policies are only implemented when they align with local priorities. Most of the time national groundwater regulation policies are in conflict with local priorities of short-term socio-economic development (De Stefano & Lopez-Gunn, 2012). Over the last decades this seems to have impeded effective groundwater regulation in the Hei and Shule River basins. Only recently has groundwater regulation been taken more seriously in the Hei River basin, after the local land resources department started to undertake measures against acute problems with sand storms and desertification.

By comparing the three cases of local groundwater management in China, this article has explored how different institutional dimensions of the administrative structure influence local authorities to effectively implement national groundwater regulation policies. But the analysis does not provide a deeper understanding of why the local administrative structure differs from place to place. Why are surface water and groundwater responsibilities assigned to the same government agency in one place and not in another? And why are groundwater abstraction targets not everywhere included in local officials' evaluation performance? Although an in-depth analysis cannot be provided here, it is clear that the acuteness of groundwater depletion has been an underlying factor in the emergence of most institutions relevant for groundwater policy implementation. The river basin management reforms in the Shiyang River basin came at a time when groundwater over-exploitation was already advanced. In contrast, in the Hei and Shule River basins the problem started to become more acute only after the RBOs were formed. Likewise, the pervasive attention from the central government in the case of Minqin may also have its roots in the severity of the problem.

Conclusion

This article has analyzed why China's national groundwater policy is implemented at the local level in a fragmented way. The analysis focused on the institutional context in which local agencies responsible for groundwater irrigation operate. The cases presented in this article show that effective groundwater regulation in China is primarily implemented under pressure from the central government, realized through the performance evaluation system whereby higher-level authorities steer lower-level authorities. Yet, it was also found that the designation of groundwater management responsibilities over different government agencies and the goals of the respective agencies strongly influence the importance attached to groundwater regulation.

Despite recent reforms in China's water administration which should facilitate an integrated management approach, fragmented structures may still saddle local government agencies with conflicting surface water and groundwater management goals, undermining effective groundwater policy implementation. In the Shiyang River basin this problem was overcome through the integration of surface water and groundwater allocation and management from river basin to water user level. Based on this example, it could be argued that integrated administrative structures for surface water and groundwater management pave the way for effective groundwater policies. However, the case of the Hei River basin, where the local land resources department stepped in to urge groundwater regulation, shows that problems of conflicting goals can also be overcome through coordination between lower-level agencies. Therefore, it is more plausible to conclude that the integration of surface water and groundwater management is an important precondition for reaching effective groundwater regulation, but this integration cannot be attributed to one single model of the local administrative structure. This is a valuable conclusion for places where intensive groundwater pumping occurs in a conjunctive-use setting, also beyond the Chinese context.

All in all, this research shows that under exceptional conditions the Chinese government is able to implement national groundwater policies despite opposition at the local level. However, the approach relying on instruments of political control does not in itself address the underlying problem of local livelihoods depending on intensive groundwater use. Therefore, the case of the Shiyang River basin is not necessarily the best example of groundwater policy implementation for other cases inside or outside China where smallholder livelihood strongly depends on irrigated agriculture.

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