How Can China Achieve A Sustainable Development of Shale Gas? Implications of River Chief System to water governance for shale gas in China

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Abstract. Along with China’s ambitious strategy for shale gas development, water contamination risks with shale gas extraction has aroused great attention. Meanwhile, an innovative water management mechanism called as ‘River Chief System’ has been popularizing around China to improve the river water quality efficiently. Could this mechanism be available in shale gas water risk management? And how could it be adapted to improve the sustainable development of shale gas? Therefore, this paper starts by a discussion on the logic of River Chief System’ success and worries; then, a comprehensive examination of current multi-channel governance system of shale gas in China is presented to explore the dilemmas in its water governance; and a causal loop model is built to clarify interrelations among these dilemmas. The result identifies that River Chief System’s superiorities which can be learned are mainly reflected in clear responsibility, authority and multi-sectoral collaboration system. However, its temporary "campaign-style" character, over-reliant on the commitment and capability of river chief, blurred evaluation mechanism has hindered its expanding in the long run. Accordingly, 5 policy implications based on River Chief System for the sustainable improvement of shale gas is presented.

Keywords: water contamination risk, water management, shale gas, river chief system, governance.

1. Introduction

Recently, China pledged to have CO2 emissions peak before 2030 and lower the emissions per unit of GDP over 65% from the 2005 level in September and December 2020, separately [15]. To develop clean energy is a promising approach. China is estimated to have the largest technically recoverable shale gas resources in the world (1115 tcf), in addition to the third-largest shale oil reserves (32 billion barrels) [5]. As early as in China’s 12th Five Year Plan, shale gas has been identified as a policy priority and set out to be ‘promoted and accelerated’ [7]. In the 13th Five Year Plan (2016-2020), shale gas production in China is expected to reach 30 bcm by 2020 – this represents 15% of total natural gas consumption in the country [7]. In June of 2020, ‘Guidance on improving energy security in 2020’ by National Development and Reform Commission (NDRC) and National Energy Administration (NEA), continued
to emphasize to accelerate the development of shale gas and keep growing in production. China’s ambitious goal indicates rapid development for shale gas.

However, the environmental risks from fracking activities of shale gas extraction (particularly, flowback and produced water) have gained great environmental concerns. Such as the flowback water mainly contains extremely complex dissolved chemicals, hydrocarbons, heavy metals, naturally occurring radioactive material (NORM), bacteria and water-soluble salts, such as potassium, calcium, sodium, carbonate, and chloride [13]. Good evidence suggests these large volumes of contaminated water are difficult for the industry to manage on site [9], and able to cause adverse health effects to humans [1][2]. Water risk associated with shale gas extraction needs to be extremely carefully controlled. However, these risks have not been appropriately managed yet [16].

Meanwhile, a new management system in China that called ‘River Chief System’ (RCS) has been proved which could improve water management efficiently in a short-term. The so-called RCS means that leading local officials are appointed as “He Zhang” (river chiefs) for a specific river section, and the RCS makes them responsible for water protection and management within their own jurisdictions [11]. Given the effectiveness and success of RCS, this policy had been fully implemented in 30 provinces, and more than one million officials had been assumed as the river chiefs at the provincial, municipal, county, township, and village levels by the end of 2018 [6]. And this RCS is being expanded to forest management already [8].

Therefore, since China’s shale gas development produce more fragmented environmental problems, especially water contamination related problems, which beyond the capacity of shale gas companies even water supervision departments; meanwhile, RCS are proved efficient in water governance, therefore, could this RCS mechanism be applicable in shale gas water contamination management? and how could it promote the sustainable development of shale gas? This study could provide more insights into the mechanism of RCS and its feasibility in shale gas water governance. The remainder of this paper proceeds as follows. Section 2 describes the research methods and Section 3 discusses the logic of RCS’s success and worries, as well as applicability of the RCS to water governance for shale gas; after a comprehensive examination of current multi-channel governance system and the dilemmas of shale gas in Section 4; a causal loop model is built to clarify interrelations among these dilemmas; and finally, 5 policy implications based on RCS for the sustainable improvement of shale gas are provided.

2. Materials and methods

This study adopted a literature review and field research as the main methods. The literature included domestic and foreign studies both on RCS and shale gas environmental and water governance in China and outside China.

To obtain a further understanding of the current status of water governance in China, in addition to the literature review, we conducted field research to several shale gas fields in both Sichuan and Chongqing (they are the largest shale gas fields in China). What’s more, we also held several discussions with relevant scholars, corporate representatives of oil companies and government officials. What we discussed involved the development of shale gas, current situation and dilemmas of shale gas environmental and water governance, and third-party assessment indicators and mechanisms et al.

3. The success and worries of RCS

RCS is an innovative policy instrument in China which purposes to overcome fragmentation in water management and improve water quality effectively in a short time. The development of RCS can be divided into three phases: Emergency phase, Local extension phase, and Large-scale expansion phase:

Phase 1: Emergency phase. RCS was first innovated to address a blue algae outbreak in Taihu Lake as a policy instrument by the local government of Wuxi Municipality of Jiangsu Province in August of 2007.

Phase 2: Local extension phase. Since the water environment of Taihu Lake has rapidly improved, RCS was introduced to the entire Jiangsu Province, followed by Yunnan and Henan, and other provinces in 2012.
Phase 3: Large-scale expansion phase. RCS has been approved by the China’s central government and began to be applied throughout the whole China in 2016 to reinforce river and lake protection.

Obviously, RCS has achieved a transformation from local trials to a national mechanism. It can be considered following a parallel, bottom-up and eventually top-down routine. And it also means that RCS can be available in various positions because of its performance generation mechanism.

3.1 The logic of RCS’s success
As shown in Figure 1, the essence of RCS is the river chief, which follows Chinese traditional governance logic ‘the most powerful man should in charge of the most important thing’. With a clear accountability system, effective multi-sectoral collaboration system, and an accessible and differentiated goals, the river chief has been involved, centralized and maximum use in RCS. And the whole RCS has become a positive feedback mechanism, and delicacy management has been achieved.

3.1.1 Clear accountability system. RCS sets the government leaders as river chiefs at several levels, making them the first responsible persons for the water environment within their respective geographical jurisdiction. River chiefs are responsible for the drinking water safety, water source dispatching, water saving management, and sewage treatment, which were once subordinate to the respective authorities of environment, agriculture, resources, and transportation [6]. Additionally, ‘one vote veto power’ has been generally introduced to RCS, which means if the river’s water quality failed to the goal, the responsible river chief will also be failed to their annual government performance evaluation. Accordingly, an accountability system is feasible. To some extent, the administrative efficiency of river chiefs and officials has been improved.

3.1.2 Effective multi-sectoral collaboration system. As shown in Figure 2, a multi-sectoral collaboration system has been built for RCS. Vertically, a hierarchical system of four levels’ river chief office is constituted (including provincial, municipal, country-level and township). Horizontally, RCS office coordinates the operation of various department agencies in charge of environmental protection, water affairs, land use, agriculture, industries etc. What’s more, in order to promote the inter-agency collaboration, even the officials of RCS office are from various department agencies.

Consequently, with this multi-sectoral collaboration system, local authorities have been associated directly to environment affairs. Additionally, the senior government officials (also as the river chiefs) would have a comprehensive understanding to the complexity and systematicness of environmental issues as well.

![Figure 1. Performance generation mechanism of river chief.](image-url)
3.1.3 Feasible implementation system. The features of each river diversified, and the challenges river chiefs face also different, for instance, existing water quality, enterprise quantity and industry type. Even just for water pollution control, the distinguished quality, composition, and spatial distribution of pollution sources and specific natural conditions of each river requires targeted control measures. Therefore, instead of traditional ‘one-size-fits-all’ environmental policy, RCS has conducted “one river, one file” and “one river, one plan” to promote differentiated measures on each river with achievable goals.

3.2. The worries on RCS
RCS has brought prominent improvement to China’s river management for its innovation in accountability, collaboration and goal setting. However, based on literature review, field research as well as interview with related staffs, we found that the weaknesses of RCS remain in several aspects, which have already appeared in its implementation across the country, and impairing the effect and limiting this system’s promotion in other environmental protection issues:

3.2.1 River chief-driven mechanism. The river chief is regarded as the center of the whole RCS (as shown in Figure 1 and Figure 2), whose abilities, prestige and values can greatly determine the work efficiency. However, these could be influenced by many factors, including personal knowledge in pollution control, subjective initiative, values, individual attention distribution, local economic level, personal social network situation and so on. Therefore, the “rule of man” mode is flexible when facing diversified river conditions but hard to constant in efficiency and implementation more broadly.

3.2.2 Campaign-style governance model. RCS was initially innovated as an emergency setting for water security of a large-scale cyanobacteria bloom occurred in Taihu Lake. However, since RCS has been promoted to the whole country from 2016, it falling into the trap of ‘Campaign-Style Governance’ (CSG) in some places. Because CSG can concentrate resources to accomplish large undertakings and achieve the effect of governance quickly, CSG model has been adopted in China’s governance system for decades, and getting further developed in recent years, especially in dealing with major social problems. For the river chiefs, in order to pass the achievement assessment, they tend to adopt CSG model in a short time (generally, half to 1 year before the assessment) to expect an immediate result. Similar as CSG, RCS is original an emergency policy without systematical design, which already breaks the conventional river administrative system, and it inevitably brings a series of problems, such as high resource dependency, non-institutionalization, less specialization and so on. Consequently, if RCS is adopted to be a new mechanism for water governance in whole China, to promote its regularization and constancy will be important.

3.2.3 Out of social participation. As plural subject system has been widely accepted in public governance, especially in solving environmental and other social problems, to attract more subjects involve in environmental governance should be a promising option. However, as the core of Chinese bureaucracy is considered as ‘always responsible to a higher authority system’ [17], the local policy-making process tends to be less systemic for chasing the immediate results, such as ‘one-size-fits-all’ environmental policy. A shorter policy-making process could imply not enough consideration for all stakeholders, especially, which will finally result in extra economic loss for the enterprises and farmers. Hence, fewer enterprises and farmers are motivated to participate in RCS. Additionally, since the river chief has been commonly considered as the responsible person for the river pollution affairs, which would lead to ‘The Tragedy of Commons’. The public could form a concept of ‘river pollution is only government’s responsibility’ in a long run.

4. Water governance of shale gas in China

4.1 The status of water governance system in shale gas
In the Sichuan basin of China, (mainly including Sichuan province and Chongqing region) the environmental governance system (including water governance) of shale gas can be classed into 4 levels bureaucracy hierarchies, every hierarchy has its corresponding supervision departments, as shown in Figure 3. Besides, the shale gas company, local residents, public, NGO and social medias are designed to be responsible in this system.
4.2 The dilemmas of water governance in shale gas

RCS’s success identifies that the effectiveness of water contamination control is directly positive correlated to environmental governance. According to the literature review, field research as well as discussions with officials at various government levels and shale gas companies, we find mainly 5 dilemmas in China’s shale gas water governance system as following:

4.2.1 Dilemma of governance departmental coordination: China implements multi-channel management system for shale gas industry (as shown in Figure 3). However, without a unified governance model/authority, this system function complicated and fragmented. For instance, water issues have triggered high attentions in the world, but Ministry of Water Resources is not included in management system. Departments fight with each other for the departmental interests, especially between shale gas and environmental protection departments. And environmental protection is an unobvious political achievement which has been belittled involuntarily. Moreover, shale gas development in China is open to all types of firms now, firms even without any experience in oil or gas exploration are allowed to enter this industry. This institutional loophole could be exploited by some developers and sowing the seeds of the accidents.

4.2.2 Dilemma of governance incentive and capability: The environmental governance in China represents the characteristic of ‘Inverted pyramid’. Which means, despite that the governance work is mostly carried out by the basic- hierarchy government/local government, the government with higher hierarchy owns not only more financial resources, but more advanced eco-environment technology and stronger sense of responsibility, and vice versa. In terms of shale gas industry, firstly, the exploration fields are mainly located in undeveloped cities/towns, where the most important assessment criteria for local government is GDP, and shale gas industry plays an irreplaceable role in advancing the local economic growth. Consequently, local government has no incentive to governance it. Additionally, local water specialized supervision institutions are required by Ministry of Environmental Protection as well as Department of Water Resources, however, these water supervision institutions are affiliated with local government, and their employees basically have neither college degree nor major in water or
environmental protection. Therefore, there is no incentive and capacity for local government to struggle with powerful oil enterprises.

4.2.3 Dilemma of governance criterion: over rely on the enterprises and lack of sector-specific standards:

The applicable water regulations for shale gas activities can be only referred to oil and gas laws. Such as the ‘Environmental Protection Law’, ‘Water and Land Conservation Law’. However, China’s oil and gas related water protection regulations are not complete yet. Even the largest shale gas fields in China, such as Sichuan and Chongqing, they also do not have their own shale gas water.

4.2.4 Dilemma of local authority environmental awareness:

With the improvement of living standard, Chinese people and government put more emphasis on environment in recent years. However, start from the 50s-60s of last century, natural environment has once been regarded as an ‘enemy’ in China, people must fight with to survive. Based on this point of view, China has taken a development strategy of ‘Pollution first, Treatment later’ for a long time. Hence, governments at various levels and local residents have to change their traditional mentality of ‘destruction first, repair later; emissions first, reduction later’. For example, ‘Shale gas development plan (2016–2020)’ promulgated by NEA targets of shale gas to 30 billion cubic meters by 2020 and Sichuan province is set as the key region. Despite of its high population density, complicated geologic conditions, seasonal water shortage and even near earthquake zone, mainly for the vast shale gas reserves.

4.2.5 Dilemma of public and NGO participation:

Dislike a common facility, expertise is required in shale gas environmental governance. For instance, fracturing fluid contains extremely complex dissolved chemicals, heavy metals, NORM, bacteria and water-soluble salts etc., and the contents of each component various depend on properties of fracking shale reservoirs. Specialized knowledge is a precondition for public participation. What’s more, since the shale gas well sites are located in the countryside and locked by gates, the only feasible approach to visit these places is to apply to Petro China Company officially. It’s time-consuming, and even the application is accepted, information public can receive is limited and unintelligible.

4.3 Causal linkages among the dilemmas

In order to clarify interrelations among above dilemmas, we use system dynamics theory to build a causal loop diagram (CLD) model of the water governance in shale gas, as shown in Figure 4. In a CLD, variables are connected by an arrow and an assigned positive (+) or negative (−) polarity to represent causal relationships among the variables. A positive polarity indicates that both variables move in the same direction (increasing or decreasing) in response to a change in the variable, and vice versa (J Singh, et al.,2019). In this study, the CO2 emission reduction pressure, sustainable development and national energy demand are exogenous variables which promote the amount of shale gas enterprises and production; meanwhile, if the governance is more effective, the environmental pollution should decrease, which will lead to a higher demand for shale gas again. However, departmental coordination, governance capability and driving force, sector-specific regulations and standards, local authority environmental awareness and public participation form negative feedback to shale gas pollution control.

5. The implications of RCS to China’s shale gas water governance

Shale gas has been heavily backed to China’s sustainable development. Simultaneously, since water contamination issues of shale gas involved in all stages of its product life cycle, which has also injected uncertainties into the development of its upstream and downstream enterprises and local resident living conditions. Considering the feasibility and effects of the RCS, as well as the challenges it facing, we argue that a reinvented RCS would play an important role in water governance of shale gas. Therefore, how to achieve the governance innovation and keep the advancement of RCS in shale gas water governance is our major concern. We find three keys to the success of RCS: firstly, in the initial stage, as local government leaders are appointed to be river chiefs, which indicates the authoritativeness and significance of water affairs, as well as ensuring the effectiveness of multi-sectoral system; then, since local government leaders are pushed to be river chiefs, a clear accountability system was established to ensure the responsible persons with clear tasks to ensure the efficiency of water management; the third
is a feasible implementation system, which means, through scientific object design and effective implementation measures to ensure the accessibility of water management goal. Consequently, regarding the status quo and dilemmas of China’s shale gas water governance, some policy implications based on the experience of RCS are discussed as following:

1) Ensuring a seamless governance to explore and perfect the chain of responsibilities.

An integrated chain of responsibilities should include government, departments, enterprises, social organizations (third parties) and the public. The RCS emphasizes the “Administrative Subcontract” and clarifies the water management responsibilities of the local government leaders, but the participation of enterprises, social organizations and the public is insufficient and unclear. Moreover, due to the information asymmetry, the local governments are relatively incapable in the supervision of shale gas exploitation. Therefore, in a sense, China’s shale gas water governance system can be regarded as a largely enterprise self-regulated system. Actually, in the largest shale gas development area, such as Sichuan province, there are many third-party organizations are capable of participating in the regulatory process (Southwest Petroleum University, Chengdu University of Technology, Sichuan University, Sichuan Academy of Environmental Protection Sciences, Chinese Academy of Sciences, etc.). What’s more, different with the U.S., the shale gas fields in China are mostly separated over densely populated rural areas. Thus, the local public share more encompassing interests and could have greater enthusiasm to participate in the supervision.

Therefore, on the basis of defined functions of the supervision departments and the capabilities of the social subjects, water governance responsibility of shale gas could be disassembled seamlessly, so that the supervision responsibility shall be fully covered. As a result, the lack in professional supervision capabilities, over-reliant on self-regulatory of enterprises, imperfect disclosure system risk can be filled.

2) Ensuring the authority of governance: establish an environmental issue-led governance system.

River chiefs are responsible for the drinking water safety, water source dispatching, water saving management, and sewage treatment, which were once subordinate to the respective authorities of environment, agriculture, resources, and transportation (Xia, B.). As discussed above, the leading organizations and leadership are the basis for the inter-departmental coordination of the RCS. And this leading organizations should also be authoritative. Leading organizations can be undertaken by different departments towards different environmental issues. For example, in water resource conflict areas, the shale gas environmental governance should be led by the water conservancy department; in the water pollution risky areas, the system could be dominant by environmental departments; and the complex environmental risks areas, the system can be borne by the government leaders.

In terms of organizational form, based on the distribution of shale gas production areas, similar as RCS, a four-level system of responsible persons at the provincial, municipal, county, and township levels can be established. For instance, in the provincial level, a provincial leader who should be the key person in charge of provincial shale gas affairs; and in the lower level, such as county, township, and village where the shale gas platform is located, or where the surface and groundwater flow through, the local government leader should be in charge of shale gas affairs.

3) Ensuring the feasibility of implementation: refine the water governance dimensions and objectives.

A scientific and feasible implementation can be guaranteed from the following two aspects: firstly, refine the governance both from the time and the space dimension. In most cases, shale gas exploitations in China are only required environmental impact assessment (EIA) in two periods: one is in construction period and the other is in operation period. However, since shale gas production varies with each other from the length of drilling to operating life cycle (which could range from a few months to several decades). Apparently, the current EIA system is hard to prevent and control pollution risk. Therefore, if under a delicacy governance, in the time dimension, EIA can be clearly divided into 5 stages according the exposure level of risk factors, including exploration start-up period, early production period, mature production period, production decline period, and waste gas treatment period. Different stages should develop a regular and an emergency environmental governance system, respectively (such as daily monitoring and monthly review). Meanwhile, in the spatial dimension,
surface water, groundwater and geologic changes supervision ought to be included, and the scope of single well and wellsite/platform affected/involved area also should be clarified. Accordingly, through the scientific and feasibility of goal setting both from the time and the space dimension, an effective implementation can be guaranteed. Secondly, Establish a differentiated management objective of "one platform one policy". Based on the Management by Objectives (MBO) theory, objectives are the ultimate goals towards which an organization’s activities are directed. They should be specific, clear and concise enough understood by those who want to achieve them and to be used as standards for control purposes. Therefore, objectives should be measurable, specific, result oriented, realistic, attainable and time bounded [3][4][10]. The distribution of shale gas wells in China is mainly 4-5 wells to form a drilling platform. The platforms are significant different with each other from geological landforms, water, soil, climates to social conditions; additionally, surface water and groundwater pollution is latent regional, cumulative and lagging. Therefore, firstly, a comprehensive survey of the basic conditions of the utilization of shale gas resources, water environment, and ecological environment is needed. It is the basic for "one platform, one policy" policy. Then, according to the baseline survey results, "one platform, one policy" policy can be implemented. It means, the platforms which are classed as "excellent" should highlighting the "prevention" goal; the "light pollution/impact" class should highlight "protection" goal; and the "serious pollution/impact" class should highlight the goal of "control".

(4) Ensuring the effectiveness of implementation and the fairness of accountability: further improve water standards and technical specifications for shale gas.

Since the water issue is commonly regarded as the largest risk of shale gas exploration, the priority should be established environmental quantification standards for water resources utilization and wastewater treatment related to shale gas exploration, especially supervision rules focus on fracturing fluid and flowback water pollution. Moreover, based on geological condition, exploitation techniques, development processes and even social condition differences, provincial based water protection technical specification systems of shale gas are also needed to meet the practical conditions. And conventional oil and gas standards can be used as reference, and some shale gas specialized and normative enterprise standards which already be proved can also be considered as national standards.

(5) Ensuring the basis for achieving refined management and accountability: complete water quality grid monitoring network system to improve the informationization level of water governance.

Monitoring data is the core for refine management, and also the prerequisite for assessment as well as accountability. The water quality monitoring for shale gas mainly depends on samples taken from the upstream and downstream of the well site by the environment agencies and shale gas companies themselves. However, because of the low coverage, the automatic water monitoring network cannot meet the requirements of water environment and ecological management. More importantly, even now, the possible pollution elements produced by shale gas exploitation are not all included in this monitoring system. Therefore, based on the information technology such as big data, Internet of Things (IOT) technology and cloud computing, a real-time system for shale gas water monitoring is urgently needed. Based on this system, a national-wide information network of shale gas can be established and connect with relevant departments to communicate with each other, for decreasing the degree of information barrier. Consequently, information update and resource sharing throughout regions and departments can be guaranteed, the waste of information dissymmetry can be decreased as well.

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