The Operational Management Model for the Provision of Rural Drinking Water in Shaoxing City, Zhejiang Province

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Abstract. For the problems of "emphasizing construction over management" and the lack of long-term management mechanism of rural drinking water projects in China, this paper investigated and analyzed the management mode of rural water supply projects in Shaoxing City, Zhejiang Province, and summarized the project operation and management experience from the aspects of project construction, water quality assurance, water price pricing and water fee collection, "digital" platform construction, supervision and management. It provides case experience for the construction plan, operation and implementation management of village and town water supply projects in other cities and regions,which would be beneficial for studying the long-term operation management mechanism of rural drinking water safety projects in China.

Keywords: rural drinking water safety projects; management models; water quality assurance; digitalisation; case experiences.

1. Introduction

Rural water supply projects play an important role for solving the basic problem of rural drinking water and promoting the strategy of rural revitalization, and the quality of drinking water directly affects people's health[1]. China's rural water supply projects are large in volume and area, and the scale of the project is small and the distribution points are relatively scattered. Influenced by natural geographical conditions, the level of socio-economic development and the unsoundness of the management mechanisms of rural safe drinking water projects vary; the level of project construction varies; maintenance and management are difficult, making it difficult to ensure the safety of water use; sustainability is low, leading to the wastage of resources and an increase in unnecessary expenditures[2].

Developed nations generally exhibit a higher level of complexity in their rural infrastructure. In the United States, the water quality standards in rural areas are comparable to those in urban areas due to their shared emphasis on safeguarding water sources and implementing supervisory management practices to ensure adherence to potable water standards. In Japan, local governmental bodies consistently oversee the management of rural water supply initiatives, while businesses are responsible for fine-tuning and maintaining the equipment, which guaranteed a significant degree of water supply stability.

Rural water supply initiatives are of significant importance in addressing the fundamental issues related to the availability of safe drinking water in rural areas while also supporting the broader goal of rural revitalization. The quality of the water individuals consume has a direct impact on their health. China has implemented a considerable number of rural water delivery projects, there has been a significant surge in scholarly inquiries regarding the provision of clean water resources in rural regions. For Xining City, rural water supply project by the water sector is responsible for regular water quality monitoring, hydrological water resources monitoring, the establishment of a sound sectoral joint law enforcement mechanism, the establishment of a drinking water safety water source daily supervision and inspection system, the implementation of dynamic supervision of water sources, the implementation of law enforcement and regulatory responsibility, as well as combating drinking water safety violations[3]. Rural water supply project of Guizhou Province according to its various regional water supply situations and village characteristics, classification The implementation of four drinking water management models, respectively, the company management model, the villagers'

self-governance management model, the government subsidy management model, and the service outsourcing management model, effectively solving the drinking water problem of the poor population in poor areas[4]; the Chongqing Rongchang District rural water supply project by actively promoting the integrated development of urban and rural water supply; the extension of the urban water supply pipeline network to the rural areas to achieve the quality of living water; and the quantity of stable guarantee[5]; In Caobu Lake Town, Hubei Province, the local rural drinking water project adopts a centralized water supply model that ensures the water supply and water supply rate and improves the convenience of water for residents in rural areas[6].

To ensure the effective operation of safe drinking water initiatives in rural regions, the establishment of a sustainable operational management framework is of utmost importance. The analysis of operational management models utilised in rural water supply projects in China, as well as an evaluation of the achievements and obstacles faced in this area, holds significant implications for future endeavours in this field. The findings of this study hold considerable importance for regulatory bodies in the local industry across different administrative levels. Additionally, they contribute to the development of a sustainable operational management framework for initiatives aimed at providing safe drinking water in rural areas. This research investigates the operational management model of the rural safe drinking water project in Shaoxing City, located in Zhejiang Province. The study specifically focuses on the construction and management practices implemented in the Shangyu District. The primary objective of this initiative is to offer significant perspectives and practical knowledge pertaining to the execution of projects aimed at ensuring the safety of drinking water in rural areas.

2. The study area

The Shangyu District is located in the northeastern part of Zhejiang Province and covers a land area of 1,403 square kilometres within the administrative boundaries of Shaoxing City. The geographical features of the area clearly show a difference in elevation, with higher terrain in the southern region and lower terrain in the northern region. Low ranges and hills make up the majority of the geographical features in the southern region, whereas an intricate network of canals distinguishes the northern plains. The geographical location of the area under consideration is situated in the southern region of the North Subtropical Zone. This particular region is characterised by an East Asian monsoon climate. The mean annual temperature is recorded at 16.4°C, with an approximate duration of 251 frost-free days annually. In addition, the geographical area experiences an average annual precipitation of 1,662.6 millimetres, with an accompanying evaporation rate of 1,462.9 millimeters. The total volume of surface water resources is estimated to be 12.4062 billion cubic metres, which constitutes a significant portion of the overall water resource volume, amounting to 13.4044 billion cubic meters. In 2020, the overall volume of water utilised was recorded at 3.1843 billion cubic metres, with a corresponding consumption of 2.1966 billion cubic metres.

3. Status of rural water supply projects

The population of Shangyu District, as officially recorded, is approximately 777,500. Among this population, 594,500 individuals are categorised as belonging to the rural water supply population. The allocation of potable water in the rural regions of Shangyu District can be classified into two separate sectors: the expansion of the water distribution network from urban water plants and the provision of water to individual villages. The service jurisdiction of the urban water plant encompasses a significant proportion of towns and streets within the district, excluding the area of Lingnan. The aforementioned establishment supplies water to approximately 563,000 individuals who dwell in rural regions, accounting for 94.8% of the total rural populace. The responsibility for overseeing the expansion of the network supply area lies within the jurisdiction of the water supply enterprise, which operates in accordance with the principles of fair pricing and uniform service

delivery across the network. The rural drinking water project consists of a collection of 91 individual village water supply stations, predominantly located in the Yunan mountain region. The aforementioned stations are situated in Tangpu Town, Fenghui Town, Zhangzhen Town, Xiaguan Town, Chenxi Township, and Lingnan Township, thereby facilitating connectivity across a network comprising 30 administrative villages (Table 1). Within the designated cohort, there are four significant water stations classified as Class IV, which serve a population of 8,163 individuals. Furthermore, it is worth noting that there are a total of 87 smaller water stations that have been categorized as Class V. These stations play a crucial role in providing water access to a population of approximately 22,360 individuals. The total number of individuals in rural areas who have access to water through individual village water plants is 30,054, which accounts for approximately 5.1% of the total rural population.

Table 1. Distribution of Individual Village Water Supply Projects in Shangyu District

No.	Township Name	Number of Stations	Population Served
1	Tangpu Town	1	2 903
2	Fenghui Town	3	564
3	Zhangzhen Town	14	5 500
4	Xiaguan Town	18	5 668
5	Chenxi Township	20	3 088
6	Lingnan Township	35	12 331
Total	/	91	30 054

The Shangyu District effectively implements a water supply operation and management strategy referred to as "district-level centralized management." The responsibility for overseeing the day-to-day operations and maintenance of integrated water supply projects in both urban and rural areas is assigned to the district water affairs group. Local township governments frequently assume responsibility for the management, operation, and maintenance of both township and individual village water supply projects. These governments have the option to either directly supervise these projects or assign the responsibility to external organizations. Regardless of the scenario, the centralized management organization at the district level assumes the responsibility of coordinating various activities to ensure the implementation of effective management practices. In the year 2020, a modification occurred in the organizational structure overseeing rural drinking water projects at the district level. This modification involved a transition from the District Water Technology Guidance Centre to the District Water Affairs Group. This group assumes the responsibility of overseeing rural drinking water projects within the district, with a specific emphasis on the subsidiary water supply company. The organization has established a specialized department responsible for overseeing the operations related to rural drinking water. This department has clearly outlined the managerial responsibilities and work assignments associated with its role. The responsibilities associated with each hierarchical level encompass: The District Water Resources Bureau functions as the governing entity tasked with the oversight of potable water in rural regions, with a primary focus on ensuring its safety. The main responsibilities of the organization include the strategic coordination and implementation of initiatives aimed at addressing drinking water supply issues in rural areas. These responsibilities include the development of integrated plans and strategies, the establishment of a regulatory framework and evaluation criteria for the management of these projects, and the provision of expert advice and oversight throughout the construction and operation phases. The District Water Affairs Group is the main regulatory entity responsible for overseeing and managing rural drinking water programmers at the regional level. This group takes on the responsibility of overseeing these initiatives throughout the district, and the water supply company receives specific tasks to carry out. The main duty of this organization involves the operation and administration of pipelines for raw water and water supply stations, with a particular focus on managing water production. The local townships bear the responsibility of ensuring the protection of water sources within their jurisdiction as well as overseeing the maintenance of water supply and distribution networks that extend beyond

the water stations. Furthermore, they are assigned the responsibility of collecting water fees. The villages designated as beneficiaries are entrusted with the duty of conducting patrols, overseeing the management, and ensuring the maintenance of projects within their assigned regions. The primary aim of water supply facility management is to mitigate any potential harm, modification, destruction, or infringement on the infrastructure. Moreover, their responsibilities encompass the establishment of regulations and agreements within the village context, specifically addressing the operation and management aspects of drinking water initiatives. The involvement of beneficiary villages is essential in overseeing the management and utilization of water supply facilities and equipment. Moreover, it is anticipated that they will engage in collaboration with inspections of a more advanced nature in order to guarantee adherence to regulations and standards.

Since 2018, the Shangyu District has allocated a total of 177 million yuan towards the improvement of rural drinking water infrastructure, with the objective of attaining conformity with established standards. The water supply assurance rate in towns and villages exceeds 98%, indicating a significant degree of dependability in facilitating water accessibility. Furthermore, it is noteworthy that the rate of compliance with water quality regulations exceeds 90%, indicating a substantial level of adherence to established standards in the field of water quality. Furthermore, the rate of collection for water fees has reached an impressive level, exceeding 98.1%. As a result, these accomplishments collectively contribute to the achievement of consistent drinking water quality in both urban and rural regions. The Shangyu District is actively involved in the promotion of rural water supply project construction and operational management. This endeavour involves enhancing the deployment of automated monitoring systems and gradually implementing the digitalization process for each individual village water supply station. The completion of the mapping, database entry, and online management of each distinct village water supply project has been achieved.

4. Experience of rural water supply management model

The main goal of Zhejiang Province is to prioritise the achievement of consistent drinking water quality in both urban and rural areas while also guaranteeing the safety of the water supply. In order to accomplish this objective, the province is committed to implementing a comprehensive digital management system that encompasses the entirety of the clean water supply process, extending from the initial water source to the final point of consumption. The proposed system aims to seamlessly incorporate diverse elements, including data management, collaborative business practices, online monitoring, and mobile services, in an efficient manner. The system places considerable emphasis on the establishment and integration of a cohesive database, map, and network. This involves the development of a comprehensive database for the provision of uncontaminated water in urban and rural regions, an interactive map that presents pertinent data on the availability of uncontaminated water, and a digital management system that encompasses all aspects of the water supply process, encompassing sources, treatment facilities, distribution networks, and endpoints within the province.

The Shangyu District has adopted digital technology to improve the "supervision and service" aspects of the urban and rural water supply industry, in line with the guidelines established by Zhejiang Province's urban and rural clean water supply digital management system. This initiative encompasses the creation of a digital management system that consolidates diverse entities, such as urban and rural water supply authorities, operational management, and users. Moreover, the district has intensified its endeavors in the implementation of automated monitoring systems, encompassing video surveillance, online metering and monitoring, online water quality monitoring, and remote control. The district has adopted a sequential strategy to digitally enhance the development of individual village water supply projects. This methodology encompasses the systematic process of conducting comprehensive mapping, entering data into a database, and managing the information online. The overarching objective is to establish water stations that operate without human intervention and effectively accomplish the digital construction tasks for each water supply station in

the district. In order to mitigate various challenges, the district endeavours to tackle issues such as deficient network monitoring, prolonged maintenance, and inadequate hazard investigation.

The comprehensive management of clean water supply in both urban and rural areas involves three fundamental elements: the management system for clean water supply, the platform for operational management, and the digitalization of water plants or stations. The Clean Water Supply Management System is implemented at the provincial level, primarily catering to water resource agencies at the province, municipal, and county levels, in addition to departments overseeing construction, ecological environment, health, and urban and rural water supply management. The system incorporates various functionalities, including the provision of urban and rural water supply information, monitoring capabilities, early warning systems, analytical tools, and features for corporate collaboration. The main goal of this initiative is to facilitate the establishment of extensive data connectivity across regional water supply networks, encompassing the entire water distribution process from the source to the consumer's point of use. The operational management platform is a comprehensive system designed to streamline and optimise the management of operational processes within an organization. The establishment of water supply management units in both urban and rural regions is facilitated through the utilisation of provincially constructed operational management platforms or by employing a generic version of these platforms. The platform enables the execution of information management for water supply projects throughout the county. This entails the incorporation of counties into the urban-rural integration at the city level, enabling them to be seamlessly integrated into the operational management platform of the city-level water supply unit. As a result, this leads to an improvement in water production efficiency and the optimization of water supply management services. Digital Construction of Water Treatment Plants: Enabling Real-Time Monitoring, Testing, and Early Warning Systems through Information Technology Enhancements The successful establishment of a comprehensive information-based operational management system is effectively executed across the entirety of the territory.

5. Conclusion

Shangyu District has promoted and developed the collective supply of drinking water in rural areas through the improvement of regulations and systems related to safe drinking water in rural areas, the innovation of the "district-level unified management" management mode, digital construction, etc. The water supply project facilities are complete, the supervisory responsibility is clear, and the division of labour is coordinated so as to guarantee the safety of drinking water for rural villagers and achieve the complete water supply facilities and the supervisory responsibility. A safe rural water supply system with complete water supply facilities and clear supervisory responsibilities has been realised. In order to promote the healthy and sustainable operation of rural water supply projects in Shangyu District, it is recommended that continue to improve the rules and regulations, standardise the disclosure of information on rural drinking water, and build a mechanism for the active release of information, online and offline disclosure, collection and feedback of public opinion, as well as accountability, and so on. Regularly update the digital system and do a good job of system training. Make full use of the platform data analysis to guide the operation and management of water supply projects according to the daily management information and projected information to achieve the problem feedback, early warning information, and causes from the fundamental analysis to solve the problem. Strengthen to carry out the construction of the project information technology water price management, for the development of scientific water price management systems to provide information security, deal with the water price, and project maintenance of the financial relationship.

Although there are differences in the natural geographical conditions and economic development between regions in China and the problems they face are also different, the Shangyu model can, to a certain extent, provide case studies for the construction, operation, and standardised management of rural drinking water projects in other cities and regions and supplement the theoretical system of constructing a perfect rural drinking water safety guarantee. Other regions can recognize from the

model of rural water supply management in Shangyu District that implementation of a unified professional management system, such as the: ① Implementation of a unified professional management system, such as the implementation of the district level in the district of Shangyu, Management mode: the district government-issued operation and management methods; improving the operation and management of rural drinking water safety engineering rules and regulations; the district water group undertaking the overall management of the region's rural drinking water projects; the formation of a set of rural drinking water safety engineering operation and management systems; and effectively enhancing the level of professional management of rural drinking water safety engineering. ② in accordance with the principle of centralised rather than decentralised, to promote centralised large-scale water supply, decentralised water supply according to local conditions. In accordance with the principle of not dispersing if it can be centralised, standardize and unify engineering design and construction standards, do a good job of project construction management and acceptance, and improve the quality of project construction. Upgrading rural, safe drinking water infrastructure Strengthen the operation and maintenance management of the project, implement construction and maintenance funds, and focus on repair and maintenance, equipped with a full complement of inspection, operation and management, maintenance, rescue, and other daily management personnel, to achieve standardisation of project operation and management. ③ Information technology is necessary to enhance the operation and management of rural safe drinking water projects. This means that the conditions of the region proposed to carry out the water supply project, digital construction, water supply data interconnection, and the rest of the region can be carried out in phases to explore digital information management. The provincial level will unify the construction of an urban and rural water supply supervisor, operation and management, and user trinity "urban and rural clean water supply digital management system" to achieve the interconnection of water supply big data; an urban and rural water supply management unit through the platform of all water supply projects in the county to implement information management; and a water plant (station) to achieve real-time monitoring, real-time monitoring, and real-time early warning. Automated monitoring systems such as video monitoring, online metering and monitoring, online water quality monitoring, and remote control provide technical protection for water supply services.

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