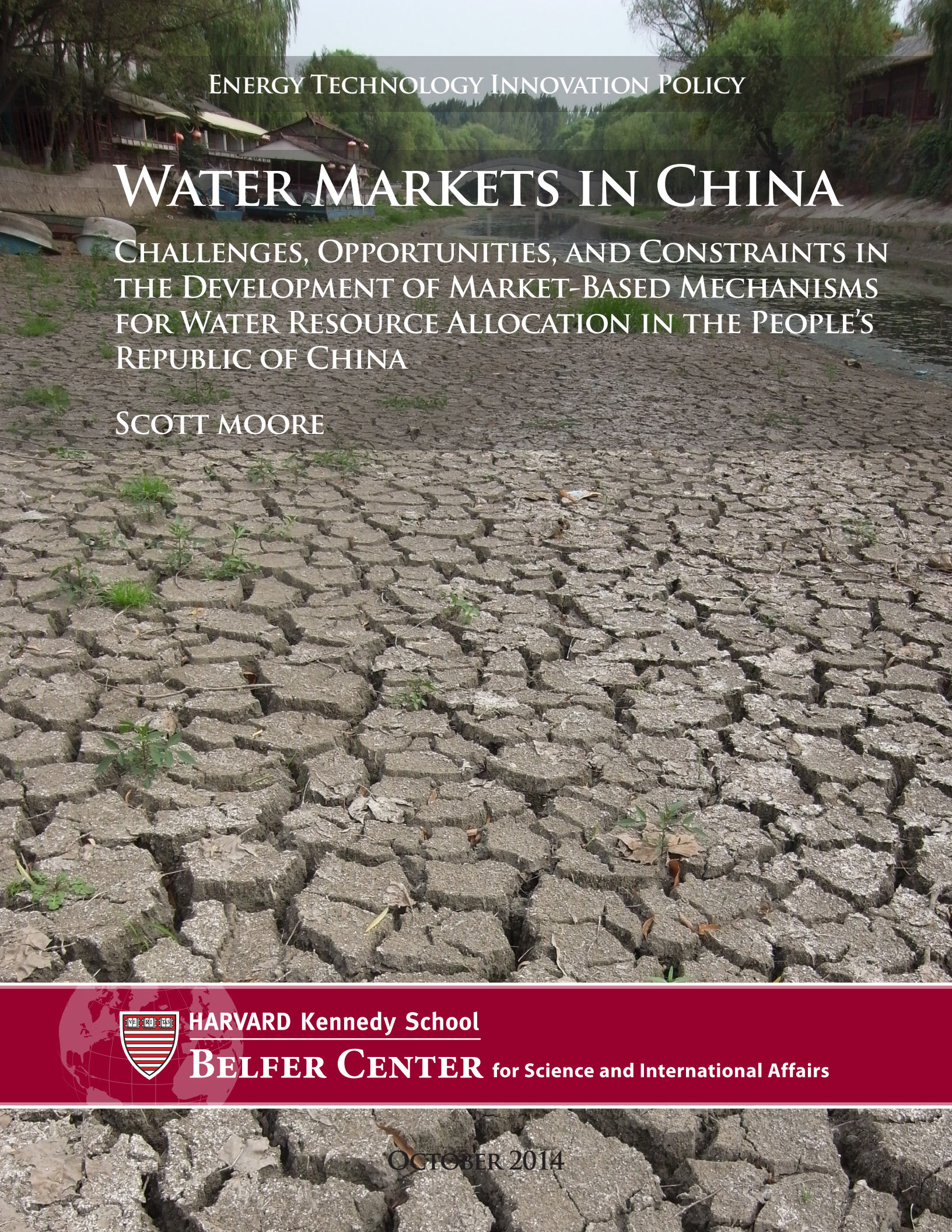

Energy Technology Innovation Policy

Water Markets in China

Challenges, Opportunities, and Constraints in the Development of Market-Based Mechanisms for Water Resource Allocation in the People's Republic of China

Scott Moore

HARVARD Kennedy School
Belfer Center for Science and International Affairs

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Cover photo: View of the cracked bed of the nearly dried-up Qingni River during a drought in Xuchang city, central Chinas Henan province, 29 July 2014. (Niu Shupei, Imagechina / AP)

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Abstract

This discussion paper examines the development of water markets as a solution to water scarcity in China, with particular focus on Water Rights Trading (WRT). Water scarcity is an issue of growing concern for China, particularly in the north, where a combination of limited water supplies, economic growth, and population increases are increasingly straining water resources. The Chinese government has moved enthusiastically toward an embrace of market mechanisms to address water scarcity, with WRT being the preferred policy instrument in the agricultural sector, which accounts for the majority of water use in China. Proposed advantages of WRT include a more efficient allocation of scarce water resources and the ability to limit total water use in a given region by carefully limiting rights allocation. However, the implementation of WRT has encountered significant challenges in China, which include a lack of effective monitoring and enforcement of water use, conflicts of interest between various units of government, which prevent effective administration, and a lack of integration with other approaches to water scarcity, including supply augmentation. In light of these challenges, this analysis concludes that market-based mechanisms in general, and WRT in particular, have an important but only partial role to play in alleviating water scarcity in China. This discussion paper proposes several policy recommendations to improve the development of water markets in China, in particular by lowering the transaction costs to establishing markets and improving policy coordination.

Table of Contents

Introduction: Market-Based responses to Water Scarcity in China

China is facing an acute water scarcity challenge, which is likely to substantially increase in the coming decades. On a per-capita basis, China is already seriously deficient in water resources; it possesses only about one-third of the global average of water resources per person per year (World Bank, 2011). In large part this is due to a combination of population growth, demographic changes, and economic development, which together have dramatically increased demand for urban and industrial water use (Yong, 2009). Throughout China as a whole, total water use by all sectors is expected to increase from about 550 billion cubic meters in 2005 to over 800 billion cubic meters by 2030, with municipal and domestic demands increasing by 2.7% and industrial demand by 2.9%, both significantly higher than overall population growth over the same period (see Figure 1) (2030 Water Resources Group, 2009). In some parts of China, these demand-driven pressures are exacerbated by groundwater mining and increasing aridity due to long-term climatic shifts (Xia, Zhang, Changming, & Yu, 2007); (Cai, 2008).

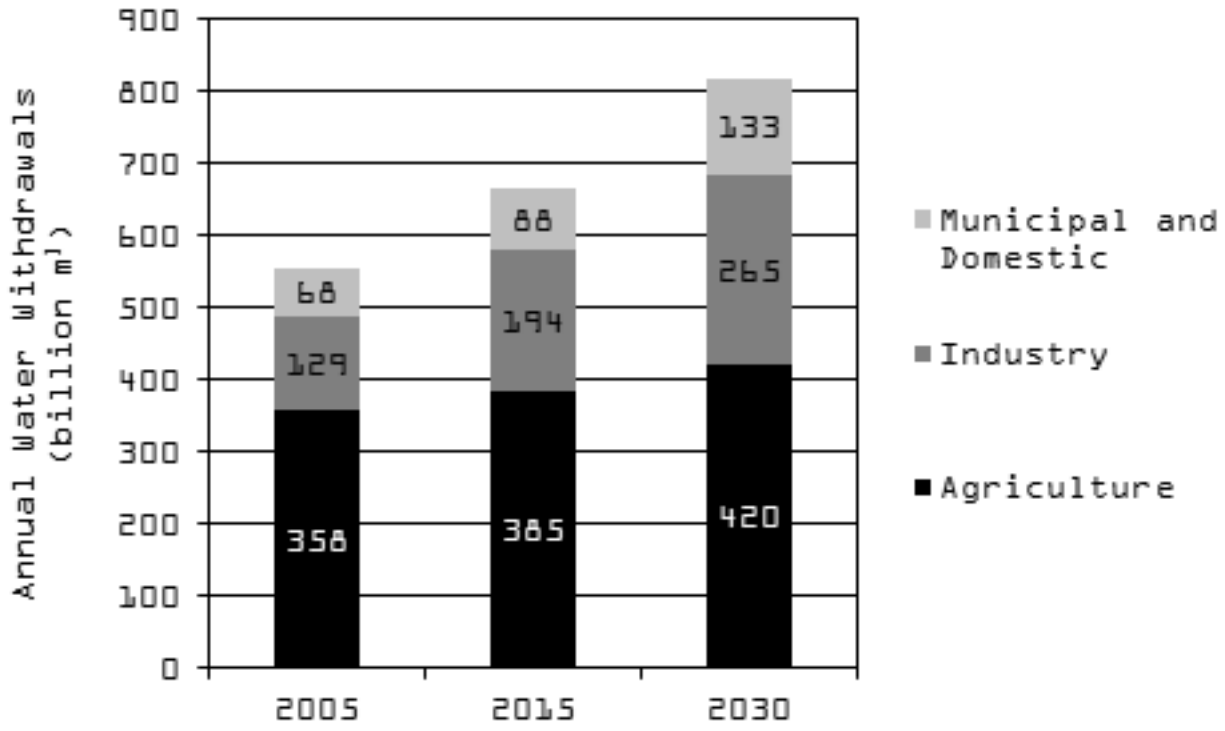

Figure 1: Actual and Predicted Water Withdrawals by Sector (billion m^3) (Source: 2030 Water Resources Group)

In addition, China realizes very low water use efficiency, which results in large quantities of water being appropriated for agriculture and industry while contributing little to economic output (Zhu, Zhou, Ouyang, Deng, Kuang, & Huang, 2001). The UN Food and Agriculture organization estimates, for example, that only about 45% of water withdrawn for irrigation is applied to crops, with the remainder lost to leakage and evaporation. Moreover, China's water productivity

is about US$3.6 per cubic meter of water utilized, which is one-tenth the developed-country average (UN Food and Agriculture Organization, 2011).

In response to these challenges, the Chinese government has joined a global trend toward the use of market-based mechanisms to address water scarcity. The simplest such mechanism is water price reform, which generally means increasing the price of water to encourage conservation and a shift to higher-value-added water uses. Although the Chinese government has publicly embraced water price reform as a solution to water scarcity, price increases have to date been very gradual and confined to urban areas, while the price of water in the agricultural sector, which accounts for some 65% of total water withdrawals, remains very low (Zhong & Mol, 2010). Moreover, recent research casts doubt on the ability of price increases to markedly reduce water use in the Chinese agricultural sector given price elasticity (Aregay, Zhao, & Bhutta, 2013). In contrast to these halting efforts to address water scarcity, the Chinese government has made it clear that it intends to make another market-based mechanism, Water Rights Trading (WRT), the foundation of a new "water-saving society" (Xia & Pahl-Wostl, 2012). A WRT system allocates usage rights to a defined quantity of water to various water users, who can then buy, sell, and trade their usage rights to other users. Under ideal circumstances, WRT effectively caps total water use in a given region, while also allocating the quantity of water available for use under this cap to its most productive uses. Thus conceived, WRT achieves a socially-optimal allocation of water resources in which, put simply, scarce water resources are consumed by those who value it most (Howe, Schurmeier, & Shaw, 1986); (Chong & Sunding, 2006); (Debaere, et al., 2014). For this reason, WRT has emerged as a leading solution to water scarcity in many parts of the world, and has received widespread backing among Western scholars and development institutions like the World Bank (Holden & Thobani, 1996); (Webber, Barnett, Finlayson, & Wang, 2008). WRT has also become a signature policy response to water scarcity within China. In July 2014, the Chinese Ministry of Water Resources announced that water rights exchanges would be established in seven provinces, expanding several existing pilot water-market projects (Chen & Reklev, 2014).

However, the suitability of WRT both in general as well as in developing-country contexts such as China is contested. As many analyses emphasize, while WRT promises to achieve an economically-efficient allocation of water resources, it does not necessarily achieve an equitable distribution of those resources, which in turn raises concerns about the impact of WRT on poor and disadvantaged water users (Johansson, Tsur, Roe, Doukkali, & Dinar, 2002); (Araral, 2010); (Ray, 2013). Further concerns stem from possible third-party effects of trading water rights. These include the impact of consumptive use on downstream users, and the need to ensure minimum flows for ecological and recreational uses (Gould, 1988); (Liu Y. , 2004); (Etchells, Malano, & McMahon, 2006). Some commentators further worry that large-scale transfers of water rights from rural to urban areas might induce "socioeconomic out-of-area effects" which could depress and destabilize rural areas (Chong & Sunding, 2006); (Grafton, Libecap, Edwards, O'Brien, & Landry, 2012), a prospect that is of no small concern to a heavily agrarian country such as China.

In light of these concerns, this paper evaluates the current and prospective future development of water markets in China, particularly as a solution to the country's pressing challenges of water scarcity. The paper proceeds in three parts. First, it surveys the legal and institutional

framework for WRT in China, in the process highlighting some distinctive features of the Chinese case that complicate the implementation of WRT. Second, the paper describes and analyzes the development of WRT in China to date, focusing on three individual case studies. These cases form the basis of the third section, which identifies and discusses a number of challenges to and constraints on the future development of water markets as a solution to water scarcity in China. Finally, the conclusions section offers a prognosis of the role that WRT might play in addressing future water resource management issues in China, and then issues several recommendations for policy reform. The overall message is that market mechanisms in general, and WRT in particular, can and should play a vital role in addressing the challenge of water scarcity, but that implementation will have to be highly sensitive to local conditions, and that demand-management policies such as WRT and water price reform must be closely coordinated with supply-augmentation approaches to water scarcity.

Anatomy of WRT in China: Policies and Institutions

In order to properly evaluate the role that WRT has and might play in meeting China's water scarcity challenges, it is first necessary to detail some peculiarities in the development and implementation of water markets in China. As presently constituted, WRT in China differs considerably from that advocated by most Western scholars and economists. For the most part, Chinese WRT mechanisms generally facilitate the transfer of administrative water usage permissions, rather than market exchange of property rights between economic actors. This more expansive government role thus distinguishes Chinese water markets from their counterparts in other countries, and consequently political and policy issues of concern to the Chinese government crucially shape the development of water markets. In this section, I detail some of these distinguishing characteristics, with particular focus on the legislative and institutional framework for water rights designation and allocation.

China possesses a long history, in some cases going back over a millennium, of administrative control over water resource allocation, which recent developments have mostly served to enhance (Webber, Barnett, Finlayson, & Wang, 2008). Prior to 1978, agricultural water allocation was hierarchical and largely took place at the level of the irrigation district (*guanqu*), which would then allocate water to individual production units (Nickum, 1981). The present system of water resource allocation, which emphasizes administrative water use regulation in the context of state ownership of all water resources (Gao E. , 2007), dates to around 1982, when Shanxi Province required major water users to apply for abstraction permits. Other provinces subsequently adopted similar provisions (Zhang & Jia, 2012). China's 1988 Water Law codified the abstraction-permit (*qushui kexu*) principle for water allocation, while also including a provision for "compensated" transfers of abstraction permits. Nonetheless, because of a variety of capacity problems and "traditional thinking," these tentative steps toward market-driven water resource allocation achieved only partial results (Wang, 2013).

In recent years, the Chinese government has made a renewed push to promote the development and implementation of WRT. The Ministry of Water Resources (MWR) has pursued a policy of "promoting water rights and moving toward the market" by establishing water quantity controls,

strengthening the legal foundations of water rights, and using WRT to promote water conservation (Wang, 2013). In 2001, the Ministry of Water Resources (MWR) issued a plan for establishing a water rights system based on an initial administrative allocation of usage rights to both regions and enterprises. If either regions or enterprises saved water, they could transfer usage rights for compensation. The 2002 revisions to China's Water Law strengthened the legislative basis for this form of compensated transfer.

More recent regulations have been oriented toward implementation of these provisions: in 2005, MWR issued instructions requiring water resource agencies at all levels to "take water rights seriously and establish appropriate water rights systems." Most significantly, in 2007, following the enactment of the landmark Property Law, MWR issued new regulations which strengthened the water-permitting system while also establishing a number of basic criteria for water quantity allocation, including consideration of equity, historical water use, and environmental water requirements (Zhang & Jia, 2012). Under select pilot projects, water rights have been granted to individual farmers in the form of a usage certificates (*shiyongzheng*), which then entitles farmers to purchase tickets (*shuipiao*) allowing them to use a defined quantity of water in a defined period of time (Calow, Howarth, & Wang, 2009).

Somewhat paradoxically, these efforts to move toward market allocation of water resources have also strengthened the role of the government in addressing water scarcity. Long-standing administrative allocation plans for several of China's major river basins, most notably the Yellow, govern the initial allocation of water rights (Liu B. , 2005). Moreover, the hierarchical model by which state-owned water resources is allocated by the central government to various provinces, and then by the provinces to local governments, persists (Shen, 2012). WRT in China therefore represents a transfer of water usage entitlements allocated to administrative entities, rather than constituting true trading between individual rights-holders (Wang, 2013). As two leading scholars of water resource management in China have written, "At present most of China's water rights practices have stopped at the level of [administrative] water quantity allocation…[which] are relatively simple and easy" to establish (Zhang & Jia, 2012).

In a further paradox, the outsize role of the government in the development of water markets means that WRT implementation is uneven across China. The country possesses a distinctive governance structure in which decision-making is tightly controlled by the central government, but policy implementation is left largely in the hands of local governments (Xia & Pahl-Wostl, 2012). In the water sector, this is manifested in a principle of "the center controls, the local [level] implements" (Gao E. , 2007). In practice, this division of responsibility means that local jurisdictions implement policies quite differently, and engage in region-specific experimentation with various institutional models for WRT in response to local conditions (Jia & Yan, 2012); (Li, Gupta, & Van Dijk, 2013). According to 2006 guidelines issued by the State Council, each province must develop a framework to manage water abstraction, including establishing provisions for reviewing abstraction permit applications. Provinces are supposed to consider sustainability, water scarcity, and other factors in making their decisions (Gao E. , 2007), but are otherwise free to formulate their own policies. As a result, the implementation of WRT mechanisms in China follows several institutional models. Each of these models presents individual challenges, as the following case studies illustrate.

Current WRT Implementation in China: Three Case Studies

The implementation of WRT in China has been largely cautious and incremental, relying on localized experimentation with a variety of institutional design arrangements. According to one categorization, however, there are three primary institutional models: mechanisms primarily designed to facilitate the transfer of water between administrative jurisdictions, which I refer to as inter-jurisdictional transfers; mechanisms primarily designed to transfer water from one economic use to another, which I call inter-sectoral transfers, and finally agricultural water exchanges, which facilitate water quantity trading between agricultural water users, and therefore most closely approximate the ideal form of WRT advocated by economists (Gao E. , 2007). This section examines case studies of each of these three institutional models, in the process describing each case while also highlighting some challenges in institutional design and implementation.

Inter-Jurisdictional Transfers: Dongyang – Yiwu, Zhejiang

The primary example of inter-jurisdictional transfers is a 2000 agreement between two cities in Zhejiang Province, Yiwu and Dongyang. Beginning in 1998, downstream Yiwu invested 3.1 million RMB to upgrade a reservoir in upstream Dongyang, enhancing its storage capacity by 10,000 m^3, while also investing a further 35.7 million RMB in water conservation projects to save an additional 13,000 m^3. This investment increased water supply capacity for both cities at a cost of 0.73 RMB/m^3, saving Yiwu an estimated 100 million RMB from having to build its own reservoir (Yi, 2010); (Wang, 2013). The Yiwu-Dongyang transfer remains viewed as one of the most successful market-based water management policies in China (Gao E. , 2007).

However, the Yiwu-Dongyang case exhibits several special features that make it difficult to replicate elsewhere. The level of water conservation investment in Zhejiang was already relatively high, as was the general level of economic development and the resources available to both Yiwu and Dongyang cities. The two cities also enjoyed a history of unusually close cooperation, manifested in a "special partnership" status. City officials communicated frequently, and business relationships between the two cities were already extensive at the time of the deal. As several Dongyang leaders put it, "The two cities see themselves as a single integrated market…and view cooperation from a strategic perspective" (Wang, 2013). Dongyang, for its part, had also engaged in water supply contracts before, and so was well-disposed to Yiwu's proposal.

This history of cooperation played a critical role in allowing the two cities to conclude what is effectively a long-term water supply contract, with Yiwu paying Dongyang 200 million RMB for the transfer of its water entitlements, plus a 0.1 RMB/m^3 reservoir management fee. The long-term nature of the agreement and investment was designed to provide water security for Yiwu—as a city official put it, "spending money buys certainty" (Wang, 2013). However, the very nature of this long-term water supply agreement indicates both the special circumstances which led to its conclusion, as well as the fundamental differences which separate it from individual water rights transfer schemes operative elsewhere.

Inter-Sectoral Transfers: Ningxia and Inner Mongolia

A second institutional model aims to facilitate transfers of water from agriculture to industrial and urban drinking water uses. These transfers are most common in the province-level regions of Ningxia and Inner Mongolia, where rapidly increasing industrial water demands combined with physical water scarcity have created an especially pressing need for re-allocation of water away from agricultural uses. In 2003, Ningxia submitted a pilot project to the Yellow River Conservancy Commission (YRCC), which approves water transfers in the Yellow River Basin on behalf of MWR, to invest some 47 million RMB in irrigation district conservation projects in order to transfer 144 million m^3 of water entitlements to two new hydropower plants for a period of 25 years. Along with a further two pilot projects initiated shortly afterward, some 19.22 kilometers of canals were lined, yielding a water rights transfer from agricultural to industrial uses of 539 million m^3 at a cost of 2.68-3.1 RMB/m^3 (Zhang L. , 2012b).

By 2008, the Yellow River Conservancy Commission, which manages both regions' water resources on behalf of MWR, had approved 26 water rights transfer projects, with 20 of these located in Inner Mongolia alone. Together, these projects accounted for a total of 23 million m^3 of water, with a total investment of some 123 million RMB (Wang, 2013). These efforts have been highly successful on some measures: the additional investment in water conservation has reportedly reduced the quantity of water required for irrigation by half and cut expenditures for farmers by a third. Moreover, investment in these projects rather incredibly represented ten times total investment in irrigation water conservation over the preceding fifty years (Zhang L. , 2012b).

However, much like the case of inter-jurisdictional transfers between Yiwu and Dongyang, inter-sectoral water rights transfer projects in Ningxia and Inner Mongolia do not represent true water rights trading, nor are they easily replicated in other contexts. As several Chinese water resource scholars point out, pilot projects in Ningxia and Inner Mongolia represent transfers of water usage rights under government leadership, rather than market exchange of water property rights between economic actors (Zhang L. , 2012b). More significantly, however, special conditions obtain in Ningxia and Inner Mongolia that limit the applicability of pilot projects in other regions.

Both regions face growing water demands as a result of skyrocketing coal production, and at the same time feature exceptionally low irrigation water use efficiency. In Ningxia, some 18-24% of water abstracted for irrigation is lost through canal seepage, creating large scope for investments in canal lining in order to transfer usage rights to industry (Zhang L. , 2012b). Finally, both regions are subject to particularly dire water shortages as a result of over-abstracting both surface and groundwater. According to one interview informant, water use in Ningxia's urban regions is 80% above the natural rate of replenishment, prompting special concern from the local government (41-BJ, 2014). This combination of factors distinguishes the case of Ningxia and Inner Mongolia from other regions in which inter-sectoral allocation issues are less pronounced, and where transfers are less easily implemented.

Agricultural water exchanges: Shiyang River Basin, Gansu Province

The final form of WRT consists of agricultural water exchanges, and is illustrated by a mechanism currently operative in the Shiyang River Basin, Gansu Province. The implementation of WRT in the Shiyang Basin was driven primarily by a combination of physical water scarcity and long-standing tensions between upstream and downstream water users. In the early 2000s,

groundwater abstraction was estimated at 135% of the natural rate of recharge, and irrigation accounted for 86% of basin water use (Zhang L. , 2012b). In 2005, the Gansu Provincial government approved a plan to reduce basin water consumption by 60 million m^3 annually, largely through agricultural water conservation and strict limits on groundwater use, while also providing for environmental water requirements (Gao E. , 2007).

The plan consisted of three primary elements, including the initial allocation of water rights to individual water users, establishment of popular participation mechanisms, and investment in water use monitoring technologies (Zhang L. , 2012b). Distinctive features of the Shiyang Basin WRT system included relying on Water User Associations instead of Irrigation Districts as the basic unit for water rights assignment and trading, and the installation of smart meters on individual wells to monitor abstraction (Gao E. , 2007). Furthermore, the basin has recently developed an online platform to record trades in an attempt to increase peasant participation and monitoring capability (see Table 1). The Shiyang Basin pilot project follows the Western model of individual water rights allocation, and incorporates many of the features, such as popular participation, that are emphasized as international best practices.

Table 1: Recent Water Trades in the Shiyang River Basin *(Gansu Shiyanghe Liuyu Jiaoyi Zhongxin [Gansu Shiyang River Basin Trading Center], 2013)*

Record Number	Trade Date	Buyer Type	Seller Type	Market Water Price (RMB/m3)	Quantity of Water Traded (wan m3)
1	Dec-13	WUA	WUA	0.03	0.6
2	Dec-13	Village	Village	0.2	8
3	Dec-13	Village	Village	0.2	8
4	Nov-13	Group	Group	0.05	0.26
5	Nov-13	Group	Group	0.05	0.2
6	Nov-13			0	0
7	Nov-13	Village	Village	0.2	5
8	Nov-13	WUA	WUA	0.04	5
9	Nov-13	Village	Village	0.17	0.17

Nonetheless, the Shiyang Basin case is unusual for the degree of high-level attention it has attracted. Although Gansu is host to several other WRT pilot projects which share some of the same institutional features (Gao E. , 2007); (Li B. , 2013), the Shiyang Basin example stands out for the degree to which the central government encouraged the establishment of WRT. The basin had previously manifested a number of acute tensions between water users, attracting the attention of the Chinese Communist Party Central Committee and the State Council. The degree of

high-level interest in the matter is indicated by the fact that former Premier Wen Jiabao had by 2007 visited the Shiyang Basin no fewer than eight times (Gao E. , 2007). Yet even this high-level attention did not prevent the Shiyang Basin pilot project from evincing a number of weaknesses which reflect systemic weaknesses in water resource management in China.

First, the initial allocation of water rights in the Shiyang Basin conflicted with the allocation plans of individual localities within the Basin, in the words of one commentator "undermining the government's credibility and [water users'] respect for the law" (Gao E. , 2007). Furthermore, the pilot project failed to establish sanctions for abstracting water without possessing the necessary usage rights (Gao E. , 2007). Finally, as Table 1 indicates, both trading prices and trading volume are quite low (Gansu Shiyanghe Liuyu Jiaoyi Zhongxin [Gansu Shiyang River Basin Trading Center], 2013). Thus, even though it represents perhaps the most sophisticated example of WRT in China, and the most extensive high-level commitment, the Shiyang Basin case illustrates several important challenges which impede the development of water markets and WRT in China. Accordingly, the following section explores these challenges in greater detail, adding additional information and context from interview sources.

Challenges to the Development of Water Markets in China

The three case studies illustrate the patchwork implementation and constrained function of WRT mechanisms in China. Additional documentary source and interview research conducted for this paper sheds further light on how these features translate into challenges for the future development of water markets in general, and WRT in particular, in the People's Republic of China. I have grouped these challenges under three broad headings. The first, definition, enforcement, and participation, refers primarily to operational issues encountered in implementation that, generally speaking, can be effectively remedied through reform of relevant regulations, procedures and practices. The second, coordination and management, refers to problems encountered in the working relationship between different functional bureaucracies as well as between central and local levels of government. Effective reform will therefore require more fundamental institutional change. Finally, the third category, strategic policy integration, encompasses the challenge of relating market-based mechanisms to other solutions to water scarcity, especially supply-augmentation. Overcoming these challenges requires a new vision for China's water resource policy.

Definition, Enforcement, and Participation

The first set of challenges concerns issues of definition, knowledge, and communication. Chinese water resource experts have long emphasized the unclear legal foundations of WRT in China. These deficiencies include a failure in many areas to clearly define annual water use entitlements, and the fact that in many cases the duration of granted water rights is of uncertain duration. This is particularly problematic when, as is often the case, pilot WRT projects end after a certain period of time, and it is unclear whether rights-holders must re-apply to maintain their water allocations (Gao E. , 2007). Unclear legal definition contributes to a number of issues that undermine the exchange of water rights. In Ningxia and Inner Mongolia, for example,

Chinese-language assessments report a low percentage of verified water rights trades, large differences between estimated and actual water savings, and uncertainty as to whether water rights refer to abstraction or to actual consumption (Zhang L. , 2012b).

The lack of clarity surrounding water rights entitlements possesses two additional dimensions that are of particular concern. First, agricultural water use in China is dominated by Irrigation Districts (IDs), which constitute the primary unit of agricultural production (Wang, 2013). Within IDs, water rights are effectively communal, making it very difficult to assign rights to individual users (15-BJ, 2014). The lack of clarity surrounding water entitlements within IDs reduces incentives to invest in water conservation technologies, since it is unclear who should benefit from trading the resulting savings (Gao E. , 2007). Second, the unclear legal foundations for water rights in China undermine the goal of protecting environmental water requirements, which are meant to ensure that sufficient water is maintained for use by ecosystems and to maintain minimum streamflows in major water bodies. Despite being mandated by regulation, it is unclear who is supposed to designate and protect these entitlements (Liu B. , 2005); (19-BJ, 2014).

A second major issue in the implementation of WRT systems, especially in the Shiyang River Basin, concerns the monitoring and enforcement of water use. Particularly at the level of the individual water user, compliance with the permitting system is weak, and consequently overconsumption of water is rife (21-BJ, 2014). In theory, every well requires a water abstraction permit, but according to Chinese water resource specialists these are rarely obtained, and due to the sheer number of such wells, enforcement is almost non-existent. Moreover, water users, who do obtain abstraction permits, regularly exceed their abstraction quotas, and there is in many cases no effective means of ensuring that these quotas are adhered to (Gao E. , 2007). This phenomenon is especially significant in areas like the Shiyang River Basin, where groundwater abstraction constitutes a high percentage of total water withdrawals.

Interview accounts further suggest that the lack of effective enforcement in large part reflects inadequate efforts to promote participation by water user groups, especially peasant farmers. Although there have been substantial efforts in recent years to encourage the creation of Water User Associations (WUAs), these organizations often fail to engage individual water users. One Chinese water resource scholar has characterized WUAs as "still a representative of the local irrigation district management organization, and not representative of the interests of peasants" (Gao E. , 2007). Interviewees further suggest that this lack of participation may undermine the commitment of policymakers to WRT implementation. According to a former MWR official, "opposition to WRT is mainly opposition to change, [and] even MWR doesn't think things need to change" (22-BJ, 2014). Nonetheless, issues of definition, enforcement and participation are fundamentally operational, and call attention to the reform of implementation procedures.

Integrated Coordination and Management

More fundamental reform is needed to address a second basic challenge facing the expansion of WRT in China, namely integrated coordination and management between bureaucratic units and administrative jurisdictions responsible for water resource management. In some regions it is unclear who should be responsible for trans-provincial water trading, for example, and surface

and groundwater regulation has historically been the responsibility of separate bureaucratic units, undermining efforts to integrate them in WRT systems (Gao E. , 2007). Indeed, despite the fact that water scarcity is viewed as a strategic issue by the government, interviewees note that WRT is seen as an issue only of concern to particular rural areas. Because of this, policies and regulations concerning WRT are often not coordinated with efforts to address water scarcity in urban areas, such as water price reform (18-BJ, 2014); (13-BJ, 2014).

The bureaucratic stove-piping described in these interviews is matched by competition between different administrative jurisdictions, which undermines the function of water rights trading in many regions. Interview accounts indicate that the effectiveness of WRT systems is compromised by the failure of local governments to properly manage inter-sectoral water transfers, often for fear of offending either agricultural or industrial economic interests. In Ningxia and Inner Mongolia, for example, rapid development has produced dramatic conflicts between agricultural water users and coal companies (24-BJ, 2014). An interview informant who works directly with local governments in Ningxia suggested that under these circumstances, officials prefer to deal with coal companies to finance water conservation measures to transfer water away from agriculture, rather than approving direct agriculture-industry transfers. Instead, local governments simply finance water conservation projects, such as canal lining, out of government budgets (28-BJ, 2014). In another case cited by an interviewee in Shaanxi Province, a local government cut off the municipal water supply in order to provide water to a favored energy production company for a test of hydraulic fracturing techniques (28-BJ, 2014). These accounts suggest that while WRT is often seen as a way to resolve multiple contradictions in China's water resource policy (Gao E., 2007) it may in fact exacerbate them.

Strategic Policy Integration

The prospect of increasing contradiction is particularly evident in the relationship between market-based responses to water scarcity such as WRT and the regulatory and engineering responses which continue to form an important component of China's water resource management policies. Indeed, despite the prominence of market-based mechanisms in the Chinese government's water resource policy statements, regulatory reform is far more ambitious. In 2011, the No. 1 Policy Document issued by the Communist Party Central Committee, traditionally viewed as one of the most important statements of government policy for the forthcoming year, pledged to strengthen China's water resource management system through enhanced regulation. This represented, in the words of two Chinese water resource specialists, the first time that water resource issues had been "raised to the level of a strategic and security issue" (Jia & Yan, 2012). In 2012, the State Council issued related regulations intended to strictly limit water use throughout China, including by establishing a cap on total national water use to be implemented by 2030.

Although principally intended to strengthen central control over water resource management, the regulations, known as the "Three Red Lines" (*santiao hongxian*), call on provinces to develop individual implementation plans, raising the prospect of uneven implementation. Perhaps most significantly, however, the government's vision for implementation of the Three Red Lines relies upon extensive inter-regional WRT on a scale so far yet to be realized. As one leading Chinese water resource scholar concludes, while water rights trading now occurs primarily within provinces, "the next step is inter-provincial trading" (Wang, 2013). Detailed implementation

plans are not yet available, but in general the vision for the Three Red Lines relies on establishing mechanisms for water rights trading between cities and provinces nation-wide (Jia & Yan, 2012). Interviews indicate that province-level jurisdictions like Ningxia, which have already implemented forms of WRT, face significant policy uncertainty as a result of the Three Red Lines regulations (28-BJ, 2014).

Yet despite the significance of the regulatory reforms embodied by the Three Red Lines for WRT in China, a supply-augmentation initiative, the South-North Water Transfer Project (SNWTP), may well prove to have the greatest impact on the future of WRT in China. The SNWTP is envisioned as a series of three canals and related infrastructure which will eventually transport some 45 cubic kilometers of water annually from southern to northern China. The purpose of this enormous project is to increase the supply of available water in the north, which suffers from acute water scarcity. The first phase of the SNWTP is complete, but final project completion may only be realized toward the middle of the century (Moore, 2014 [Forthcoming]). Eventually, the SNWTP may be complemented by other supply-augmentation strategies such as desalination, but to date these other sources of augmented supply are insignificant in terms of total water use (Zheng, 2014).

The growth of these supply-augmentation policies raises questions concerning their relationship to market-based mechanisms like WRT, which along with re-allocating water are also intended to limit overall water use. Interview informants indicated their belief that the SNWTP is viewed as a compliment to, rather than a substitute for, market-based mechanisms such as WRT (13-BJ, 2014). But the fact remains that, as a supply-augmentation engineering project, the SNWTP represents a fundamentally different approach to addressing water scarcity and water resource allocation. The continued commitment of the government to completing the SNWTP project, as described by several interview informants (21-BJ, 2014); (39-BJ, 2014), illustrates the fact that water markets are seen by Chinese policymakers as part of a system of responses to water scarcity, rather than the dominant solution. As one informant predicted, "Water rights trading will play only a very limited role" in addressing water scarcity (15-BJ, 2014). The apparent failure to integrate market-oriented policies, such as WRT, into a broader set of responses to water scarcity raises profound questions about their role in meeting China's water scarcity challenges in the coming decades, and illustrates the scale of reform necessitated in the expansion of WRT.

Conclusions and Policy Recommendations: Towards a More Durable WRT Policy Framework

The development of water markets in China generally, and the development of water rights trading in particular, has made substantial progress in recent years. The basic institutional provisions for market-based allocation of water resources have been dramatically strengthened, and several successful pilot and model projects have been established. Perhaps most importantly, the Ministry of Water Resources appears committed to a significant expansion of WRT in seven provinces across China. Nonetheless, as this paper has emphasized, WRT in China is presently confined to relatively small areas instead of covering entire provinces, and it primarily serves as a mechanism for inter-jurisdictional and inter-sectoral transfer rather than true market exchange. Moreover, this article has highlighted a number of challenges, including weaknesses

in participation and communication and deficiencies in inter-governmental coordination, which have impeded the development of WRT in China. Some of these challenges pertain mostly to operational issues, and appear to be relatively easy to overcome. Others, however, are likely to require significant reform not only in China's approach to the development of market-based responses to water scarcity, but in its overall water resource management policy. Most fundamentally, it is unlikely that market-based solutions to water scarcity will be appropriate in all regions, but will rather play an important role in selected parts of China.

Among the challenges that could be improved in implementation, perhaps the most important concerns effective monitoring and enforcement of water use. Newer technologies, including networked streamflow and well-level monitors, are likely to reduce the presently high cost entailed in tracking and verifying water use. Some of these technologies have been applied in the Shiyang River Basin, but further integration would do much to ensure that water rights holders do not exceed their allotted quantity of water use. The experience of the Shiyang Basin also suggests that better engagement of Water User Associations and Irrigation District governance structures can help to improve compliance by securing the buy-in of water users. Water governance reform along these lines could also help to address more general water resource management and allocation issues in water-scarce areas in northern China.

Other challenges identified in this analysis will require more fundamental institutional reform to alleviate conflicts between bureaucratic units and administrative jurisdictions. The biggest challenge to the expansion and future development of WRT in China, however, concerns its place in China's overall water resource policy framework. If not properly integrated with supply-augmentation, market-driven policies to address water scarcity may be undermined in some regions. Moreover, it is doubtful that WRT represents an effective solution to water scarcity in all regions. A leading Chinese scholar of WRT estimates, for example, that the current cost of WRT in China is approximately 0.5 RMB/m^3 of water traded; if costs rise to 1 RBM/m^3, trading would become economically infeasible (Wang, 2013). Given the many challenges which face existing WRT mechanisms, it is unclear whether transaction costs can be reduced to this level without significant institutional learning.

Despite these issues, this analysis suggests several steps which could increase the effectiveness of WRT in China. First, to address its history of administrative control over water resources, the government should formulate a strategy explicitly outlining the relationship between traditional administrative regulation, market-based allocation, and supply-augmentation projects like the South-North Water Transfer. Such a strategy would help to ease coordination and planning problems, and to address apparent contradictions between the three approaches as currently formulated. Second, to better address the interests of peasant farmers and ameliorate sectoral conflicts in water use, China should continue to refine the legal basis for WRT, invest in technology to better monitor water use, and work harder to educate peasant farmers as to how water rights trading works. Third and finally, in order to alleviate central-local tensions and control problems, the Chinese government should establish a high-level Leading Group, similar to the one which has long existed under the National Development and Reform Commission for energy issues, to coordinate water resource management across the many relevant bureaucratic agencies and levels of government (National Development and Reform Commission, 2006).

Market-based mechanisms have an important but limited role in play in helping China to alleviate water scarcity. In particular, WRT can be an important means of re-allocating water from inefficient agricultural uses to higher value-added industrial and municipal uses in areas where competition for water is highest, such as Ningxia and Inner Mongolia. However, in order to be effective in limiting total water use, WRT must be closely integrated with regulatory reform, and balanced by supply-augmentation strategies. In sum, WRT is a powerful but partial solution to China's challenge of water scarcity, and its expansion and development will require careful and sustained attention from the country's leaders.

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