



Structuring water rights in China: a hierarchical framework

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ABSTRACT

The rapid development of China's market economy compels the adoption of water rights and associated market mechanisms to optimize the allocation of water resources. The complexity of understanding and practising Chinese water rights is highlighted by the unique contextual characteristics of an authoritarian political regime, rapid socio-economic change and increasing scarcity of water resources. This article proposes a hierarchical framework to describe the particular water-rights structure in China based on natural resources institutional economics. It provides an analysis of emerging water markets and key factors affecting the formation of a modern water-rights system in contemporary China.

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Introduction

Over the past three decades, China has experienced rapid industrialization and urbanization. In the rapid socio-economic development, a serious challenge to Chinese water resources management has occurred, which is evidenced by the transition from strict governmental control of water resources to a market-driven approach, such as that used by many developing countries (Araral & Wang, 2013). The development of a modern water-rights system including the introduction of water market has been considered one of China's top strategic priorities since the turn of the century (Calow, Howarth, & Wang, 2009; Sun, 2009), which is of concern to both academics and policy makers. However, the development of China's water market faces complex difficulties that can be primarily attributed to the fact that China has been ruled by an authoritarian political regime for more than a thousand years.

Since ancient times, the power to control water allocation in China has been exercised by the central government within a hierarchical structure. In ancient China water control was of vital importance to national stability, as frequent floods and droughts posed constant threats to the Chinese society. The centralized system of management was primarily for safeguarding irrigation systems (Needham, 1981). The hydraulic state is represented by state investment in dikes and hydraulic projects in Hunan and Hubei, in the Middle Yangzi area, in the Ming and Qing dynasties (Perdue, 1987), where irrigation and flood control were dependent on government-managed waterworks (Wittfogel, 1957). Centralized government as the basic form of state governance in China has not changed much since the ancient

times, because important human and economic resources for preventing natural disasters are provided by this centralized system. Therefore, water allocation and associated water rights were predominantly exercised by the state through strict administrative methods.

The Reform and Opening-Up Policy of the late 1970s created demand for private water rights in a period of rapid market economic development, leading to severe water scarcity and increased competition for water use among various regions and user groups. The market economy has created many independent interest groups, diverse property-rights entities, and investors, all of whom create a huge demand for property rights in water resources. Water rights, as a prerequisite for the development of a water market, are considered crucial to improving the efficiency of water use (Zheng, Wang, Hu, & Wei, 2012). Various aspects of the development of water rights in present-day China have been studied: an integrated approach to water resources allocation, linking water abstraction permits to water resources allocation plans (Shen & Speed, 2009); water-rights reform in contemporary China (Calow et al., 2009); duration-based water-rights management, in which water entitlement is based on a fixed number of water-intake days and is not affected by hydrological uncertainty (Wang, Zhu, & Zheng, 2015, p. 2928); and cross-regional water trading in the South-to-North Water Transfer Project (Du, Fan, & Tang, 2016). Nevertheless, very little is known about the basics of how water resource property rights are structured in China. China suffers a severe water shortage, and related issues in water resources management shed light on how to understand property rights in water resources. Property rights are of particular importance in the study of natural resources governance (Agrawal, 2001, 2007; Schroeder & Castillo, 2013), and they encompass a diverse set of tenure rules and consideration of various aspects of access to and the use of resources, as well as knowledge about the relationships between people and water resources (Meinzen-Dick, Brown, Feldstein, & Quisumbing, 1997).

This analysis theorizes the water-rights structure based on natural resources institutional economics. It argues that a hierarchical water-rights structure results from minimizing transaction costs by the process of creating entitlements and allocating property rights in water resources among decision-making entities at different hierarchical levels. Underpinned by the framework of a water-rights hierarchy, this analysis aims to deepen understanding of the structural characteristics of the water-rights concept and its development in China, and its evolving mechanisms. It proceeds as follows. First, it offers a review of the literature that examines Challen's (2000) institutional hierarchy model of natural resources. On this basis, a Chinese water-rights hierarchy framework is developed, emphasizing that decision-making power plays a critical role in analyzing structures of property rights. Next, it examines the theoretical basis of the water-rights hierarchy framework by analyzing its structural characteristics and mechanisms and exploring practical implications. Further, through the lens of a water-rights system framework, it reviews critical issues related to developing Chinese water rights in transition from the period of formation of China's planned economy to the present day, illustrating different types of water-rights trading that occur in the course of water market development. This analysis concludes with a discussion of both the theoretical and practical contributions of the water-rights hierarchy framework in understanding and practising water rights in China.

A framework of water-rights hierarchy

Transaction cost is a key concern in understanding property rights and the sustainable governance of resources (Agrawal, 2001). The influential work *The Problem of Social Cost* (Coase, 1960) proposes the concept of a zero transaction cost, arguing that given well-defined property rights and a zero transaction cost, resources would be used efficiently and identically regardless of who owns them. It suggests that an efficient outcome will be achieved through bargaining processes instead of governmental intervention. Transaction cost is further studied from the aspect of governance structures (Krutilla & Krause, 2010; Williamson, 2000). These studies illuminate the hierarchical and nested nature of property rights (Challen, 2000; Easter & McCann, 2010; Meinzen-Dick et al., 1997; Ostrom, 1990). According to Schlager and Ostrom (1993), property rights in natural resources are the rights of access, withdrawal, management, exclusion and transfer, which are viewed as a bundle of rights determined by access to and use of a certain amount of resources. In these studies, institutions play a crucial role in developing the definition and understanding of property rights in natural resource management.

An institution is a set of working rules 'to determine who is eligible to make decisions in some arena, what actions are allowed or constrained' (Ostrom, 1990, p. 51). Rules for determining property rights are categorized into three levels: operational rules, collective rules and constitutional rules. These three levels of rules work in a nested manner, and changes to the rules at one level are restricted by rules at higher levels. Intertwining among rules at different levels forms a system of nested institutions (Ostrom, 1990). Institutions at any given level of a nested set are legally supported by a superordinate level. The complex nature of an institution is associated with the emergence of bureaucratic costs when a structure moves from unsophisticated to complicated governance structure (Williamson, 2000). These institutions have their own resource-management objectives, and different types of decisions are revealed in the patterns of resource use (Challen, 2000).

Based on the argument for a system of nested institutions, Challen (2000) develops a conceptual model of institutional hierarchy. At each level of property rights structure, there are three types of institutions for managing natural resources: entitlement systems that define the physical basis for dividing the resources among resource users; mechanisms for making an initial allocation of entitlement among users; and mechanisms for adjusting allocations. According to Challen's proposition, a critical analysis of property rights in natural resources looks beyond who holds decision-making power, and property rights are asserted as one of the components of an institution conveying power to manage natural resources. Thus, 'decision-making entity' is proposed as the core of the institutional hierarchy model, highlighting the importance of entitled rights in the property of natural resources. Property rights are a subset of institutions, and the nature of property rights is determined by the nature of the decision-making entities. From this viewpoint, water rights are concerned with not only water ownership but also choices about resources allocation at various levels.

Furthering the above discussion, a framework of water-rights hierarchy (Figure 1) is developed to analyze the structural characteristics of water rights in China. It is composed of decision-making entities, the entitlement system, and mechanisms for adjusting allocations. Decision-making entities exercise their rights, including the right to allocate, the right to withdraw and the right to use. A decision-making entity, which holds the rights pertaining

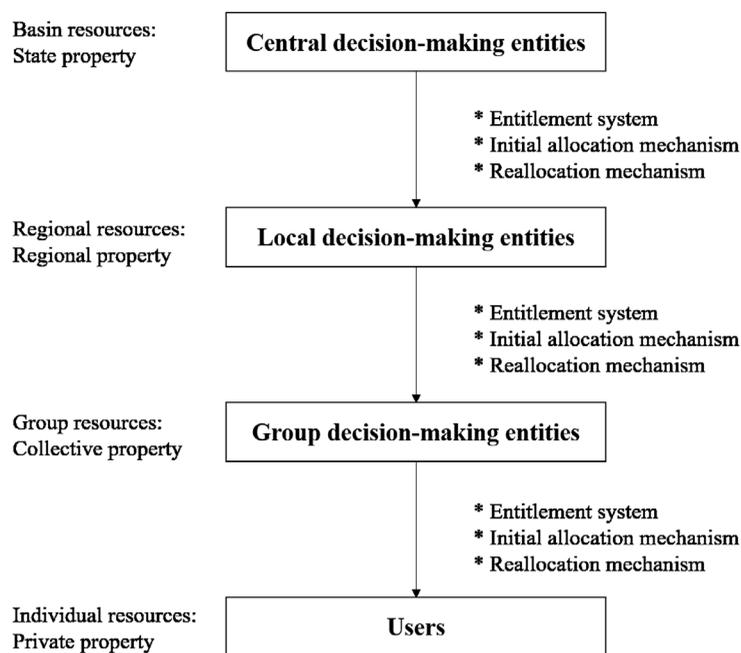


Figure 1. Conceptual Framework of Water-Rights Hierarchy.

to the use of a resource in contemporary China, is defined at four levels: central decision-making entities; local decision-making entities; group decision-making entities; and users. The entitlement system, mechanisms for making an initial allocation of entitlement, and mechanisms for adjusting allocations constitute a set in a nested hierarchy.

The water-rights hierarchy framework provokes a discussion of Challen's institutional hierarchy model, arguing that the institutional hierarchy model is actually a multilevel structure rather than a hierarchy. Limitations on understanding are attributed to specific political and social contexts. Challen's study is set in the Murray-Darling basin in Australia, which is a federal state, whereas China is a unitary and authoritarian political system. Water-rights transfer in the Murray-Darling basin started in 1984 in a small basin area. It was initiated by local water users, and local government facilitated the process of establishing a water market (Challen, 2000). In China, the government not only owns the rights to resources but also exercises the power to engage in the public management of natural resources; property rights are subordinate to administrative authority. This is explained by the concept of residual rights of control (Anràs, 2014; Grossman & Hart, 1986). The more the residual rights of control are held in the upper levels, the higher the degree of hierarchy. In a hierarchical structure, the residual rights of control are held in the hands of the government, and local governments are merely the agents of the central government. China's hierarchy model represents a unique hierarchical system of water rights, created by the Qin Dynasty's unified political system more than 2000 years ago (Huang, 2002).

Basics for understanding the water-rights hierarchy framework

Structural characteristics

In addition to a system of nested institutions where multiple types of parties simultaneously hold decision-making power over a resource (Challen, 2000), the water-rights hierarchy framework illuminates the uniqueness of the Chinese hierarchical water-rights structure. Water rights in China are conceptualized as a hierarchical system encompassing decision-making entities, an entitlement system, an initial-allocation mechanism and a reallocation mechanism. Decision-making entities refer to both individuals and groups, including government agencies, enterprises and social groups at all levels. Nevertheless, in China decision-making entities and water-allocation entitlements are determined by authoritarian rules, taking a typical top-down approach. At the top of the hierarchy, central decision-making entities hold water property rights, representing the state's control of water resources. The control bodies are the State Council, Ministry of Water Resources, and major water-basin resources management organizations. Local decision-making entities are water-rights holders at the regional level, i.e., provincial, prefecture and county governments and their associated water administration departments. Group decision-making entities are irrigation and water supply organizations and water supply enterprises. Users at the lowest level of the hierarchy are represented by urban and rural water-using individuals, households and organizations.

China has long had an agricultural civilization that has been dependent on large-scale waterworks for irrigation and flood control. Its hierarchical water-rights structure is demonstrated by Wittfogel's (1957) assertion of hydraulic society with a centralized bureaucratic administrative system. The existence of a bureaucratic system is attributable to the need to maintain large irrigation systems (Needham, 1981). The water-rights hierarchy holds the key to understanding China's state governance structure (Tsai, 2016). In this study, the hierarchy is analyzed from the perspective of water resource allocation, which is the opposite of market mechanisms. China's governance structure is popularly termed 'despotism' or 'bureaucracy' (Wang, 2013). The complexity of Chinese water governance is illuminated in the water-rights hierarchy framework by its hierarchically structured entitlement and allocation system. There is no doubt that in this type of structure, the managerial cost for administrative authorities is much higher than the cooperative costs among individual users, resulting in basic differences in water governance structure between China and Western societies. Water rights in China are underlined by administrative operation in a top-down hierarchical manner; whereas in the West, with fewer hierarchical characteristics (Matthews, 2004; Poirier & Schartmueller, 2012; Speed, 2009a), water rights are primarily determined by cooperative operation among individual users at the bottom level, and the higher levels are concerned with developing related laws and constitutions. The former is considered a hydraulic society, and the latter a contract society. Residual rights of control are primarily held by an upper decision-making entity in a hydraulic society, where power is delegated in a top-down manner. In a contract society, there is considerable individual autonomy; the top-level government's decision-making power is provided by written constitutions, whereas residual rights of control are primarily held by citizens. Fundamental differences between these two forms of water-rights structures are highlighted by the issues of who holds the residual rights of control and whether there are constitutional institutions.

Formation of water-rights allocation mechanisms

The discussion of water-rights allocation mechanisms is based on Challen's (2000, p. 26) definition of water-rights allocation mechanisms as three essential institutions:

the system of entitlements by which the resource is physically divided amongst holders of property rights; the means by which the entitlements are initially allocated amongst the holders of property rights; and the means by which the entitlements may be re-allocated amongst holders of property rights according to changes in the socioeconomic or biophysical parameters of the resource system.

At each level of a hierarchical structure, the allocation mechanism is determined by an entitlement system, an initial-allocation mechanism and a reallocation mechanism. An entitlement system is a system of physically dividing a resource among property rights holders, which defines the quantity of resources according to different decision-making entities (Wang, 2017). Moreover, in an entitlement system, there are direct and indirect methods of allocation of water resources. Indirect methods include limiting the number of projects for withdrawing water, limiting the depth of water extraction wells, banning high-water-consumption crops and limiting areas of farmland for irrigation (Wang, 2017).

Though in China the initial-allocation mechanism uses both administration- and market-based approaches, the market-based approach is dominated by administrative authority through administrative processes in a hierarchical structure. At lower levels, taking an administration-based approach, water rights are administratively allocated to decision-making entities; whereas through price mechanisms, the market-based approach allocates water rights among competing decision-making entities. If an initial-allocation mechanism does not exist, decision-making entities tend to rely on informal rules. For example, priority is given to those at the upper reach of a river basin, and there is a principle of giving priority to those who are capable of withdrawing water. This informal way of decision-making is a typical practice in China when there is no initial-allocation mechanism. Underlined in the Chinese 2002 Water Law (National People's Congress's, 2002), in developing and using water resources attention is paid first to urban inhabitants' need for water in daily life, while taking into consideration the need for water of agricultural and other sectors. In terms of the diversion of water across river basins, overall consideration is given to the need for water at the basin level and also to sustainability of the ecological environment.

The reallocation mechanism as an indispensable element in the Chinese water-rights system is subject to economic and social changes. Changes in water use by decision-making entities result in water-rights adjustments and reallocation. It is akin to the initial-allocation mechanism, taking both administrative and market approaches. In the process of water-rights reallocation, water rights are transferred by the market approach through price mechanisms among decision-making entities at the same level, whereas the administrative approach adjusts water-rights allocation among decision-making entities at lower levels by following administrative directives.

The initial-allocation mechanism and reallocation mechanism are marked by a structural distinction in the water-rights hierarchy. Both administrative and market allocation in the initial water-rights allocation flow from the upper level to the lower level in the hierarchical structure, whereas market allocation at the reallocation stage occurs among decision-making entities at the same level. The Chinese water-rights hierarchy has significant impact on the

implementation of market mechanisms, and this is further explained by the typical cases of the developing water market in China in the following analysis.

Developing a water-rights system and water market in contemporary China

Changes of water-rights structure from the planned-economy period to the present

The use of water markets is considered an effective tactic to achieve the highest value of water use (Hart, 2016). Under the current Chinese water resource reform, how does the concept of water rights impact water resource management in China? And how is the development of water rights shaped in the context of an authoritarian system? In response to these questions, differences between water rights in the planned economy and water rights in today's China are reflected by the theoretical implications of the water-rights hierarchy framework. Figure 2 presents the water-rights structure for surface water from 1949 to 1987. It shows that at the basin and regional levels, water-rights allocation mechanisms were non-existent from the founding of the People's Republic of China in 1949 to the implementation of the Yellow River Water Allocation Plan in 1987 (An, 2007). During this period, water-rights allocation mechanisms were established more at the group level; and the initial allocation and reallocation of water rights were accomplished administratively at various

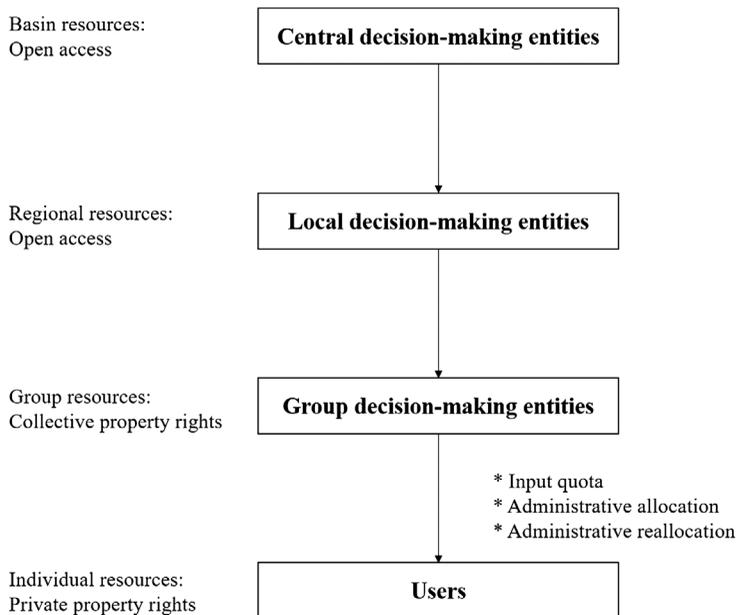


Figure 2. Water-Rights Structure for Surface Water in China from 1949 to 1987.

levels. Due to a lack of water usage rules and appropriate incentives for economizing water use at that time, water scarcity occurred at the group, regional and even basin levels.

The market-oriented economic transition and socio-economic development have encouraged the establishment of water-rights allocation mechanisms at higher levels of the water-rights hierarchy. Since the 1988 Water Law (Boxer, 2001), water-allocation mechanisms have been established at all levels. For instance, almost all of the provinces in the Yellow River basin have defined their water rights according to water-allocation agreements, and they have allocated water withdrawal rights among groups within a Water Withdrawal License System (Wang & Ching, 2013). These water rights establish an administrative control structure, and thus the water rights at both the initial and adjustment stages are administratively allocated from the central decision-making entities to the bottom users (Figure 3). In this figure, the entitlement system of the water-rights hierarchy framework is viewed from the perspective of water-allocation quotas. Direct allocation of water is considered as a resource quota; and indirect methods, such as limiting water withdrawal and consumption, are referred to as input quotas (Wang, 2017).

The market-oriented economic reform and associated changes, such as the creation of a water market, have made it increasingly costly to manage this hierarchical governance structure. The state's inadequate input into the management cost leads to an 'absence of government' situation in water resources allocation. By contrast, a lesser degree of market mechanism is developed as a cooperation cost that is covered by the market to offset the

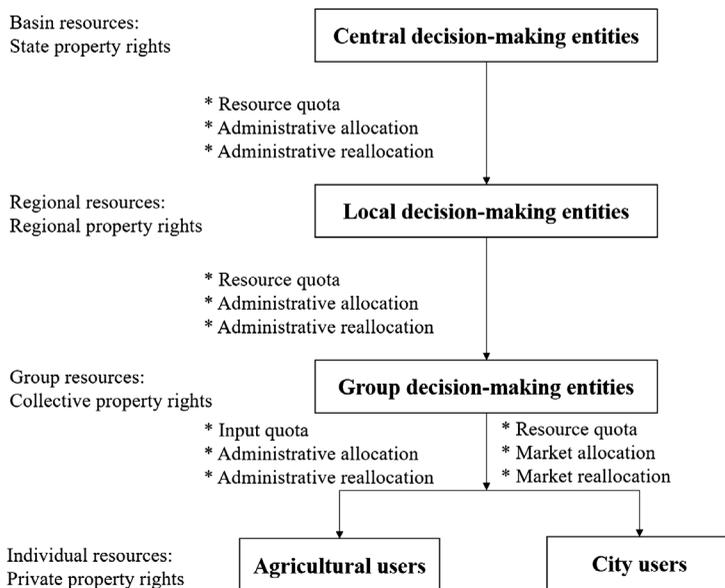


Figure 3. Water-Rights Structure for Surface Water in China since 2002.

inadequate support from the government. This explains why water-rights allocation in China involves the coexistence of dominant administrative practices and semi-market practices.

Corresponding to the rapid pace of the economic transition, industrialization and urbanization, urban areas have seen an increased expansion in water supply markets. A market mechanism has been introduced and integrated into the administrative allocation system. The development of market mechanisms in the hierarchical structure helps reduce the cost of managing urban water supplies. Because of the variety of local geographical, demographic and socio-economic contexts in rural China, the management and monitoring costs of irrigation-water allocation are much higher than the costs of supplying water in cities and towns, with the result that administrative allocation methods are commonly used for agricultural water. Throughout the Chinese economic reform, market mechanisms have been expanding into the area of irrigation water, penetrating the higher levels of the hierarchy. How do market mechanisms develop in the water-rights hierarchy? With respect to water market development, the following analysis illustrates types and patterns of water trade in today's China.

Cases of water market development in contemporary China

Building on the water-rights hierarchy framework, we use six typical cases of water trade to explore how the concept of a water rights hierarchy has affected the development of market mechanisms in contemporary China. These cases are based on the collection of field data since 2001 as part of our project to explore the initiation of Chinese water-rights reform. The types of water trade at different levels of China's hierarchy are outlined in Figure 4. They fall into five categories: user-level trades of short-term water rights (Case 1); group-level trades in which industrial enterprises purchase agricultural water rights (Case 2); local government-level transactions, including cross-regional transfers of long-term and short-term water rights (Cases 3 and 4); water banks aiming to lower transaction costs and establish high-quality water rights and water markets (Case 5); and the South-to-North Water Transfer Project, which is the initial water-rights allocation through market mechanisms (Case 6).

Chinese farmers pay water fees based on volume of use (Wang & Chen, 2014). Irrigation management organizations allocate water through a planned method among channels and canals, and the quantity of water allocation is primarily adjusted through administrative means (Chen, Wang, & Zhu, 2014). Thus, it is not easy for farmers to engage in water trade among themselves, and the ability to reallocate water at the bottom level is usually weak. Case 1, fieldwork data collected through interviews and notes, presents water-rights trading in the Hongshuihe Irrigation Area in Zhangye City, Minle County, Gansu Province, through the pilot project Water-Saving Society (Xia & Pahl-Wostl, 2012b). The Hongshuihe Irrigation Area experienced water scarcity. Before the water-saving project was implemented, only two out of every three *mu* (about 0.21 hectare) of farmland could be irrigated. This constraint became the initial impetus for establishing irrigation-water trade. The issuance of Water Withdrawal Permits in the Hongshuihe Irrigation Area in 2001 represents the initial water-rights allocation mechanism at a preliminary stage, where water-rights transfers are one-to-one, low-quantity, and short-term. From a perspective of differentiating the relationship between water rights and land rights, this case also illustrates that long-term rights trading is difficult to implement, because land held by farming households is not tradable and the right to irrigation water is closely attached to land rights.

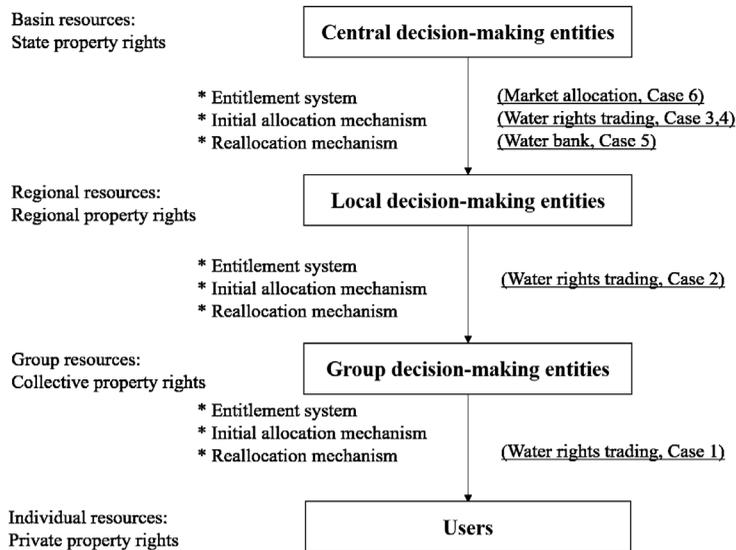


Figure 4. Classification of Water Market Cases in Present-Day China.

Case 2 is concerned with water trade at the group level. It is developed by an industrial enterprise, and further operated and optimized by decision-making entities at the group level. In 2000, the Datang Tuokeduo Power Company of Inner Mongolia, a large, state-owned, power-generating enterprise, purchased irrigation water in the Yellow River basin. An interview revealed that the company submitted a report (document no. Tuo Dian [2001] No. 23) to the Planning Commission of the Inner Mongolia Autonomous Region in 2001, in which it committed to invest RMB 89.5 million (approximately USD 13 million) in a water-saving irrigation project in five major rural irrigation areas in Inner Mongolia. In exchange, the company would obtain water-use rights of 50 million m³ from the quota of 5.86 billion m³ for Yellow River water (Wang & Tian, 2010). This case highlights the high managerial costs and ineffectiveness of administrative means that can occur with water-rights regulation, particularly for new groups that need more water and are forced to adopt market mechanisms. The transition to a market economy gives rise to increasing independent group interests with independent interests and awareness of their rights, and water trade in this case is complicated by intra-provincial water reallocation between independent groups and users. Thus, it becomes increasingly difficult to use administrative methods to regulate water rights. For example, the Yellow River Water Allocation Plan was implemented in 1987, and in 1999, the Yellow River Conservancy Committee ceased further allocation to provinces that were running out of their water-use quotas (Xia & Pahl-Wostl, 2012a). Consequently, intra-provincial water reallocation became a potential solution (Wang, 2012).

Cases 3 and 4 present long- and short-term cross-regional water trade, respectively, at the local level. Case 3 is the first Chinese water-rights transfer (which occurred in 2001) at

the local level, between Dongyang City and Yiwu City in Zhejiang Province (Gao, 2006; Shen, 2014; Speed, 2009b). The water trade between these cities was based on long-term established rights and was negotiated by their local government administrators. The city of Yiwu opted to purchase water instead of making an administrative request for a water quota because the cost of trading water was much lower than the cost of the administrative procedures. Case 4 involves short-term and cross-provincial water-rights trading in the Zhanghe basin, which was carried out by regional Water Conservancy Committees, to resolve temporary seasonal water shortages.

Case 5 discusses the establishment of water banks. In 2001 experimental water banks were established in the lower reach of the Yellow River basin in Henan and Shandong Provinces (Water Regulation Bureau, 2002). This enabled the deposit of saved water into a water bank for trade and transfer. A water bank is an advanced form of water market and is built on the basis of water-rights trading among decision-making entities at the same administrative level. Here 'advanced' refers to the evolving forms of water rights in the developmental process of water markets in China. Yet, in China water rights held by provinces and regions are considered 'controlled quotas' rather than 'assets' (Wang, 2017), and China's water bank apparently remains at the elementary stage of theoretical exploration, without clearly established conditions for standard practice.

The previous five cases of water-market development fall within the scope of water-rights reallocation. Case 6 involves the South-to-North Water Transfer Project, which represents an important case in China's initial market allocation of water rights (Wang, 2000). The initial allocation of water rights in the South-to-North Water Transfer Project introduced market mechanisms, at least to a certain degree; however, the rights have not completely achieved market-allocation status. In fact, the project is directed by the central authorities, with investment from the central and provincial financial departments, and aims to resolve water resource shortages in the Yellow, Huaihe and Haihe basins. This project's initial allocation of water rights incorporates administrative and market methods, and its basic operation is based on the regulation of water supply between superordinate and subordinate decision-making entities.

Developing a modern water-rights system: a challenge to hierarchical structure

The above discussion of the development of water markets in China demonstrates that water-rights reforms and associated experiments involve implementing a mixture of administrative and market methods at different levels in the hierarchical governance structure. Currently water rights are dependent on a market-based water trading system, which includes both long-term water access entitlements and the short-term periodical allocation of certain volumetric quantities of water (Speed, 2009a). The manner in which water resource allocation rules are established among decision-making entities has been a major concern in the field of water-rights development. China's water-rights hierarchy is distinctively characterized by its entitlement and allocation of water rights among decision-making entities with a top-down and supply-oriented approach that does not meet the demand from users at the bottom level.

The critical issues emerging in establishing a water-rights allocation and transfer system are the rights to allocate, abstract and use water resources. In practice, in a typical irrigation district, water rights go through stages of initial water allocation, with bulk volumetric

charges for farmer groups and area-based charges for farmers; and then irrigation agencies grant rights to each farmer group by providing a water certificate, a limited entitlement to purchase, and water tickets for irrigation periods, which are tradable based on actual water use (Zheng, Wang, Liang, & Calow, 2009). In addition, rights-based reforms in water resources management are introduced at various levels of decision-making entities, mainly from local government, to both groups and users (Wouters, Hu, Zhang, Tarlock, & Andrews-Speed, 2004). A transparent and rule-based system is of significant importance to farmers, who require clearly defined rights to help them make decisions and investments in irrigated agriculture (Calow et al., 2009). Arguably, establishing a water-rights concept and structure is fundamental to developing water-allocation rules and mechanisms. The core of China's water-rights system development is the construction of a mechanism for sharing available water resources among users at various levels (Sun, 2009). For this concern, a further discussion of the motivation mechanisms introducing market elements into the water-right hierarchy is suggested. On the one hand, market mechanisms are theoretically incompatible with a hierarchical structure; but on the other hand, in a water-rights hierarchy, there is no doubt that absolute administration means result in extremely high managerial cost and reduce the efficiency of water resources allocation, so market elements are gradually introduced for the sake of cost-effectiveness.

Natural resources institutional economics asserts that transaction cost plays a critical role in analyzing natural resources management (Agrawal, 2001). Furthering this point, it argues that motivation mechanisms of introducing market elements are generated by the rise of management costs and reduced cooperation costs. In a water-rights hierarchy, when management costs are kept low, administrative means are capable of managing water resources. However, when management costs are increased due to water shortage and change of environmental conditions, transaction costs for maintaining the hierarchical governance structure rise. In this case, introducing market elements becomes necessary. Consequently, market practices lead to higher cooperation costs. The introduction of market elements is demonstrated as a necessity for minimizing transaction costs in maintaining a governance structure. The six typical cases of water trade in China discussed above illustrate that at the lower level there are stronger motives for introducing market means than at the upper levels. This is because there are larger numbers of decision-making entities at the lower levels, with high heterogeneity and high cost of administrative means; whereas the number of decision-making entities is smaller at the upper levels, and they are relatively more homogeneous, and the costs of administrative means are relatively low. The mechanisms of introducing market means in the Chinese water-rights hierarchy is viewed as an critical aspect in developing a modern water-rights system, which is underlined by the Chinese 2002 Water Law (Shen, 2004).

Moreover, the modern water-rights system requires developing demand-management strategies related to water pricing, permitting and trading at different levels (Calow et al., 2009). Importantly, in a modern water-rights system, decision-making entities are not unique to the governmental agencies at the top of the hierarchy, although water rights for users at the bottom levels are generally informal and not clearly defined. Therefore, protecting farmers' long-term water rights and ensuring group water entitlements poses a challenge to institutional reform of water resource management in China's water-rights hierarchy. Another critical issue is the weak connections between allocation plans at different administrative levels (Speed, 2009a). It is posited that creating sustainable, efficient and strategic water

rights allocation plans should focus on defining and allocating rights based on water users' future demand, which requires adopting an integrated (top-down and bottom-up) approach to developing a new and innovative water-rights system (Wang, Zheng, & Wang, 2009).

Further lessons for developing a water-rights system come from the comparison between the evolution of water rights and related policy solutions (Speed, 2009a). Although the differences in the water-rights systems in China and Australia are highlighted by their political systems, the one a socialist republic and the other a liberal democracy, issues and problems that emerged in Australian water rights reform in the past decades have also emerged in present-day China, in particular the existence of unidentified and unprotected entitlements to and restrictions on water-rights transfers. In Australia, there is a significant shift towards federal control of water resources in the Murray-Darling, whereas the Chinese central government moves to downplay its leadership role in water resources management by adopting a semi-market-based approach (Speed, 2009a). At its embryonic stage of water-rights development, China's water-rights transfer system involves a series of government-facilitated projects: a water-saving project, the right to transfer saved agricultural water to industry, and the trade of long-term water access rights between regional governments (Speed, 2009b). This is meant to encourage the participation of users, who are shaping decision-making rules and making changes in institutional structures, and contributes to building a modern Chinese water-rights system that includes the participation of non-governmental organizations (Wheeler, Garrick, Loch, & Bjornlund, 2013). However, entitlements to water at the river basin, regional and abstractor levels lack a solid legal basis (Speed, 2009a, 2009b). Legal recognition and protection of water rights, along with transparency in the decision-making process in the hierarchical structure, are considered an important challenge for China (Dou & Wang, 2017). The actual rights in the Chinese water-rights system are water-use rights rather than property rights. Property rights incorporate ownership rights, use rights and other rights, but in China water is owned by the state, and local regions do not have regional ownership rights. Arguably, a water-rights concept in China is in fact best understood as water-use rights. This is concerned with how to recognize and protect the legal status of water rights.

Western experiences of reforms in the water sector shed light on how to implement a comprehensive system of water entitlements, make water entitlements tradable, and create specific and clearly defined relational rights within a property-rights system (Matthews, 2004; Wheeler et al., 2013). This poses the formidable challenge of developing a modern water-rights system in China's water-rights hierarchy. Several aspects are important for responding to this challenge: separating water property rights from land rights, modifying operational rules to encourage conservation, creating a public ombudsman to protect the public's interests, and introducing a tax on each water transfer for the ombudsman's use (Matthews, 2004).

Conclusions

Based on Challen's (2000) institutional hierarchy model of property rights, this article has argued that a hierarchical structure of water rights is the outcome of minimizing transaction costs in the process of creating entitlements and allocation of property rights in water resources among decision-making entities at different hierarchical levels. A conceptual framework of a water-rights hierarchy was developed, providing a robust theoretical

explanation of fundamental elements of China's water-rights structure. This analysis makes a significant contribution by theorizing water rights and offering an analytical lens, thus enabling a better understanding of water rights and potential institutional arrangements in Chinese water rights development. Three aspects of implications are summarized: the water-rights hierarchy framework for theorizing water rights; the water-rights hierarchy framework as a lens to envisage future water-rights reform; and identifying vital principles in establishing a modern water-rights system in China.

First, this theoretical framework of water rights demonstrates that a water-rights concept is defined at multiple levels and in many dimensions. Multilevel characteristics are illuminated by a variety of institutional options at different levels; for instance, between central and local governments, between local governments and groups, and between groups and individual users. Multiple dimensions refer to allocation mechanisms in a water-rights system. These are developed on the basis of three basic mechanisms: the entitlement system, the initial-allocation mechanism and the reallocation mechanism. Further, in the process of defining the water-rights concepts, the entitlement system is viewed as both a resource-quota entitlement and an input-quota entitlement. The initial-allocation mechanism and reallocation mechanism are analyzed through market-allocation and administrative-allocation approaches, which are considered two distinct paths of developing a water-rights system. Second, the water-rights hierarchy framework provides a lens through which we can better understand water rights and future reforms of the Chinese water-rights system. A market economy and its associated mechanisms have a significant impact on the water-rights structure, and future reform will move towards developing more efficient and effective managerial structure for a modern Chinese water-rights system. Finally, in terms of defining water-allocation mechanisms, policies that ensure equity, efficiency and sustainability are held in prominence; however, in practice these principles are interpreted differently in different countries (Zheng et al., 2012). Market-oriented reform prompts the formation of groups and users with diversified interests, further increasing the heterogeneity of water-rights holders. The administrative cost of reallocating water rights increases during this process of encouraging users' participation at the bottom level of a hierarchical system. Accepting equity as a universal principle, it remains crucial to establish legal protection for users' interests to exercise water rights at the local level.

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