Hydrosocial reconfigurations:
State-led agricultural modernization and the (re)shaping of water governance in Shandong, China

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Abstract

Water is crucial for agricultural production, yet its role in agrarian change is underexplored. While existing literature has examined how shifts in water access, use, and control reinforce neoliberal state hegemony and capital accumulation, less is known about the processes and power dynamics of water governance transformations in China, which are entangled with state-led agricultural modernization, de-collectivization, and market-oriented reforms. This thesis addresses this research gap by investigating how state-led agricultural modernization shapes and is reshaped by water governance in Tancheng county in Shandong, China. It advances three main arguments. First, China's state-led agricultural modernization has transformed water governance through the development of small-scale farmland irrigation infrastructures to access water, state-reinforced self-governing organizations to manage water, and quasi-market institutions to reallocate water between agricultural and industrial sectors. The transformed water governance hybridizes formal and informal, modern and traditional, state-directed and market-oriented, and governmental and folk practices at local and grassroots levels. Second, this hybrid form of water governance entails "hydrosocial reconfigurations" in the relationships between central and local states, state and society, and state and market, driven by state logic rather than capital logic. Local governments strategically and pragmatically navigate central directives and market tools within a dynamic rural society. Third, water plays an agential role in the agricultural modernization process, reproducing the state's multifaceted agendas with both intended and unintended political, social, and environmental outcomes. This thesis bridges agrarian political economy with political ecologies of water by examining the intricacy, diversity, and adaptability of hybrid water governance co-constituted by agrarian change in rural China.

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Acronym and Glossary

cm	centimeter
CPC	Communist Party of China
CBM	Community-based Management
FAO	Food and Agriculture Organization of the United Nations
FLID	Farmer-led Irrigation Development
guanxi	social relational networks
hukou	China's household registration system
HRS	Household Responsibility System
IMT	Irrigation Management Transfer
km	kilometer
km^2	square kilometer
kuai	horizontal network of local governments' work units
kW	kilowatt
m	meter
m^3	cubic meter
MARA	Ministry of Agriculture and Rural Affairs
MWR	Ministry of Water Resources
mu	a land area unit, 1 *mu* equals to 666.67 square meter.
NDRC	National Development and Reform Commission
tiao	vertical line of state's functional agencies
WUAs	Water Users Associations
yuan	China's currency

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Chapter 1 Introduction

1.1 Modernizing agricultural water

Water is not only essential for sustaining life, but also lays the foundation for the development of human society. Particularly, it is a crucial input for agricultural production. According to a World Bank study (2022), 70% of freshwater withdrawn globally is used for agriculture, with irrigated agriculture covering 20% of all cultivated land and contributing to 40% of the world's food production. Such a high share of water consumption places great stress on the agricultural and water sectors. In response, international agencies have widely advocated for modernizing agricultural water through the advancement of technologies, management practices, and institutional arrangements to enhance water efficiency and productivity (ibid.).

The modernization of water has unfolded along two interconnected waves. First, large-scale irrigation systems evolved dramatically following the agricultural modernization driven by the Green Revolution of the 1950s, which introduced a package of technological inputs to liberate agricultural productivity from the constraints of nature (Hazell, 2009; Hurt, 2020). These advancements included on-farm water-saving techniques along with upgrades to the main and distribution systems, aiming to improve water delivery efficiency (Plusquellec, 2009).

Second, the modernization of water shifted the focus from hydraulic infrastructure towards new forms of governance structures and institutional arrangements that govern water use practices. Under neoliberal programming of water, market-oriented approaches such as privatization, commercialization, and decentralization have been promoted globally to reconcile economic growth with environmental sustainability (Furlong, 2010; Bakker, 2014). For example, the introduction of private water rights and water market systems facilitates the reallocation of agricultural water to higher-value uses in the industrial sector (Speed, 2009; Bauer, 2015).

However, these take-it-for-granted initiatives are problematic and often fail to deliver the anticipated results in practice (Mollinga et al., 2017). They did not address water scarcity as expected (Budds, 2020) and, in some cases, led to socio-environmental injustices, such as water grabbing by agribusinesses and industrial capital during the global land rush for capitalist and commercial agricultural development (Mehta et al., 2012; Ayelazuno, 2019; D'Odorico et al., 2024). This is because these initiatives, underpinning a modern and scientific worldview, simplistically regard water as a mere biophysical resource to be harnessed, transformed, and utilized, thereby abstracting it from the political-economic contexts in which it is embedded (Linton, 2010). This reductionist thinking romanticizes and depoliticizes water governance, overlooking place-specific sociopolitical and economic dynamics and day-to-day practices (Wilson et al., 2019; Whaley, 2022). As Barker and Molle (2004: 25) emphasize, the development of irrigation and agriculture cannot be considered in isolation from agrarian change and the broader political economies in which it occurs.

The remainder of this chapter presents China's unique trajectory of agricultural modernization and its manifestation on water governance. I then provide a brief introduction to the case study area, a traditional agricultural county (Tancheng) in Shandong province, before outlining the research objectives and research questions. This chapter concludes with an overview of the thesis structure.

1.2 China’s state-led agricultural modernization and water transformations

The interrelationship between water and agrarian change is particularly salient in China, where a state-centric hydraulic paradigm—rooted in Wittfogel’s (1957) definition—has persisted across distinct political eras. During the Maoist era[1], mega-engineering projects that were built through mass mobilization drove the expansion of irrigated agriculture (Shapiro, 2001; Pietz, 2015). Post-1978 reforms[2] introduced market mechanisms and decentralized governance, but the state retained its central role (Jiang et al., 2020; Xu et al., 2023). A pivotal moment in this trajectory occurred with the onset of “building of a new socialist countryside” in 2006 (see Chapter 4.2.1 for details), a state-led agricultural modernization campaign targeting food security, agricultural productivity, and rural livelihood improvements against the backdrop of rapid urbanization and an expanding urban-rural divide (Ye, 2015; Zhang et al., 2015).

This initiative exemplifies China’s distinctive approach to agrarian transformation, characterized by substantial fiscal transfers from the central government to fund small-scale on-farm irrigation infrastructures at localities, alongside institutional reforms that promote market-oriented and participatory approaches such as water pricing, water markets, and water users associations (Wang et al., 2016; Wang, 2017). Although these strategies have profoundly reshaped agricultural practices, water governance, and rural society (Clarke-Sather 2012, 2019; Xu et al., 2024), water receives relatively less attention in the debate of the agrarian question dominated by land and labor (Bernstein 2006, 2015; Vijayabaskar, 2020).

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[1] The Maoist era lasts from the founding of the People’s Republic of China in 1949 until Chairman Mao Zedong’s death in 1976.

[2] China’s reform and opening-up, also known as the Chinese economic reform, was launched in 1978 under the then leadership of Deng Xiaoping.

What makes China's experience analytically noteworthy is that its agrarian trajectory diverges from the prevalent capitalist agricultural development paradigm in neoliberal contexts (Byres, 1996). The Chinese state plays a leading role in the agricultural modernization, directing policy agendas of poverty alleviation and rural revitalization with strong capacity of the party-state (Ye, 2015). This socialist agrarian transition also contrasts to scenarios in post-colonial countries of the developing world where weak states enable foreign capital-driven accumulation by dispossession (Shiva, 1991; Borras et al., 2012a). Yet, while agrarian reform is initiated and supported by the central government and its political elites, local implementation often complicates the realization of well-intentioned policy directives (Oi, 1999; Wang et al., 2018; Rogers et al., 2021). This tension underscores the need to examine how the state-led agricultural modernization operates in local water practices.

Existing literature has emphasized governing techniques of China's hydraulic state, highlighting a continued reliance on techno-scientific approaches to enhance state legitimacy and regime consolidation (Pietz, 2010; Rogers, et al., 2016; Crow-Miller et al., 2017; Sheng et al., 2020). However, these studies often view the state as "a unitary, solitary reality that can be brought into theory as some kind of a measurable force" (Nordlinger et al., 1988: 891), often neglecting diverse and everyday practices at localities. In practice, a hybrid model of water governance emerges with a combination of administrative control and market mechanisms, central planning and local initiatives, institutional structures and everyday practices (Yeh, 2013; Lin, 2017; Wang et al., 2018; Wang et al., 2021a). These configurations are shaped by localized political-economic contingencies, mediated through water and negotiated amongst multiple stakeholders in daily interactions (Xu et al., 2024). Such localized socio-environmental processes and power dynamics underpinning these transformations remain largely underexplored, particularly their implications for governance structures and rural communities.

This study addresses these gaps by adding a water question in the agrarian studies and shifting the focus of inquiry from central policy-making to local policy implementation. The study area of this research is located in Tancheng county in Shandong province. As Barnett and Vogel (1967:117) note, the county is the "most important administrative unit in rural China now, as in the past…The county seat has served not only as an administrative headquarters but also as the economic and social center of a fairly well-defined region." Despite water scarcity, Shandong stands as one of China's large food production bases and a pilot site for modernized agricultural production and water market development. Tancheng, located in the southern part of Shandong, is a typical agricultural-producing county undergoing unprecedented agricultural intensification, industrial expansion, and urban growth. It represents a critical nexus in the governance of agricultural water, bridging the state and rural society, urban and rural domains, and agricultural and industrial sectors (Yang, 2022).

Through a county-level case study of Tancheng, this thesis explores how local actors navigate state-led agrarian reforms in their everyday practices, and provides a nuanced understanding on the dynamics of rural politics and agricultural modernization in China, as illuminated by the complex interplay between water, politics, power, and governance.

1.3 Research objectives and research questions

This research investigates state-led agricultural modernization and the shaping and reshaping of water governance in rural China. It aims to characterize a hybrid form of water governance and unpack the underlying power dynamics to explain how diverse actors interact, how hybrid institutions and practices are formed, and how uneven social-ecological consequences are generated at local and grassroots levels.

To accomplish these objectives, the main research question of this thesis is: **How has China's agricultural modernization transformed water governance, and how has this transformed water governance reshaped agricultural modernization?** To further explore this question, three sub-questions are identified as follows: 1) What new water infrastructures, institutions, and organizational arrangements have emerged within state-led agricultural modernization in China, and with what characteristics? 2) How do institutional dynamics and power relations embedded in this agrarian change account for these governance shifts? 3)What political and socio-environmental effects and responses arise from these new forms of water governance and agrarian change?

Transcending the conventional technical and managerial understanding of water and water governance, this thesis draws on the political ecology of water from a relational and dialectical perspective, which regards water as not merely a biophysical element (H_2O) but complex hydrosocial relations intertwined with and co-constituted by society over time and space (Swyngedouw, 1999; Linton and Budds, 2014). Water governance is therefore a power-laden, contested, and complicated process, given that it is embedded in the local socio-political and economic contexts, with both intended and unintended consequences (Wilson et al., 2019; Wang et al., 2021b).

In line with this critical inquiry, this research employs the concept of "hydrosocial reconfigurations" as a theoretical lens to uncover the technological, organizational, and institutional transformations of water governance in the Chinese agrarian context under the parallel driving forces of state-led agricultural modernization, marketization, industrialization, and urbanization.

This thesis makes three main arguments, using a traditional agricultural county—Tancheng—in Shandong, China as a case study. First, it argues that agricultural modernization and water governance affect and constitute one another. The state-led agricultural modernization in China entails the transformation of water governance in the promotion of small-scale farmland irrigation infrastructures to access water, state-reinforced self-governing organizations to manage water, and quasi-market institutions to reallocate water between agricultural and industrial sectors. This transformed water governance demonstrates a hybrid and mixed feature of modern and traditional, formal and informal, and governmental and folk practices at the local and grassroots level.

Second, the hybrid water governance modality embodies hydrosocial reconfigurations in the relations between the central and local states, state and society, and state and market within the Chinese agrarian context. These reconfigurations are driven by state logic rather than capital logic, with local governments strategically and pragmatically navigating central imperatives and market-based toolkits in everyday practices within a dynamic rural society.

Third, water and its political entanglements play an agential role in the processes of hydrosocial reconfigurations, enabling agricultural productivity, food security, and rural revitalization while also leading to the reinforcement of centralized government intervention in grassroots irrigation governance, uneven water access between large producers and smallholders, and the unregulated groundwater extraction in the agricultural sector.

The contributions of this research to existing knowledge are twofold. Firstly, it fills the gap of a missing water dimension in agrarian studies through the investigation of the processes and power dynamics of hybrid water governance that shapes and is reshaped by state-led agricultural modernization, providing an alternative pathway to the prevalent capitalist development paradigm. Secondly, it advances and enriches critical water studies in the discussion of hydraulic state hegemony and neoliberal water reforms, by examining a hybrid form of water governance with a complex mix of practices and outcomes in the Chinese rural society. This hybrid water governance, with an intricate interplay between agricultural and water bureaucrats at the central and local government levels, water supply companies, industrial enterprises, irrigation districts, village committees and peasant households, both enables and constrains China's state-led agricultural development interventions.

1.4 Thesis structure

Chapter 2 reviews two bodies of literature and identifies two research gaps that this study aims to address. The first gap is the neglect of a water dimension in critical agrarian studies—a crucial aspect for understanding the dynamics of agrarian change. The second gap is the oversimplified portrayal of the hydraulic state and the predominant neoliberal and capitalist development paradigm in existing critical water studies, which falls short to capture the nuanced and hybrid water governance arrangements with blurred lines between formal and informal, public and private, state and market in the Chinese agrarian context. It puts forward an analytical framework of "hydrosocial reconfigurations" from a political ecology perspective, elucidating water transformations in aspects of infrastructure, organization, and institution under the driving forces of state-led agricultural modernization, marketization, industrialization, and urbanization.

Chapter 3 presents my research methods, including the epistemological and methodological considerations of the case study approach. It provides a brief introduction of my case study area and describes the methods employed for data collection and data analysis. Additionally, this chapter reflects on the ethical considerations and the researcher's positionality in the field.

Chapter 4 sets the stage for the research by outlining China's agricultural and water transformations occurring in the broader political economic tendencies. It begins with an introduction of the political structure of the Chinese party-state system, followed by an overview of key agricultural modernization reforms and measures. This chapter also traces the evolution of water governance philosophy and approaches, and provides a detailed description of the research area, including its geography, agricultural, industrial, and urban development.

Chapter 5 to 7 are the empirical and analytical chapters of the thesis. Chapter 5 analyzes the transformation of water governance through the production and reproduction of small-scale farmland irrigation infrastructures. Using the case study of the "high-standard farmland project" in Tancheng county, this chapter unpacks the exercise of the Chinese state's infrastructural power and its interactions with various local actors, both state and non-state, human and non-human, discussing the intended and unintended political, socioeconomic, and environmental consequences.

Chapter 6 zooms in on Gui township in Tancheng county to investigate the organizational transformation of grassroots irrigation governance generated by the infrastructural changes. Examining the state-operated and de-collectivized canal irrigation system in parallel with the diverse and adaptive groundwater irrigation system on the ground, this chapter challenges the conventional understanding of collective action and self-governance theories by revealing a complex interplay of traditional and modern, formal and informal, governmental-led and folk practices within the China's rapid changing rural hydraulic society.

Chapter 7 scrutinizes the creation and operation of the quasi-market institution with a combination of strong government control and market-oriented mechanisms that enables water reallocation within a central planning water allocation system. Drawing on an agricultural-to-industrial water rights trade in Tancheng county, it details the coevolving process of state-directed marketization with a range of stakeholders included. Moving beyond the dichotomy of commons versus commodity or state verse market, this chapter argues that the state and the market are concomitant in China, with the water market emerging as an expedient and pragmatic practice to balance competing interests and values in water use and allocation.

Chapter 8 synthesizes nuanced insights from China's context-specific case study. It critically analyzes the hybrid form of water governance and the resulting hydrosocial reconfigurations that underpin evolving power relations between the central and local states, the state and rural society, and the state and the market amidst agricultural modernization. It argues that these transformations follow the logic of the state rather than the logic of capital, as local states strategically and pragmatically navigate central policy directions and market-based mechanisms in their daily routines within a dynamic rural society.

Chapter 9 concludes with main findings of the thesis. It underscores the theoretical and empirical contributions of this research and outlines a research agenda for future studies on agrarian change and water governance.

Chapter 2 Literature review

2.1 Introduction

This chapter aims to give a comprehensive literature review of agriculture modernization and its interrelationship with water governance. To approach this topic, the chapter starts by discussing main research themes in critical agrarian scholarship in section 2.2. This section highlights inadequate attention paid to water compared with its significance in farming and agricultural development. In section 2.3, critical water studies are explored to demonstrate the manifestation of modernization in two waves of water reforms and to highlight power dynamics under the hegemony of the hydraulic state, neoliberal markets, and participatory organizations in grounded water governance practices. However， most of these studies follow a default mode of westernized capitalist development paradigm. Notably, it does not include many empirically grounded and theoretically informed studies in the Chinese context. In section 2.4, I adopt a political ecology perspective to conceptualize water governance as “hydrosocial reconfigurations”. This relational-dialectical approach provides valuable insights to understand how power and politics shape the materiality and meanings of water, and also how water serves as a pathway to shift power relations between central and local states, state and rural society, and state and market in the process of China’s state-led agricultural modernization.

2.2 Critical agrarian studies

Modernization, defined as a linear progression and a method of ordering society (Scott, 1999), is a major driver of agricultural transition. It is closely related to the meanings of progress, growth, and development, and it signifies the transformation of countries into industrial-capitalist societies or the adaptation to a more globalized form of capitalism (Harvey, 2003). Agricultural modernization, in particular, refers to the processes of developing agriculture that is capital-intensive, high-input, and high-output, which began with the Green Revolution in the 1950s. During this period, scientists and experts saw agricultural technology as a catalyst for economic growth through efficient use of material and human resources (Shrum and Shenhav, 1995). This approach involves introducing high yield seeds, chemical pesticides and fertilizers, and mechanized irrigation infrastructure to support the development of land- and water- intensive, industrialized, and commercialized agriculture (Hazell, 2009; Hurt, 2020).

Although starting in the West, and particularly in the US, agricultural modernization was then promoted as a development model to meet the needs of the "hungry, poor and ignorant" in developing countries. In these countries, national governments received financial aid and technological support from international donor agencies, such as the Rockefeller Foundation, and implemented nationwide agricultural reforms through intensive commercialization and corporatization (Shiva, 1991; Wicab-Gutiérrez, 2018; Karamchedu, 2021). Although successful stories are dominant in policy narratives and the media, social science scholars from a wide range of research fields have challenged the idea of modernization as a universal and monolithic pattern that all countries and societies must follow, from traditional agricultural and rural societies to modern and post-industrial urban forms (Chirot and Hall, 1982; Escobar, 1995). They argue that this development scheme, which is based on western knowledge and technology transfer, is reductionist and patriarchal in orientation, and displaces social and cultural arrangements through the conversion of land and water for agro-exports (Shiva, 1991; Scott, 1999; Arce and Long, 2000; McMichael, 2005).

Engaged with critical reflections on the dominant paradigm of agricultural modernization, agrarian scholars examine fundamental components of political economics, such as property, labor, income and consumption/reproduction, to uncover dynamics of capital accumulation and class formation during the process of agrarian transformations (Bernstein, 1996; Zhang et al., 2015). In this section, I will provide an overview of critical agrarian studies that have widely discussed land-centric agricultural development and the changing relation between labor and capital under the ongoing rapid agrarian change, particularly focusing on three main research themes.

2.2.1 Land-centric agricultural development

Following the Marxist tradition of political-economic analysis, classical agrarian studies have focused on land-centric capital accumulation and class differentiation in the transition to capitalism. A basic explanation of the agrarian change is given on the penetration of capital in the commodification of land and labor, which in turn has transformed the countryside and the peasantry (Byres, 1996; Bernstein 1996, 2004, 2006). As Karl Kautsky (1988) argues, large-scale capitalist farming, which is more efficient, labor-saving, and scientifically managed, will eventually replace small-scale agriculture. This will result in the differentiation of peasants and the proletarianization of smallholders, as wage labor increasingly becomes a norm in capitalist farms (ibid.). Critical agrarian studies draw on classic agrarian studies and extend the investigation in the current radically transformed agrarian world amid neoliberal globalization (Akram-Lodhi et al., 2021). Three main research themes concerning land and labor are at the core of the analyses in this research field.

First, a large body of research centers on the global land rush and its political economic dynamics. The global rush to land began around 2008 and took place in the context of food, energy, climate and financial crises within the current period of neoliberal globalization (Borras and Franco, 2012). Unlike in classical political economy that views land as a source of rent and associated with agricultural productivity, the contemporary land rush incorporates farmland into circuits of speculative and financial capital within the international corporate food regime (McMichael, 2009; Bernstein, 2016; Vijayabaskar, 2020). Confronted with world market prices, international investors discovered a new appetite for land and farming. Large-scale land deals for agricultural investments have arisen in the Global South. Farmland becomes a financial asset and thus is a frontier for capital accumulation (Fairbairn, 2020; Ouma, 2020). These changes are driving a further expansion of capitalist control over natural resources for the purposes of production, extraction and speculation. States become subservient to global capital and are constrained by rules imposed by free markets, which institutionalize corporate power in the world food system (White et al., 2012; McMichael, 2013). This has since sparked intense global debates on “land grabbing”, a phenomenon of land and peasant dispossession by large-scale, cross-border, and capital-intensive investments as labelled by critics (Borras et al. 2012a, 2012b; Holmes, 2014; Xu 2018, 2020).

The second research theme is concentrated on domestic land reform under national developmentalism. This body of research has highlighted an essential role of the state in leveraging capital into the countryside through land redistributive policies and land transfer systems (Bernstein, 2004; Tafon and Saunders, 2019). In particular, land reform in contemporary China remains a significant point of interest. Studies have found complicated rural capitalist dynamics under the ongoing agricultural modernization in China (Zhang, 2015; Huang, 2015; Yan and Chen, 2015). These findings move beyond classic paths of agrarian transitions as identified by Terence J. Byres (1996), that is, a landlord approach of “capitalism from above” whereby agrarian capitalism is driven by the transformation of feudal landed property, and a peasant approach of “capitalism from below”, which generates capitalist classes and wage labor through social differentiation.

The Chinese state is found to play an important role in facilitating capital from above and below (Gong and Zhang, 2017). Zhang and Zeng (2021) describe this pattern as "politically directed accumulation" where local states directed urban-industrial capital and investors into the countryside, and supported capitalist agricultural production with land grants, financial subsidies, and bank loans. Local cadres, acting as land brokers, employed coercive methods to mobilize farmers' compliance with government-backed land consolidation and acquisition for modern agriculture (Luo and Andreas, 2020).

Third, increasing attention is being paid to agrarian populism and the rediscovery of the peasant. These studies focus on how different peasantries are integrated into capitalist agricultural development and their political responses. They have widely engaged with everyday politics of social movements and peasant struggles over land and rural livelihoods in the Global South (Nielsen, 2018; Mckay et al., 2020; Andreas et al., 2020). In addition, the assumption that modernizing agriculture leads to de-peasantization has been revisited. There is a renewed focus on the reproduction and prospects of small farmers and the concept of re-peasantization, which implicates alternative institutional dynamics of agrarian change (Vergara-Camus, 2009; van der Ploeg, 2018).

For example, Huang et al. (2012) describe Chinese agricultural development as "capitalization without proletarianization" due to the unexpectedly low rate of hired workers in agriculture production. Building on Chayanov's pioneering work, Jan Douwe van der Ploeg (2013) argues that peasant agriculture persists globally and plays a crucial role in food production and agricultural sustainability. Peasant farms are tied together through reservoir of informal and non-commoditized relations (ibid.). Farmers regain control over the labor process by developing a range of agroecological practices. This creates new forms of peasantry in a new area of globalization (van der Ploeg 2018, 2021).

2.2.2 The missing water dimension in agrarian studies

Agrarian studies acknowledge the significance of rural politics and power imbalances in the development of capitalist agriculture. These studies are primarily concerned with the transformation that occur in land use and the associated class relations. They recognize that the emergency of agrarian capitalism, which is characterized by the expansion of market and the penetration of commodity relations in farmland, labor, and subsistence, has resulted in disparity in resource uses and excluded landless and smallholder producers (De Schutter, 2011; Borras et al., 2018; Andreas et al., 2020).

While land and labor have received considerable attention in agrarian studies, water has not been explored to the same extent. Few political economic scholars have questioned the productivist paradigm of agricultural modernization through the lens of water, although irrigation has long been given a significant role in manifesting a modernist ideology and approach to agricultural transformation (Molle et al., 2009). As Mehta et al. (2012:193) argue, "water as both a target and driver of this phenomenon has been largely ignored despite the interconnectedness of water and land."

This omission can be attributed to the disparate policy processes governing land and water reform, with the latter mostly directed at water service for domestic use in urban areas, leaving water resources for productive use relatively unexamined (Debbané, 2007). Although these processes may run in parallel, the lack of integration creates a separation between land and water rights, thereby preventing agricultural water use from being connected to redistributive farmland. In South Africa, for example, the farmland restitution to Black communities in the post-apartheid period did not include any provision for the reallocation of water resources (Woodhouse, 2012a). This resulted in a "locking in" effect of land and intensive water use within the established pattern of commercial agriculture among large landowners and agribusinesses (ibid.).

There is a growing body of literature that recognizes the importance of water in land reform and calls for increased attention to water issues and governance in the global discussion on agrarian change (Mehta et al, 2012). On one hand, these studies have emphasized that water resource is indispensable and essential to intensive modern agriculture. For example, farmland with irrigation potential is preferred by profits-driven investors, which often results in the simultaneous acquisition of water resources accompanied by land acquisition (Woodhouse, 2012b; Franco et al., 2013). Baumann (2022) argues that land rental markets represent a form of land-water control in irrigated agricultural landscapes, which often excludes landless and smallholder producers from land- and water-based livelihoods.

On the other hand, increasing attention has been paid to the materiality of water and its agential role in enabling and/or disabling agricultural development. Unlike land, which is typically perceived as static and fixed in place, water is dynamic and less easily to be bounded above or below ground (Bakker, 2002). Given its multiple physical and material characteristics, it suggests to consider not just the volume of water, but also the scale of water flows that change the distribution of water over time and space (Franco et al., 2013). The fluid nature of water also makes it blur between de jure ownership of water and de facto use rights of water. Rather than stipulated by formal laws and regulations, water rights “in action” is formed through actual use of and control over water by local users (Lund, 2009; Woodhouse, 2012a; Bosch and Gupta, 2020), rendering the “unruliness and disobedience” of water rights institutions (Boelens, 2009). And thus, processes of depriving control over water and its benefits are obscure and complicate, making water grabbing an ongoing contestation between peasants and agribusinesses and often hidden beneath land-oriented and capital-intensive agricultural production (Mehta et al., 2012; de Bont et al., 2016).

In summary, as Marcus Taylor (2015: 114-115) states, it is relevant to "ask where the ecology is hidden away within the agrarian question considering that the drivers of rural change have tended to be represented as emphatically anthropocentric, and the social categories of capital and labour seemingly impose themselves on the natural substrate of the rural landscape." A water dimension could shed light on additional and distinct observations about the processes and power mechanisms involved in agricultural modernization. This perspective has the potential to open up new forums and enrich agrarian studies. The next section will explore critical water studies to gain more knowledge about water governance in the context of agricultural modernization.

2.3 Critical water studies

Over the past several decades, agricultural modernization coupled with neoliberalism has led to substantial alterations in water governance, which has manifested materially in technologies designed to support water use practices and institutional arrangements that administer them in two successive waves of reforms. The first wave involved a technological upgrade through extensive development programs that has been accelerated since the Green Revolution in the 1950s (Hurt, 2020). Technical knowledge and engineering skills were widely deployed and transferred to leverage new access to water resources, increase the cost efficiency of water usage, and boost the output and productivity of irrigated agriculture (Carrillo, 2021). From supply-side and large-scale waterworks to demand-side and water-saving technological devices such as drip irrigation in arid and/or semi-arid regions, hydraulic infrastructure played a crucial role in promoting agricultural growth in the process of state building (Rusca et al., 2018; Poblador et al., 2021).

This “diffusion model” of agricultural development (Rogers, 1962) has been criticized for a hierarchical approach in which new technologies, typically from the Global North, are provided to traditional agricultural communities by government departments (Mitchell, 2002). Therefore, the second wave included neoliberal institutional reforms since the 1990s that has shifted water management to water governance. This wave of reform involved not only improving hydraulic technologies, but also modernizing agricultural behavior, structures, and institutions (Plusquellec, 2009). Following the 1992 Dublin principles for higher end-use water efficiency, the responsibility for operating and maintaining irrigation systems has been gradually transferred from governments to private sector entities (WMO, 1992). Business and market proxies have been adopted in the centrally planned water sector, such as exclusive private property rights to water, private sector participation in water service delivery, and water being priced and traded through market transactions (Goldman, 2007; Bakker 2014, 2015). Participatory irrigation management models, such as water users committees or associations, have been established in many countries with support from international financial institutions, transferring the administration, operation, and maintenance of irrigation systems to locally organized and self-regulating users (Meinzen-Dick et al., 1995; Theesfeld, 2008; Molle, 2008). These institutional and organizational water reforms privilege market mechanisms and the civil society over state-centric regulations in a global climate of neoliberal governance (Jessop, 2002). Bakker calls it “market environmentalism”, a doctrine premised on “the synergies between environmental conservation and protection, economic growth, market economies, and neoliberal governance” (Bakker, 2014: 474).

The transformative changes in water governance have attracted attention from critical water scholarships who attend to the role of water in agrarian change and speak with the bigger issues of modernization, neoliberalization, and globalization. To demystify the discursive development model, critical water studies have delved into the ways in which modernization is enacted in the water sector in various context-specific places. They explain how the values and aspirations of modernization are manifested into local and concrete water governance practices (Le Visage et al., 2018; Closas, 2018; Gladfelter 2022), and how the transformation of control over, access to, and use of agricultural water entails a reconfiguration of power and social relations, leading to diverging social and ecological outcomes (Birkenholtz 2016, 2023; Budds and Loftus, 2023). This section draws a panorama of critical water studies into three streams of literature, respectively around the topics of hydraulic state (Section 2.3.1), neoliberal water market (Section 2.3.2), and participatory irrigation management (Section 2.3.3).

2.3.1 Hydraulic missions and state building

The first strand of scholarly work focuses on the deep relationship connections between the modernization process, water engineering projects, and state-building efforts, highlighting how the consolidation and contestation of state power are embodied in the installation of hydraulic infrastructure and technology in the modern nation/state-building process (Menga and Swyngedouw, 2018; Rusca et al., 2018).

This body of research suggests that modernization serves as both a narrative and ideological framework for national development and state expansion, achieved through the administrative ordering of nature and society (Menga and Swyngedouw, 2018; Closas, 2018). The creation of hydraulic works, driven by state-led and engineering-based approaches, is central to this vision of progress, aiming to craft an environment conducive to modern, competitive, and irrigated agriculture (Scott, 1999; Swyngedouw 1999, 2007). Iconic development projects, such as dams and reservoirs, are sustained over time by modernization narratives and political mandates (Harrison, 2018). The establishment of territories via irrigation infrastructure and technology, the "technozone" as Akhter and Ormerod (2015) defined, exemplifies the state's imperial and hegemonic power to manage natural resources and reshape socio-political hierarchies in rural settings (Bertoncin et al., 2019; Hommes et al., 2016; Hommes and Boelens, 2017; Hommes et al., 2019).

For example, Swyngedouw's studies on the Spanish waterscape transformation in the nineteenth and twentieth centuries illustrate the use of political power to promote economic growth, regional unity, and national identity through the "hydraulic regenerationism" program. This initiative, aimed at redistributing water from humid regions in the northwest to arid areas in the southeast, resulted in the consolidation of local irrigation systems into a unified, centralized network (Swyngedouw 1999, 2007). The paradoxes of the emerging "utopian hydraulism" raised questions about the suppression of local irrigation collectives' autonomy and the reliance on a technocratic governance model (Boelens and Uiterweer, 2013).

In postcolonial states such as Tanzania, Mozambique, and Malawi, the legacy of colonial high-modernist ideologies continues to influence agricultural and irrigation policies (Harrison, 2018; de Bont, 2018; de Bont et al., 2019). These countries have witnessed a surge of mega-engineered hydraulic projects such as irrigation dams and water supply schemes in the post-independence era, aimed at territorial consolidation and enhancing agricultural production. This trend reflects a broader pattern observed across Africa, where engineered hydraulic projects play a pivotal role in shaping the agricultural landscape and the state's capacity to control and utilize water resources (Hill and Woodland, 2003; Minoia, 2012; Bertoncin et al., 2019).

In addition, an emerging group of studies started to explore the contestation and resistance in the adoption of water infrastructure and technology. They argued that local knowledge—traditions, social norms, and experiential practices—are reported to persist as alternatives to scientific and engineering expertise. These local ways of knowing and living enable the rearrangement of technological infrastructure from a bottom-up approach, tailored to fit specific social contexts (Poblador et al., 2021; Gladfelter, 2022).

For instance, when faced with waterways designed by formally trained engineers, Tharu farmers in Nepal excavated intake canals and constructed flexible brushwood dams in the Budhi Kulo irrigation system to direct flows of Karnali River to their fields (Gladfelter, 2022). Similarly, farmers in the region of Valencia in Spain redesigned a centralized dripping irrigation system, particularly realigning control over irrigation to suit the community's goals and needs (Garcia-Molla et al., 2020; Poblador et al., 2021). These studies resonate findings by Le Visage et al. (2018), who document how groundwater-based farmer irrigators in Turkey have challenged the construction of small dams by the Turkish government that aims to pursue the modernizing hydraulic mission with the development of public surface irrigation. Hebinck et al. (2019), conduct a case study of the Kenyan shores of Lake Victoria, also arguing that the dissemination of petrol pumps—symbolic artefact of modernity—is a self-organizing process within which socially differentiated vegetable growers employ various strategies to overcome constraints and seek to maximize profits in pump-based irrigation under distinct socio-economic conditions.

2.3.2 Neoliberal water market and global coloniality

The second strand of water literature shifts attention from a technocratic ground to the global hegemony of neoliberal water markets. These critical studies have cast doubt on neoliberalism-induced modernization that presented as cost-recovery and win-win solutions for growth-compatible sustainability, and have framed it as "neoliberalization of nature" which "alienates and dis-embeds nature from the socio-natural relations by which it is constituted" (Bakker, 2010: 727). Paying attention to contradictions, differences and unevenness in terms of in situ processes and outcomes, they have unraveled a disjuncture between the ideological slogan and political operational practices, the abstract economic doctrine and the world reality, and its promising visions and disruptive socioecological effects (Brenner and Theodore, 2002; Castree 2006, 2008a, 2008b; Brenner et al., 2010). The neoliberalization of water is reconceptualized as "a historically specific, ongoing, and internally contradictory process of market-driven socio-spatial transformation, rather than as a fully actualized policy regime, ideological form, or regulatory framework" (Brenner and Theodore, 2002: 353).

First, scholars critique the underlying rationales and practices of establishing private tradable water rights and water market systems, which free up water as an economic commodity (Bakker, 2010). They challenge the prevailing political narratives of scarcity crises and economic efficiency, which have been used to justify the adoption of market-oriented institutions by policymakers and the private sector (Derman and Ferguson, 2003). These narratives, as demonstrated in Australia and South Africa, are neutralized through biophysical constraints and climate changes (Edwards, 2013; Peters and Woodhouse, 2019), and try to optimize the end-use efficiency through the commodification of water that may be most profitably privatized, monetized, and exchanged as economic assets (Bakker, 2015). As a consequence, the water market system does not fulfil its promises to secure water amid scarcity; instead, it resulted in uneven allocation and access among water users, particularly marginalizing poor smallholders, women irrigators, and indigenous communities (Zwarteveen, 1997; Davidson and Stratford, 2007; Perreault, 2008; Ahlers and Zwarteveen, 2009; Mendez-Barrientos et al., 2018).

For example, Chile's 1981 Water Code created a private and freely traded water market with weak regulation at a time when radical neoliberal ideologies prevailed throughout the world (Bauer, 2013). As Bauer puts it in an assessment that "the freedom to buy and sell water rights has led to the reallocation of water resources to higher value uses in certain areas and under certain circumstances" (Bauer, 2004: 132). Therefore, poor smallholders often faced unstable water supplies for agricultural production, while large commercial farmers protected, secured, and controlled more water under the leverage of market systems (Bauer 1997, 2015; Budds 2004, 2020). Peasant movements aimed at protecting indigenous identity and water-based livelihoods are also frequently observed in Andean countries during the implementation of neoliberal water reforms (Boelens and Zwarteveen, 2005; Prieto 2016, 2022). These movements challenge the prioritization of market mechanisms over traditional and community-based water governance practices.

Second, critical scholars have highlighted the role of water in reinforcing the power of elites and corporate entities, particularly within the context of neoliberal agendas. Swyngedouw (2004) describes water as a "lubricant" of capital accumulation essential for all forms of economic development activities, making it a strategic resource sought by capitalists. This has led to critiques of neoliberal agrarian and water policies for facilitating regulatory capture and enabling capital accumulation, particularly benefiting the mining and biofuel industries that are capable to afford higher costs for water rights and pumping (Borras et al., 2011; Bauer, 2015; Hoogesteger, 2018).

For instance, Urteaga-Crovetto (2016) shows how a transnational energy company in Peru's Chira Basin forged a strategic alliance with the regional government and negatively impacted local farmers by securing additional water rights for ethanol production. In this sense, the concept of "market triumphalism" in water governance is contested as "ecological fixes"; instead, it appears to have enabled capital accumulation by dispossession (Harvey, 2003; McCarthy and Prudham, 2004; Bakker, 2009).

Third, there is a growing body of literature pointing to the phenomenon of "water grabbing", driven by capital-intensive and commercial agricultural development supported by foreign direct investment in post-colonial African countries (Mehta et al., 2012; Allan et al., 2012). This modernization process often entailed forced cultivation methods introduced by former colonial powers and international donors, utilizing narratives of "unexploited" land and water resources (Ertsen, 2006; Gilmartin, 2015). The colonial agrarian model has underpinned development policies in these post-independent countries, integrating foreign private capital into government programs. Mozambique's agricultural policy, for instance, sought to recuperate the "lost" modern agriculture of colonialism by repurposing settler farms into state-run mechanized farms with foreign investment (de Bont et al., 2019b). Similarly, the Tanzanian government established the Investment Promotion Centre to attract foreign direct investment in agriculture (van Elden et al., 2016). Such approaches have led to agriculture being a site of capital accumulation through dispossession, establishing settler property forms and giving rising to the contested water grabbing (ibid.).

2.3.3 Participatory irrigation management and organization

The third strand of literature challenges the prevailing decentralized irrigation governance models, such as Irrigation Management Transfer (IMT) and Community-based Management (CBM), which assign responsibilities for administration, operation, and maintenance of irrigation systems to locally organized water users. These studies argue that imposed management models and organizations have not resulted in inclusive participation and fostered local autonomy (Dewan et al., 2014; Alba et al., 2016; Ali, 2020). Instead, elite domination and the marginalization of farmer-led irrigation initiatives are often observed in the real-world contexts (Zhou, 2013; Harmon et al., 2023).

First, organizational arrangements for irrigation management, particularly water user committees or associations (WUAs), have been questioned for the re-centralization of water control. Contrary to the ideal of collective self-governance, many studies have revealed that WUAs are discursively and materially constituted to govern water users as part of governmental techniques (Rap and Wester, 2017; Giner and D'Amaro, 2019). They are, in fact, controlled by local elites, village leaders, and/or large commercial farmers instead of small water users (Wilder and Lankao, 2006; Zhou, 2013). The contradictory development and evolution of WUAs can be attributed to historical legacies and political economic dynamics. For instance, Theesfeld and Boevsky (2005) emphasize that a breach of collective irrigation tradition during the Socialist period, along with state interventions, transformed Water Syndicates into pseudo-cooperatives and thus hindered bottom-up collection actions in Bulgaria.

Second, diverging from small-scale and community-level irrigation models that are formally planned and designed, the potential and paradoxes of widespread farmer-led irrigation development (FLID) in sub-Saharan Africa have received much scholarly attention. FLID is a trend in which individual farmers take the initiative to establish, improve, and/or expand irrigated agriculture (Veldwisch et al., 2019). Although regarded as traditional, backward, and inefficient by policy makers, FLID has been found to be more adaptable and flexible (Woodhouse et al., 2017). Instead of relying on a modern, single, and fixed irrigation scheme, socially differentiated farmers, ranging from homestead irrigators to large-scale commercial producers, are able to deploy a variety of technology assemblages, such as pumps, pipes, wells and buckets in agricultural production (de Bont et al., 2019a; Scoones et al., 2019). However, recent studies have also pointed out policy paradoxes that these farmer-led irrigation initiatives are exposed to. With increasing recognition by governments and multilateral donors, FLID has been disturbed by development policies and agribusiness projects that aim to scale up farmers' collective actions, yet have minimal impacts on agricultural productivity and sustainability (de Bont and Veldwisch, 2020; Harmon et al., 2023).

2.3.4 Beyond a capitalist and neoliberal paradigm of water governance

Existing critical water studies have revealed spatiotemporally differentiated processes of water governance transformed by agricultural modernization and neoliberalization, which tend to follow a capitalist and neoliberal development paradigm to restore power of the hegemonic state and economic elites, and re-establish conditions for capital accumulation through market institutions (Harvey, 2005). There are two limitations in existing literature.

Firstly, scholarly studies focusing on hydraulic missions and nation/state-building often highlight the legitimacy derived from water engineering. However, the concept of the "state", as discussed in these works, lacks the precision that we might expect. Many studies treat the "state" as a monolithic entity (Nordlinger et al., 1988; Ho, 2022), separate from civil society, and seldom address its internal complexities, forms and functions (Byrant, 1992; Eker and Loftus, 2008). As Nickum (2010: 548) pointed out, "Assumptions of an unchanging authoritarianism, whether from indigenous or imported legacies, at best miss critical features of ongoing reforms in China's water sector." Thus, I contend that the notion of "state" remains underexplored in the current discussion on "hydraulic state." The varying and sometimes conflicting goals of state policies, along with the dynamic interactions between state and non-state actors during the implementation of these policies, merit closer examination. How top-designed agricultural and water policies are mediated and implemented by local actors in everyday practices? How water governance schemes are adopted, resisted, neglected, assembled, and/or transformed at local and grassroots levels? Further investigation on these questions will provide a deeper understanding of state power and its interactions with the rural society.

Secondly, the trajectories and outcomes of neoliberalizing water have been critically investigated across various sites and scales. However, existing empirical studies are predominantly concentrated on sub-Saharan African, Latin American, and South Asian countries, where state capacity is relatively limited and foreign capital is pronounced. Neoliberal water governance reforms—in parallel with agricultural modernization—in socialist contexts are poorly understood, which may display a different pathway with intertwined power dynamics. In particular, China experience is underrepresented in the academic literature.

Departing from the neoliberal doctrine of self-regulating market that is liberated from all forms of state interference, water governance in China has recognized an authoritarian state in the imposition of modernized and market-oriented initiatives, usually displayed in slogans and discourses such as economic growth, rural development, and poverty alleviation (Clarke-Sather, 2012; Magee, 2013; Ye, 2015). The disciplinary Chinese state dates back to ancient irrigation civilization of China, as Wittfogel (1957) showed, when political elites entrenched their power in the construction and maintenance of large-scale hydraulic infrastructure. While state power remains centralized, China's bureaucratic system has fragmented power structures, characterized by the honeycomb-like "*tiao-kuai*" system, in which "vertical" lines of functional agencies (*tiao*) and "horizontal" threads of territorially-based government units (*kuai*) compete and bargain in the policy domains (Lieberthal and Oksenberg, 1988; Lieberthal, 2004). Through a case study of irrigation governance in rural Northwest China, for example, Wang et al., (2018) showed gaps between centralized water directives and localized policy implementations, providing evidence that county-level officials and water suppliers were reluctant to cut off water supply for the sake of their own interests.

Under the authoritarian political system, China's transformation is also a path-dependent process, marked by strategic selectivity, institutional pragmatism, and adaptive capacity (Jing, 2017). As Peck and Zhang (2013: 369) put it, "its unique experience of 'capi-communism' has been effectively co-constituted not only with 'external' forms of globalizing capitalism but also with a unique state-socialist trajectory, in an extended and reciprocal process of recombination." Studies have demonstrated that China's water governance has a legacy of administrative command and control on one hand, and integrates with neoliberal elements on the other hand, such as pricing, eco-compensation, and public-private partnerships (Yeh, 2013; Sheng and Webber, 2019; Sheng et al., 2020). Sheng et al. (2020) designate this form of manifestation as "authoritarian neoliberalization" in which authoritarian centralization and neoliberal decentralization are interlinked. Political legitimacy of China's water governance regime is not offered through its ideological power but through effective governing of water (ibid.). In this sense, the application of market-derived neoliberalism is utilized as a set of practical instruments, rather than an ideal goal to achieve. The entrepreneurial state proactively deploys market instruments to fulfil its developmental objectives and increase governance capability to maintain economic growth, stability, and capital accumulation (Wu, 2020).

As a result, the boundaries between modern and traditional, public and private, and formal and informal are blurred in practice. Hybrid water governance emerged and coexisted in China. For example, Wang et al. (2021a) identify four irrigation institutional modalities within a county, namely pumping stations, WUAs, village committees, and individual villagers, which are sustained and legitimized in the institutional bricolage process to accommodate local conditions. These diverse water institutions and practices shape and are reshaped by existing power relations at the complex interfaces between the state, market mechanisms, and local communities (ibid.).

To summarize, the modernization of water governance in China displays a combination of dynamics and power networks amongst central and local states, the state and the market, and the state and rural society. How state-backed agricultural modernization initiated by market-oriented agrarian reforms shapes and is reshaped by water governance at local and grassroots levels in rural China? Further inquiries deserve to offer a nuanced understanding of the interrelationship of agricultural modernization and water governance in the socialist agrarian context. This thesis asks the following research questions:

1. What new water infrastructures, institutions, and organizational arrangements have emerged within state-led agricultural modernization in China, and with what characteristics?
2. How do institutional dynamics and power relations embedded in this agrarian change account for these governance shifts?
3. What political and socio-environmental effects and responses arise from these new forms of water governance and agrarian change?

2.4 Theoretical perspective and analytical framework

To conduct the research and answer the abovementioned research questions, this thesis draws on the perspective of political ecology, which is a dominant research field of human-environment relations in geography. Responding to the apolitical Malthusian theory of global environmental crisis of the late 1960s, and deriving inspiration from critical social and cultural ecology studies (Robbins, 2012), political ecology goes beyond the biophysical attributions of environmental problematics and aims to "develop an integrated understanding of how environmental and political forces interact to mediate social and environmental change" (Bryant, 1992: 12). Applied in a flagship study of land degradation, Blaikie and Brookfield (1987: 17) defined the field in this way: "The phrase 'political ecology' combines the concerns of ecology and a broadly defined political economy. Together this encompasses the constantly shifting dialectic between society and land-based resources, and also within classes and groups within society itself." This echoes with Karl Zimmerer's definition of political ecology as the study of "the fusing of biogeophysical processes with broadly social ones" (Zimmerer, 2000: 153).

From the perspective of political ecologists, natural resources are viewed as "social life of things" (Appadurai, 1988) possessing value beyond their material utility, and the materiality of these resources is intertwined with broader structures of meaning (Amita, 2003). They place power at the center of their conceptual frameworks to "unravel the political forces at work in environmental access, management, and transformation" (Robbins, 2012: 3). Social, political, and economic inequalities behind environmental issues are further revealed under the interrelated assumptions that "costs and benefits associated with environmental change are for the most part distributed among actors unequally...[which inevitably] reinforces or reduces existing social and economic inequalities...[which holds] political implications in terms of the altered power of actors in relation to other actors" (Bryant and Bailey, 1997: 28–29).

The political ecology of water is a distinct subfield within political ecology studies. It criticizes technical and managerial viewpoints of water and its governance, and emphasizes social and political dimensions of water from a relational and dialectical perspective (Linton and Budds, 2014), appreciating the complexity and inherently power-laden and contextual nature of water governance (Wilson et al., 2019). This section first introduces conceptual frameworks raised by political ecologists and critical geographers that re-conceptualize water as "hydrosocial relations". It then sums up existing knowledge on how to approach and unpack power and politics in water governance. Building on these theoretical insights, this section ends up with proposing the notion of "hydrosocial reconfigurations" as an analytical framework of this thesis.

2.4.1 Re-conceptualize water as hydrosocial relations

Drawing on the discipline of hydrology, traditional views separate water from its societal context, and reduce it to its biophysical properties as a mere chemical compound (H_2O) circulating in the "hydrological cycle" (Linton, 2010). Endorsed by hydrological expertise from a scientific-engineering perspective, the mainstream approach to water governance focuses on state-led, techno-centric, and market-oriented measures, controlled by hydraulic bureaucracies, to develop, manipulate, and manage water resources for human benefits (Baker, 2013; Linton, 2014). This dominant way of knowing and representing water, defined as "modern water" by Linton (2014), characterizes water governance as apolitical, rational, and development models that can be applied worldwide.

In contrast, scholars in political ecology reconceptualize water as hydrosocial relations, with explicit regard to the intertwined relationship between water and human society. Rooted in the nature-society dialectic of Karl Marx's theory of labor, the hydrosocial relations approach regards water as "a socially mediated thing" with a complex web of social relations, circulating in not only a hydrological cycle but also broader political economic processes (Swyngedouw 2004, 2009; Bakker, 2012). For example, the flow of water, when transported from source to tap and redirected through canals and pipes, is a deeply human and social endeavor with inputs of labor, technology, capital and natural resources (Robbins, 2012).

Erik Swyngedouw (1999, 2004) describes this social-political understanding of water as a "socio-natural hybrid" produced in historical, political, and geographical processes that merges nature and society into an internally interrelated and inseparable engagement. As showed in Figure 2.1, socionatures such as water are all hybrids or quasi-objects, internalizing the multiple dialectical relations woven together in the discursive, ideological, cultural, material, and scientific practices during the process of hybridization—the historical-geographical "process of production, of becoming, of perpetual transgression" (Swyngedouw, 1999: 447). The notion of socio-natural production argues that water and society do not relate to each other as pre-given and independent entities, but are internally related and constituted each other reciprocally and continuously, therefore transcending the binary between nature and society, material and discursive, and subjects and objects (Swyngedouw, 2009; Linton, 2010).

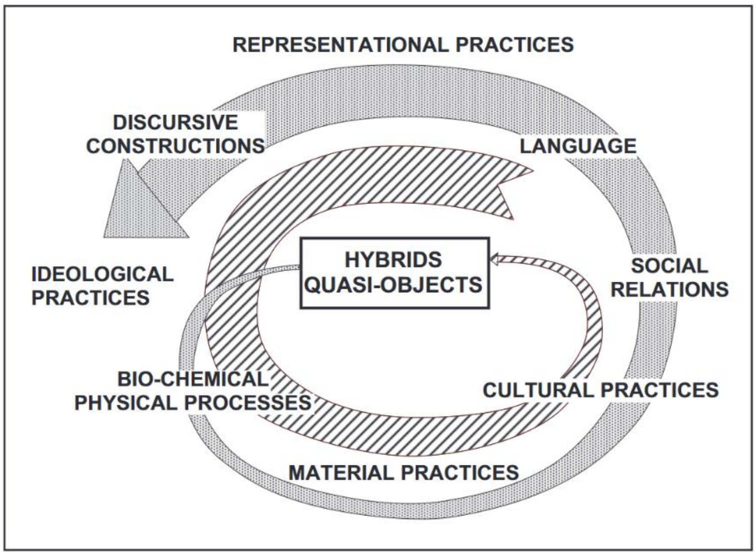

Figure 2.1. The production of socionature.

Source: Swyngedouw (1999).

Linton and Budds (2014) further define and mobilize the "hydrosocial cycle" as "a socio-natural process by which water and society make and remake each other over space and time" (p.170). As Figure 2.2 illustrates, a variety of heterogeneous entities including social power and governance structures, technologies, infrastructure, and material water (H_2O) intertwined with each other and produced a particular kind of "water" within specific moments, contexts, and relations (Budds et al., 2014). In this cyclical socio-natural process, the intervention of water's materiality (H_2O) perchance stabilizes and perchance disrupts human society (social power/ structure), which arises forces that intervene by manipulating material flows in the hydrological cycle (technology/infrastructure), and which in turn affects the materiality of water (H_2O), and so on.

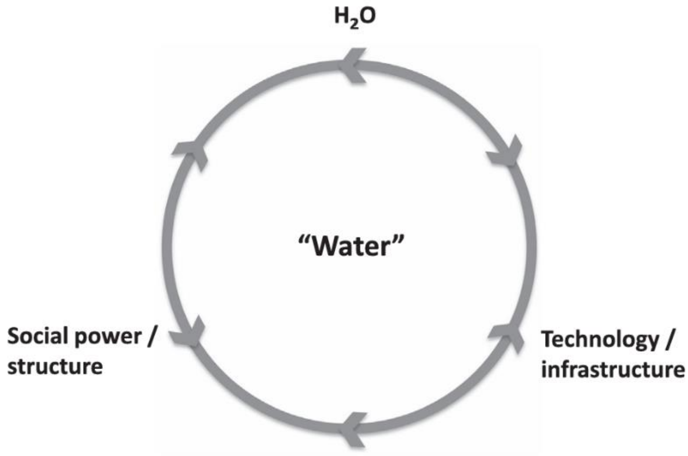

Figure 2.2. The hydrosocial cycle.

Source: Linton and Budds (2014).

The hydrosocial relations provides an analytical tool to interrogate the complexity and context particularity of social production, discursive construction, and political mobilization of water, and how it, in turn, shapes society (Budds et al., 2014). It encourages us to consider how water is produced through social and political processes and, conversely, how water reshapes social relations, structures, organizations, and identities across time and space (ibid.). This mutual constitution reveals water's active and dynamic agential role in social-technical formations, moving beyond viewing it as merely material flows, an inert resource under human control, or a backdrop of politics (Bakker, 2012).

2.4.2 Approach power and politics in water governance

Reconceptualizing water as hydrosocial relations relates to a critical examination of water governance, highlighting the political nature of governance arrangements, practices, and processes. In contrast to traditional views that frame water governance primarily as a depoliticized technical or economic issue (Molle, 2008; Budds and Sultana, 2013), critical scholars define water governance as the practices and processes of coordination and decision making between multiple actors on how water is to be used, by whom, for whose benefits, and with what distributional outcomes (Zwarteveen et al., 2017). Such practices are inherently political, contested, and uneven, marked by diverse interests, ideas, and knowledge in the complex intersection of institutional, socioeconomic, and cultural conditions (Agnew, 2011; Zwarteveen et al., 2017; Wilson et al., 2019).

Power is a central focus in the term of water governance, which is posited not as an attribute possessed by individuals or entities but as emerging from the interactions among people, places, and resources at different scales (Derman and Ferguson, 2003; Paulson et al., 2003; Hornborg et al., 2013). Politics, in turn, is viewed as the processes and mechanisms of contestation and negotiation, dynamically interacting with biophysical environments and through which multiple forms of power are wielded (Paulson et al., 2003; Walker, 2007). As Bear and Bull (2011) note, politics plays out not around water, but is embedded in, pursued through, and often driven by water, thereby shaping differential accesses and outcomes among diverse social groups.

Then how can we approach power and politics in water governance? Existing studies have categorized different modes of power by synthesizing a broad range of theoretical approaches. Paerregaard (2018) enquires into water's fundamental properties with transgressive, transmutable, and transparent characteristics, and explores three different forms of power it impinges on human society: 1) power *in* water (its physical force); 2) power *of* water (its social and political bearings); and 3) power *as* water (its cultural and imaginary potential). It is argued that water "represents raw physical power, malleable social and political power, and soft imaginative power at one and the same time" (p.9).

Wilson et al. (2019) theorize power and politics in water governance into instrumental power, structural power, and discursive power: 1) *Instrumental* power is exercised through regulations and disciplinary forces (e.g., financial, technical, and social); 2) *Structural* power, drawing from Marxist political economy, refers to the broader histories and socioeconomic and political contexts (e.g., neoliberal hegemony, racial capitalism, and colonialism) through which particular forms of water governance and systematic inequalities are (re)produced (Himley, 2008; Vos and Boelens, 2018); 3) *Discursive* power is characterized by using governmentality, "the conduct of conduct" as defined by Foucault (1991), to direct and regulate people's beliefs and behaviors in a diffuse, subtle, and self-oriented manner (Dean, 2010). This form of power differs from grand displays of hegemonic power in state-centric hydraulic engineering and formal institution structures. It permeates into dispersed practices, discourses, ideologies, and knowledge that underpin everyday forms of rule (Paulson et al., 2003; Ekers and Loftus, 2008).

In addition to Marxist and Foucauldian power perspectives, Svarstad et al. (2018) also mention an actor-oriented power perspective in their review article. From the actor-oriented perspective, planned development intervention is conceptualized as an "ongoing, socially-constructed and negotiated process" (Long and van der Ploeg, 1989: 228). The exercise of power is held by different actors and it is constrained or enabled by various types of structures. In opposition to the traditional structuralist analysis, this social constructionist form of inquiry argues that these actors have their own agency in spite of structural limitations, and they have a marked influence on the development dynamics (Long, 2001).

To sum up, water governance from a hydrosocial lens calls to investigate how power relations are enacted and circulated through the reworking of hydrosocial relations, which encompass water flows, social relations, infrastructure, institutions, practices, and discourses. It underscores the need to scrutinize the nature and impacts of water policies, the role of multiple actors in decision-making, and the dynamics of conflicts and cooperation surrounding water.

2.4.3 The analytical framework of “hydrosocial reconfigurations”

Drawing insights from the political ecology of water, this thesis understands “water” as hydrosocial relations inseparable from human society, and attends to the politics and power relations of water governance transformations. I use the term “hydrosocial reconfigurations” as an analytical framework to explore how water governance arrangements and processes are both shaped by, and reshape state-led agricultural modernization in the Chinese agrarian context. As illustrated in Figure 2.3, this analytical framework entails that:

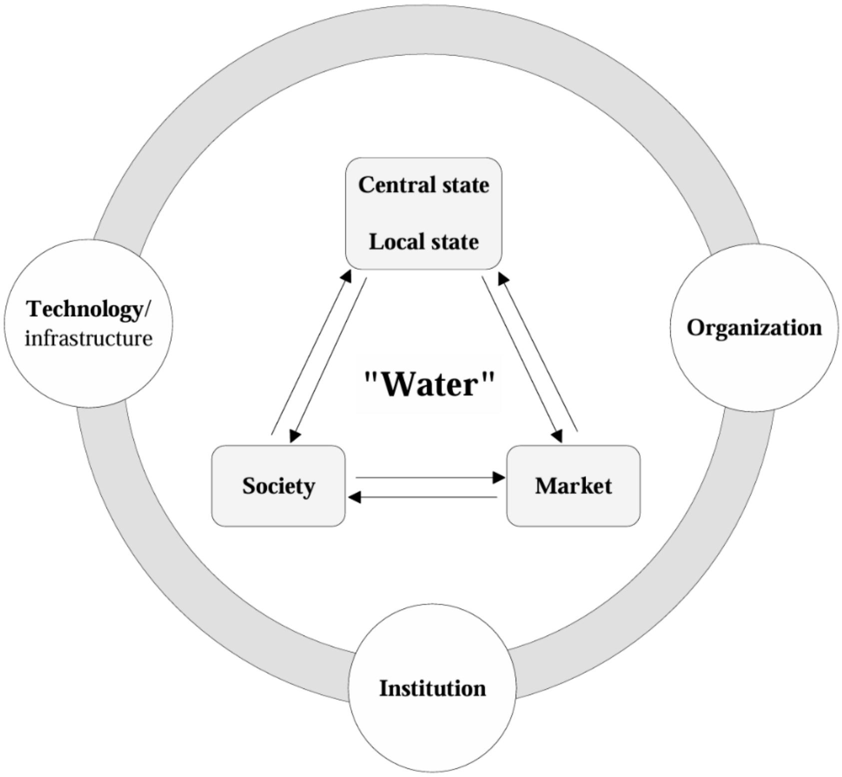

Figure 2.3. The “hydrosocial reconfigurations” framework.

Source: produced by author.

First, state-led agricultural modernization has significantly reconfigured water governance arrangements and practices through which hydrosocial relations are governed. Based on the rapid ongoing China’s water reform practices, this thesis investigates the technological, organizational, and institutional transformations of water governance and their interconnections. These three aspects provide a panoramic view of China's water governance transformations that are unfolding on the ground.

1. **Technological:** it focuses on the strategic design and application of small-scale on-farm irrigation infrastructures to enact political and economic goals, with a specific emphasis on how infrastructures mediate social and political power relations among different actors with competing interests, such as levels of governments, village communities, large producers, and smallholders;
2. **Organizational:** it concerns on the evolution of organizational modalities including grassroots water bureaucrats, village committees, and water users associations in the management of canal and groundwater irrigation systems, with a specific focus on their roles and responsibilities in water allocation, operation, and maintenance;
3. **Institutional:** it attends to quasi-market institutions that enable the reallocation of water among different water users through the quasi-market mechanisms, with a specific focus on the agricultural-to-industrial water transfer under the central-planning water allocation system.

Second, the transformed water governance has, in turn, reconfigured social and power relations therein. This thesis adopts an actor-oriented perspective in development studies and approaches the intricate and evolving power relations between the central and local states, the state and rural society, and the state and market actors in relation to the transformation of the use, management, and distribution of water. I borrow ideas from Evans (1997) and Fox et al. (2023) who assert that state, market, and society are embedded in and interacted with each other, altering structural constraints as agents of institutional changes. Power is articulated through interactive dynamics between actors mediated by the access, allocation and reallocation, and management of water.

1. **central-local state:** it unpacks the complexity of China's fragmented bureaucratic system ("*tiao-kuai*"), with specific foci on the agency and actions of local states in

the variegated, selective, and pragmatic implementation of central agrarian policies and governmental earmarked irrigation projects;

2. **local state-society-market:** it explores the state-society-market synergy in an interactive, dynamic and relational way, focusing on how local states navigate multiple and sometimes contradictory goals in rural societies, and how rural communities react towards modernized, de-collectivized, and market-oriented water transformations.

Third, state-led agricultural modernization in parallel with marketization, industrialization, and urbanization are key driving forces to the transformation of water governance in the rapid changing rural China. These forces and dynamics both shape and are reshaped by water governance and the underlying intra-state, state-market, and state-society relations. This thesis situates the actual working of water governance and the relations of power inscribed therein through localized and everyday hydraulic practices, exploring how local governments at county level and below, private companies, village committees, agricultural producers, and others engage, deal, and live with water in their daily routines.

This hydrosocial reconfigurations framework thus provides a theoretical lens to capture the forms and characteristics of water governance shifts in rural China, discover the underlying institutional and power dynamics, and analyze the resulting political, social and ecological effects. As identified in the section 2.3.4, this framework in particular assists to unpack the nuanced role of the Chinese state in the water transformation process, which is not understood as a single and monolithic entity, but complex contours produced in everyday engagement with the local states, the market actors, and rural society.

2.5 Summary

This chapter examines two bodies of literature—critical agrarian studies and critical water studies—to advocate for bridging the political economy of development and the political ecology of water. The role of water in reinforcing hegemonic power relations within the process of agricultural modernization is crucial, yet such engagement can also be contested and potentially undermined. While this dialectical and relational perspective is subtly present in existing literature, it has not been sufficiently emphasized to date. By integrating political economy insights into the framework of political ecology, we can deepen our understanding of the process of China's state-led agricultural modernization by illustrating how politics and power dynamics intricately operate through daily interactions in water access, management, and allocation, and thus reconfigure hydrosocial relations. The following chapter introduces research methods and the case study area of this research.

Chapter 3 Research methods

3.1 Introduction

This chapter outlines the research methods to investigate how agricultural modernization in China shapes and is reshaped by water governance and its hydrosocial reconfigurations. It starts with the critical realism ontology and epistemology, the case study methodology, and a description of the case study area in section 3.2. Then I introduce data collection methods and data analysis processes in the following sections (Section 3.3 and 3.4, respectively). This chapter ends with a reflection on the research ethics and positionality during fieldwork.

3.2 Research approach

To explore the interrelationship between agricultural modernization and the transformation of water governance, this study adopts the critical realism ontology and epistemology. Critical realism is a philosophical paradigm that distinguishes between the "real" world and the "observable" world (Bhaskar, 2008). It posits that the real world has three domains: the empirical one could be directly observed with knowledge and experiences, while the actual and the real domain are unobservable and independent of our conceptions (Bhaskar, 2008). This complex reality is knowable, although partially and imperfectly. Critical realism considers the ultimate goal of scientific inquiry is to explain observed phenomena in terms of underlying processes and generative mechanisms within contextual conditions. "It is the business of science to 'dig deeper' and beyond the immediate experiences of events in the world" (Danermark et al., 2019: 33-34).

Adhering to the critical realism paradigm, my research uses a county-level case study to examine the power dynamics and mechanisms embedded in the process of agrarian change that account for water governance shifts in China. This section details my case study selection and methodology, followed by a brief description of the case study area.

3.2.1 Case study methodology

Qualitative research is a way of exploring the real world by understanding and explaining the meanings that people assign to social phenomena (Denzin and Lincon, 1994). Amongst which, case study is a commonly-use methodology of qualitative research that "investigates a contemporary phenomenon (the "case") in depth and within its real-world context" (Yin, 2014:16). The case is not chosen based on its representativeness, but on its theoretical relevance and the insights it offers for theoretical reasoning. And therefore, a qualitative case study can provide a deep understanding of social phenomena and help build or develop theories by revealing the underlying rules, mechanisms, and laws (George and Bennett, 2005).

A county-level case study is an appropriate unit of analysis for the investigation of agricultural water transformations in the Chinese rural society. "County" is the second lowest level in the five-layered and hierarchical administration structure of China[3]. It is a relatively complete, stable, and longstanding administrative unit that encompasses political, economic, social, and cultural systems within its spatial jurisdiction (Tian, 2024). Unlike the township government, which has limited formal authorities and resources, the county government has both formal and informal institutional arrangements for decision-making and policy implementation (Yang, 2022). As Tian (2024: 22) notes, "County, which is at the junction of the state and society, plays a connecting role in the whole political system…The central policy is transmitted layer by layer to the county level, and the county government converts it into practical and grounded measures…The operation of political power at the county level can be regarded as the epitome of the operation of

[3] There are five levels of governments in China's multi-layered administration structure: the central, province, prefecture, county, and township (Färber and Wang, 2018).

state power to some extent" (with author's emphasis).

More crucially, the county also serves as an important interface in the urban-rural continuum, and plays a vital role in driving urbanization and rural revitalization. The NO.1 central policy of the Communist Party of China (CPC) in 2021 has proposed to grant more autonomy to the county to coordinate the use of resources and strengthen its service delivery capacity for an integrated urban-rural development (CPC, 2021). It has thus become the main arena for political operation, urbanization, and rural development in China. As a bridge connecting both urban and rural areas, county governance has the adaptability to the bureaucratic system and the flexibility of rural society (Zhou and Luo, 2025). A burgeoning body of studies has adopted "the county as a method" to understand the organizational forms and development paths of China at local and grassroots levels (Yang, 2022; Tian, 2024; Zhou and Luo, 2025).

Shandong province is the largest food production base in North China Plain, even though it is constrained by water resources. Tancheng is one of the agricultural counties in Shandong that has experienced rapid agrarian change and water governance shifts in recent years. I conducted a scoping study in Shandong between April and May in 2023. With the introduction by professors and their research teams from Peking University and Shandong Normal University in China, I managed to pay a visit to three counties and two prefectures across the south, central, and north regions of Shandong province. During the scoping study, I mainly talked to the gatekeepers, such as the deputy township governors, large farmers, village committee leaders and members to know about the social and environmental conditions (e.g. climate, land and water resources, etc.), water governance institutions, different types of irrigation facilities, and different kinds of crop growing practices in the field (e.g. grain, vegetable, fruit, etc.).

After the scoping study, which has provided me with basic information and impressions of agricultural production and water governance across Shandong, I identified Tancheng county as my case study area out of three reasons. First, in contrast to places located in the mountainous areas, Tancheng is one of the largest grain-producing counties in China because of its flat terrain, and thus has been attracting the influx of governmental development projects on farmland and irrigation. This provides an exact context for my research. Second, based on my initial observations, Tancheng depends on both canal and groundwater for irrigation and has developed different kinds of technological infrastructure, institutions, and organizational arrangements, which captured a great variation of agricultural water governance in practice. Third, for accessibility and feasibility concerns, I have built up trust and rapport with the deputy head of one township in Tancheng, who worked in the county government before and is now in charge of agricultural affairs of the township. This well-established personal network would enable and facilitate my further investigation.

By conducting a county-level case study of Tancheng, I can examine how rural actors interact with the macro-level political economic system in their concrete and daily practices, and renew our understandings of China's rural politics and agricultural modernization with a specific focus on water governance transformations.

3.2.2 The case study area

Tancheng county, standing at the southern part of Shandong province, covers 1,195km^2 across 13 township-level jurisdictions with 114 administrative villages and 16 urban communities (Tancheng County Government, 2023a). The terrain is higher in the north-east and lower in the south-west, with the highest elevation reaching 184m and the lowest at 26m. It has diverse landscapes, with hills in the north and northeast, intermountain plains in the center, and plains in the south (Tancheng County Government, 2021a). Tancheng receives abundant and concentrated rainfall (annually 867.7mm on average), and the vast majority of rainfall occurs from July to September, which sometimes causes floods in summer and droughts in the early growing season. Groundwater resources vary by locations, with less in the north dry land while more in the south paddy fields.

It belongs to the Huai River Basin, where 45 rivers flow for 620.7km and most of them are seasonal (ibid.). Three of the main rivers—Yi River, Baima River, and Shu River—run through the county and convey nearly 100 million m^3 of water to its three medium-sized[4] irrigation districts every year. The Lizhuang irrigation district in the north spans four townships and irrigates 13,340 hectares of farmland. In the central and southwestern parts of the county, the Matou irrigation district covers six townships with an irrigation area of 19,676 hectares. The Qingquansi irrigation district, located in the southeast of Tancheng, covers 6 townships with an irrigation area of 13,340 hectares (Tancheng Water Resources Bureau, 2022).

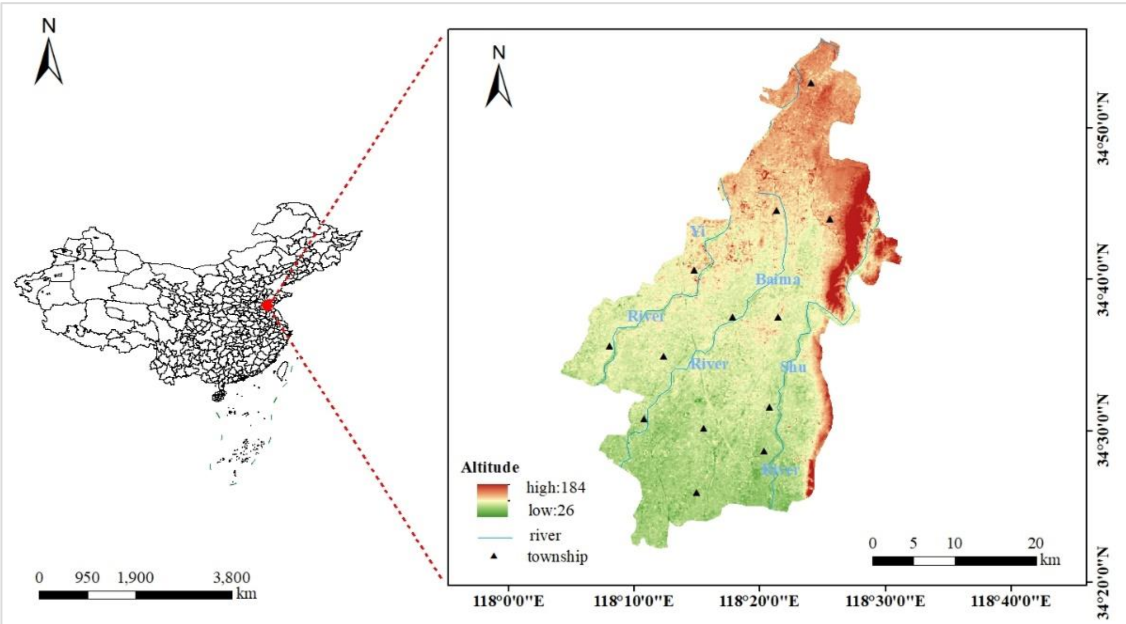

Figure 3.1. Map of Tancheng county in Shandong, China.

Source: produced by author.

[4] The classification of irrigation districts in China is based on their effectively irrigated areas (EIA), a commonly used measure referring to "level land with water sources and complete facilities to provide adequate water under normal conditions" (Nickum, 2005). Irrigation districts with an EIA exceeding 20,000 hectares (300,000 mu) are defined as large irrigation districts. Those with an EIA ranging from 667 to 20,000 hectares (10,000 to 300,000 mu) are considered as medium-sized irrigation districts. Irrigation districts with an EIA below 667 hectares (10,000 mu) are categorized as small irrigation districts.

Tancheng achieved an increasing GDP of 38.5 billion *yuan* (around 5.3 billion USD) in 2022 (see Figure 3.2). Of which, the agricultural sector (e.g. agriculture, forestry, animal husbandry, and fisheries) accounts for 10.7%, the industrial sector (e.g. mining, manufacturing, electricity, heat, gas, water production and supply, and construction) accounts for 29.8%, and the service sector (e.g. retail trade, transport, accommodation and catering, finance, real estate, etc.) accounts for 59.5%. Although the share value of agricultural production accounts relatively low, Tancheng is the largest grain-producing county in Shandong with 845,320 *mu* (around 56,355 hectares) of farmland. It grows two seasons of food crops—such as wheat, corn, and rice—and cash crops such as vegetable and fruit. In the industrial sector, chemicals, home building materials, modern agriculture (food), and clothing are its four dominant industries.

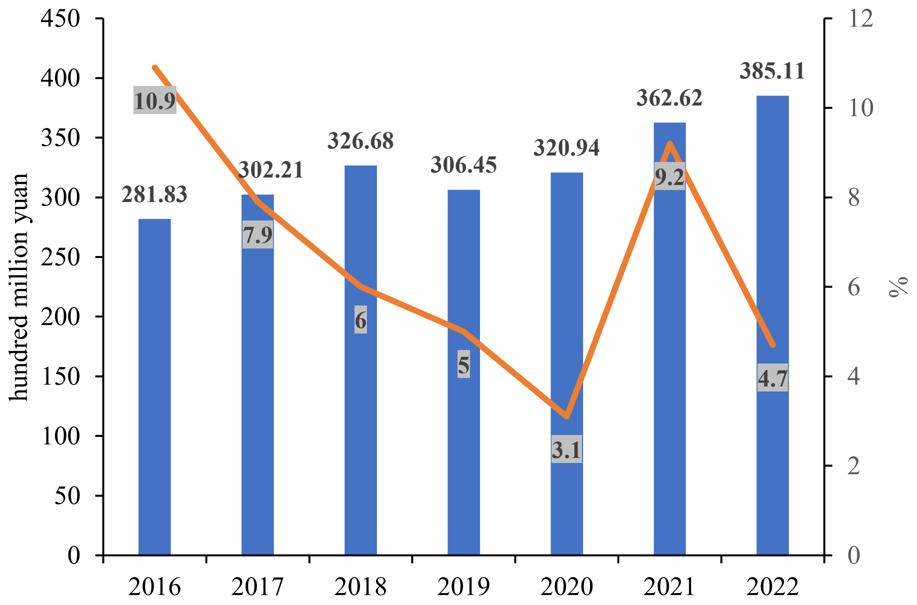

Figure 3.2. Annual GDP and its growth rate in Tancheng.

Source: The Statistical Yearbook of Tancheng County (Statistics Bureau of Tancheng, 2017 to 2023).

According to the national census survey in 2020, there was a total of 885,156 residents in Tancheng, with 326,202 people living in the cities and towns while 558,954 people living in the countryside. The urbanization rate[5] of Tancheng was 36.85%, well below the national level (63.9%) in that year (Statistics Bureau of Tancheng, 2021). There is also a wide income gap between urban and rural residents over years. The annual per capita disposable income in 2022 is 33,114 *yuan* (around 4603 USD). While the annual per capita disposable income among urban residents is 44,020 *yuan*, and that of rural residents is 18,886 *yuan* (see Figure 3.3).

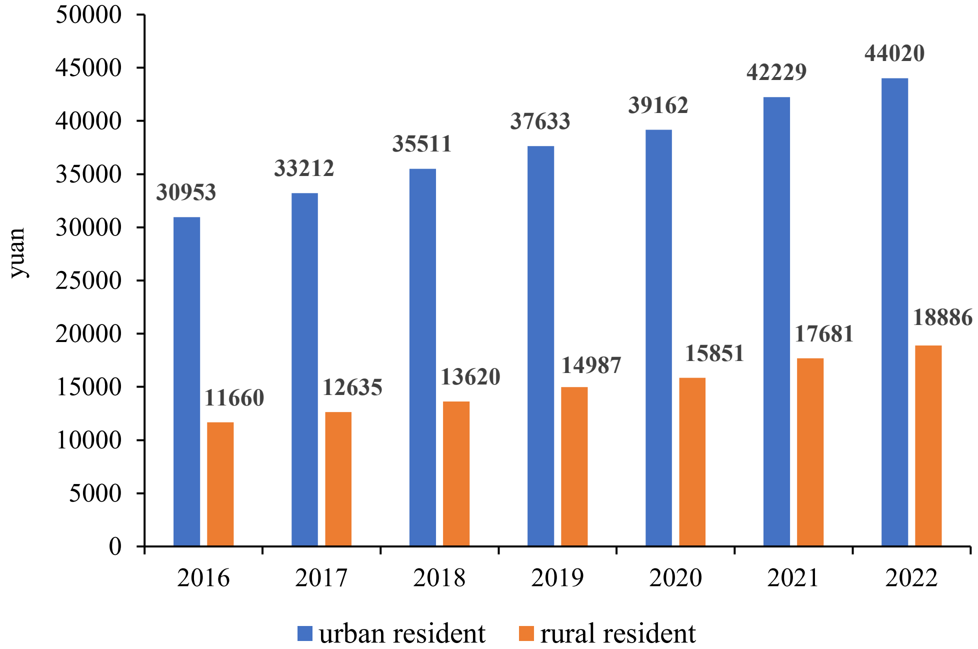

Figure 3.3. Per capita disposable income in Tancheng.

Source: The Statistical Yearbook of Tancheng County (Statistics Bureau of Tancheng, 2017 to 2023).

Detailed information about the case study area within the national political, socioeconomic, and environmental contexts is presented in Chapter 4. The next session introduces my data sources and data collection methods.

[5] The proportion of urban residential population is an important indicator for the urbanization rate in China. It is measured by the proportion of people who reside in cities and towns for more than half a year to the total residents in a certain area.

3.3 Data collection

Fieldwork is a data collection method for qualitative case study that originated in anthropology and later expanded to other social sciences. It involves researchers observing events in the field and developing understandings of social phenomena through embodied engagement (Emerson et al., 2011). To understand how water infrastructures, institutions, and organizations are transformed by agricultural modernization and rural development at the county level in the Chinese context, I conducted a nine-month fieldwork in Tancheng with a combination of first-hand and secondary data collection methods. This section discusses my fieldwork processes and the methods that I used for data collection: focus group discussions, interviews, on-site observations, and secondary data collection.

3.3.1 Fieldwork process

My fieldwork lasts for nine months across April 2023 to July 2024. It is split into two stages covering both monsoon and dry seasons and various planting seasons of different crops in Tancheng: one from April to May 2023 for the scoping study, and the other from July 2023 to July 2024 for data collection. I conducted three rounds of data collection in total, respectively commencing from July to September 2023, from November to December 2023, and from June to July 2024 (see Table 3.1).

Table 3.1. Two fieldwork stages.

Stage	Time period	Crop growing
Scoping study	April to May 2023	Wheat, vegetable
Data collection	July to September 2023	Rice and corn
	November to December 2023	Wheat, vegetable, and fruit
	June to July 2024	Rice and corn

In the scoping study period, I mainly contacted the key gatekeeper, the deputy head of the Yang township, through recommendation by a local professor who has personal connections with him. The initial and informal interviews with this deputy township governor, together with agribusinesses and large farmers he recommended, familiarized myself with the socioeconomic and environmental setting in Tancheng. I decided to select another four townships as my field sites for data collection. These five field sites cover three major irrigation districts from north to south and various farming practices in Tancheng. The Miao township, in the north, grows a season of wheat and a season of maize. The Gang township, in the central, has the least amount of farmland and is specialized on greenhouse vegetable and strawberries. The Gui, Hong, and Yang townships, in the south, are main producers of wheat and rice. And the Hong township has the largest amount of farmland and grows cash crops, such as vegetable and watermelons (see Table 3.2).

Table 3.2. Basic information of five selected townships.

Township	Location	Area/ hectare	Farmland/ hectare	Irrigation district	Main crop
Miao	North	7160	2868	Lizhuang	Wheat, corn
Gang	Central	4010	2201	Matou	Vegetable, strawberry
Gui	Southwest	5960	4069	Matou, Qingquansi	Wheat, rice
Hong	Southeast	12120	6537	Qingquansi	Wheat, rice, vegetable, watermelon
Yang	South	8130	5336	Matou	Wheat, rice

Source: The Statistical Yearbook of Tancheng County (Statistics Bureau of Tancheng, 2023).

During the main data collection period began in July 2023, I sent an invitation letter to the Agriculture and Rural Affairs Bureau and the Water Resources Bureau in Tancheng to get governmental consent and approval to conduct this research. Apart from this official protocol at the county level, I also called the deputy head of the Agriculture and Rural

Affairs Bureau through the liaison by my friends who happened to know this deputy head. After communications with her on my research plans, the deputy director nicely introduced me to other officials working at the agricultural and water bureaus, and led me to the offices of the selected township governments. I also had personal connections with one of my graduate alumni who was born in Tancheng. He kindly put me in connection with his three schoolmates who are living and working at different townships. Through these multiple networks, I was able to locate key informants at the township level and even reach to the village level.

Since it is not far away from the county center to the selected townships (within one hour drive), I chose to rent an ensuite room in the county center where the county governmental bureaus locate, and commuted to the field sites by taxi. It is possible to catch a ride from the field sites through ride-sharing apps (e.g. DiDi) since most people who work for the township governments live in the county center. Occasionally, I lived in the township hostels for a few days for a continued investigation and observation. It is not feasibly for me to live in the village as a female guest, and I don't want to disrupt people's daily routines to host me. However, I had more accesses to people than I expected as a doctoral student with guest status in the village. This is because being a student in the university is often viewed as educational and respectful, making villagers feel safe to share openly their stories and local knowledge with me.

In addition to the selected field sites, I also had opportunities to visit other townships since some large farmers have rented land from different jurisdictions. For instance, one family farm owner I met has rented more than 6,600 hectares of farmland across five townships to scale up agricultural production. He kindly showed me around his dispersed farmland in these townships. By comparing and contrasting different spatial areas, I am able to depict and characterize agricultural water governance at the county level as a whole, which represents the situation in rural China in a nutshell.

3.3.2 Focus group discussion

To identify informants and familiarize myself with the local context, this research started with focus group discussions at both the county and the township level. With the kind introduction and liaison by the deputy head of the agricultural bureau in Tancheng, I managed to conduct six focus group discussions: one at the Water Resources Bureau and another five respectively at each of the selected township governments.

The focus group discussions at the township governments were convened by the township governors, usually the party secretary or the deputy head of the township who are in charge of agricultural production. Township governmental officials or staff members, such as the director from the Rural Economic Management Station, the Agricultural Machinery Station, and the Water Station, were asked to introduce their work in the discussion meeting. As requested, large-scale agricultural producers registered in these townships—such as agribusiness companies, family farms, and farmers' professional cooperatives—and village committee leaders were invited to share their experiences and challenges on land transfer, farming practices, and irrigation management. Sometimes, the county officials from the agricultural bureau accompanied and joined me in these focus group discussions.

The focus group discussion at the water bureau was organized by the deputy director of Water Resources Management Office. He convened his colleagues from relevant work units that are responsible for farmland irrigation affairs and flood and drought preventions. The party secretary and the director of the Water Group Co. Ltd., a state-owned water supply company, were also invited to attend. We mainly discussed the topics of total water use caps, water allocation amongst different sectors, the agricultural-to-industrial water use rights transfer, water supply costs and benefits, and the use and management of groundwater, etc. An overview of representatives and topics of the focus group discussion is summarized as follows (see Table 3.3).

Table 3.3. Overview of representatives and discussion topics.

Representative		Topic
County government officials and staff	Agriculture and Rural Affairs Bureau	➢ Agricultural and water policies ➢ Farmland and irrigation project distribution ➢ Total water use caps ➢ Water allocation among sectors ➢ Groundwater use and regulation
	Water Resources Bureau	
Township government officials and staff	Township governors	➢ Township demography ➢ Farming practices ➢ Farmland area and land transfer ➢ Water resources and agricultural water quota ➢ Farmand and irrigation project construction and maintenance ➢ Irrigation operation, management and institutions ➢ Water conflicts
	Rural Economic Management Station	
	Agricultural Machinery Station	
	Water Station	
Water supply company	Water Group Co. Ltd.	➢ Water use rights transfer ➢ Water plant construction ➢ Water supply cost and benefit
Large-scale agricultural producers	Agribusiness companies	➢ Basic information ➢ Land transfer ➢ Farming and irrigation practices ➢ Governmental subsidies
	Family farms	
	Farmers' professional cooperatives	
Village Cadres	Village committee leaders	➢ Village demography ➢ Land and water resources ➢ Farming practices ➢ Irrigation operation, management and institutions ➢ Water conflicts

3.3.3 Interview

After the focus group discussion, data were preliminarily analyzed to inform the design of the follow-up interviews with key informants. A variety of interview techniques such as semi-structured interviews, informal casual talks, and walking interviews have been used to collect data. In total, I have conducted 39 semi-structured interviews with 4 county-level government officials and staff members, 11 township-level government officials and staff members, 8 village committee cadres, 3 water supply or engineering company managers, 10 large-scale agricultural producers (including 3 state-owned or private agribusinesses, 1 family farms, 3 farmers' professional cooperatives and 3 large households), and 3 smallholders[6].

Table 3.4. Semi-structured interview participants.

Group	Female	Male	Total
County official and staff	0	4	4
Township official and staff	1	10	11
Village committee cadre	1	7	8
Water company manager	0	3	3
Large agricultural producer	0	10	10
Smallholder	2	1	3
Total	4	35	39

Semi-structured interviews with these government officials and staff members were conducted either in the meeting room with more than one participant, or in individual offices one by one. During the conversation, they told me land and water conservancy projects constructed to promote agricultural productivity in recent years, and institutional and organizational irrigation arrangements and practices in the local context, which gave me a comprehensive view of agricultural development and the transformation of water governance in this county.

Following the township government's recommendations, I contacted and had semi-structured interviews with various local actors involved in agricultural production. I spoke to agribusiness managers, family farms owners, specialized farmers' cooperatives leaders,

[6] Smallholders refer to household-based peasants who use family labor to produce staple grains for subsistence on scattered plots of farmland, which are generally around one *mu* per capita and no more than ten *mu* per household in Tancheng county.

and large household farmers, exploring how they accessed and managed irrigation water for farming or greenhouse planting, and what cost and benefit they gained from government-backed infrastructural projects. The leaders of family farms or specialized farmers' cooperatives are often the leaders of village committees, who acted as brokers in land consolidation and transfer as well as irrigation coordination. Through liaison with these village committee cadres, I managed to navigate the fieldwork in the villages and learn about rural livelihoods and water-related tensions among smallholders.

I revisited these key informants at least twice through rapport building in previous visits. Each semi-structured interview lasted for over an hour to enable in-depth conversations. All the interlocutors were approached in a way of "snowball sampling" until the information was saturated, with the key informants who were engaged in agricultural water allocation, use, and management being identified in advance. To ensure the validity of the data, all information sources were cross-verified through triangulation.

Apart from the 39 in-depth and semi-structured interviews, I also had casual talks with many governmental officials and staffers in commuting cars and at lunch or dinner table, where they felt more comfortable to express their honest opinions about opportunities and challenges of irrigation governance transformations. Moreover, I had walking interviews with people I met in the village to gain more insights informed by the landscape. The larger growers usually walked me around in the field during the interview, which allowed me to relate their experiences and perspectives to the material environment. Sometimes, I followed the elderly and female smallholders encountered on their way to weed and irrigate their farmland, and had informal conversations with them about their daily practices. The flexibility of casual talks and walking interviews enabled me to have more accesses to female and less advantaged groups of people in the field, and supplemented information I got from semi-structured interview with almost male participants. In total, I conducted interviews with 51 people that I encountered in the field, either in semi-structured conversations or in more casual talks (see Appendix A for details).

3.3.4 Observation

For participatory observations, I was led by the county and township officials to the sites where small-scale farmland irrigation projects were constructed to know about how these infrastructures actually worked. I also had opportunities to attend public events with invitations from the county government, such as agro-industrial forums and expos, where the municipal and county governors and representative agribusiness entities, such as private companies, family farms, and specialized farmers' cooperatives, presented and gave speeches. In addition, I was invited to a private feast held by a village committee party secretary to celebrate the birth of his granddaughter, where I happened to meet the former director in the agricultural bureau and learned about his working experiences.

In order to better understand and validate the interviewees' statements, I visited farms and greenhouses many times for non-participatory observations. I interacted with wage farmers from the nearby villages, who had either partially or entirely leased out their farmland. These farmers were hired by large household farmers and agribusiness enterprises for temporary jobs, such as hand weeding, watering, and cultivation. Additionally, I observed a few smallholders managing their own land and carrying water tanks for irrigation. Occasionally, I encountered irrigation maintenance groups employed by the township government, who were engaged in repairing broken wires and restoring collapsed wells. These site visits and participant observations gave me insightful information and enriched my understanding on agricultural development and irrigation transformations in rural China.

(a) Electromechanical well (b) Water outlet

Figure 3.4. Small-scale farmland irrigation infrastructures.

Source: Author, July 2023. Note: (a)These electromechanical wells with a depth of 40 meters are newly built by the governmental water conservancy projects. They use electric machinery as power to pump groundwater to the field for irrigation. Farmers tap their water IC cards on the electricity box to access water and pay water bills by electricity. (b) Each electromechanical well is equipped with several water outlets. When farmers tap their water IC cards after turning on the outlet, water flows directly into the paddy field.

Figure 3.5. A smallholder was filling up his water tank.

Source: Author, August 2023. Note: Smallholders usually fill up water tanks with water from home or public taps, and carry them with their tricycles to irrigate small plots of edamame or maize.

3.3.5 Secondary data

In addition to first-hand data collection techniques, comprehensive desk research was conducted before the fieldwork stages. It was also supplemented with field-based archival research to gather contextual and historical information on agrarian reforms, agricultural and groundwater-related statistics, and water institutions and regulations in Tancheng. These secondary data sources include laws and governmental policies, five-year work plans, annual work reports, statistical yearbooks, records of water trades, and project tender documents in digital version. They were accessed through various platforms such as official government websites, academic journals, newspapers, and social media. In total, I collected 59 documents issued by the CPC, the State Council, and ministries of the central government, 19 documents from the provincial government of Shandong, 10 documents from the municipal government of Linyi city, 82 documents from the county government of Tancheng, and 19 documents from the township governments.

Furthermore, historical archives in hard copy were reviewed and collected in public libraries and archives. These comprised three books (e.g. The Chronicles of Tancheng 1984-2000, The Chronicles of Tancheng 2000-2013, and Water Conservancy Chronicles of Tancheng), seven copies of governmental documents, press reports, and manuscripts in the 1970s and 1980s.

3.4 Data analysis

3.4.1 Data classification

The collected documents in digital format were classified into different folders stored in my laptop. I used Evernote to take notes during the fieldwork—a software helps to organize my notes anytime and anywhere. A total of 50 field notes containing focus group discussion minutes, semi-structured interviews and casual talks with different stakeholders, and field observations on public events and rural livelihoods were stored in Evernote. These notes were named after time, place, and participants. For interviews, I took shorthand notes during the conversations and sorted out the interview transcripts on the same day, expanding on the detailed information according to my recollection. I only transcribed audio recordings of interviews with key informants when necessary, while other interviews were manually documented in a timely manner, even with some interesting and thought-provoking direct quotes.

To comprehensively analyze the contextual dynamics of agricultural development and water reforms in China, I conducted a meticulous review of documentary archives, including government publications, policy drafts, historical records, and scholarly analyses. This process involved identifying critical turning points, such as the launch of the "Building New Socialist Countryside" campaign in 2006, alongside key figures who shaped policy trajectories and government discourses surrounding agricultural modernization and water governance. Through qualitative content analysis, I systematically categorized these materials to map evolving political economics of China's agrarian change, which provided broader and nested institutional contexts where this study was situated. Concurrently, field notes stored in Evernote were iteratively re-examined to identify emergent themes and contextual nuances. This iterative reading fostered data triangulation, enhancing the reliability of insights before transferring and coding the annotated notes in QSR NVivo 12, a qualitative data analysis software.

3.4.2 Coding and analysis approach

I used both descriptive and interpretive coding strategies to conduct a thematic analysis of the data (Clarke and Braun, 2013), which enables categories and concepts are contextualized and constructed in the process of iterations between data and my interpretations (Glaser and Strauss, 1967; Patton, 2002). Initially, I adopted a closed coding strategy to descriptively label the basic information of each piece of field notes, encompassing elements such as names, located places, groups of participants, discussion topics, etc. Subsequently, I implemented an open coding strategy to categorize research themes and interpret the diverse, grounded water governance arrangements and practices reported by the informants. Multi-level data were linked and brought together with theories through tracking back or following clues from local sites, which contributed to identifying the key themes, issues, and meanings in the data sets with both data-driven and theory-driven analyses.

With a combination of deductive and inductive coding strategies, I organized the material into nodes addressing themes like "infrastructure production and technological adoption", "grassroots irrigation organizations", "water rights transfer", "central-local tensions", "state-society relations", and "state-market relations", each of them containing secondary and even third-layer nodes. This thematic analysis approach enabled a holistic and contextual understanding of how historical legacies, bureaucratic decision-making, grassroots adaptation, and everyday practices intersected to shape China's agricultural modernization and water transformations.

I understand that data analysis in qualitative research is a circular process, in which researchers engage in continuous interpretation, reflection, and refinement throughout every stage of the project (Thorne, 2000). Therefore, data analysis occurs before, during, and after data collection. The abovementioned archive analysis, fieldnote re-reading, and the hybrid coding process have evolved iteratively, allowing me to triangulate findings across data types and capture dynamic interactions between structure, agency, and context.

3.5 Ethics and positionality

3.5.1 Research ethics

Ethical concerns were taken into serious consideration in this research. I was given ethical clearance in July 2022 by the School of Global Development Research Ethics Subcommittee under the UEA research ethics protocol. During the fieldwork, I honestly introduced myself as a postgraduate researcher who is pursuing a doctoral degree, and openly conveyed the purpose of my research to the participants. In the Chinese rural society, the identity as a university student is admirable. Especially, I was enrolled in a split-site PhD program from the world-leading universities both at home and abroad. This identity makes me less harmful and my honesty has helped build up trust among governmental officers and local villagers. They were talkative on the topic of agricultural and water transformations, and were proud to share their life stories and working experiences with me.

I followed the principle of using consent sheets to gain permission from participants for data collection, recording, and photography. I had brought consent and information forms (see Appendix C for details), but I didn't ask people to sign their name on it. This is because in the Chinese context, signing one's name means a commitment to take up responsibility. Especially for governmental officials, they are cautious to sign any paper. Instead, I showed the consent forms to the participants and asked for their verbal consent to participate in my research project before or during the data collection processes.

In particular, Peter Walker (2007) raised a critical but less visible ethical dilemma in political ecology research. He argued that political ecologists have made the most of people's stories, experiences, and knowledge to advance their academic careers, while providing few tangible benefits or positive changes to the communities and individuals. While I agree that researchers do have the obligations to "give back" to their participants, I believe this reciprocity could be made in various ways. Beyond huge material and participatory interventions, elevating marginalized narratives—making invisible struggles visible and amplifying silenced voices—can itself constitute a meaningful form of ethical engagement.

In my own research, I cared about the feelings and agency of vulnerable groups (e.g. the poor, the left-behind elderly, and smallholders), and clearly informed them of their rights to withdraw from the study at any time. I explicated that my research is not aiming for profits and would avoid negative impacts on their daily lives. Recognizing the potential ethical complications of monetary compensation such as power imbalances or perceived transactional dynamics (Lunn, 2014), I instead brought small gifts like pens, milk, and fruits to the participants as culturally appropriate gestures of gratitude. For example, when invited to a local household's celebration of their newborn, I gave a university-branded souvenir pen as a token of goodwill and a symbolic blessing for the child's future. While such actions may seem modest compared to tangible positive changes, ensuring their stories are heard with respect and integrity, I argue, is a part of a broader ethical commitment.

The collected data are only used for academic research. Personal information of participants is protected through anonymization and confidentiality. All data are locked and stored in password protected phones and laptops. The original non-anonymized records even have additional protection and encryption.

3.5.2 Positionality and reflexivity

I acknowledge that my positionality may make a difference on the research findings and relationships with participants in the field, and that reflexivity is important for researchers to identify their own role in the generation and interpretation of data (Emerson et al., 2011). As a young, female, and doctoral student, there are power asymmetries and biases in the access to different kinds of knowledge in rural China (Lowell et al., 2024). For example, senior male officials often dominated the conversation in the focus group discussions and semi-structured interviews, talking about their own working accomplishments. In this case, I could only listen respectfully at the beginning, while seized opportunities to shift the topics or reapproached them privately at lunch or dinner table. In addition, some bureaucratic elites were not willing to share personal views on the negative impacts of reforms. In this case, I tried to prompt with some open-ended questions to get a sense of what they were comfortable to talk about, and then asked for details.

Moreover, I realized implicit gender dynamics during the fieldwork and data collection process, as most key informants I encountered were male including water bureaucrats, village cadres, and large producers. To mitigate the male-dominated perspectives, I have actively tried to reach out to more female participants to incorporate their viewpoints and lived experiences. There were also nuanced power relations in rural communities, given the fact that I had connections with both government entities, private companies, large producers, and smallholders. To avoid involving in any conflict, I didn't stand by any side; rather, I remained neutral and open-minded to their views and learnt to balance distance with involvement in farming communities (Heimer and Thøgersen, 2006).

As a Cantonese born and raised in southern China, I also encountered cultural differences when conducting fieldwork in northern China. Although the local dialect sounds quite similar to Mandarin which I am good at, sometimes I had still misunderstood what the elderly or the native speakers said about, and I needed to reiterate for clarification. This happened when I first arrived in Tancheng, but I gradually adapted myself to the locale after several dialogical engagement with local people. In particular, I learnt a lot of local dialects from taxi drivers every time I commuted to the field (They are really cultural messagers!). Now I am even used to saying “Jiang” instead of its Mandarin pronunciation “Gang” to name one of the townships.

Shandong is renowned for its deeply embedded drinking culture, which functions as a critical mechanism for social bonding and institutional trust-building. During my fieldwork, I was surprised by intricate dining and drinking etiquette practiced by the Shandong people, such as the strict hierarchy of toasts, the use of both hands when offering/receiving drinks, and the practice of keeping guests’ glasses perpetually full. These rituals are not mere formalities; they operationalize “*Renqing*” (in Chinese), a deeply valued social norm in Chinese culture emphasizing the importance of reciprocal exchange to sustain interpersonal relationships, particularly manifesting at dining tables and alcohol-infused feasts (Bian, 2001; Wang, 2014; Lin et al., 2025). Through dining and drinking with bureaucrats and village elites, I recognized the role of such social networking in building rapport, gaining access to the field, and connecting with a broader range of informants. However, it also entangled the researcher in local patronage systems, where the obligation to reciprocate favors shifted bargaining power toward informants. After accepting lavish hospitality, I sometimes felt pressure to reciprocate through research assistance or policy advocacy, which may influence data interpretation or disclosure. Also, refusing drinks occasionally strained rapport with key elites.

I understand that doing fieldwork is a process of building relationships between the participants and myself through trust, friendliness, respect, and communication. In this process, I don’t regard myself as the outsider who is observing from a bird’s-eye view, but as the insider who walks in the field wandering and tracing people’s everyday life, according to Michel de Certeau’s (1984) study. It is also a process of self-discovery and self-education of the researcher (Daniels, 1983), during which I have had my physical and mental health grown and deepened my understanding of the real-world society through coping and learning.

3.6 Summary

In this chapter, I described the critical realism epistemology and case study methodology to design and conduct my research project. I introduced the case study area, methods to collect data during the fieldwork, and the data analysis approach. I also reflected on the ethical considerations and my positionality of being a researcher in the field. The next chapter provides further contextual information about the political and socio-economic settings in both China and the case study area of Tancheng.

Chapter 4 Research context

This chapter introduces China's agricultural modernization and water governance evolution at the national level, followed by the background information of the case study area in Tancheng county. Tancheng is one of the main grain-producing counties in China with a long history of food production and is experiencing a rapid transformation of agricultural modernization, industrialization, and urbanization with significant impacts on water and water governance. And thus, it provides a unique case study to examine the interrelationships between agricultural modernization and water governance. This chapter begins with a concise outline of the structure of China' s political system. The following section 4.2 first reviews the development of the Green Revolution and national food security campaigns in China, and then spotlights associated land reforms and governmental infrastructure projects. Section 4.3 traces the evolution of water governance philosophy and approaches since the founding of the People's Republic of China in 1949, in particularly, introducing main actors in the water governance system. Then, I respectively report the basic geography and its fast-developing agricultural modernization, industrialization, and urbanization in Tancheng (in section 4.4) before ending up with a brief summary.

4.1 Political structure of the party-state system

China is a party-state in which CPC governs and co-exists with the Chinese government. The National Party Congress and its elected Central Committee are the highest leadership of the party. The Politburo and its Standing Committee are the command headquarters of the party. The Central Committee meetings (plenum) are convened by the Politburo once a year to discuss and announce policies. Under the central leadership of CPC, party committees are established at each level of the locality in parallel with government administrative structures.

China has five levels of governments nested in a multi-layered administrative structure: the central, province, prefecture, county, and township (see Figure 4.1). This governance structure at various hierarchies was established by the 4th Constitution of the People's Republic of China released in 1982. At the central level, the National People's Congress and its Standing Committee exercise the highest legislative power, and the State Council with its ministries and commissions are top executive bodies for administration. At the provincial level, there are 23 Provinces, 5 Autonomous Regions, 4 Municipalities, and 2 Special Administrative Regions. Provinces have autonomous authority and control the appointments of all but highest provincial officials. Subordinated to the provinces are local governing bodies including prefectures, counties or districts, and townships (Färber and Wang, 2018). At the prefectural level, there are cities or autonomous prefectures that function as economic centers. The county-level governments are major implementers of policies and they have both formal and informal institutional arrangements for decision-making and policy implementation (Oi, 1999). Township is the lowest level of administrative government and governs neighborhood and village committees with limited formal authority and resources (Yang, 2022).

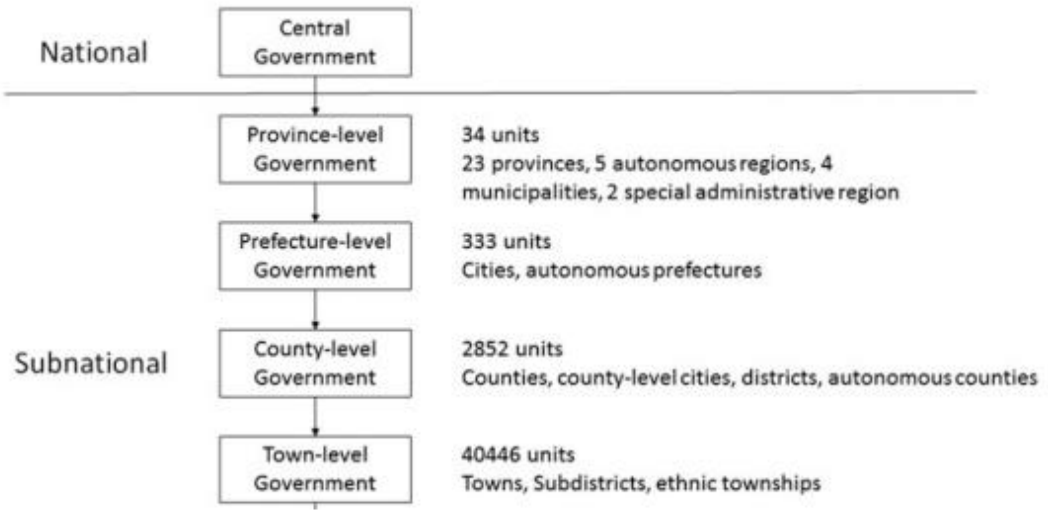

Figure 4.1. A hierarchical structure of government in China.

Source: Färber and Wang (2018). Note: The Chinese government will optimize and adjust its administrative divisions according to dynamic political and socioeconomic factors. This figure is based on data collected at the end of 2012.

The nationwide bureaucratic system is called "*tiao-kuai*" system that meshes both vertical (coordination from center to locality) and horizontal (coordination within a given geographic area) governing bodies. "Vertical" lines of functional agencies (*tiao*) reach down from ministries of the central government through a five-tier administrative structure and assign normal economic and social governance responsibilities, while "horizontal" threads of territorially-based government units (*kuai*) coordinate within localities that they govern under the leadership of each layer of government (Cai et al., 2022). Functional and territorial governments who share the same bureaucratic rank, ministers and provincial governments for example, can not issue a binding order to each other. It has therefore long been challenging to coordinate two lines of authorities segmented by territory, by function, and by ranking (Liu et al., 2022). It is fragmented over a honeycomb-liked administrative system in which cross-level and cross-sectoral bureaucrats bargain and negotiate in the policy battlefield (Lieberthal and Oksenberg, 1988; Lieberthal and Lampton, 1992).

For example, at the county-level (see Figure 4.2), the county party committee exercises leadership over the county government, setting the overall policy goals and directions and appointing key government officials; while the county government is the executive body of the county's administration for policy implementation. Both the county party committee and the county government have parallel structures, with their own commissions and departments, and are respectively responsible for the party committee or the government of the higher level. The county government departments are functional agencies and need to report work to at least two immediate supervisors. The first one is their counterparts at an upper level of the territorial hierarchy in the same functional system ("*tiao*"), and the second one is the county government at the same level of the territorial unit ("*kuai*").

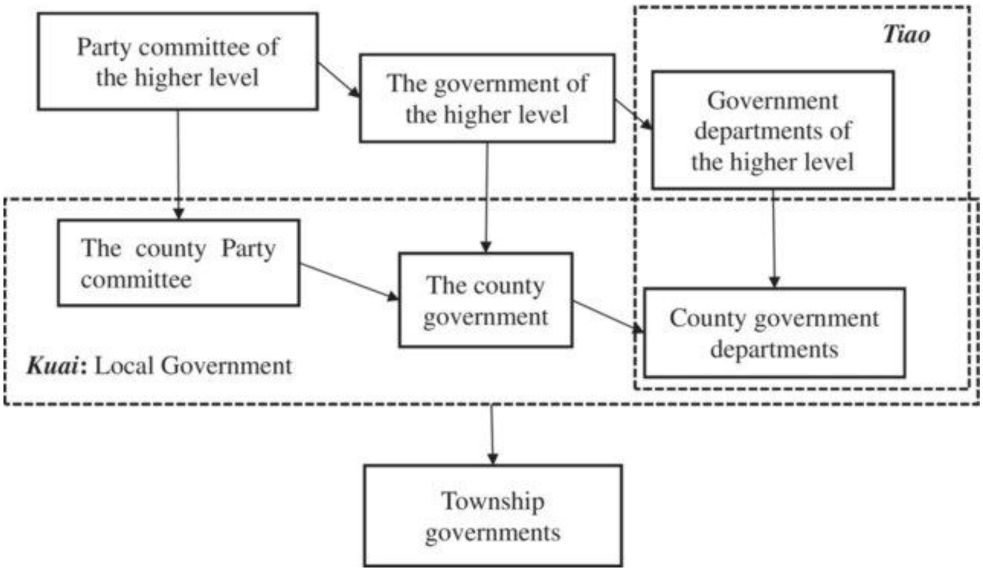

Figure 4.2. An organizational structure of the Chinese county government.

Source: Cai et al. (2022). Note: "*Tiao*" describes the assignment of the normal economic and social governance responsibilities to specific departments from the central government. "*Kuai*" refers to the leadership of each layer of government that receives tasks and guidance from a higher-level government.

4.2 Agricultural modernization in China

4.2.1 The Green Revolution and national food security campaigns

Since the founding of the People's Republic of China in 1949, the Chinese government has embarked on the Four Modernization—agriculture, industry, science and technology, and militarization—to eradicate hunger, poverty and backwardness across the new socialist country. These Four Modernization missions were officially launched in 1964 by the then Premier Zhou Enlai[7], and marked the beginning of the Green Revolution in China. Since then, the Chinese government has been committed to a major technical transformation for agriculture with expanded government-sponsored agricultural research

[7] The "Four Modernization" aims to build a strong socialist country with modern agriculture, modern industry, modern science and technology, and modern national defense (Zhou, 1984).

and evolutionary technologies of high-yielding dwarf rice and winter wheat varieties, chemical fertilizers, irrigation, and mechanization (Hurt, 2020). The technological outbreak in agricultural production sustained food supply in the urban area for the beginning of industrialization in new China.

With the development of industrialization and urbanization in the 1990s, as well as the increase in population and the improvement of people's living standards, the demand for food consumption has been rapidly growing. Meanwhile, the constraints on food production, such as the reduction of cultivated land, the decrease of soil fertility, water resource scarcity, and rural-urban migration, were becoming increasingly prominent in China. As gain-production reached its limits for land areas and yields, many young generations from rural communities (averaging only 45% of urban incomes) left for employment in the cities, leaving the elderly, women, and children to till the land (Hurt, 2020). Lester Brown (1995) released a report on "*Who will feed China?*" and showed that the area of arable land fell from 90.8 million hectares in 1990 to 85.7 million hectares in 1994 with a decrease of 1.4% per year, while the total population reached over 1.2 billion with an increase of 59 million in the meanwhile and was anticipated to reach a peak of 1.66 billion in 2045. He urgently warned that China's food shortage and food import in the near future would lead to global food shortages and soaring food prices, causing a global food crisis if no actions taken immediately. This warning call attracted highly attention of Chinese political leaders and policymakers. The first white paper on food security in China was launched in 1996, in which food security was considered as an important matter of national security. And the Chinese state promised to maintain a self-sufficient grain production rate of 95% with imports not exceeding 5% of domestic consumption (State Council, 1996).

Rural poverty was regarded as a root cause for food insecurity and a new wave of agricultural modernization was initiated by the central government in 2006, followed by the No.1 Central Policy "Building New Socialist Countryside" issued by the Central

Committee of the CPC and the State Council. This wave of agricultural modernization, under the then leadership of President Hu Jintao and Premier Wen Jiabao (2002-2011), emphasized to continually transform traditional, manual, and inefficient agricultural production with modern science and technology as well as economics and management, in order to create a moderate scale, mechanized, standardized, intensified and commercialized agriculture system with efficient use of land, water, labor, etc. (CPC, 2006). With food security as its core, the objectives of modern agriculture encompass comprehensively improving food productivity and enhancing economic and social stability in the countryside amidst rapid urbanization and a widening urban-rural divide (Ye, 2015; Zhang et al., 2015).

Placing agricultural modernization at the front, it aimed to improve rural livelihoods and secure the future of farming communities through well-equipped, high-yield, and high-quality agricultural production. In 2008, the National Development and Reform Commission (NDRC) issued a mid- and long-term plan for national food security and set up major targets for farmland protection and food production by 2010 and 2020 (see Table 4.1). It established a red line of arable land area of 120 million hectares (1.8 billion *mu*) in order to maintain self-sufficiency for grain security, and enacted a strict protection system for permanent basic farmland that is mainly dedicated to producing food crops such as rice, wheat and corn, and cannot be converted into other types of agricultural land, such as forest and orchard (Ministry of Land Resources, 2005).

Since President Xi Jinping took the lead in 2012, the central leadership further determined to “hold firm the rice bowl in our own hands” and introduced a national food security strategy of “sustainable farmland use and innovative application of agricultural technology to increase farmland productivity” (“藏粮于地、藏粮于技” in Chinese). The “Rural Revitalization” campaign was further launched in 2018 to modernize countryside and improve agricultural quality, efficiency, and productivity with advanced technologies and management (CPC, 2018).

Table 4.1. Main indicators to ensure national food security.

Indicator	2007	2010	2020	Status
Area of farmland/ hundred million *mu*	18.26	⩾18.0	⩾18.0	Mandatory
Area of basic farmland/ hundred million *mu*	11.2	＞11.0	＞11.0	Expected
Area of food production/ hundred million *mu*	15.86	15.8	15.8	Mandatory
Area of grain production/ hundred million *mu*	12.88	12.7	12.6	Expected
Grain yield/ kilogram per *mu*	316.2	325	350	Expected
Food production capability/ hundred million kilogram	5016	⩾5000	＞5400	Mandatory
Grain production capability/ hundred million kilogram	4563	⩾4500	＞4750	Mandatory

Source: NDRC (2008). Note: According to the National Bureau of Statistics, food production capability refers to the total output of cereals (e.g. rice, wheat, corn, sorghum, oats, buckwheat, etc.), beans (e.g. soybeans, mung beans, red beans, etc.), and potatoes including sweet potatoes in the current year. Grain production mainly refers to three major types of cereals, such as rice, wheat, and corn in China.

Over the past decades, the Chinese government has worked hard to make the whole country basically self-sufficient in food supply, producing a quarter of the world's food in 7% of the world's arable land and feeding a fifth of the world's population (Chen, 2022). According to the updated white paper on food security (State Council, 2019), the total output of food production in China reached nearly 660 million tons in 2018, increasing more than 30% from 500 million tons in 1996. In accordance with agricultural modernization and national food security campaigns, China also launched a series of institutional reforms in land tenure and farming operation, and significantly increased public expenditures in agriculture production, which are detailed in the following sections.

4.2.2 Land and agricultural production reforms

The land reform played an important role in China's rural development and has accelerated the process of agricultural modernization. In 1953, the Chinese government started the collectivization of agricultural production and all private land was distributed to the state or village collective economic organizations (see Table 4.2). By 1956, the state had completely collectivized farming through the formation of agricultural production cooperatives, which replaced the earlier mutual aid teams set up in the early 1950s. In 1958, people's communes were established, and each commune was divided into several production brigades (the former agricultural production cooperatives) to manage a portion of the commune's land. Within each production brigade, there were smaller units of production teams responsible for day-to-day farming operations (Zhou et al., 2021). Under the unitary collective ownership of land, agricultural production was centrally planned with the state procurement of grain and other agricultural products. Each commune had production targets, and commune members worked together in the fields and shared the product and annual incomes, which were distributed based on "work points" earned through individual labor (Hurt, 2020; Zhou et al., 2021).

Table 4.2. Agricultural land reforms in China.

Phase	Rural land status	Policy and law	Production and operation
1953-1977	Rural collective ownership	Rural People's Commune Regulations (Amendment) 1962	Collective farming, people's communes, production brigades, and production teams
1978-2013	Household Responsibility System and Two Rights separation	Rural Land Contract Law 2002, Rural Land Contract Law (1st Amendment) 2009	Family-based farming, formal and informal land transfer
2014-present	Three Rights separation	Rural Land Contract Law (2nd Amendment) 2018	Moderate-scale farming operation, family farms, farmer cooperatives and agribusinesses

Source: Zhou et al. (2021).

As China's reform and opening-up policy was initiated in 1978, rural economy gradually transited to a market-oriented economy, however, still with state's direction. President Deng Xiaoping at that time formally terminated the people's commune system, replacing it with township governments (the former people's communes) and village committees (the former production brigades) (CPC, 1983). A de-collective land reform known as "Household Responsibility System" (HRS) was initiated to mobilize personal enthusiasm by providing greater flexibility in grain production. Under the HRS, land ownership and land contract rights were separated. Peasant households were contracted with land use rights and could operate agricultural production independently, while the land ownership remained collectively (Ye, 2015; Zhou et al., 2021). Individual remuneration now depended on production rather than work points. Peasant households were obligated to meet state procurement quotas (that is, the amount of crops that farmers had to sell to the government), after which they could grow additional crops or sell surplus for profit in local markets (Harvey, 2005; Ye, 2015; Huang and Rozelle, 2018). In the mid-1980s, the Chinese government ended its mandatory procurement quota and would purchase certain quantities of selected agricultural commodities at contracted prices. Although land transfer was limited in this stage, informal land leasing and transfer activities among neighbors and relatives began to emerge, particularly when increasing rural migrants flowing to cities for jobs in the 1990s.

To promote agricultural modernization and rural economic development, the Rural Land Contract Law of China was adopted by the Ninth National People's Congress in 2002, further clarifying the legal status of peasants' land contract rights and land transfer. Both formal and informal land transfer activities proliferated in rural China. Since 2006, the Chinese government has further increased its support to develop various forms of moderate-scale farming and enhance agricultural productivity, encouraging peasant households to transfer their contracted land through subcontracting, leasing, exchanging, transferring, and forming shareholding cooperatives. A series of policy documents have been issued since 2013 to standardize the procedures, rights protection, and supervision measures for land transfer, known as the “Three Rights Separation” (see Figure 4.3). Under this reform, the three rights over rural land were separated into (1) collective ownership of rural land, (2) peasant households contract rights, and (3) rural land management rights. The ownership of rural land remains to the village collective, while individual peasant households retain the contract rights, and management rights become transferable to investors who work on agricultural production on the ground (Wang and Zhang, 2017; Huang and Rozelle, 2018; Zhou et al., 2020).

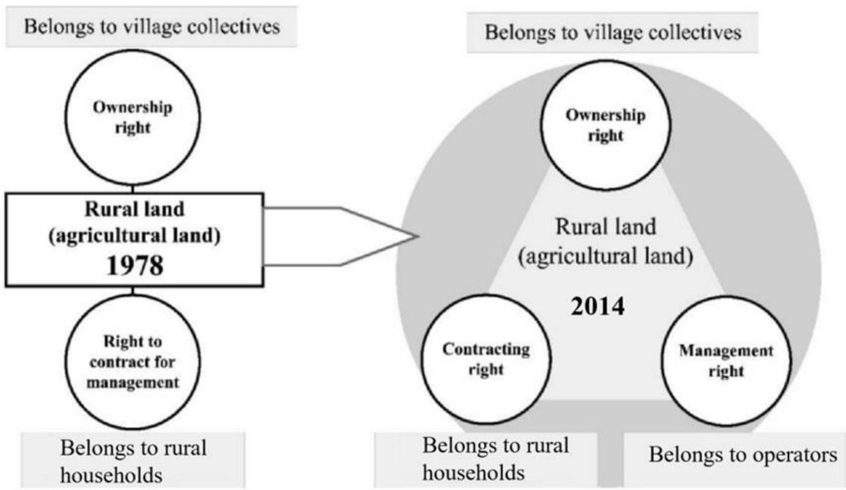

Figure 4.3. Three Rights Separation of rural land.

Source: Zhou et al. (2020)

The primary object of this land reform is to facilitate the transfer of contracted land from traditional and fragmented plots to commercial and concentrated ones, thereby reformed rural production relations, formed moderate-scale operations, and cultivated professional agricultural service organizations and new agricultural operation entities, such as large households, family farms, farmer cooperatives, and agribusiness companies (CPC, 2017).

4.2.3 Governmental investment and infrastructural projects

Unlike many developing countries that depend on international aid and foreign-imported packages for agricultural modernization, China's approach is distinguished by a central role of the state. Redirecting resources to rural areas through project initiatives is a strategy utilized by the Chinese government to advance agricultural modernization and rural development. The Green Revolution since the 1960s witnessed substantial government expenditures in agriculture and direct subsidies for smallholders to purchase improved seeds, fertilizers and pesticides, and farm machinery (see Table 4.3).

However, the proportion of government funds on agriculture, relative to total government spending, decreased in mid-1980s. In particular, agricultural expenditures on farmland irrigation and water conservation were significantly reduced from 7.1% in 1978 to merely 1.9% in 1988 (Wang et al., 2019). This substantial reduction in funding led to the deterioration or destruction of many collectively owned irrigation facilities, raising agricultural production risks and rural poverty in the 1990s.

Table 4.3. Government expenditures on agriculture in China.

Year	**Agricultural expenditure** (million dollars)	**Total government expenditure** (%)
1972	11,595	8.5
1975	17,843	12.1
1980	24,542	12.4
1985	21,113	8.3

Source: Hazell (2009), calculated by1985 US dollars (purchasing power parity).

To narrow the widening development gap between urban and rural areas, the Chinese state has channeled subsidies and urban-industrial capital into rural areas since the 2000s. Since 2003, the Chinese government has embarked on a nationwide agricultural tax reform to reduce the burden on farmers[8]. Since the No.1 Central Policy's inception in 2005, annual government investments in agriculture have significantly increased. The central government has established specific funds and directed substantial budget allocations towards farmland and water conservancy infrastructural projects to improve the fundamental conditions for agricultural production, particularly renovating or reconstructing the aging and deteriorating irrigation facilities (see Table 4.4). Several central ministries or commissions have earmarked different field engineering construction projects to improve the quality of farmland and end-use efficiency of agricultural water.

For example, the State Agriculture Comprehensive Development Office has granted funds to upgrade medium- and low-yield fields with supporting irrigation infrastructures. NDRC has subsidized farmland waterworks to increase grain production capacity. The Ministry of Water Resources (MWR) has been conducting the "Small-scale Farmland Water Conservancy Key-County Construction Project" in several counties since 2009. Small-scale farmland irrigation infrastructures, such as reservoirs, surface and underground pipes, wells, pumping stations, ditches and drains, have been renovated or newly built to expand irrigated areas.

[8] The agricultural tax reform included: 1) the abolition of administrative fees and government-managed funds specially collected from farmers, such as rural education fund-raising; 2) the abolition of slaughterhouse tax; 3) the abolition of rural voluntary labor services; 4) the adjustment of agricultural tax and special agricultural tax policies; 5) reform the methods for reserving, collecting and using rural levies. Following the repeal of the "Regulations on Agricultural Tax" in 2006, the tax on agricultural special products except for tobacco leaves was abolished, and all animal husbandry taxes were exempted (Xinhua Net, 2006).

Table 4.4. No.1 central policy on agricultural and rural development (selected).

Year	Document	Highlight
2005	Opinions on Several Policies for Further Strengthening Rural Work and Improving Overall Agricultural Production Capacity	Setting up special funds to subsidize the construction of farmland and water conservancy projects by the central and provincial governments
2007	Opinions on Actively Developing Modern Agriculture and Promoting the Building of New Socialist Countryside	The construction of farmland water conservancy facilities should be taken as a major task for agricultural modernization.
2008	Opinions on Strengthening Agricultural Infrastructure to Further Promote Agricultural Development and Increase Farmers' Income	The construction of agricultural infrastructure with a focus on farmland water conservancy is an urgent task to reinforce the foundation of agriculture.
2010	Opinions on Increasing the Integration of Urban and Rural Development to Further Solidify the Foundation for the Development of Agriculture and Rural Areas	Prioritizing farmland water conservancy in the construction of agricultural infrastructure, significantly increasing the scale of special funds for subsidies from the central and provincial governments.
2011	Decision on Accelerating the Reform and Development of Water Conservancy	The first systematic deployment of water conservancy reform and development, focusing on accelerating the construction of farmland water conservancy and promoting leapfrog development in water conservancy

Source: Collected by author. Note: The annual No. 1 central policy is the first document issued by the Central Committee of the CPC and the State Council, which conventionally provides directions and specific actions for China's agricultural development and rural reforms.

These farmland and irrigation projects are allocated through special-purpose transfer payments under the China's fiscal system, in which the central government provides financial support to local governments for the implementation of certain projects that are aligned with the policy priority of agricultural modernization and rural revitalization. Local governments or relevant departments apply for funding by submitting project proposals from a multi-layer administrative process (Qu, 2012). Nevertheless, with different departments on board, issues such as scattered use of funds, disordered project designs, varying management requirements and inconsistent investment standards have been prominent (Zhang, 2015). In 2018, the institutional reform proposed integrating responsibilities of various ministries in farmland and irrigation projects. These projects were then synthesized into the “Well-facilitated Farmland Construction Project” (also called the “high-standard farmland project”) led by the Ministry of Agriculture and Rural Affairs (MARA). State funds for small-scale farmland water conservancy, which were previously managed by multiple departments, were integrated as a uniform subsidy.

Led by the MARA, the high-standard farmland project mainly targets consolidated farmland within designated basic farmland protection zones and equips it with irrigation infrastructures suitable for large-scale, intensified, and mechanized agricultural production. Beyond enhancing agricultural productivity and national food security, the high-standard farmland project is expected to lower production costs and boost rural community incomes by improving the quality of cultivated land and soil and enhancing supporting facilities for public interest. It also aims to promote environmentally sustainable agricultural development by encouraging the intensive and efficient use of land and water through well-established infrastructures, including road, electricity and water-saving irrigation systems (MARA, 2021).

The construction of the high-standard farmland project involves eight aspects, such as land, soil, water, road, ecology, electricity, technology, and management (see Table 4.5). With integrated subsidies, it has higher inputs in per unit of land compared with previous projects. From 2019 to 2023, this comprehensive project has received central government subsidies amounting to 305.34 billion yuan[9] and has upgraded more than 29.48 million hectares[10] of high-standard farmland across the country.

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[9] Data are collected from the Ministry of Finance’s central-to-local transfer payment management platform and calculated by the author. Available at: https://www.mof.gov.cn/zhuantihuigu/cczqzyzfglbf/zxzyzf_7788/ntjsbzzj/. [accessed 4 June 2024].

[10] Data are collected from the official website of the MARA and calculated by the author. http://www.ntjss.moa.gov.cn/tzgg/202304/t20230421_6426031.htm?eqid=cea1c6a800175744000000364983466.

Table 4.5. Construction of the high-standard farmland project.

Aspect	Content and standard
Land	Consolidate farmland, appropriately combine the terraced blocks.
Soil	Fertilize soil and promote the integration of water and fertilizer. *Soil thickness reaches 25cm or more, its organic matters increase by 10%, and the pH value is between 6.0 and 7.5.*
Water conservancy	1) Renovate or reconstruct small-scale farmland irrigation infrastructure, such as small dams, ponds, large wells, electromechanical wells, pump stations, etc. 2) Line canals, dredge ditches, culverts and associated facilities to improve irrigation and drainage capabilities. 3) Promote high-efficiency and water-saving technology to increase irrigation efficiency, such as pipe irrigation, sprinkler irrigation and drip irrigation. *Irrigation efficiency rates 50% or more, the design frequency of heavy rain once every 5~10 years, and the farmland drains out of heavy floods within 1~3d.*
Road	Repair and re-build machinery roads, production roads and associated facilities to facilitate mechanization and transportation in the field. *Road accessibility up to 90% with 4~6m width of machinery roads and no more than 3m width of production roads.*
Ecology	Accelerate the construction of shelterbelts and prevent soil erosion.
Electricity	Install high, medium, and low voltage electricity facilities to meet the needs of electromechanical wells and pumping stations for digitalized agricultural production.
Technology	Level up agricultural mechanization, strengthen the training of farmers, and accelerate the transformation and application of scientific and technological achievements.
Management	Identify main entities, responsibilities, and funds for operation and management, and ensure the durable operation of the engineering facilities within their life circles.

Source: MARA (2021).

[accessed 4 June 2024].

4.3 The evolution of water governance in China

4.3.1 Water governance philosophy and approaches

Water governance in China has seen significant shifts, particularly in how water is perceived, utilized, and managed in the face of challenges related to land and water. These shifts are deeply interwoven with broader political and socioeconomic change and structural transformations over the past 70 years.

During the Maoist period, Chairman Mao Zedong held a strong believing that human can conquer, master, and transform nature through agricultural practices, exploiting water to boost agricultural productivity. His famous assertion that “water conservancy is the lifeblood of agriculture” fueled mass and political campaigns to construct extensive water infrastructure, such as dams, reservoirs and canals, to combat floods, enable irrigation, and reinforce socialist ideals of collective production (Shapiro, 2001; Moore, 2018; Xu et al., 2023). From 1950 to 1978, China invested nearly 100 billion *yuan* in water infrastructure, accounting for 6.9% of the total national infrastructure investment. As a result, the area of effectively irrigated land expanded from 16 million hectares in 1950 to over 48 million hectares in 1978, with the percentage of cultivated land equipped with irrigation facilities growing from 16% to 48% (Wang et al., 2019).

Mao’s development strategy not only saw a rapid development of hydraulic infrastructure by mass mobilization of peasant labor, but also left a lasting legacy of a state-hydraulic paradigm that is dependent on techno-engineering solutions (Crow-Miller et al., 2017). With China’s reform and opening up unfolding, the 1980s witnessed a growing demand of industrial and urban water use, driven by agricultural surpluses and labor shifts towards industrialization and urbanization. This period saw a transition from state-centric water management towards a more market-oriented water governance approach, treating water as limited resources to be economically optimized and efficiently allocated.

The 1988 Water Law initiated a regulatory framework for water use, allocation, and conservation in China, introducing a water abstraction permit system to regulate the abstraction of water by individuals or entities. Agricultural water was charged by volumes or land areas, with rates being adjusted upward to cover water conservancy management expenses. Business activities were mandated to apply for licenses and pay water fees proportionate to the volume of water extracted (Article 32, 34). In response to consecutive droughts and growing water scarcity in Northern China in the late 1990s, the Water Law was amended in 2002 and provided a legal framework for water resources allocation at the river basin, regional and sub-regional levels.

Under the 2002 Water Law, water resources are owned by the state. The State Council exercises the ownership over water on behalf of the state, conducting unified planning, management, and allocation of water resources (Article 3). The river basin commission is responsible for allocating water to the provincial governments located within the river basin, according to a long-term allocation plan (see Figure 4.4). Within each province, the provincial water resources department is tasked with the distribution of water resources among various prefectures, and so on down the administrative hierarchy (Article 44-46). Within the administrative regions, the allocation of water to abstractors, such as irrigation districts and urban water supply companies who withdraw water directly from rivers, lakes or underground sources, is regulated by a water abstraction permit system. This system necessitates the acquisition of an abstraction license from local governments that specifies the volume, location, purpose, duration, water source and discharge conditions (Article 48). Water allocation amongst individual end-users takes place within public water supply systems, including farmers in irrigation districts or consumers served by urban water utility companies. According to the long-term water resources allocation plan, which is usually founded on average annual or monthly volumes, water abstraction and usage each year are adjusted in accordance with the actual water availability, as determined by the annual water use plans at each level of allocation (Shen and Speed, 2009).

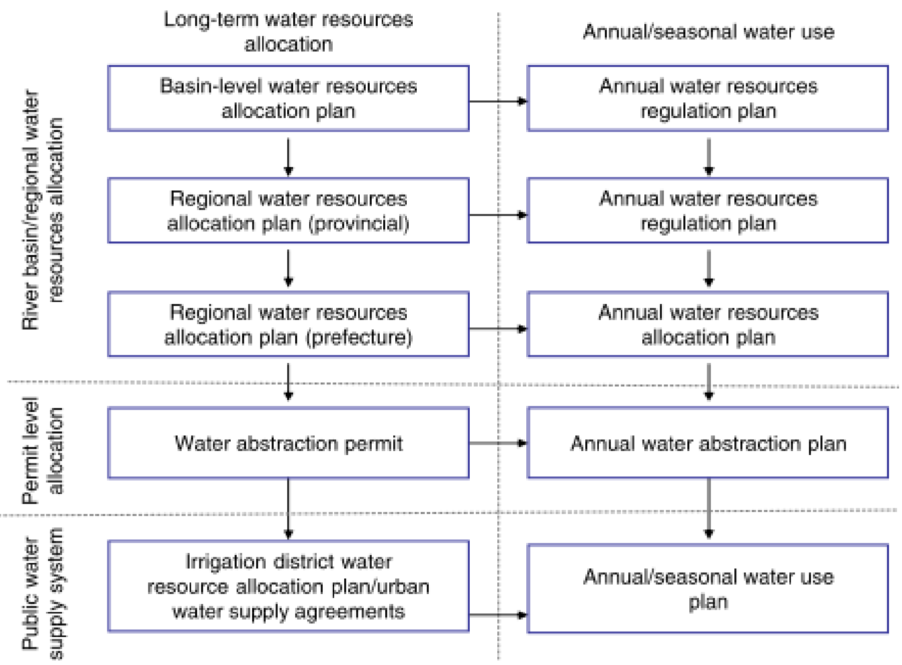

Figure 4.4. Framework of water resources allocation in China.

Source: Shen and Speed (2009).

Within the framework of the centrally planned water allocation, a water-use rights transfer system was introduced to grant the rights to use water to regional administrations, water abstractors and end-users, while the state remains its ownership of water. That is to say, these water-use rights do not constitute private ownership of water; instead, they are water-use quotas defined by a share of the annual mean runoff of a river or water-abstraction permits within the limits of regional water quotas (see Figure 4.5). These water-use quotas are regarded as volumetric tradable water-use rights to facilitate a quasi-market for water trades amongst regional governments, between sectors (e.g. factories, water supply companies, and irrigation districts), and amongst individual farmers (Speed, 2009; Zheng et al., 2021). For example, industries could claim extra water-use rights from the irrigation districts through renovating and investing in water-saving facilities, such as lining the main and branch canals with concrete and installing underground pipes to enhance irrigation efficiency.

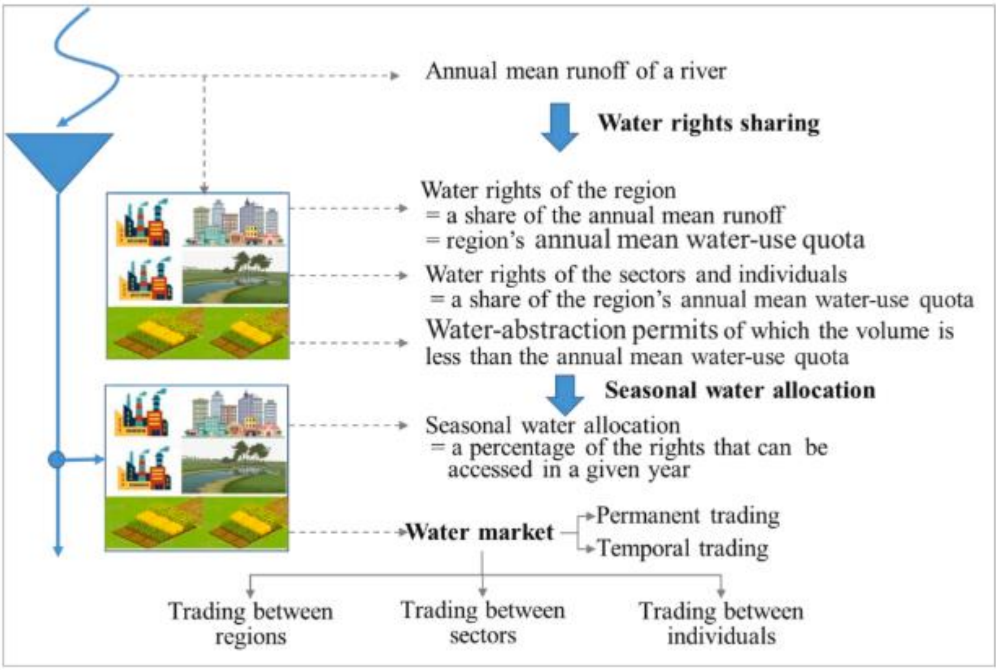

Figure 4.5. Framework of water rights transfer in China.

Source: Zheng et al. (2021).

A "two-hand" approach of water governance with coordinating state and market efforts was reinforced under President Xi's leadership. In contrast to previous market maneuvers, the government is more active in balancing the treatment of water as both commons and commodities, and addressing several water challenges. Following the "Strictest Water Resources Management System" (also known as the "three red lines" policy) in 2011, which set forth strict controls on the total water use, water use efficiency, and water waste and pollution (State Council, 2012), a comprehensive monitoring and evaluation framework on water use was established in 2014. Local governments were assigned with specific water quotas, and local officials were required to provide detailed and regular work updates to their superiors (Moore and Yu, 2020).

While remaining control, the state has also played a pivotal role in facilitating the development of water markets, establishing a tradable water-use rights system with supporting mechanisms. In 2014, seven provinces and autonomous regions, including

Ningxia, Inner Mongolia, Gansu, Guangdong, Henan, Jiangxi and Hebei, were selected to explore three types of water trades across the whole province. The China Water Exchange platform was established in Beijing in 2016 to oversee water trading practices and offer consultation services (Jiang et al., 2020). Furthermore, a comprehensive reform of agricultural water price and the water pricing system for additional uses in the industrial and service sectors, as well as for domestic consumption by urban residents, has been gradually implemented. This reform differentiated water price between the quantity, source (e.g. groundwater and surface water), and type of water use (Moore and Yu, 2020).

However, a mixed success of these water reforms was found. The practice of water transfers has been confined to ad hoc initiatives to a limited degree (Speed, 2009; Sun et al., 2016). Agricultural water prices have not been adjusted sufficiently to cover the full cost of water provision or to encourage water-saving measures (Webber et al., 2008). With agricultural water supply continuing to receive substantial subsidies from the state, mainly through fiscal transfer payments from the central government, challenges persist in empowering village autonomous governance and achieving water sustainability over the long term.

4.3.2 Main actors in the water governance system

China's water governance system is structured hierarchically, extending from the MWR to the river basin commissions, and further to provincial, prefectural, and county-level water resources bureaus. The MWR, as the water administrative department under the State Council, has an overall responsibility for the formulation and implementation of China's water policies.

The 2002 Water Law stipulates a water governance system that integrates river basin management with administrative region management (Article 12). Under the MWR's leadership, river basin commissions are established for seven major river basins in China. These commissions are responsible for comprehensive planning, unified allocation, coordinated development and conservation of water resources at the river basin level. Given that these basins often span multiple provinces, the commissions have to work collaboratively with provincial water resources departments. Prefectural and county-level water resources bureaus function as hierarchical administrative entities, responsible for water development, management, and conservation within their respective jurisdictions.

In addition to river basin management, China has established irrigation districts to govern agricultural water use in the water sector, which were primarily set up between the 1950s and 1970s. For irrigation districts within one single administrative jurisdiction in a certain county, prefecture or province, the water resources department at that level is responsible for its management. In case where irrigation districts across multiple jurisdictions, the responsibility falls to the water resources department at the higher administrative level or the region that benefits most from the irrigation districts (MWR, 1981). The corresponding water resources departments establish specialized management offices for irrigation districts, which operate as quasi-public institutions to allocate agricultural water and maintain small-scale farmland irrigation infrastructures. In response to the challenges of technical upgrading and financial sustainability of irrigation management, decentralized and market-oriented mechanisms have been introduced into irrigation districts nationwide since 1985, with emphases placed on the need to assess and collect water fees based on the cost of water delivery determined by the provincial pricing departments (MWR, 2008).

Water stations serve as the fundamental administrative units for water conservancy at the township level, acting as dispatched agencies of the county-level water resources bureaus and co-led by the township governments. In response to the weakening management of farmland and water conservancy after the break-up of people's communes, water stations were initially established in the mid-1980s to strengthen the irrigation management and service system at the grassroots level (Ministry of Human Resources and MWR, 1986). Following the agricultural modernization and rural development initiatives since 2006, water stations have been integrated into agricultural service centers (including forest, fishery, technology and machinery stations, etc.). This institutional reform has led to a shift in leadership, with the township government taking a more direct role.

The role of village committees in grassroots water governance has evolved over time. During the planned economy era, irrigation and other water-related affairs were managed collectively by the people's communes through mass mobilization. The reform and opening-up policy marked a shift in responsibility from the people's commune system to the village committee. Village committees, recognized as self-governing entities, were tasked with managing a range of rural affairs, including irrigation. They had the authority to collect rural taxes and fees, which funded public irrigation facilities, cooperative health care, and administrative expenses. However, the rural tax and fee reform, culminating in the abolition of agricultural taxes in 2006, limited the village committees' capacity to provide public goods, such as maintaining collective irrigation infrastructures. This led to a "collective action dilemma" in rural communities (Wang et al., 2016).

To encourage participatory and community-based irrigation management in rural China, water users associations (WUAs) were introduced in 1995, supported by the World Bank's Yangtze River Water Resources Project in Hubei and Hunan provinces. Promoted by water resources departments, the number of WUAs has been growing rapidly nationwide. By 2009, it was reported that there were 52,700 WUAs throughout China, encompassing 23% of the irrigated farmland, and more than 20,600 had been registered with local civil affairs bureaus (Nickum, 2010). Whereas, many WUAs are constraint by financial and labor resources. They often overlap organizationally and functionally with village committees, and in some cases, are dominated by village committee elites. Consequently, the expected level of community participation in self-governing irrigation governance has not been fully realized (Li, 2009; Nickum, 2010).

4.4 Tancheng county in Shandong province

4.4.1 Basic geography

North China Plain is an important agricultural production area, encompassing three main river basins—the Yellow River Basin, the Huai River Basin, and the Hai River Basin—and covers approximately 44.17 million hectares cross seven administrative jurisdictions: Beijing, Tianjin, Hebei, Shandong, Henan, Anhui, and Jiangsu (see Figure 4.6).

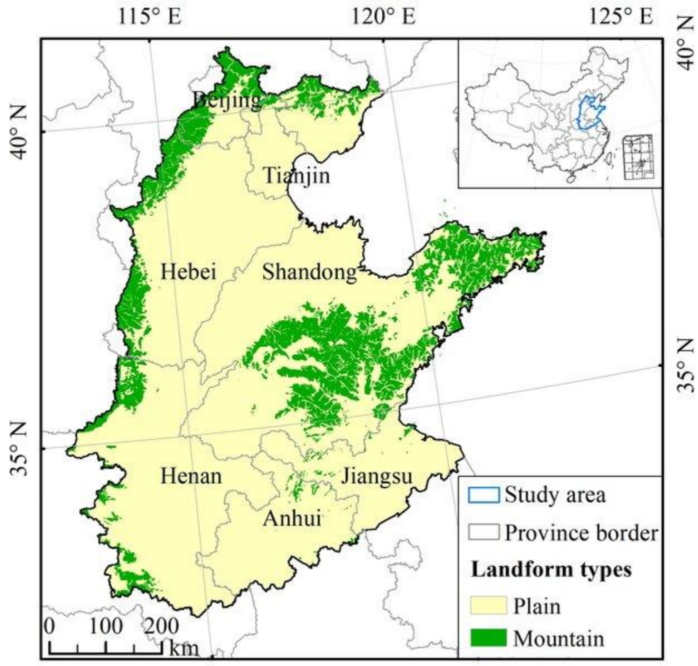

Figure 4.6. Map of the North China Plain.
Source: Yang et al. (2018)

Shandong is situated in the eastern coastal line of China to the north of Jiangsu Province and to the south of Hebei Province, with Anhui Province to the southwest and Henan Province to the west. It covers the Yellow River Basin and the Huai River Basin with over 156.7 thousand square kilometers and a hundred million population, ranking the second most populous provinces in China. Shandong is one of the important agricultural production bases even though it is constrained by water resources, irrigating approximately 5% of the national farmland, producing 8% of the total grain output and supporting 7% of the national population with only 1% of the country's water resources (Qiu, 2023).

Tancheng county is located at two tributaries of the Huai River Basin— Yi River and Shu River— at the southern part of Linyi prefecture in Shandong province (see Figure 4.7). It has a generally flat terrain, with small hills in the north and northeast. With 45 main rivers and streams crisscrossing the county, it provides significant surface water for irrigation; while its groundwater is mainly exploited for drinking water supply and industrial purposes. Tancheng receives abundant and concentrated rainfall in July and August, with monthly precipitation over 160mm on average amongst a total annual precipitation of 868mm. The maximum temperature is around 30 °C on average in July, and the minimum temperature is -4.2 °C on average in January. Historically, floods and droughts happened alternately year after year.

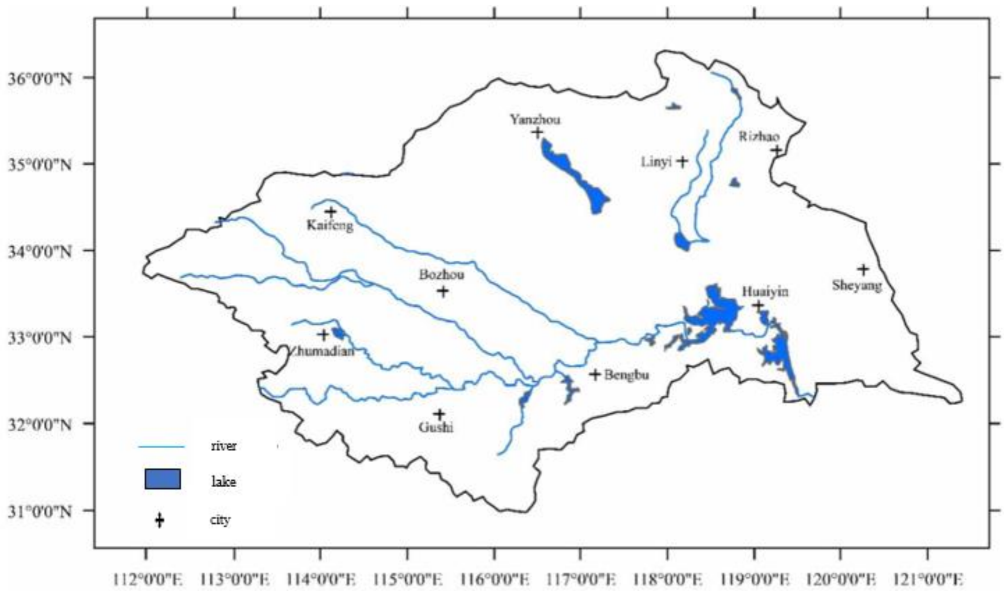

Figure 4.7. Map of the Huai River Basin

Source: Zhao et al. (2022).

4.4.2 Agricultural production

Tancheng is one of the main grain-producing counties in China with a total of 56,355 hectares of farmland that alternates between wheat (winter crop) and corn or rice (summer crop) throughout the year. The development of agricultural production is closely linked with the historical and geographical transformations of the county's water and landscape. In response to the state's "Control the Huai River Movement"[11] in the early 1950s, the county government initiated a large-scale recruitment of mass labor to combat flooding and waterlogging in the Huai River Basin. Although the initial focus of the hydraulic engineering projects was on flood control, the latter half of the decade marked a new phase of the collective farming era, which was characterized by an emphasis on enhancing water productivity through the development of hydropower and irrigated agriculture (Pietz, 2010; Marks, 2017). Extensive water conservancy facilities such as reservoirs, storage dams, and ditches were constructed through mass mobilization of rural labor. This wave of hydraulic construction has greatly changed its agricultural production conditions and enabled rice cultivation in the paddy fields since the 1960s (Tancheng County Government, 2021d).

To date, the total area of its grain production has increased to around 95,000 hectares. Amongst which, the wheat planting area reaches around 45,000 hectares, the corn planting area has increased to nearly 27,000 hectares, and the area of rice cultivation remains stable, at around 21,000 hectares (see Figure 4.8).

[11] The Huai River Basin was flooded in the summer of 1950, and Chairman Mao mobilized mass labor to manage the Huai River by dredging the channels and building dikes on its main streams to control floods, as well as constructing earth dams on its tributaries to storge water for irrigation (Marks, 2017).

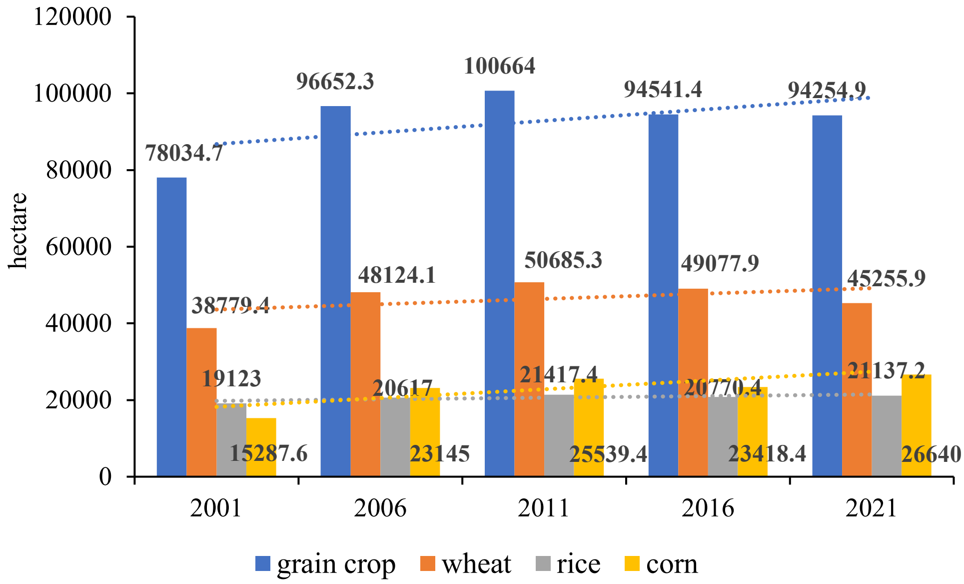

Figure 4.8. Planting area of grain crops in Tancheng.

Source: Local Chronicles Office of Tancheng (2019); Statistics Bureau of Tancheng (2017, 2022).

Compared with grain crops, the proportion of cash crops is relatively low but has been increasing since the market-oriented reform and opening up in the 1980s. As the agricultural structure underwent further adjustments in the 1990s, the area of cash crops increased annually and reached 17,482 hectares in 1999, accounting for 25% of the cultivated land in that year (Tancheng County Government, 2021b). In particular, the county government emphasized industrialized and market-based vegetable production for agricultural development. Commercial vegetable bases in several townships have been established, and the proportion of vegetable in the total cash crop areas exceeded 60%. As we can see from Figure 4.9, the vegetable planting area increased from 2147.7 hectares in 1981 to 16,695 hectares in 2006, before declining and stabilizing at around 10,659 hectares in 2021.

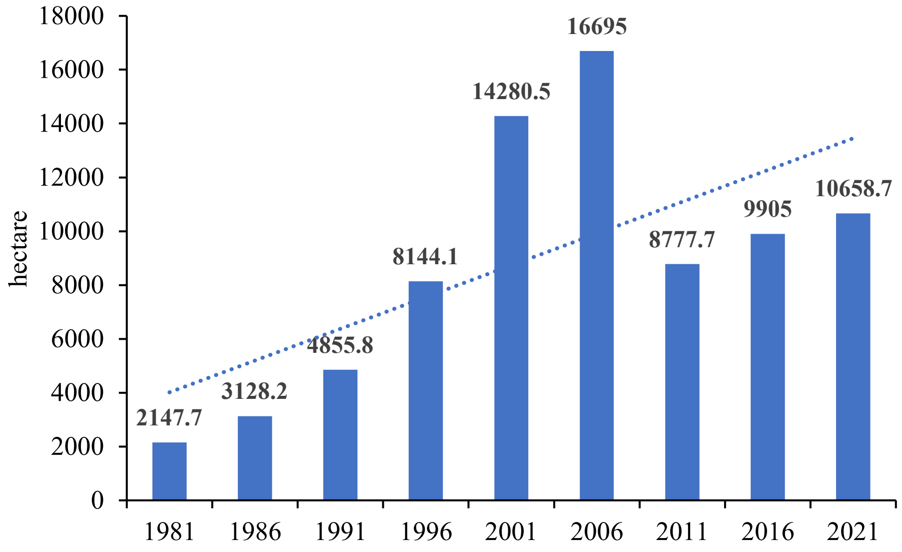

Figure 4.9. Planting area of vegetable in Tancheng.

Source: Local Chronicles Office of Tancheng (2019); Statistics Bureau of Tancheng (2017, 2022).

As a major agricultural county for food production, Tancheng has undertaken several farmland and water conservancy projects supported by various central ministries and commissions. From 2011 to 2015, it implemented a total 29,835 hectares (447,300 *mu*) of farmland and irrigation projects with a total investment of 244 million *yuan*. Among which, 3669 hectares were invested by the County Development and Reform Commission, 2134 hectares were invested by the Agriculture Comprehensive Development Office, 4089 hectares were invested by the Water Resources Bureau, and 19,943 hectares were invested by the Land Resources Bureau (see Table 4.6).

Table 4.6. Farmland and irrigation projects in Tancheng, 2011-2015.

Government agency	**Areas /*mu***	**Investment /million *yuan***	**Input /*yuan* per *mu***
County Development and Reform Commission	55000	48.75	1500
Agriculture Comprehensive Development Office	32000	45.08	1179
Water Resources Bureau	61300	68.20	1036
Land Resources Bureau	299000	81.78	306
Total	447300	244	/

Source: Tancheng County Government (2021c).

Since 2015, Shandong provincial government has been promoting the integration of farmland and water conservancy funds to construct high-standard farmland for modernized agricultural production. Tancheng, as a major agricultural county in Shandong province, was designated as one of the pilot counties for the integration of farmland and irrigation projects into the high-standard farmland project. It was further identified by the provincial government as a pilot county to accelerate the construction process across the entire county in 2021. From 2019 to 2024, Tancheng has been allocated 20,533.3 hectares of the high-standard farmland project, with subsidies totaling 547.2 million *yuan*.

Through the improvement of farmland quality and the efficient use of water resources, the development of high-standard farmland project has significantly advanced agricultural infrastructures and scale of operation. The proportion of irrigated farmland in Tancheng has significantly increased over the years, now accounting for nearly 89% of the total arable land. This, in turn, has improved the overall food production capacity and resilience against natural disasters. The total grain yield increased from 433,600 tons in 2001 to 656,500 tons in 2006, reaching a peak of 808,000 tons in 2010, and has consistently remained above 700,000 tons over the past decades. Concurrently, the county has seen a surge in the number of family farms and professional cooperatives, which reached 685 and 2203, respectively, by 2023 (Song et al., 2023). Additionally, the per capita rural disposable income has significantly increased, from 2627 yuan in 2001 to 20,430 yuan in 2023 (see Figure 4.10).

Figure 4.10. Annual grain yield and per capita rural income in Tancheng.

Source: Data are collected from the annual Statistical Bulletin on National Economic and Social Development in Tancheng, available at the government official website: http://www.tancheng.gov.cn/zjtc/rstc/tjgb.htm.

These newly built irrigation infrastructures, while laudable in their accomplishments, are more than simple technological advancement. They are hotspots of encounters between the state and rural societies. Chapters 5 and 6 will analyze the nuanced politics and power dynamics channeled and manifested through the construction and operation of irrigation infrastructures, which have transformed water access, use, and management.

4.4.3 Industrial and urban development

In parallel with agricultural modernization, Tancheng has also experienced a rapid change of industrialization and urbanization as many other counties in China. These transformations, driven by the market reform, have increased water demands and resulted in competition with farmland and agricultural water use.

According to two national land-use surveys conducted in 2005 and 2020, farmland in Tancheng has declined from 83,437.4 hectares in 1996 to 78,935.8 hectares in 2005, accounting for 60.11% of the total land area. The area of farmland decreased to 71,500 hectares in 2011. In 2020, farmland occupied 56,731.1 hectares, accounting for only 47.47% of the total land area. Meanwhile, construction land in Tancheng has increased from 17,613.4 hectares in 1996 to 22,829.5 hectares in 2011. In 2020, construction land occupied 22,196 hectares, accounting for 18.57 % of the total land area (see Figure 4.11).

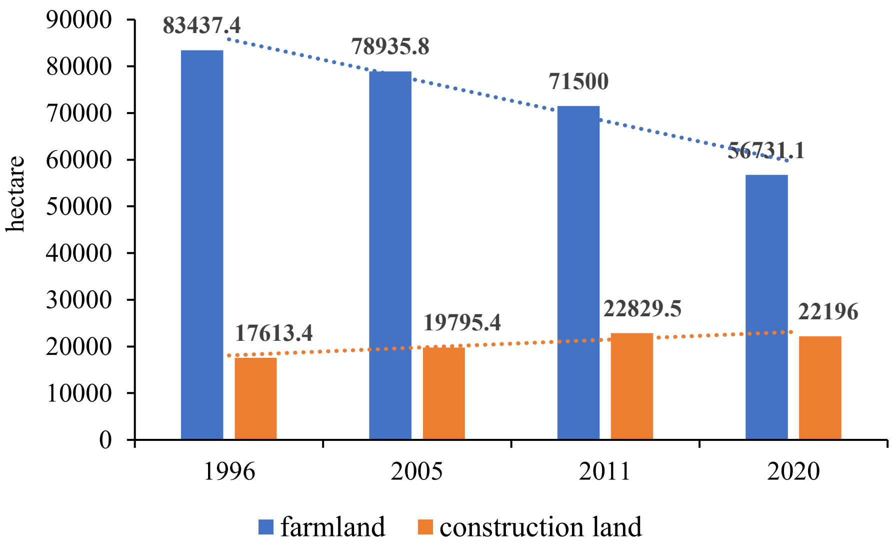

Figure 4.11. Area of farmland and construction land in Tancheng.

Source: Tancheng County Government (2010, 2023b).

In order to attract industrial investment and promote economic development, Tancheng Economic Development Zone, located on the western part of Tancheng county, was established in 2003 and was recognized as a provincial-level economic development zone in 2006. It covers an area of 2100 hectares and has gathered four leading industrial clusters—green chemicals, electronic information, medical devices, and intelligent logistics—supported by well-equipped transportation, water, electricity, and heating infrastructures as well as preferential land use and fiscal policies. In 2018, six chemical and new materials projects were signed and started, with a total fixed asset investment of 2 billion *yuan*, an industrial output value of 6 billion *yuan,* and a total tax payment of 300 million *yuan* (Select Shandong, 2024).

In terms of water and sewage facilities, it has established two water supply plants and one sewage treatment plant to serve industrial enterprises within the economic development zone. One of the water supply plants was built in 2020 to relieve groundwater pressure in the county center, diverting surface water from Lizhuang irrigation district through the agricultural-to-industrial water-use rights trade under the water market system (see Chapter 7 for details). Another water supply plant with a scale of 20,000 m^3/d uses recycled water from the sewage treatment plant as water resource for non-drinking purposes, and it is planned to expand to the scale of 40,000 m^3/d, with a land area of 5 hectares. The sewage treatment plant has a daily treatment capacity of 40,000 tons, and a 36-kilometer sewage pipeline network has been built to connect the sewage pipes to individual enterprise (Tancheng County Government, 2023b).

According to the national census survey conducted in 2020, there were 885,156 residents in Tancheng, and 326,180 people living in the cities and towns. The urbanization rate[12] of Tancheng county was 36.85%, far lower than that in Linyi prefecture (55.06%) and Shandong province (63.94%). The county government planned to increase the proportion of urban residential population to 54.88% by the end of 2035 (Tancheng County

[12] The proportion of urban residential population is an important indicator for the urbanization rate in China. It is measured by the proportion of people who reside in cities and towns for more than half a year to the total residents in a certain area.

Government, 2023b). That is to say, Tancheng is still on the rapid transition towards industrialization and urbanization, and this unprecedented scale of transformation will exert great pressure on industrial and domestic drinking water supply in the urban area.

4.5 Summary

This chapter introduces the political and socioeconomic context in China and in the case study area of Tancheng, a traditional agricultural county that is experiencing rapid agricultural modernization, industrialization, and urbanization. This political economy setting with significant water implications is crucial to understand China's agrarian transition, which shapes and is reshaped by water and water governance. The following chapters are going to analyze the transformation of water governance and the underlying hydrosocial relations in three dimensions: irrigation infrastructures, irrigation organizations, and water market institutions. Chapter 5 details the production of small-scale farmland irrigation infrastructures by a state-led development project and its associated hydrosocial reproduction at the local and grassroots levels. Chapter 6 demonstrates the diversity of water organization modalities in local agricultural practices, and analyses their formation and challenges. Chapter 7 illustrates a quasi-market system under the central planning and administrative operation in China, with a specific focus on the cross-sectoral water-use rights trade in Tancheng, which utilizes market toolkits to leverage agricultural water for economic development.

Chapter 5 The production and reproduction of small-scale irrigation infrastructures

5.1 Introduction

On a sunny afternoon at the early beginning of my fieldwork, I was taken on a field tour led by Mr. Liu, a large household in Gang township in Tancheng. Sitting in his motor tricycle and driving along the country roads, large plots of neat, green paddy fields passed by. In one side of the paddy field stood several signs written with the Chinese characters of the "high-standard farmland" (see Figure 5.1a). Mr. Liu told me that these signs were placed alongside the governmental farmland and irrigation projects constructed in the recent years. These government projects have transformed the landscape by consolidating the farmland and upgrading it with supporting on-farm irrigation infrastructures, such as lined canals, small sluices, electromechanical wells, and underground pipes. While dropping me off to show me around the canals lined up through the government projects (see Figure 5.1b), Mr. Liu started to complain about the absence of project wells (see Figure 5.1c) in his 1160 *mu* of farmland for their proximity to the canal. Instead, he had independently drilled 20 wells with each around 80cm in diameter and ranging from 35 to 45m deep. These private wells, operating like the public project wells, were equipped with submersible pumps that use electricity as power to extract groundwater for irrigation.

(a) The sign of the “high-standard farmland”.

(b) The lined canal branch.

(c) The electromechanical well for irrigation.

Figure 5.1. The high-standard farmland project infrastructures.

Source: Author, July 2023. Note: The electromechanical well is an advanced tubewell constructed to provide irrigation water. Different from a simpler hand-pumped tubewell, it is equipped with the electric box, submersible pumps, and IC cards to pump up greater volumes of groundwater for irrigation.

Not only on Mr. Liu's farm, these small-scale farmland irrigation infrastructures are ubiquitous in Tancheng. Built by the governmental projects, they stand out as significant state-led technological interventions to enhance agricultural productivity through the improvement of irrigation conditions in rural China. As symbolic and material representations of modernization, the technological mediation of water use and water provision is often viewed as actualizing and achieving development goals by the hydraulic state, with much more foci on large-scale engineering projects and grand plans (Swyngedouw, 1999; Kaika, 2006). Swyngedouw (2004) posited that such "hydraulic mission" involved the state becoming the master hydraulic engineer, producing and reproducing new waterscape and changing its flow, availability, and value. However, as I dived deeper in the field, I gradually realized that the implementation and installation of irrigation infrastructures are far more complicated than the normative and apolitical depictions in the policy discourses and social media. Why are these types of infrastructures not others provided in certain spaces? How are they distributed among different locations, farmland, and producers? What are the varying irrigated landscapes they have reproduced? These smaller water infrastructures are not neutral, technological advancement; instead, they are imbricated with political and social power relations, materialities of water, and the contradictions of modernist technology-led development, which reconfigure hydrosocial relations and challenge the dominant and simplified thinking of the hydraulic state in processes of agricultural modernization and rural development (Birkenholtz, 2009; Clarke-Sather, 2012; Sultana, 2013; Xu et al., 2024).

This chapter draws attention to small-scale farmland irrigation infrastructures constructed by the high-standard farmland project in Tancheng, and analyzes the interaction of water, technology, and sociopolitical power to produce and reproduce uneven geographies of access and use of irrigation water at the local and grassroots level. Although the high-standard farmland project is a centrally-directed and engineering-based initiative aimed at improving agricultural productivity and sustainability, it is subtly implemented by local states and non-state actors to enact varied political and economic interests. Section 5.2 briefly introduces the development of state-led hydraulic technology interventions in Tancheng, with an emphasis on the shift from large irrigation schemes to small-scale farmland irrigation infrastructures that mediate water in the field. Section 5.3 unpacks the flexible and nuanced coping strategies towards this centrally-earmarked and goals-oriented infrastructural project at the local and grassroots level, which are driven by diverse political and economic interests of the county and township governments as well as village communities, mediated by informal rural social relations. Section 5.4 reveals a variety of rural landscapes reproduced by the high-standard farmland project, demonstrating the rigidity of uniform project designs, uneven cost and benefit among large and small producers, and the uncooperative nature of water that constrains the spatial deployment of farmland irrigation infrastructures. This chapter ends with a discussion and conclusion on the nuanced understanding of power dynamics in the interplay of water, technology, and development in the Chinese rural society.

5.2 The development of hydraulic interventions in Tancheng

This section introduces the technological interventions of irrigation development in Tancheng county, which can be divided into three phases. First, in the late 1950s and early 1960s, the county government started to establish a centralized gravity-fed canal irrigation system across the whole county, constructing main canals, big reservoirs, dams, and sluices. Following a decline of canal water supply in the mid-1970s, the county government began to develop smaller-scale groundwater-abstraction technologies, such as shallow-dug wells and hand-pumped tubewells. Since the 2000s, extensive governmental farmland and water conservancy projects have been conducted to renovate and upgrade small-scale, on-farm irrigation infrastructures in order to effectively deliver agricultural water to the field. In particular, the integrated high-standard farmland project since 2019 has further increased investment on irrigation development. While lining canals, dredging ditches, and installing automatic sluices, advanced electromechanical wells and associated water outlets and underground pipelines are widely equipped. The transformation of hydraulic interventions marks a shifted focus from large-scale irrigation projects towards small-scale, individual, and groundwater-accessing technologies and infrastructures.

5.2.1 From large irrigation schemes to small-scale farmland water conservancy infrastructures

The first era of irrigation development in Tancheng was characterized by a centralized gravity-fed canal irrigation system. Starting from the early 1950s, the county government launched several water conservancy campaigns to dig channels and divert surface water from lakes and rivers for agricultural production. Between the winter of 1957 and 1963, its three major irrigation districts—Lizhuang, Matou, and Qingquansi—were established. From the late 1950s to the 1960s, the county government had constructed 9 major dams and 11 reservoirs through the mobilization of rural mass labor, and a significant proportion of county's surface water storage and diversion capacity was created in this period (Tancheng County Government, 2021d).

In the 1970s, Tancheng faced increasing water demands and a declining surface water supply as upstream irrigation areas in Linyi municipality expanded. In addition, extensive surface irrigation had caused serious salinity problems in many irrigation districts. To address these challenges, the county government vigorously pursued the exploitation of groundwater to supplement the unstable supply of surface water. In 1973, the well-drilling office under the leadership of the Water Resources Bureau and several professional well-drilling service teams were set up to mobilize mass labor for the development of groundwater-led irrigation (Tancheng County Government, 2021d). Agricultural shallow-dug wells and tubewells with small electric and diesel pumps became widespread across rural communities in the county. By 1985, there were 4536 agricultural wells in the county, of which 610 were equipped with electric pumps and 2578 were motor-pumped (Local Chronicles Office of Tancheng, 2001).

Following the breakdown of many irrigation infrastructures in the 1990s due to inadequate agricultural expenditure, the third stage of irrigation development in Tancheng saw extensive farmland and water conservancy projects funded by the central government's special-purpose transfer payments (see Table 5.1). These project initiatives reached down from central functional ministries and commissions to the county counterparts—mainly the Agriculture Comprehensive Development Office, the Water Resources Bureau, and the Agriculture and Rural Affairs Bureau— via the "*tiao*" political structure. Instead of constructing large dams and headworks, these governmental projects focused on renovating the lateral canal systems and relevant supporting infrastructures in the field, such as lining canal branches, dredging ditches, installing automatic sluices, and building electromechanical wells with water outlets and underground pipelines. These small-scale farmland irrigation infrastructures were enrolled with development goals of agricultural modernization, which aim to promote agricultural productivity, sustainability, and rural livelihoods through efficient uses of land and water. Since 2019, all these farmland and irrigation projects were integrated into the high-standard farmland project to coordinate the project design and funding expenditure (see Chapter 4.2.3 for details).

Table 5.1. Farmland and water conservancy projects in Tancheng, 2000-2018.

Government agency	**Project**	**Year**	**Investment /million *yuan***	**Lined and dredged canal/km**	**Newly-built well**
Agriculture Comprehensive Development Office	Land Consolidation Project	2000-2014	131.2	1179	1063
Water Resources Bureau	Small-scale Farmland Water Conservancy Key-County Construction Project	2010-2017	242.3	314	769
Agriculture and Rural Affairs Bureau	The High-standard Farmland Project	2015-2018	130.9	100	298

Source: Tancheng County Government (2000 to 2014); Local Chronicles Office of Tancheng (2017, 2018, 2020). Data are collected and calculated by author. Note: In addition to lining and dredging canal branches and equipping electromechanical wells, these projects also involve renovating bridges, culverts, and sluices, building supporting power facilities, improving soil quality, and constructing field production roads.

5.2.2 The integrated high-standard farmland project

The central MARA took the lead in coordinating the integrated high-standard farmland project after 2019, allocating annual financial subsidies and implementation tasks to each provincial government. Specific amounts of project areas are then assigned to subordinate prefectures and counties in a top-down approach. From 2019 to 2024, Tancheng has been allocated 308,000 *mu* (20,533.3 hectares) of the high-standard farmland project, with subsidies totaling 547.2 million *yuan* (see Table 5.2). In particular, water conservancy infrastructures associated with electrical engineering account for over a half of the annual total investment (see Figure 5.2).

Table 5.2. Annual tasks of the high-standard farmland project in Tancheng.

Year	Area/*mu*	Investment/ million *yuan*	Input per *mu*/ *yuan*
2019	40,000	52	1500
2020	50,000	69	1500
2021	80,000	120	1500
2022	80,000	162	1950
2023	38,000	95.1	1950
2024	20,000	49.1	2400
Total	308,000	547.2	/

Source: Data are collected from the annual high-standard farmland project design and implementation plans. The project documents for 2019 and 2020 are available on the government official website (http://www.tancheng.gov.cn/zt/tcxghjh/zxgh.htm), and those of the remaining years are provided by township government officials during the fieldwork.

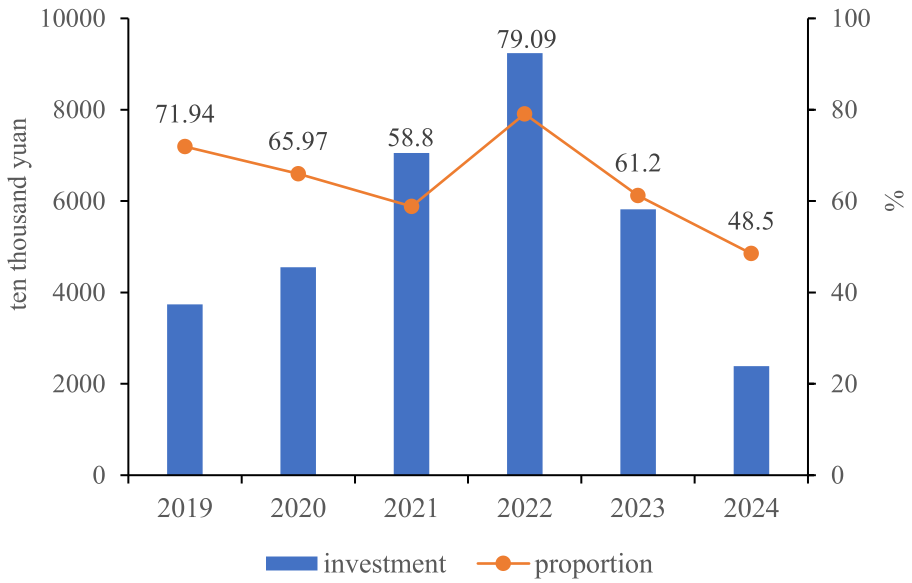

Figure 5.2. Investment and proportion of water conservancy and electricity.

Source: Data are collected from the annual high-standard farmland project design and implementation plans. The project documents for 2019 and 2020 are available on the government official website (http://www.tancheng.gov.cn/zt/tcxghjh/zxgh.htm), and those of the remaining years are provided by township government officials during the fieldwork.

When the project landed at the county level, the county government and its agricultural bureau played a dominant role in the sub-allocation of the project tasks to the township governments, exercising significant discretion in determining the locations and beneficiaries of the projects. The township governments are the main executives of the project construction and implementation in the village communities. As we can see in Table 5.3, there is an uneven distribution of the high-standard farmland project across 13 townships in Tancheng from 2019 to 2024. The Quan and Li townships have been allocated the largest amount of project areas, while the Sheng and Chong townships did not receive any project.

Table 5.3. Distribution of the high-standard farmland project among townships.

Township	Project year	Total area/ *mu*
Quan	2019,2020,2021,2022,2023	58,000
Li	2019,2020,2021,2022	57,300
Tan	2020,2021,2022	39,000
Yang	2021,2022,2023, 2024	35,000
Hong	2019,2020,2021	28,000
Hua	2021,2022, 2024	25,300
Ma	2020,2021,2023	23,400
Gui	2022	14,000
Miao	2023	10,000
Gao	2022	10,000
Gang	2019	5000
Sheng	/	0
Chong	/	0

Source: Data are collected from the annual high-standard farmland project design and implementation plans. The project documents for 2019 and 2020 are available on the government official website (http://www.tancheng.gov.cn/zt/tcxghjh/zxgh.htm), and those of the remaining years are provided by township government officials during the fieldwork.

The construction of the high-standard farmland project and associated small-scale farmland irrigation infrastructures is deeply embedded within the context-specific political and economic structures and rural society, as they are technologically mediated, produced, and contested, and therefore recasting the existing relationships of power and hydrosocial relations (Sultana, 2013). The following sections are going to illustrate how the high-standard farmland project is produced at the local and grassroots level, and how it has reproduced the variegated landscapes that divert the development goals of state-led agricultural modernization.

5.3 Nuanced reactions and coping strategies from local and grassroots actors

This section examines the varying reactions and coping strategies employed by state and nonstate actors—the county government, township governments, and village cadres— in implementing the high-standard farmland project. It reveals the politics of small-scale farmland irrigation infrastructures and the complicated role of the state at various levels during the construction process. The county and township government officials do not deal with abstract and numerical task targets; instead, they navigate specific project areas, villages, and individual plots of land where these irrigation infrastructures are installed. This process is not as linear as the uniform project design and implementation plan might imply. It requires intricate coordination with various villages and farming households, taking the landholding sizes and crop cultivation patterns into consideration. Despite facing top-down political pressures, grassroots bureaucrats adopt flexible strategies to preserve local political and economic interests, and leverage social relational capital to resolve conflicts that arise. These nuanced coping mechanisms, as described by Scott (1985), are embedded within everyday practices of rural governance. However, they are not actions of resistance to the authority but rather pragmatic responses to navigate implementation challenges.

5.3.1 Showcase political achievements

After the integration into a united project and taken over by the MARA, the high-standard farmland project has elevated its importance, transforming from a business of agricultural departments into a political imperative (the so called "central task") of local governments within the "*kuai*" system. It becomes one of the criteria for the assessment of local governors' responsibility for national food security and basic farmland protection. And therefore, the county government of Tancheng, directs more attention and resources to the selected townships in the allocation of the project, in order to showcase political achievements ("doing excellent") in agricultural development and cater to superior leaders during inspection tours. This prioritization has led to an uneven distribution of the high-standard farmland project among the various townships, with some receiving greater benefits than others.

The selected showcase townships, distinguished by their unique designations (or "titles") and favorable transportation locations, are granted priority in the distribution of governmental projects and financial resources. These townships, often labeled as sub-centers for urban-rural integrated development or as hubs for agricultural industry, attract attention from political leaders, given that the development within these areas serves as a tangible manifestation of political accomplishments for both the township and county governments. Furthermore, their advantageous locations also help facilitate a comprehensive project planning and implementation along major traffic routes, or in local officials' parlance, implementing "roadside projects". It simplifies the process for on-site inspection tours organized by a team of upper-level officials to assess and observe the progress (Gong and Zhang, 2017).

Li township, for example, is the largest township in Tancheng with a total area of 152km^2 and 7871 hectares of farmland. It has been designated as a sub-center of the county given its strategic position along the G205 national highway. In parallel to the county center, the sub-center in Li township aims to promote a coordinating development of agricultural modernization, urbanization, and industrialization through the establishment of high-tech industrial centers as well as modernized agricultural demonstration zones (Li Township Government, 2024). Prior to this designation, the township's engagement with agricultural initiatives was limited to a single farmland and irrigation project conducted in 2015.

Following its recognition as a sub-center poised to drive urbanization and rural revitalization, the Li township has been allocated a series of high-standard farmland projects, encompassing 573,00 *mu* (3822 hectares) over four consecutive years from 2019 to 2022 (see Table 5.4). These projects were constructed in its modern agricultural development zone alongside the G205 national highway (in yellow districts as seen in Figure 5.3), in order to improve land and water conditions for intensified and specialized agricultural production. In 2021, this modern agricultural development zone in Li township was listed as one of the stops during the rural inspection tour led by political leaders from the Linyi government.

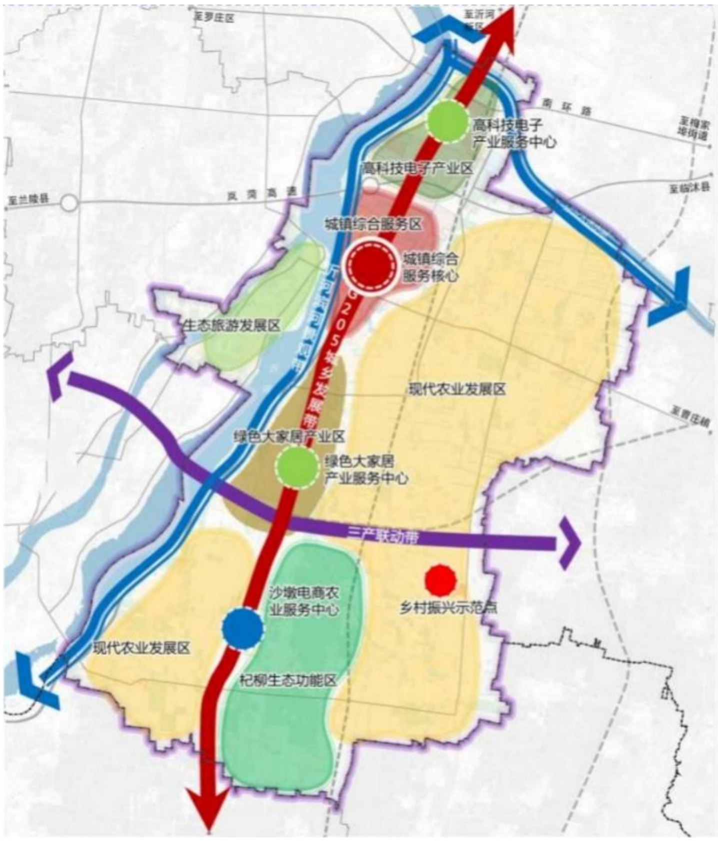

Figure 5.3. The territorial spatial development plan of Li township.

Source: Li Township Government (2024). Note: The planning of the territorial spatial development in Li township is described as “One Core, Four Points, Three Belts, and Six Areas”. One Core: Urban Comprehensive Service Center (the big red dot); Four Points: High-Tech Electronic Industrial Center (the upper green dot), Green Furniture Industrial Center (the lower green dot), E-commerce Agricultural Service Center (the blue dot), Rural Revitalization Demonstration Point (the small red dot); Three Belts: G205 Urban-Rural Development Belt (the red arrow), Riverside Landscape Belt (the blue arrow), Industrial Integrated Development Belt (the purple arrow); Six Areas: High-Tech Electronic Industry Area (the upper green district), Urban Comprehensive Service Area(the red district), Green Furniture Industry Area (the brown district), Ecotourism Development Area (the middle green district), Modern Agricultural Development Area (the yellow district) , Ecological Functional Area (the lower green district).

Table 5.4. The high-standard farmland project in Li township.

Year	Area/ *mu*	Investment/ million *yuan*	Location
2019	12,000	15.6	7 villages in the northeastern
2020	4000	6	6 villages in the southwestern
2021	33,300	46.5	13 villages in the eastern
2022	8000	12.95	7 villages in the southeastern
Total	57,300	81.05	

Source: Data are collected from the annual high-standard farmland project design and implementation plans. The project documents for 2019 and 2020 are available on the government official website (http://www.tancheng.gov.cn/zt/tcxghjh/zxgh.htm), and those of the remaining years are provided by township government officials during the fieldwork.

Miao township, situated beneath Li township along the G205 national highway, also gained increased attention and project allocation following its inclusion in the 2023 National List for the Development of Agro-industrial Towns by the MARA. In the same year, it received 667 hectares of the high-standard farmland project, with the purpose of establishing a demonstration zone for agricultural development. This prioritization, however, has come at the expense of other agricultural townships with urgent irrigation renovation needs.

For example, Yang township, located in the southwestern part of Tancheng, is a traditional agricultural township that lacks proximity to the county center and major transportation routes. Mr. Guo, a government official in charge of agricultural affairs in the township, told me that initially a total of 1668 hectares of the high-standard project areas were allocated for the reconstruction of aging irrigation infrastructures within the township's jurisdiction, which were installed a decade ago and have since become no longer usable. Despite these pressing needs, the final allocation resulted in only 667 hectares being allocated to the Yang township. The remainder of the planned areas was redirected to

Miao township and another one to develop agricultural demonstration zones, which aligned with its new position as a pilot agro-industrial town. This reallocation reflects a strategic decision by the county government, negotiated with township governments, to focus on creating showcase projects for agricultural development, potentially at the cost of immediate infrastructure improvements in other areas. I met Mr. Guo in his office and he complained about the neglection by the county government, recalling angrily that:

> *"The amount of the constructed area has dropped from 25,000 mu to 15,000 mu, and eventually decreased to 10,000 mu…The amount of investment has also decreased from 1950 yuan per mu to 1400 yuan per mu this year. In contrast, the investment for the high-standard farmland demonstration project is 2400 yuan per mu, although it was 3000 yuan per mu before."*

What makes it worst is that certain demonstration projects serve merely as symbolic "white elephants", intended to display development achievements during inspection tours rather than address the actual needs of local communities. An interview with a village committee leader in Miao township revealed a telling example. He stated that the branches of a canal situated along one side of the main road in the township were neatly lined and dredged through the high-standard farmland project in recent years. Despite the fact that the canal contained minimal water flow and was rarely used by local communities, who continued to rely on groundwater for their irrigation needs.

The prioritization of showcase roadside projects for the purpose of inspection tours over the practical needs of local communities highlights a significant disconnect between the central government's development goals and on-the-ground realities. This usually happens because of the project's visibility and being completed in time for local cadres' review for promotion during their tenures within the political system (Cook, 2005; Clarke-Sather, 2012).

5.3.2 Trade-offs of diverse agricultural livelihoods

While the county government and its agricultural bureau are primarily responsible for the allocation of the high-standard farmland project, it is the township governments that work as street-level bureaucrats in the implementation process. Adhering to the national food security campaign, one of the mandated regulations of the high-standard farmland project is that it should be constructed on the designated basic farmland, which must be dedicated to cultivating food crops such as wheat, corn, and rice. And therefore, the project often resulted in negotiations and balances of diverse choices of agricultural livelihoods. Township governments and village committees with different crop patterns and agricultural industries hold different attitudes towards the project. In contrast to the townships specialized on food crop production, townships that are specialized on cash crop production have negotiated with the policy goal of national food security, and managed to sustain local, traditional, and diversified agricultural livelihoods.

Gang, Sheng and Chong townships in the western part of the county have a relatively small amount of farmland and specialize in producing vegetable, fruit, and ginkgo. The planting of ginkgo has a long history in these three townships, branding Tancheng as the "Ginkgo Hometown" across the country. According to the local chronicles, the cultivation of ginkgo originated to the Northern Wei Dynasty (AD 520-524), and it reached its peak during the Ming and Qing Dynasties in the Chinese Empire history. During the fieldwork, rural communities in these areas expressed the importance of ginkgo plantation because they could make a living on both its fruits, leaves, and trucks, which have brought them significant medical and economic values. Villagers recalled that a large ginkgo tree could be sold at a good price for over ten thousand *yuan* in the past years, except for incomes generated from ginkgo fruits and leaves. While the food crops have much lower market values with an average net income of hundreds per *mu* and normally there are less than 10 *mu* in every peasant household. In this case, they mainly grow a small amount of wheat and corn for self-sufficient consumption, and are dedicated to cash crop production.

Figure 5.4 shows a typical landscape in Chong township, where a total of 1934 hectares being used for ginkgo cultivation out of its 2868 hectares of farmland. Ginkgo trees are planting widely both in front of and behind the residential houses in the villages. Food crops scatter across the farmland, which are surrounded by dense ginkgo trees.

(a) Ginkgo trees around the residential houses.

(b) Wheat scatters across the farmland.

Figure 5.4. The cropping landscape in Chong township.

Source: Author, November 2023.

Government officials in these townships are not willing to accept the allocation of the high-standard farmland project in their jurisdictions, which comes with a prerequisite for grain production within the project area. Rather than viewing it as a benefit, they consider it an unnecessary burden or an unworthy cost. On one hand, they recognize the significant challenge in convincing villagers to cut down ginkgo trees without adequate compensation for the project's construction. The older the ginkgo trees, the greater their value, which makes their removal a contentious issue that could lead to conflicts with rural communities and undermine social stability. To avoid such disputes and the potential disruption of villagers' livelihoods, township officials would rather reject the project, thereby sparing themselves the ensuing troubles. On the other hand, the agro-industry and tourism that have developed around the ginkgo trees are a vital economic development pillar for these townships. As I observed in the field, some of the ginkgo trees were planned and built into scenic spots to promote the development of the local agricultural tourism industry. The township government shares interests with the rural communities in maintaining these better-off agricultural livelihoods, as they contribute to sustainable local economic development. In light of these considerations, the township government is inclined to preserve the existing economic activities centered on ginkgo cultivation, rather than adopting a project that could disrupt these established and beneficial economic practices.

Gang township is another case in point to illustrate the trade-offs of diverse agricultural livelihoods by the township government. It has the smallest amount of farmland amongst other townships and specializes in ginkgo, greenhouse planting, and timber industries. In 2019, it was allocated 200 hectares of the high-standard farmland project and went through a long negotiation process for the project location. The project was finally placed to its three village communities which still grew wheat and rice. However, some of the villages had a tradition of rotating to grow a season of watermelon, building simple and removable greenhouses on their farm. And therefore, the township government had a hard time working with these villages before and after the project construction. Mr. Xu, a township government official, regretted having taken this project and insisted on not to have it any more during the discussion meeting. He argued that:

> *"It is not good to have the project, because it must grow grains within the project area. Although a small number of smallholders do grow grains, some of them rotate to plant a season of watermelons. In this case, we had a difficult time working with village committees and growers during the design and construction process. The requirement of grain production is not practical in this township."*

In contrast to completely turning down the project by townships that specialize in cash crop production, pro-project townships and villages also adopt strategic responses to the ongoing inspections by the county government after the project's construction. The high-standard farmland project, situated on the basic farmland, is subject to the surveillance by the county Natural Resources Bureau, which utilizes remote sensing satellites to capture real-time images and verify that the basic farmland has not been used for purposes other than grain production. Should any conversion to non-grain crops—such as tree planting—be identified, the bureau would issue a notice to the relevant townships and villages, mandating corrective actions to reinstate grain production. In instances where tree removal is required to comply with the project's goals, the township governments and village committee leaders had a pragmatic understanding of the challenges involved in the enforcement, and often granted a grace period of three to five years for the trees to be cleared out by individual households, rather than demanding an immediate cutting-down. During an interview with a village cadre in Yang township, Mr. Lei, he explained a practical strategy in his words:

> *"We will start with the easy ones and the difficult ones later. If the issue cannot be immediately solved, we will put it off."*

This reveals a nuanced approach to project implementation, where villages balance the demands of the project with the practicalities of local circumstances. In addition to the pursuit of political and economic interests, the influence of social and cultural nexus of power is more subtle yet profoundly effective to deal with the intricacies in the implementation process, which is detailed in the following sub-section.

5.3.3 The mediation of social relations

Chinese rural society, rooted in familiarity and intricate social relational networks ("*guanxi*" in Chinese), operates on the foundation of mutual trust and reciprocity. These social relations profoundly shape interpersonal interactions, decision-making processes, and conflict resolution strategies within the village community (Nickum, 2010). The role of social relations in the implementation of development projects in Chinese rural society is particularly pronounced due to the close-knit nature of these communities, where everyone knows everyone else and personal connections are pivotal in getting things done

(Fei, 2006). The mediation of social relational networking in the project implementation can be seen in two ways.

Firstly, village committee leaders actively build up relationships with the township government to secure greater policy attention and project resources for the development of their villages. These social ties are not merely part of the social structure; they also function as valuable social resources, as conceptualized by Coleman (1988). The strength of these relationships has a tangible influence on the priorities set by the township government. The village cadres' personal capability to navigate and maintain these connections is crucial, as it not only reflects their individual skills but also the collective strength of the village's social capital.

Mr. Lei, a middle-age party secretary of a village in Yang township, is such a person with strong capability and networking skills. He worked for a company in Shenzhen in his early career and came back to his village in the 2000s, where he ran the business of a water supply plant and served as a community secretary for six years before being elected as the village party secretary in 2020. Mr. Lei has committed to serve for the village community and worked diligently to fulfill the tasks delegated by the township government, leading his village to earn high marks in county-wide performance evaluations. His proactive engagement in village affairs is matched by his strategic use of personal networking to advance the community's interests. He often showed up at informal gatherings over tea, lunch, or dinner with the deputy township governor, discussing the needs of his village with the aim of securing additional government projects and funding. My own visits to the township government office had consistently coincided with his presences, either providing updates on the village's working progress or engaging in casual conversation with the deputy governor.

During one such encounter, when Mr. Lei offered me a ride back to the rental house in the county center, he openly shared his view that "We cannot afford to wait for projects to find us; we must actively seek them out". His proactive way of networking did result in more favorable allocation of attention and resources by the township government. Eight electromechanical wells were installed in Lei's village amongst another four villages, when Yang township was firstly allocated 200 hectares of the high-standard farmland project in 2021.

Secondly, the establishment of these relationships is not a one-sided affair; it requires a reciprocal effort from both the villages and the township governments. The township government also relies on the reputation and collective leaderships of village leaders acting as intermediaries to smooth the construction process of the high-standard farmland project. The project's design, which is often an abstraction that may not fully reflect local conditions, outlines a general area for the placement of irrigation facilities. It is through collaboration with village committees during the construction stage that specific plots of land are determined. While these irrigation facilities significantly enhance irrigation convenience, their placement in the fields inevitably results in the occupation of a small amount of farmland (see Figure 5.5). Villagers are eager to reap the practical benefits but are reluctant to bear the cost of losing their own farmland for the project, which can't be used to grow crops anymore. Moreover, farmland around the electromechanical wells needs to be sown and harvested manually to avoid damage to the well-equipped irrigation infrastructures from the operation of agricultural machinery.

And therefore, the successful implementation of the project hinges on the ability of village committee leaders to work as brokers, bridging the gap between the project's requirements and the concerns of the villagers. Unlike formal command-and-control mechanisms, informal institutions often prove to be more effective in rural societies, where tasks are typically accomplished through personal connections and acquaintance.

Figure 5.5. The placement of an electromechanical well on the farm.

Source: Author, November 2023.

In the case of Mr. Lan, the owner of a family farm, the encroachment on his riverside land during the construction of the high-standard farmland project in 2022 highlights the mediation of social relations in resolving disputes within rural communities. According to our casual talks at the dinner table, the construction activities, which involved trenching and dredging ditches, not only resulted in the occupation of Mr. Lan's land but also in the destruction of over 1000 trees he had planted along the riverbank. Given the government's failure to provide land rent compensation or to flatten the land as promised, he attempted to seek redress through formal channels by calling the governmental hotline, and yet met with a response that was deeply rooted in the social and familial ties within the rural community. The township government engaged with his father to defuse the situation, who was the party secretary of the village committee with a responsibility to support government initiatives and maintain social stability. His father's influence was leveraged to persuade him to give up complaints and demands for compensation. In this case, the government's reliance on Mr. Lan's father to mediate the conflict demonstrates the family ties, community leadership, and informal networks at play in rural settings.

5.4 Reproducing variegated landscapes through farmland irrigation infrastructures

The previous section has elaborated how local cadres at different administrative levels employ varying coping strategies in constructing small-scale farmland irrigation infrastructures through the high-standard farmland project. These strategies underscore the local state's multifaceted role of enhancing national food security, sustaining agricultural livelihoods, and maintaining social stability in the Chinese context. Specifically, irrigation technologies and infrastructures are not neutral technical interventions; they are enmeshed in the socio-political and economic systems of rural China, where county and township governments, as well as village cadres, negotiate competing interests and bureaucratic imperatives.

Just as the production of irrigation infrastructures is shaped by political economy and social dynamics; the material characteristics and agential capacities of these water infrastructures, in turn, also reproduce different irrigated landscapes and hydrosocial relations across spaces and scales (Birkenholtz, 2009; Sultana, 2013). As Meehan (2014) suggested, water infrastructures are not just "power tools" deployed by humans to exercise dominion but "tool-power" that infrastructures-in-themselves are wellsprings of power.

This section is going to unpack the variegated landscapes reproduced by small-scale farmland irrigation infrastructures. These include (1) the rigidity of standardized project blueprints, tailored for audit compliance rather than local needs, creates a disconnect between infrastructural uniformity and on-the-ground agricultural practices. While uniform designs simplify bureaucratic oversight, they often fail to account for localized variations; (2) large producers benefit from exclusive access to infrastructures and preferential water prices, while smallholders outside of the project area face higher costs and labor burden to secure irrigation water; and (3) water's material properties—its fluidity, seasonal variability, and volumetric limits—interact with infrastructural designs to reproduce spatial variation and environmental conditions, sometimes leading to waterlogging in low-lying areas.

5.4.1 Rigidities of standardized project designs

Like many state-led grand plans to reinvent agricultural production, the high-standard farmland project follows a standardized project design with uniform technical language, so as to make it easier for oversight and governance in a top-down approach (Scott, 1999). Following a project design outline issued by the agricultural department of Shandong province, the county government and its agricultural bureau entrust professional survey and design institutes to compile its annual project design[13], which is then reported to the prefectural counterpart for evaluation and approval. Although township governments have been consulted during the annual planning meeting organized by the agricultural bureau, the project design is mainly based on historical data and formula calculations in written form, completed by a group of technocrats, planners, and engineers who are sitting in their offices.

For example, the water demand for agricultural irrigation is planned and calculated in accordance with the "Quota for Agricultural Water", a local standard established by the water resources department of Shandong province (see Appendix D for details). This standard identifies irrigation quotas for wheat, corn, and rice under different reliabilities of irrigation. These values are then multiplied by a corresponding adjustment coefficient to establish the net irrigation quotas for these crops. The gross agricultural water demand is calculated based on the multiplication of the planted area by the net irrigation quotas,

[13] The standardized project design includes ten elements: 1) comprehensive description; 2) basic conditions of the project area; 3) project layout; 4) water supply and demand; 5) engineering design; 6) construction organization; 7) investment estimate; 8) operation and maintenance; 9) environmental impact assessment; 10) project benefit analysis.

divided by the efficiency of irrigation water use (Shandong Provincial Water Resources Department and Shandong Provincial Market Supervision Administration, 2020). Therefore, the amount of agricultural water demand for wheat, corn, and rice in the project townships in Tancheng is uniformly formulated and calculated under different irrigation conditions (see Table 5.5), as shown in the high-standard farmland project design and implementation plan of Tancheng in 2024.

Table 5.5. The calculation of agricultural water demand

Crop	Item	Reliability of irrigation		
		P=50%	P=75%	P=85%
Wheat	Irrigation quota/ m^3 per *mu*	160	195	195
	Adjustment coefficient	0.8	0.8	0.8
	Planting ratio	1	1	1
Corn	Irrigation quota/ m^3 per *mu*	40	65	65
	Adjustment coefficient	0.8	0.8	0.8
	Planting ratio	1	0.55	0.55
Rice	Irrigation quota/ m^3 per *mu*		420	446
	Adjustment coefficient		0.8	0.8
	Planting ratio		0.45	0.45
Net irrigation quota/ m^3 per *mu*		160	335.8	345.2
Planting area/ *mu*		20000	20000	20000
Efficiency of irrigation water use		0.85	0.85	0.85
Agricultural water demand/ million m^3		3.76	7.90	8.12

Source: The high-standard farmland project design and implementation plan of Tancheng in 2024. Note: The efficiency of irrigation water use refers to the ratio of actual water volumes delivered into the fields to the total extracted water volumes. The ratio is currently 0.52 in Tancheng and is planned to reach 0.85.

Based on the calculation of water supply and water demand, the project design also has a united planning for irrigation and drainage engineering. The irrigated area for each electromechanical well is determined to be 75 *mu* with a depth of 40m and a distance of 246m between wells. The outer diameter of the concrete tubewell is set as 50cm. With a lift of 26m for each water pump, the designed water output capability reaches 50 m^3 per hour. As part of the supporting infrastructure, PE pipelines are designed to be buried 80 cm deep with a hydrant outlet installed every 7 to 10m (see Figure 5.6).

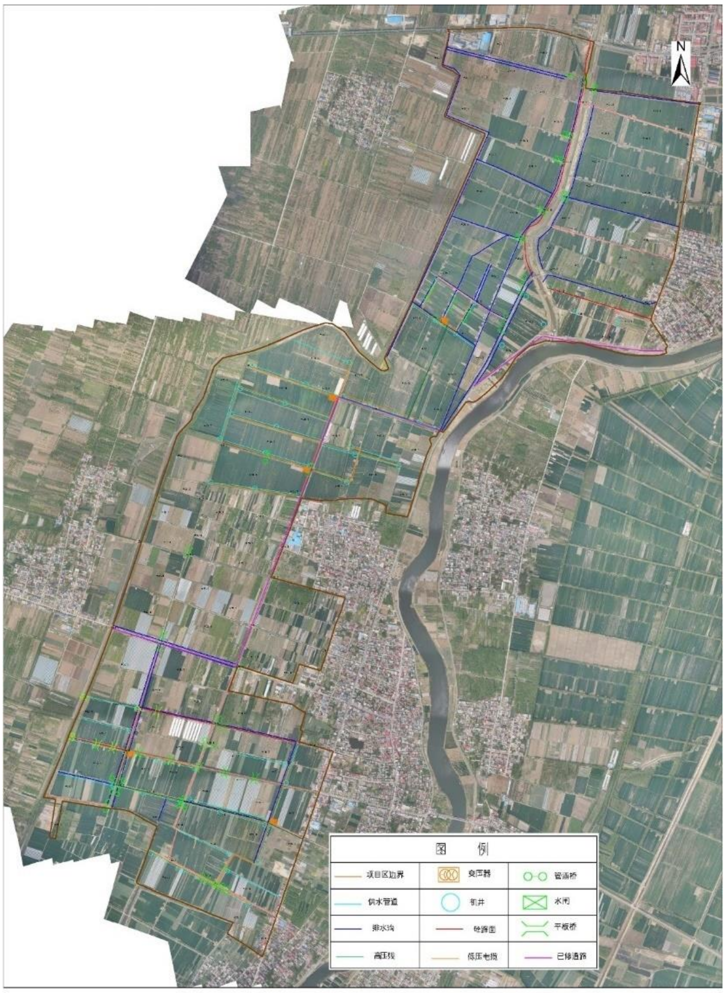

Figure 5.6. The planning layout of the project engineering.

Source: The high-standard farmland project design and implementation plan of Tancheng in 2024. Note: 1) Irrigation and drainage engineering: electromechanical wells (the blue circle); water pipelines (the blue line); ditches (the purple line); canal system structures (the green geometric figure). 2)Electricity engineering: transformers (the orange square); high voltage cables (the green line); low voltage cables (the orange line). 3)Road: the red line.

The endorsement of engineers has established this standardized design as a pivotal instrument for the agricultural bureau, offering simplified and visualized information to streamline the inspection, evaluation, and auditing processes. Despite its seemingly scientific approach, replete with numerical data and formulas, the standardization of agricultural setting falls short by oversimplifying the intricate socio-environmental dynamics into a singular and rigid model, which often overlooks the diverse biophysical and social conditions in practice. During my fieldwork, a common sentiment emerged from the feedback of township cadres: dissatisfaction with the impractical nature of the project design. Mr. Guo from Yang township, in particular, often hung the inapplicability of the uniform project design in his mouth and frustration in his face during our several times of discussions. He even wrote a work report to the county government and suggested reevaluating the allocation of investment towards farmland production roads, bridges, and soil fertilization, with an emphasis on the necessity for the designed bridge elevations to be tailored to specific local conditions.

In addition to survey and design institutes, the agricultural bureau also appointed a professional project management enterprise to act as the construction agent on behalf of the county government. This construction agent is tasked with overseeing project investment, as well as ensuring the project's timeline and quality standards are met. Despite the township governments' complaints about the impracticality of the project design and implementation plans, these rigid project designs can't be changed, even though modifications could be made within the investment limits. It is because they have been approved by the agricultural department at the prefectural level, and adopted as a key metric for monitoring the construction process at the county level.

Between May and August in 2024, I had the opportunity to visit the project management office in Hua township, which was conducting the high-standard farmland project in that year. The construction of farmland irrigation infrastructures was contracted to a private engineering company based in Linyi municipality. The construction agent on behalf of the county government was delegated by a private project management company based in Dongying municipality in Shandong province. The engineering company worked closely with the construction agent, assigning a professional engineer staffer to manage all the paperwork throughout the implementation process.

During my visit, two township officials stopped by and expressed their dissatisfaction with the project design to both the engineering company manager and the construction agent representative. Mr. Zhi, a government official from the agricultural technology station in Hua township, raised a specific concern. He contended that the length of one of the planned drainage culverts was excessive and proposed relocating it to a more suitable area. This proposed modification, he noted, would not affect the overall length of the culverts or the total investment. Despite the minimal impact of the suggested change, the construction agent representative rejected his suggestion and maintained that any alteration to the project, regardless of size, must undergo a rigorous review process by superior government authorities, in compliance with the strict auditing standards for governmental projects. He referred to a previous instance of criticism from the Linyi government towards the county government for making arbitrary project changes, as documented in an evaluation report (Linyi Municipal Bureau of Finance, 2023).

> *"Although the agricultural bureau in Tancheng submitted an application for adjustments and changes of the high-standard farmland project in 2021, the construction should not have been carried out before receiving approvals from the higher-level counterparts."*

To sum up, standardized project designs are typically imposed to streamline implementation, minimize costs, and simplify performance evaluations. The high-standard farmland projects often mandate uniform technical specifications (e.g. pipe diameters, pump capacities, grid layouts, etc.) to ensure comparability across regions and expedite inspections. However, this pursuit of uniformity clashes with the heterogeneity of agroecological and socio-economic conditions and does not align with local practical needs.

5.4.2 Uneven costs and benefits among large and small producers

The establishment of small-scale farmland irrigation infrastructures represents a significant public investment by the central government. However, the allocation of these resources is subject to existing social and economic configurations, which tend to reinforce inequalities through the uneven distribution of infrastructures among irrigators of various social strata and geographical areas.

First, large producers such as agribusiness companies and family farms, who have aggregated small plots of farmland from individual small households, normally receive more infrastructural investments and exclusive accesses to these irrigation facilities. For example, a large-scale family farm in Tancheng, has rented over 667 hectares of farmland across five townships to expand its agricultural operation. In 2023, as part of a demonstration project at the expense of other agricultural townships in urgent need of irrigation upgrades, this farm received ten new electromechanical wells, each valued at approximately 15,000 *yuan* if fully installed. This allocation occurred even though the farm already had its own wells in the field. These project wells are exclusively used by this family farm because its aggregated farmlands facilitate a quick and smooth implementation of the high-standard farmland project, aiding the county government in meeting its targets. Moreover, this family farm has benefited from other agricultural fundings such as fertilizers, deep plough, and machinery services that tied with the high-standard farmland project. These investments and resources are often concentrated on the high-standard farmland in order to build a demonstration area, which engages in upscaled operation and has higher grain production capacity with well-equipped infrastructure and services, so as to showcase the political achievements of modernized agricultural production by the government.

Second, different groups of large agricultural producers can secure preferential and lower water pricing. This is due to several social-political reasons. One key reason is the preferential treatment given to certain project wells that are exclusively constructed, used, and maintained by some privileged producers. These producers benefit from the installation of private electricity meters, which allows them to be billed directly for their water usage based only on the agricultural electricity rate of 0.54 *yuan* per kilowatt-hour, with water provided free of charge. For instance, the family farm as mentioned above, not only has exclusive access to project wells but also enjoys the discounted water price with its own electricity meter and billing account.

In contrast, other growers use shared public project wells that are equipped with uniform electricity meters. They pay a higher rate of 1.1 *yuan* per kilowatt-hour for water usage, which includes public maintenance fees collected by the Water Station under the township government. This differentiated water price increases the irrigation costs for smallholders, particularly during dry seasons. During my site visits in June 2024, Tancheng was experiencing an intense heatwave, with temperatures soaring above 38 ℃ and rainfall being scarce. Under the dry condition, smallholders reliant on the public project wells voiced their concerns regarding the rising costs of irrigation. Some of them irrigated their rice fields six times within a week after planting, with a total cost of 200 *yuan* that is equivalent to the entire season's irrigation expenses for rice production in previous years.[14] The necessity to water their crops more frequently to combat droughts and to ensure adequate hydration for their paddy fields had resulted in a financial burden on these irrigators, increasing a total amount of costs for agricultural production. For some small-scale landholders, despite having access to these public project wells, they would rather transport water in tanks from homes or public taps in order to save the expense of irrigation, which is commonly seen in the field.

[14] Smallholders usually don't know the specific amount of electricity that has been consumed, and thus the irrigation cost is roughly estimated by how many times their water IC cards are charged. For example, each time they would top up 100 *yuan* in their water IC cards, and this usually enables to irrigate their paddy fields for three times.

Figure 5.7. A smallholder was carrying her water tank to the field.
Source: Author, August 2023.

Another reason for the uneven resource distribution is that the preferential water rate can also be obtained informally. Other large producers who depend on public electromechanical wells often bypass regulations and act speculatively to avoid extra costs. A large household farmer, who acquired over 60 hectares of farmland from another village in the nearby township, managed to divert an electricity cable from the village to install a private electricity meter and secure water at the agricultural electricity rate of 0.54 *yuan* per kilowatt-hour. The installation of private electricity meters is prohibited by governmental regulations. However, this farmer used personal connections with the township government and the village committee leader who also acted as a broker in farmland transfer, to his advantage. Initially, these 60 hectares of farmland were leased to an agricultural company that later entered into a conflict with the village. To ensure continued land rents for the villagers, the village committee leader facilitated the re-transfer of the land to this large farmer through informal networking by the township government. In doing so, the leader acquiesced his informal way of accessing water for irrigation purposes. The large household farmer stated that:

"I only used the well facilities built by the high-standard farmland project and did not use their electricity. I managed to pull a cable by myself and applied for the preferential price of agricultural electricity at the rate of 0.54 yuan per kilowatt-hour."

The last reason is that large growers can secure much more free surface water through pumping irrigation facilitated by the high standard farmland project. Since 2018, agricultural water fees have been alleviated and fully sponsored by the government to reduce the burden on peasants. Large producers with extensive farmland adjacent to canals benefit greatly from this policy as the government constructs and maintains electric pumping stations at no cost to them. For example, the abovementioned family farm, a flagship of large-scale agricultural production across five townships in the county, has had four pumping stations established on its 100 hectares of canal-irrigated farmland in 2021, with each covering around 20 hectares of the farmland. The farm owner told me that:

"These pumping stations would cost more than four hundred thousand yuan if we build them by ourselves. When the water pump is broken, we directly call the manager from the Water Station. He promptly sends maintenance workers to replace the pump for us and for free."

Figure 5.8. The pumping station built for the large family farm.

Source: Author, June 2024.

Nevertheless, smallholders in a less competitive position, whose farmland lies outside of the project area, continue to depend on individual and often labor-intensive irrigation solutions, such as transporting water from rivers or homes to their fields through tricycles. Particularly in the northern part of the county, where the terrain is higher and not fully covered by the high-standard farmland project, irrigators have to individually use oil-consuming diesel engines to pump water from rivers, which nearly doubles the cost and labor force compared to using public electromechanical wells or the government-sponsored pumping stations. Even in the southern part of the county, there are villages that haven't received any project investment. For example, the M village in Gui township depends on lift irrigation without any project wells. Every household manually uses their small diesel or gasoline engines to pump surface water from ditches for irrigation. And the older generation of peasants is opting to grow drought-resistant corn instead of water-demanding rice as a means to reduce irrigation labor and costs.

Figure 5.9. Smallholders and their diesel or gasoline pumping engines.

Source: Author, June 2024.

The infrastructural project has remade the economic geography of Tancheng county, leading to unequal costs and benefits for large producers, smallholders, and irrigators in different spatial locations. While the social and spatial disparity resulting from small-scale irrigation infrastructures is apparent, equally important is the pivotal role that water itself plays in co-producing the differential irrigated landscapes on the ground.

5.4.3 The uncooperative nature of water

Karen Bakker (2003a) introduces the concept of "uncooperative water" as a metaphor to describe the fluidity and variability inherent in water, which challenges the static and controlled nature of human-engineered plans and expectations. While advancements in hydraulic engineering have notably enhanced our capacity to harness and exploit water resources, the biophysical properties of water remain an influential factor in the production and efficacy of water technologies, requiring for a tailored and adaptive approach in different regions (Birkenholtz, 2009; Bakker, 2012). This perspective is particularly pertinent when examining the configuration of diverse irrigation infrastructures across the landscapes with various hydrological conditions. These conditions have resulted in geographically differentiated irrigated landscapes that stretch from north to south within Tancheng county, underscoring the complex interrelation between water, technology, and society.

The “uncooperative” nature of water, stemming from its fluidity, constrains the neat, planned production of irrigation infrastructures, adding to the intricacies faced on the ground. In the northern region of the county, where there are hills and mountains with shallow soil layers, the depth to groundwater can reach to tens or even hundreds of meters. The impracticality of accessing groundwater at an economical and affordable cost prohibits the high-standard farmland project from employing advanced well-drilling methods, such as the widespread electromechanical wells in the south.

Consequently, the project has adapted by renovating or reconstructing shallow-dug wells, which serve as containers to store infiltrated surface water in this region. These stand-alone and hand-pumped wells, cylindrical or square in shape, are notable for their wide diameters ranging from a few meters to over 10m. To prevent structural collapse, their walls are typically reinforced with materials such as concrete, brick, or stone. Local growers rely on oil-intensive diesel or gasoline pumping engines to extract groundwater from these shallow-dug wells. The water levels within these wells are subject to seasonal fluctuation and may significantly decline during drought weathers. Under this circumstance, it requires to queue in line for irrigation, as simultaneous use of multiple pumps can rapidly deplete the well’s water supply. The lack of stable water resources prolongs the irrigation process, particularly during the dry season, when the demand of water is at its peak.

Figure 5.10. The shallow-dug well in the northern region of Tancheng.

Source: Xinhua Net, available at:
https://uav.xinhuanet.com/20211227/4e0b834dda17413d9191c5d33e632a49/c.html.

In contrast, the southern part of the county features plains with thick soil layers, where groundwater is more readily accessible within 10m. The high-standard farmland project has extensively equipped this region with electromechanical wells (see Figure 5.1 in the introduction section), which are standardized to a diameter of 50cm and a depth of 40m. These electromechanical wells, using a combination of electrical and mechanical energy to pump water from underground aquifers, are capable of pumping large volumes of groundwater quickly and efficiently and then transporting it through the underground pipeline system for irrigation purposes. Furthermore, the convenience of using chargeable IC cards to access irrigation water allows for year-round availability, facilitating irrigation for local producers in this area.

In addition to the availability of water, the high-standard farmland project is also constrained by too much water, particularly in relation to its drainage design. Although the government has extensively concentrated on addressing water shortages, the problem of water surplus, especially in the context of heavy rainfall, has not been given the same level of consideration. This oversight is particularly problematic in Tancheng, where heavy summer rains can overwhelm its existing drainage systems, thereby threatening agricultural production.

The complexity of managing water surplus is exaggerated when the farmland has been consolidated for moderate-scale operations, such as a uniform plot of 20 hectares. Drainage in these expansive areas becomes a wicked problem, as conventional methods may not be sufficient to cope with the excess water. This situation was highlighted by Mr. Lan, a large farm owner who complained about the heavy rain a few weeks ago when showing me around his flooded cornfields in August 2023. He told me that the consolidation of farmland with fewer ditches in between constrained its drainage capability during summer rains, which significantly damaged his cornfields. With nearly 600 hectares of corn planted every year, approximately 10% of the cornfields (60 hectares) would be flooded, leading to the reduction of grain yields. In response, he had to dig ditches by himself with an excavator to drain the excess water out of the cornfields, in case of bigger losses.

Figure 5.11. Dwarf corn seedlings after a summer flood.

Source: Author, August 2023.

5.5 Discussion and conclusion

China's state-led agricultural modernization and national food security campaigns since the 2000s align with a technocratic developmentalism rooted in high-modernist ideals, and the focus has shifted from large hydraulic engineering towards small-scale farmland irrigation infrastructures. Drawing on the case of the high-standard farmland project, this chapter analyzes how localized smaller water infrastructures reconfigure intra-state dynamics, state-society relations, and hydrosocial governance. By interrogating the production and reproduction of these infrastructures at the local and grassroots levels, it reveals how their uneven spatial distribution and material agency have generated variegated irrigated landscapes, which shape and are reshaped by the nuanced power dynamics among state actors, rural communities, and non-human agents.

This chapter advances two main arguments. Firstly, the development of water infrastructures challenges a simplified notion of monolithic "hydraulic state" and embodies a fragmented hydrocracy, where intra-state tensions and state-society negotiations mediate infrastructural outcomes. While Wittfogel's (1957) thesis posits a centralized despotic state monopolizing water control, China's bureaucratic system is marked by multilayered statehood, and local governments and cadres operate as semi-autonomous actors with divergent political-economic interests, worldviews, and work ethics (Xu, 2020; Pia 2017, 2024). And therefore, state-led development interventions are not always unidirectional or monolithic endeavors but dynamic processes of coproduction where micropolitics and everyday techniques coexist with and constrain the exercise of state power (Scott, 1999). These coping strategies are hidden and embedded within the everyday practice of local hydrocracy and rural society, though they are not necessarily to be resistant or violent (Ullberg, 2019; Xu et al., 2024).

The implementation of the high-standard farmland project exemplifies the complexity of China's water governance. The centrally designed project is tempered, mediated, or constrained by local bureaucrats and rural societies, making infrastructure as a techno-political terrain on the ground. As illustrated in section 5.3, the county government prioritized standardized project designs and demonstration zones to meet audit metrics and secure career advancement. Township governments navigated between central mandates and local realities, adapting or rejecting projects to sustain diverse agricultural livelihoods. Village committee leaders and the township government were mediated by a reciprocal relational network, where village leaders leveraged relational networks to negotiate resource allocation and secure village interests, and the township government relied on village cadres to resolve disputes and maintain social stability.

Secondly, I argue that water and water infrastructures act as active agents of socio-political change that entrench, subvert, or redirect state-led development interventions, diverging policy intentions and reshaping rural political economies. Water infrastructures are not passive instruments of state control but active socio-material forces to reconfigure power relations and transform agricultural hydrosocial governance (Clarke-Sather, 2012). The design, placement, and operation of these infrastructures in the rural society have reshaped the contours of existing power dynamics and reproduced variegated landscapes. As illustrated in section 5.4, the centralized planning and execution of the high-standard farmland project, as political imperatives of agricultural modernization, sometimes resulted in a disconnection with local actual needs. These infrastructures are often embedded in the existing social structures and entrench elite capture. Large producers, leveraging political connections, disproportionately benefit from state investment. Smallholders outside of the project areas face heightened costs, labor burdens, or exclusion, exacerbating socio-spatial stratification. Moreover, water's fluidity and seasonality interact with rigid technocratic designs, also generating differential spatial distribution and unintended outcomes such as waterlogging during heavy summer rains.

To conclude, the high-standard farmland project underscores a dialectical process: while the central state deploys irrigation infrastructures as a modernist-oriented, techno-centric model to drive agricultural modernization, their material and social embeddedness enables local and grassroots actors to navigate, adapt, and/or resist, and thus transforms intra-state relations and state-society dynamics. By reframing water infrastructures as co-productions of political, economic, and social forces, this chapter challenges top-down narratives of Chinese hydraulic state. It instead posits hydrosocial reconfigurations where power is continually renegotiated through mundane engagements of various actors in everyday infrastructural encounters.

Water mediating technologies and infrastructures, once adopted, have momentum on the shaping of the organization of human action and the making of new rules and social institutions in water governance. The following chapter turns to the transformation of irrigation governance modalities in rural societies, elucidating the intricate power dynamics through which various irrigation organizations are formed, develop, and face challenges in agrarian transition.

Chapter 6 Transformations of canal and groundwater irrigation governance modalities

6.1 Introduction

Since the founding of the People's Republic of China in 1949, there have been significant transformations in the structure and organization of governing irrigation commons within Chinese rural society. The changing political-economies from planned economy and collective farming to market economy, and then to agricultural and rural modernization have witnessed the process of de-collectivization of canal irrigation system in China. For example, individualized groundwater irrigation methods, such as private tubewells, have seen a dramatic increase over the past decades which has challenged collective action in the governance of irrigation affairs (Wang and Cao, 2021; Wang et al., 2022).

To improve performances of sustainable irrigation governance, the devolution of operation and management responsibility from government agencies to local user groups has gained prominence in scholarly discussions. Contrary to the state's coercive and centralized control over the commons or the privatization of these common resources to avert "the tragedy of the commons" (Hardin, 1968), Elinor Ostrom (1990) and her colleagues have been arguing for a third way to govern the commons through self-governing institutional arrangements. Community-based Management (CBM) or Irrigation Management Transfer (IMT), particularly water users associations (WUAs), have prevailed as nirvana concepts and widely adopted policy models to enhance the role of local communities in irrigation governance globally, including China (Molle, 2008; Rap and Wester, 2013; Cambaza et al., 2020).

In China, the WUAs were established and organized within township and village administrative jurisdictions as appendages of the local water resources bureaus, with the leader being appointed by the government rather than elected by the members (Nickum

2005, 2010). Most WUAs operated in parallel with semi-governmental bodies like village committees in rural China, both organizationally and financially, and were frequently dominated by village elites (Zhou, 2013; Wang et al., 2018; Wang et al., 2021a). This top-down institutional planning has led to WUAs that often operate as empty shells in a nominal manner, failing to function autonomously and achieve the pre-existing promises of self-governing as intended. In contrast, folk and customary water practices emerged as alternative sustainable arrangements in the Chinese countryside (Pia 2023, 2024). The dynamic and evolving nature of irrigation governance necessitates a nuanced understanding of the interplay between state intervention, community participation, and the adaptive capacity of local villagers.

This chapter moves towards the intricate process of grassroots irrigation management transformations within China's hydraulic society, outlining the state-operated and de-collectivized canal irrigation system in parallel with the diverse and adaptable groundwater irrigation governance under the influence of agricultural modernization, state-sponsored projects, and climate change. Zooming in to Gui township, a traditional grain-producing area in Tancheng that uses a combined canal-and-well irrigation system, this chapter aims to investigate how local water bureaucrats and rural communities navigate the operation and management of irrigation water in routine administration and interactions. Following a brief background on the institutional reform of irrigation management in Tancheng county and Gui township in section 6.2, section 6.3 explores the de-collectivization of state-operated canal irrigation system, illustrating the hierarchy of technical infrastructure, the institutional forms for water distribution, and the absence of mechanisms for resolving water conflicts among various stakeholders, including upstream and downstream townships and/or villages, as well as large-scale and small producers. Section 6.4 unpacks a concurrent trend of recentralization, re-collectivization, and individualization in the groundwater irrigation governance by examining three distinct organizational models in three representative villages: bureaucratic, self-governing, and self-dependent. This chapter concludes by rethinking the conventional social sciences approaches to collective action and self-governance, and by understanding context-specific dynamics of institutional change that involve a complex interplay of traditional and modern, formal and informal, governmental and folk practices for sustaining agricultural production and ensuring water access in rural China.

6.2 Irrigation organizational reforms in Tancheng county

This section sets the stage for irrigation management in Chinese rural society. It first draws the contour of institutional reforms in agricultural production and irrigation management in Tancheng county from the 1950s to the present, occurring in the wider changing political economies in China. It then zooms in on Gui township and provides background information on its agricultural-based livelihoods and the shrinking rural population, which affect the governance of both the canal and groundwater irrigation system.

6.2.1 From de-collectivization, re-collectivization to recentralization

During the era of agricultural collectivization (1950s-1970s), the construction and management of irrigation districts involved a collaborative effort between the state and grassroots mass organizations. The operation and maintenance of the on-farm conveyance works, both at and below the lateral level of a canal system, were uniformly managed by people's communes (Mollinga et al., 2005). Tancheng initially established 19 people's communes in 1958 to construct its gravity-fed canal irrigation system. These communes were structured into several production brigades, which were further divided into production teams consisting of groups of peasant households (Tancheng County Government, 2021b).

As the people's commune system broke up in 1984, the introduction of the HRS and market-oriented reforms resulted in the de-collectivization of both agricultural production and irrigation management. This shift enabled individual peasant households to acquire the right to contract farmland from rural collectives and each household shouldered the responsibility for watering their own fields (see Chapter 4.2.2 for details). In addition, government spending on water conservancy projects also decreased, which consequently led to a declining reliance on communal canal irrigation due to the aging and disrepair of water facilities. While individual groundwater irrigation, initially through public investments and subsequently, largely through private investments, saw a dramatic increase over years in Tancheng and especially across North China. By the mid-1990s, the proportion of groundwater irrigation supply in the water-scarce northern China had increased to about 40%, and the proportion of groundwater-fed irrigated areas had dramatically increased to approximately 70% (Wang et al. 2007, 2019). Since the 2000s, recognizing the need for intervention to boost agricultural modernization, the central government has augmented its irrigation investment to refurbish farmland and water conservancy infrastructure (see Chapter 4.2.3 for details). Meanwhile, WUAs were further promoted by government authorities and water bureaucrats in a top-down approach to encourage community involvement in local irrigation affairs (MWR, 2003; MWR et al., 2005).

Tancheng has been restructuring its water conservancy management system since 2011, transforming all the water conservancy management and service units such as irrigation district offices and township water stations, comprising 230 staff members, into public institutions that were thereafter fully funded by the government, with an annual budget increasing by 7.57 million *yuan* (Tancheng Water Resources Bureau, 2015). Meanwhile, following the launch of the "Small-scale Farmland Water Conservancy Key-County Construction Project" led by the Water Resources Bureau, 13 township-level WUAs were gradually established, which were further subdivided into branches within each township, often overlapping with village committees and agricultural cooperatives. Their primary functions included collecting water fees from users and maintaining the farmland irrigation infrastructures. The county government further implemented a reform of its grassroots water conservancy service system in 2015. Under this reform, each administrative village was appointed a water conservancy assistant responsible for irrigation, flood control, and drought management. A total of 616 such assistants were designated at the village level, each receiving a monthly stipend of 200 *yuan*, jointly funded by both the county and township budgets (Tancheng Water Resources Bureau, 2015). This decentralized and re-collectivized grassroots irrigation management system, coordinated by the Water Station—a public institution subordinate to the township government—relied heavily on the participation of peasant water users.

However, the implementation of the high-standard farmland projects since 2019 resulted in a re-centralization of government control over irrigation governance, with the township government playing a dominant role in everyday operation and maintenance. The integration of the high-standard farmland project into the evaluation criteria for rural revitalization and national food security objectives has elevated their importance. Local governments, with the chief governor assuming territorial responsibility, are accountable for the construction, management and enduring operation of newly built irrigation infrastructures. In addition, the management and maintenance of these farmland irrigation infrastructures have become a crucial factor in the annual performance evaluation of high-standard farmland projects (MARA, 2019). Financial incentives from the central government are awarded to the top-performing provinces and those demonstrating the most improvement, further motivating local authorities to excel in the project implementation.

In response to these carrot-and-stick policy incentives, Tancheng shifted to a more centralized and government-led governance model centered around the Water Station to ensure the optimal functionality of irrigation infrastructures constructed through the high-standard farmland project, especially the electromechanical wells for groundwater-fed irrigation. First, the ownership of the irrigation infrastructure has been uniformly transferred to township governments, in contrast to previous water conservancy projects that vested ownership in WUAs. This change in ownership is formally stipulated in the governmental policy that assigns township governments the responsibility for the operation and maintenance of these irrigation facilities (Tancheng County Government Office, 2021).

Second, the former grassroots organizations have either been replaced by government entities or existed only in name. The water conservancy assistants at the village level have become ineffective due to the lack of financial support. By 2019, two of the township-level WUAs had been disbanded, and the remainder were gradually integrated into the Water Station, forming a unified team under the auspices of the township government. Apart from governmental staff, the township government has also recruited maintenance technicians from nearby villages, either full-time or part-time, funded by water fees collected by the Water Station[15].

This government-led approach, expected to be more responsive and efficient, has significantly transformed relationships among the government and rural society in the daily operation and maintenance of irrigation infrastructures. It is particularly prevalent in the southern region of the county, where reliance on well irrigation is high. The frequent mechanical failures of wells in this area, due to heavy usage, require timely repairs to maintain good performance, a responsibility now is also shouldered by the government. This chapter zooms in on Gui township to analyze the trend of de-collectivization and recentralization in its canal and groundwater irrigation governance system.

[15] Source: interviews with township government officials, 2023-2024.

6.2.2 Background of Gui township

Gui township, located in the flat plain of the southwestern of Tancheng, covers an area of 59.65 km^2 with 44,510 registered population and 13,317 households across 30 administrative villages (Statistics Bureau of Tancheng, 2023). The area has a temperate sub-humid monsoon type climate, characterized by windy and dry spring, hot and wet summer, cool autumn, and cold and dry winter. The average yearly temperature is around 13.2°C to 15.8°C and the mean annual rainfall is 867.7 mm, of which most falls in the June to September period (ibid.).

A considerable area of Gui township is used for agricultural production, with 4021 hectares allocated for irrigated farming, accounting for 67.42% of the total land area (see Table 6.1). This farmland is dedicated to growing wheat and rice across two different seasons in a year. In addition to the widespread groundwater irrigation, its agricultural landscape is also serviced by two gravity-fed irrigation districts with three main rivers flowing across its jurisdiction from northeast to southwest: the Tanxin River, the Laomo River, and the Liugou River. With favorable water conditions, it stands out as a lead grain-producing area and an agro-industrial demonstration zone in the county, with an annual grain output of 72,000 tons and an average yield of 1.19 tons per *mu* (Gui Township Government, 2024).

Table 6.1. Land use in Gui township.

Type		Area/km²	Proportion/%
Arable land	farmland	40.21	67.42
	forest	4.92	8.25
	orchard	0.63	1.06
	grassland	0.06	0.10
	Sum up	**45.83**	**76.83**
Construction land	residential	5.97	10.01
	public services	0.21	0.35
	industrial and mining	0.54	0.91
	storage	0.07	0.12
	public infrastructure	0.03	0.05
	transportation	1.01	1.70
	greenbelt	0.02	0.03
	business service	0.15	0.25
	agricultural facilities	2.04	3.43
	special use	0.07	0.11
	Sum up	**10.11**	**16.96**
Environmental preservation	water area	3.70	6.21
Total		**59.65**	**100**

Source: Gui Township Government (2024).

Gui township is the only agricultural township composed solely of rural household registrations ("*hukou*" in Chinese) in the county. In recent years, it has experienced a noticeable trend of rural-urban migration (except for the year of 2018). Data from the seventh national census in 2020 reveal that the total residential population in the township was 34,672, markedly lower than its registered population of 44,843[16]. This demographic shift indicates an increasing outflow of population—primarily to cities within Shandong

[16] In contrast to the household registration under the public security authority, residential population in census of China refers to people that have actually lived in an area for a certain time, mainly including those: 1) who have lived in this area for more than half a year with a household registration in other places; 2) who have lived in this area and left their household registration places for more than half a year; 3) who have a household registration of this area while have been away for less than half a year (excluding those who work and study abroad).

province, such as Linyi and Qingdao, as well as Ningbo and Shanghai in neighboring provinces—in pursuit of employment opportunities, based on the interviews with township government officials and local villagers. Similar to other townships in the county, Gui township also has a rapid aging population, with the proportion of residents aged 60 and above continuously rising to 20.02% by 2023 (see Figure 6.1).

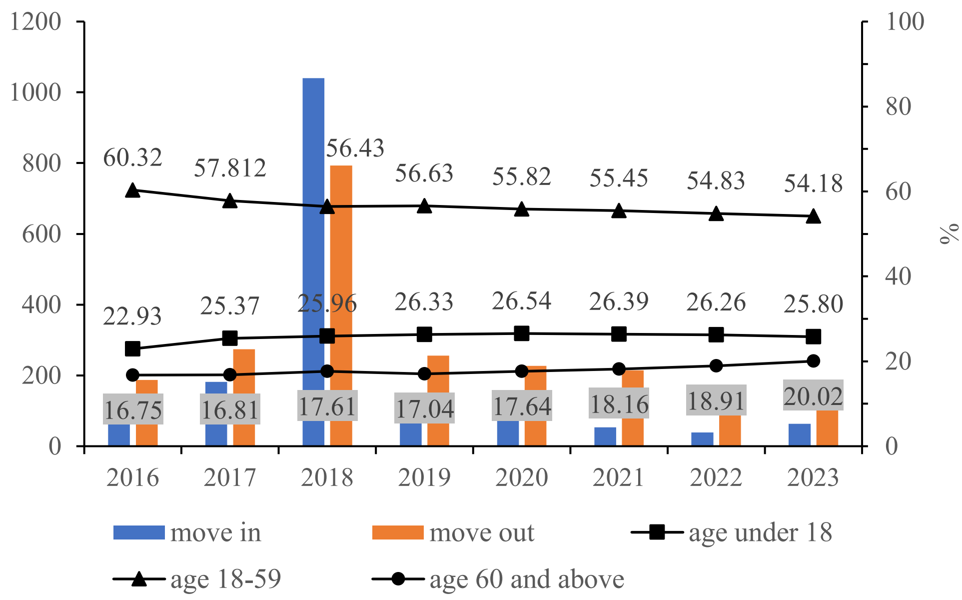

Figure 6.1. Population structure in Gui township.

Source: Statistics Bureau of Tancheng (2017 to 2024).

In this traditional agricultural township, as young generations migrate to cities for jobs, elderly family members usually stay at home to manage the farmland. According to my fieldwork investigation, most households retain some acreages of landholding to grow staple crops for subsistence, while transferring the remaining plots to large operators for annual rent. Despite non-farm income now constituting the primary livelihood for many households, especially those with middle-age male laborers, smallholders have enduring attachment to their land, viewing it as a critical social safety net. This reluctance to totally give up farming perpetuates land fragmentation, complicating efforts to modernize agricultural practices.

Gui township's agricultural landscape is bifurcated into smallholder plots and large-scale operations. The latter include a 133-hectare agribusiness founded by a village committee leader with prior experience in the local flour industry, two family farms (220 and 20 hectares, respectively), and a 12-hectare vegetable planting farmers' professional cooperative. While these enterprises signify a shift toward moderate-scale agricultural production, their coexistence with persistent smallholding creates governance challenges. The hollowing-out of rural communities and the dual agrarian structure have profoundly complicated irrigation governance. For example, aging populations and shrinking communities have eroded the collective labor traditionally required to maintain canal systems. Village cadres in Gui township told me that they now relied almost exclusively on government-backed projects for canal dredging, as collective investment and labor mobilization had dwindled. Concurrently, water governance institutions have weakened, without participatory and oversight mechanisms. The former WUAs, nominally present but dominated by village elites, were ultimately dissolved and taken over by the township water station. This institutional vacuum has hindered the establishment of formal rules for coordinated water distribution or conflict resolution, exacerbating tensions among upstream and downstream villages and between large-scale operators and smallholders. The following sections are going to further analyze how these de-collectivized agrarian dynamics have reshaped both canal and groundwater irrigation management in Gui township.

6.3 Disorder and contestation of the canal irrigation system

Gui township is uniquely positioned across two irrigation districts in the county: the eastern side is supplied by the Liugou River within the Qingquansi irrigation district, while the western side is served by the Tanxin River and the Laomo River within the Matou irrigation district. This section aims to illustrate the disorder and contestation of the canal irrigation system through everyday administration and interaction among water bureaucrats and village communities. It begins by examining the technical and institutional features of the canal system, using the Gui township within the Matou irrigation district as an example. Then, it explores the irrigation timing and water allocation frameworks of the canal system, which often leads to chaotic and incompact outcomes of water distribution. Third, it illustrates water disputes and the spatial power that arise among upstream and downstream townships or villages, as well as between growers on the east and west riverbanks. This section ends up by accounting for the disorder and contestation of the communal canal irrigation system alongside a trend of de-collectivization in rural China.

6.3.1 Canal structures and institutional forms

Matou irrigation district is a gravity irrigation system that diverts the Yi River water from a storage dam (see Figure 6.2). This storage dam, headworks of the canal system built in 1959, has been reconstructed and refurbished since 1990s to a total storage capacity of 16.1 million m^3, which benefits rural population over 6 townships with an irrigation area of 19,676 hectares.

Figure 6.2.The storage dam of Matou irrigation district.

Source: the government official website, available at: https://www.sohu.com/a/451656023_181516.

The canal system in Matou irrigation district is divided into five hierarchical levels.[17] It has a general main canal with a length of 1.05 km, which diverts water from the headworks to its three main canals with a total length of 47.4 km. Of the three main canals, the southern one is a natural river, while the east and the west ones are concrete channels. Gui township is situated in the middle and lower reaches of the eastern main canal (see Figure 6.3).

[17] The five levels of the canal system are: 1) general main canal; 2) main canal; 3) branch canal; 4) lateral canal; and 5) field channels, with each lower level forming a constituent or nested part of the upper level. The branch and lateral canals are responsible for distributing water to the fields. Waterways within individual farm plots are the last level of the canal system, which deliver water directly to sub-plots, rows, and crops. Corresponding to the irrigation system is a drainage network that removes excess water from the fields, starting from the smallest ditches and progressing to the main drainage ditches.

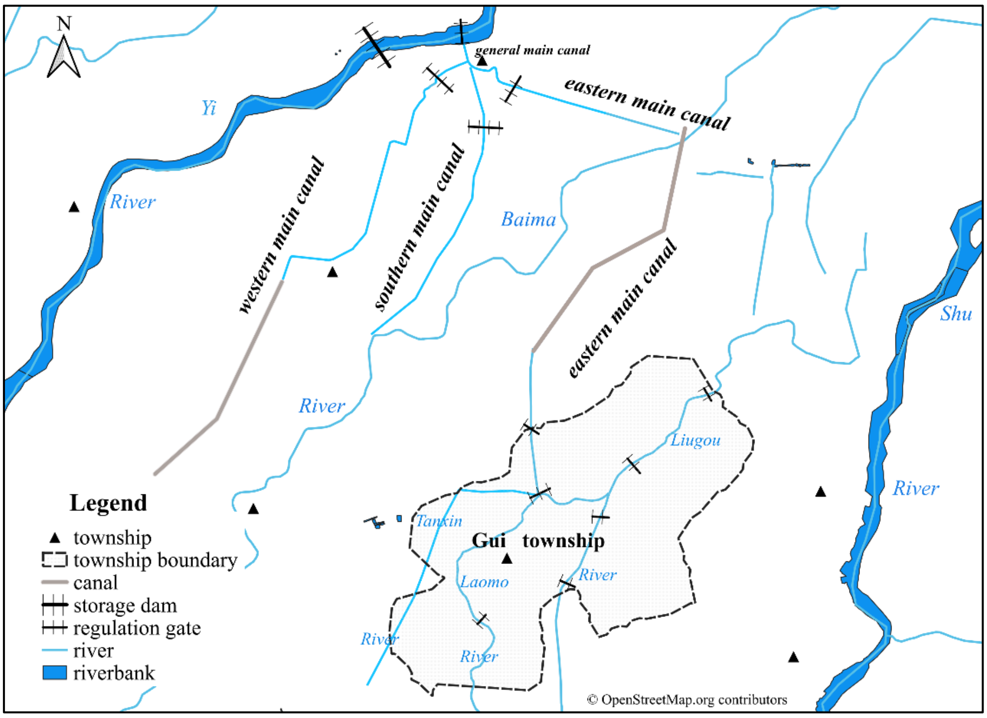

Figure 6.3. Main canals in Matou irrigation district.

Source: drawn by author. Note: Levels of canals are connected through outlet or diversion structures. The outlet structure along the main canal is known as a "regulation gate." It controls the flow of water from the upstream to the downstream side. While the outlet structure along the branch canal is referred to as a "distribution gate", which distributes water from a higher-level canal to the next level down.

In Matou irrigation district, water bureaucrats manage the first three levels of the canals, and the fourth and fifth levels are managed by village communities. To be specific, the headworks and the general main canal are managed by the irrigation district office, a public institution under the leadership of the county's Water Resources Bureau and fully funded by state finance. This office, consisting of seven staff members who rotate on duty 24 hours a day during irrigation seasons, is responsible for releasing water from the intake gate. The management of regulation gates in the associated main canal is the domain of the water station, a fully-funded public institution subordinate to the township government. In addition, the distribution gates at the main and branch canal bifurcation points are managed by village communities, usually the village party secretary or a delegate villager with subsidies from the township government (see Figure 6.4). However, this hierarchical water management structure operates independently in practice without any coordinating mechanisms that enable irrigation needs from the main canals down to the individual fields addressed in an organized and efficient manner.

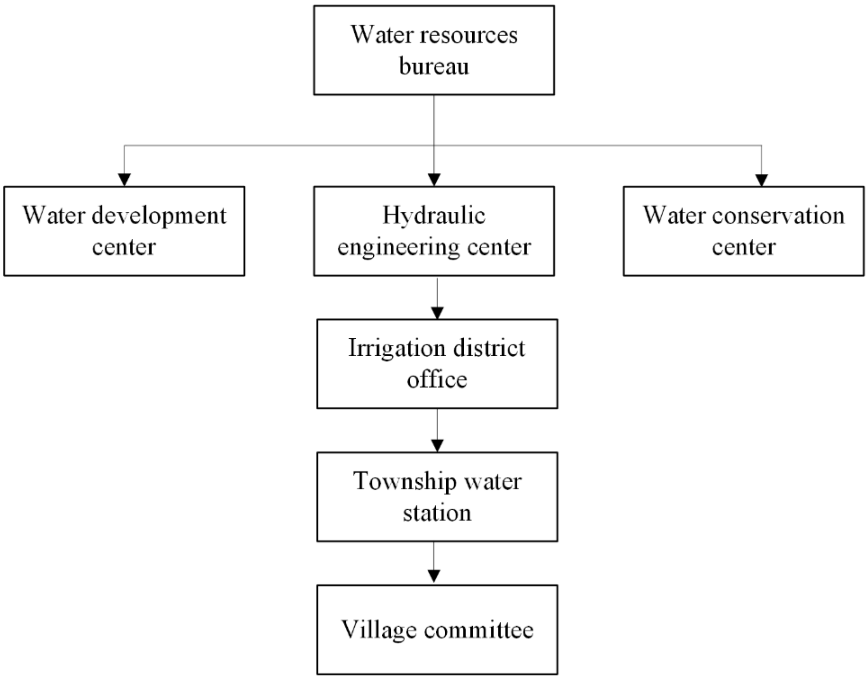

Figure 6.4. Organizational structure of the Matou irrigation district.

Source: drawn by author. Note: The county Water Resources Bureau has six internal agencies: 1) administrative office; 2) personnel office; 3) planning and financial office; 4) hydraulic construction office; 5) rural water conservancy office; and 6) water resources conservation office. In addition to these governmental agencies, there are three public institutions as supporting and service centers under the auspices of the bureau: 1) water development center; 2) hydraulic engineering center; and 3) water conservation center.

A unique technical design feature of the canal system is that the outlet or diversion structures, which are crucial in regulating the volume and timing of water supplied to growers, are differentiated at different levels of the canal network. In the main canal, almost all regulation gates have been renovated with an information-based control system through government-funded infrastructural projects in recent years (see Figure 6.5a), which allows the township-level water station to remotely and automatically open and close these gates. In contrast, the distribution gates located along the branch canals are masonry or concrete structures equipped with steel gates and require manual operation by the village committee leaders or their delegates (see Figure 6.5b). This type of manual gates often leaks as it becomes aging and broken. At the lateral and farm levels, the outlet structures are normally simpler “earth offtake” structures without steel gates, which are dug by the growers themselves to access irrigation water (see Figure 6.5c).

(a) The regulation gate in the main canal.

(b) The distribution gate in the branch canal.

(c) The “earth offtake” at the lateral and farm levels.

Figure 6.5. Differentiated outlet structures along the canal system.

Source: Author, 2023-2024.

Notably, except for the intake gate at the canal head, there are no flow metering facilities installed to measure actual water flows within the canal system. Moreover, the absence of intermediate storage means that water can only be directed to various locations and cannot be stored for more flexible management responding to local demands and needs. These infrastructure design features configure a series of arenas and locations for water distribution interactions over a large spatial extent among individuals, village communities, and the administrative sections of the Water Resources Bureau that manage different parts of the canal system. The hierarchical levels of canal structure can lead to skewed water distribution, with those located upstream enjoying a strategic advantage in terms of timing and location, as noted by Mollinga (2014).

6.3.2 Irrigation timing and water distribution

Irrigation takes place during two cropping seasons in Gui township: summer rice and winter wheat. The first round of irrigation normally begins around mid-to-late May to raise rice nurseries for a week. After wheat is harvested in early June, a second and often a third round of irrigation starts immediately for the transplanting of rice. Winter irrigation for wheat is scheduled in the mid-to-late November and early December, followed by a spring irrigation in March or April[18]. The amount of agricultural water allocated to each township, based on its total farmland area, is specified by the county's annual water allocation plan, which is made by the Water Resources Bureau. For example, Gui township was allocated 600,000 m^3 within the Matou irrigation district in 2024. Water was then reallocated by the township government to the villages according to their irrigated areas. However, in practice, water distribution is not regulated by volume but by the duration of irrigation days, due to the lack of water metering facilities at the outlet structures.

I will take the example of rice cultivation to further illustrate the water distribution process along the canal irrigation system that is linked with different stakeholders or actors. According to the central-planning water allocation quota, Matou irrigation district has acquired a water abstract permit of 66 million m^3, of which 45 million was supplied to four townships for rice cultivation in 2024. On June 10th, as the rice transplanting began, Mr. Huai, the staff of the irrigation district office, opened the intake gate to divert water from the Yi River into three main canals. He then supervised the township-level water stations to release water through the opening of regulation gates along the main canals. In order to allow water to flow from upstream to downstream in a timely manner, the upstream township was scheduled to irrigate for the first three days, followed by Gui township (in the east canal) for another three days, and finally the downstream township

[18] Source: interviews with staff members from the irrigation district office, June 2024.

for another three or four days of irrigation. This round of water allocation, with a flow rate of 15 m^3/s, only enabled 70% of the rice cultivation. The remaining growers, usually those with large-scale operations, had to rely on a second round of water provision at a reduced flow rate of 8 m^3/s.

The canal irrigation system, with its structured hierarchy, is designed to efficiently manage and distribute water resources across agricultural landscapes. Despite this structured system, the practical implementation of water distribution is characterized as a loosely organized governance framework that often leads to disorder and contention among water users. As abovementioned, the irrigation district office plays a pivotal role in the unified water supply, orchestrating the opening and closing of regulation gates along the main canal based on its predetermined irrigation schedule. However, the intricate process of coordinating water distribution among upstream and downstream townships or villages is not as systematically managed. The coordination is largely left to the township governments or village committees themselves. The absence of a centralized, county-level authority to oversee these interactions creates a scenario where timing becomes a critical and scarce resource, particularly during the peak water demand period for rice cultivation in June. In the absence of formalized coordination mechanisms at the county level, water disputes emerge as persistent challenges in effectively and equitably serving the needs of irrigators. These water conflicts recur seasonally and year after year, involving a complex negotiated process between street-level water bureaucrats, who are responsible for the day-to-day management of water resources in their townships, and among irrigators along the canal, as each seeks to secure sufficient water for their crops.

6.3.3 Contested spatial power and water conflicts

The distribution of water based on time shares of concentrated flows creates contested spatial power among irrigators at different locations of the canal irrigation system. Those located upstream and downstream, as well as along the east and west riverbanks, experience varying degrees of access to and control over canal water. Upstream townships can cultivate rice earlier at the beginning of the farming season, while their downstream counterparts face the delayed arrival of water. Additionally, villagers along each side of the riverbanks are embroiled in water conflicts over similar delays in water access. Despite the intensity and apparent chaos to casual observers like myself, these contestations are highly patterned and depend on ad-hoc negotiations without any formal mechanism for conflict resolution. I will now highlight water conflicts and the contested spatial power in the canal irrigation system, by presenting two short vignettes that persist or recur during irrigation seasons.

The first vignette is about the obstruction of water flow to downstream areas by upstream townships or villages. Yang township, located at the lowest reach of Matou irrigation district beneath Gui township, encompasses 5336 hectares of farmland. Every year, it engages in negotiations with the government and villagers of Gui township regarding the untimely water allocation. During my field observation in June 2024, amidst a heatwave in the county with a scarcity of rainfall, I witnessed one such negotiation when I visited Yang township during the last day of a first round of water supply by the irrigation district. The deputy head of the township was informed by a technician, the former director of the agricultural technology station who is now working for an agribusiness company, that water had been obstructed by a village in Gui township. This agribusiness company, one of the largest agricultural producers in the township, heavily depends on canal irrigation for its 734 hectares of low-lying farmland, which is unsuitable to install agricultural wells for groundwater irrigation. The deputy head then was occupied with resolving this water issue through a series of phone calls to the water station managers and village gatekeepers in his township. He even drove to the site to check the door gate and negotiated with the upstream village committee. After several hours of personal coordination, he managed to channel water from the Baima River to the unirrigated farmland by opening one of the regulation gates in nearby township situated within another irrigation district. The agribusiness company's technician complained that:

> *"Upstream townships and villages often block water in order to catch up with the rice transplanting season, disregarding the prescribed irrigation schedules. We, at the downstream end of the irrigation canal and in an unfavorable geographical position, suffer from alternate droughts and floods as a result.*"

The second vignette explores the strategic use of water as a weapon of resistance by villagers against land transfer to large agricultural operators along the same riverbank. A family farm, expanding agricultural production across five townships in the county, has acquired 220 hectares of farmland in Gui township to date. The owner of the family farm, one of my key informants, once told me that they previously cultivated another 67 hectares of farmland situated at the junction between Gui and Hua townships in 2019. Since then, he has faced continuing water disputes with the adjacent village in Hua township, as the two parties were positioned on the opposing east and west riverbanks of the same water distribution gate. The village committee, as a form of resistance, refused to open the gate for the family farm to access canal water. Once the village completed its irrigation, it promptly closed the gate, allowing water to flow downstream, despite the canal still containing water. The family farm owner expressed his frustration when showing me around in the field:

> *"We have tried everything to negotiate with the village, ranging from turning to the township government for help, offering it gifts, to even threatening it by violence... Yet we can't solve this issue."*

Consequently, in 2022, the family farm decided to give up these plots of farmland due to the unresolved water dispute.

These contested water practices illustrate a deeper issue within the local hydraulic society: the spatial power dynamics that underpin the allocation and management of canal irrigation water. The current canal system of water distribution, based on time shares of concentrated flows rather than measurable water volumes to individual villages, villagers, or plots of land, exacerbates spatial inequalities and conflicts among upstream and downstream as well as riverbank communities. Downstream communities suffer from the delay of water access when upstream townships obstruct water flow. The villagers' manipulation of water access serves as a means to retain control over their land and to counter large agricultural producers. The intensity of negotiation processes and the inability of both the village community and the government to resolve these long-lasting disputes reveal a de-collectivized governance dilemma amidst the political and economic change in the past decades, which I am explaining in the next section.

6.3.4 The de-collectivization of canal irrigation governance

Why is the communal canal irrigation system loosely managed and coordinated? Why do the water conflicts recur over a long period of time? Why are the uniform and formal conflict resolution mechanisms absent? The issues surrounding the management and coordination of the communal canal irrigation system can be attributed to the de-collectivization of rural governance in China, a trend that has emerged from the profound transformations in the country's political-economic and social structure over the past few decades.

Firstly, the rural governance system has experienced a significant restructure since the agricultural tax reform in the 2000s, leading to a weakening in the ability to organize and mobilize rural communities. During the planned economy era, irrigation districts and large-scale water conservancy infrastructures, as evidenced in Tancheng county, were constructed under the people's commune regime. This system organized mass peasant labor for collective farming through political mobilization (Shapiro, 2001; Pietz, 2015). However, with the transition from the people's commune to the township regime since the market-oriented reform in the 1980s, state authority over direct management of the irrigation commons at the grassroots level has waned. The responsibility for providing public goods, including water conservancy facilities, shifted to the township governments and village communities.

After repealing the agricultural tax in 2006, which abolished the levies of agricultural tax and many other administrative fees and government-managed funds specially collected from farmers (see Chapter 4.2.3 for details), the township government and village committees lacked the financial incentive to manage canal irrigation. In particular, the abolition of rural labor services[19] further weakened the participation of peasants in the

[19] The State Council issued the policy document of "Decision on Developing the Construction of Farmland Water Conservancy" in 1989, which stipulated each rural labor force invested 10-20 labor accumulation days for the construction of farmland water conservancy every year. This rural labor policy was abolished in 2002.

construction and management of farmland and water conservancy. The irrigation canals at the branch and lateral levels were nominally within the domain of village collectives, in fact, none is responsible for the management as village committees struggled to undertake a large number of administrative affairs assigned by the township government (Wang et al., 2022).

With the local government turning the management offices of large and medium-sized state-owned irrigation districts into public or quasi-public institutions funded by public finance (State Council, 2002), rural governments have pragmatically relied on state funding for the operation and maintenance of irrigation canals, rather than fundamentally reshaping the rural governance framework in the long run. In Tancheng county, the role of 616 water conservancy assistants at the village level was often fulfilled by the village accountants to increase their low incomes in practice. In recent years, due to a lack of financial allocation, these public-funded assistants existed as an additional “nameplate”, failing to fulfill their intended functions effectively.

Secondly, the area-based water fee collection and its exemption by the government also contributed to the disorganization of the communal canal irrigation system. Traditionally, in Tancheng county, water fees have been collected based on the area of land cultivated, rather than the volume of water used. This is because of the lack of metering facilities at the outlet structures except for the intake gates. This area-based approach to charging for water has insulated the supplier from responsibility for ensuring the proper delivery of water, in contrast to a volumetric system based on metered water usage, which protects users from overcharging for water that is delivered in inappropriate quantities or in an untimely manner (Nickum, 2005).

Moreover, in an effort to alleviate the financial burden on peasants within the Huai River Basin, where water charges are often perceived as a form of taxation, the county government has repaid for the irrigation water fees since 2018. Previously set at 24 *yuan* per *mu* and collected door-to-door by village committees, these fees are now directly deducted from the township's financial allocation by the county government, and then disbursed back as salaries and management funds. This shift to a greater dependence on government subsidies has further undermined the farmers' sense of ownership over the canal irrigation system, and eroded their incentive and capability for collective management.

Thirdly, the rise of groundwater irrigation as an alternative to canal irrigation has further undermined the re-collectivization of water management (Wang and Cao, 2021). While canal irrigation remains as the primary source of water for agricultural production in Tancheng county, well-drilled irrigation has become a prevalent method among rural households, whether through government-backed project wells or private individual wells. Tubewells and pumps have become ubiquitous, giving producers greater flexibility in obtaining water when needed. In Yang township, since being located downstream, well irrigation nearly covers all its irrigated farmland, providing smallholders with an individualized alternative. To avoid the blockage of canal water, the Yang township government used to send staff members from the water station to monitor the outlet structures overnight and organized night-and-daily canal patrols by the station manager. But now technological advances, such as electric pumps and water IC cards, have turned irrigation management into a convenient individual exercise, rendering canal irrigation less necessary. Water disputes are primarily confined to a small number of large households that are slower in planting with large-scale farmland and are more dependent on surface water. These individual needs, while significant, do not prompt a shift in the governance system at the grassroots level.

The transformation in the governance of irrigation commons, from people's communes to village committees, and now to individual households, reflects a broader trend of de-collectivization in rural China. The shift towards individualized irrigation methods and the decline of collective action in rural communities have led to a fragmented and less cohesive management and coordination of the canal irrigation system. Contrasting this de-collectivization trend mirrored in the development of canal irrigation, groundwater irrigation has emerged with a variety of adaptative governance modalities in Chinese rural society, which I am going to illustrate in the following section.

6.4 Diversity and adaptation in the groundwater irrigation system

Groundwater irrigation is an available alternative in Tancheng, particularly for those townships located in the lower and downstream of the canal system, where groundwater provides greater reliability and flexibility during untimely water delivery and severe droughts. Its groundwater irrigation system, developed in the 1970s, has been further promoted by several governmental infrastructural projects in the past decades, notably since the Small-scale Farmland Water Conservancy Key County Project initiated in 2011. These governmental farmland and water conservancy projects mainly drilled electromechanical wells and equipped them with electrical boxes, pumps, underground pipelines and outlets that conveyed groundwater directly to the fields. By 2015, the county had 6605 electromechanical wells for groundwater irrigation, accounting for one-third of the total in Linyi municipality. The township-level WUAs previously exercised collective ownership of the infrastructural properties, while operational and maintenance duties were delegated to their village-level branches, funded by water fees collected based on electricity usage (Tancheng County Government, 2015). Irrigators do not pay a fee for groundwater, but pay the electricity cost for the use of these project wells, at a rate of 1.1 *yuan* per kilowatt-hour.

In Gui township, for example, four major government-led infrastructural projects have been implemented since 2011, resulting in the construction of 514 project wells to support groundwater-fed irrigation (see Table 6.2). The township-level WUA was established in 2012 and operated through three village-level branches, each managing agricultural wells within their respective geographical regions. Different from a bottom-up approach advocated by the Ostrom school, the township-level WUAs were established under the top-down administrative directives by the county government; while the village-level WUAs, usually dominated by the village head, operated without formal organizational structures or charters. In 2023, the township WUA was co-opted by the water station and bureaucratized into a quasi-public institution with members designated by the township government, such as full-time or part-time contracted employees from the water station.

Table 6.2. Number of project wells in Gui township.

Year	Governmental project	Number of well
2011-2012	Small-scale Farmland Water Conservancy Key County Project	96
2011	High-standard Farmland Consolidation Project	52
2017	Grain Production Capacity Planning Field Project	252
2022	The High-standard Farmland Project	114
Total		514

Source: archive documents provided by the water station director during the fieldwork.

The widespread adoption of groundwater irrigation has reconfigured the organizational system of irrigation governance, revealing a trend towards recentralization coexisted with re-collectivization and individualization within the local context. This section examines three villages located in the upper, middle, and lower reach along a shared canal system to unpack three distinct organizational modalities of grassroots irrigation governance in Gui township: the bureaucratic model in Y village, the self-governing model in X village, and the self-dependent model in M village (see Figure 6.6).

These findings challenge the central tenets of neo-institutional policy prescription on self-governance and collective action in common-pool resources management, which are more complex than the decentralized approaches conventionally assumed in the existing literature (Ostrom,1990; Lam, 1998; Ostrom, 2005; Andersson and Ostrom, 2008).

Instead, they represent intentional efforts to sustain agricultural production and water access through a blend of traditional and modern, governmental and self-governing, and formal and informal practices.

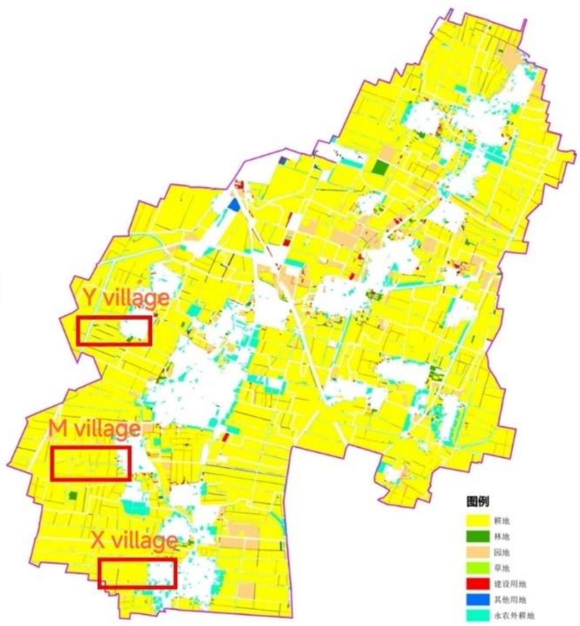

Figure 6.6. Map of the Y, M and X villages in Gui township.

Source: Gui Township Government (2024). Note: The legend polygons are respectively representing: farmland (in yellow); forest (in dark green); orchard (in orange); grass (in light green); construction land (in red); other uses of land (in dark bule); other uses of arable farmland (in light bule).

6.4.1 The bureaucratic modality: Y village

Y village, located in the upstream of the branch canal that conveys water from the Tanxin River, is a place to a registered rural population of 1380, of which 850 are permanent residents. The village covers an area of 1720 *mu* of farmland, growing 1615 *mu* of wheat and 1700 *mu* of rice across two cropping seasons. Despite its upstream location, canal irrigation reaches only 60% of the farmland, around 1000 *mu*. While groundwater irrigation, facilitated by the proliferation of project wells, basically covers the entirety of its farmland [20]. Supported by the government-led Small-scale Farmland Water Conservancy Key County Project in 2011 and the High-standard Farmland Project in 2022, a total of 22 electromechanical wells have been built in this village.

These wells were initially managed by Mr. Xu, the former village committee party secretary from the nearby village, who was serving in one of the three branches of the township-level WUAs. Mr. Xu, a prestigious person in his sixties, was responsible for collecting water fees and organizing the maintenance of the wells within the neighboring villages. The water fees were collected through the charging of individual water IC cards at 1.1 *yuan* per kilowatt-hour. Part of the fees were used to pay the agricultural electricity bill at 0.54 *yuan* per kilowatt-hour, and the rest were used for maintenance cost. As you can see from this case, although the nominal existence of WUAs in Y village, the management of well irrigation was in fact run solely by the village community leader, deviating from the participatory irrigation management intended for all villagers. The villagers were not directly involved; no meetings were ever convened, and there was no supervision regarding the spending of the collected water fees. This state-reinforced self-governing planning has led to the misappropriation of funds and surging complaints about delayed maintenance. Mr. Wei, a government official from the township water station, expressed his angry to me during the interviews that:

[20] Source: interviews with the village committee leader, June 2024.

"The village committees used the collected water fees for private interests instead of timely maintenance…Villagers often called the government hotline 12345 to complain about the broken wells."

Therefore, in March 2023, the water station of Gui township government unified the management of these project wells, transferring ownership of the infrastructures to the township government and integrating the WUA as one team of people in water station. Two staff members were deployed to take over the collection of water fees. Five technicians from the nearby villages were hired on a full-time basis with a monthly salary to ensure continuous operation and maintenance. Villagers have to recharge their water IC cards at the agricultural water service office in the township center, driving their motor tricycles. The water station manager is responsible for dispatching technicians to repair the project wells, underground pipes and electricity cables, using the collected water fees based on differential electricity tariffs. In cases where water outlets are damaged by individual villagers, the water station director coordinates repairs and ensures the responsible parties cover the costs. As for the responsibility of the village committee, Y village has established 19 public welfare positions open to the ordinary people for village affairs, including sanitation, irrigation, and flood control with a government-backed salary of 600 *yuan* per year. These groups of people conduct daily patrols and identify and report damages of irrigation infrastructures. However, due to the severe impact of the Covid-19 epidemic on government finances, the number of rural public welfare positions were cut down and the wages were unpaid.

The political imperatives of agricultural modernization and national food security facilitated the bureaucratization of WUAs in Gui township. Since farmland and water conservancy projects were integrated into the high-standard farmland project in 2019, the importance of durable operation and management of irrigation infrastructure has been escalated (see details in Chapter 5). The county government (2021) shifted its policy attention away from WUAs and instead reaffirmed the township government as the primary entity responsible for irrigation management:

> *"**Article Four** According to the benefit scope and target of the high-standard farmland project, the main body responsible for the operation and management of the high-standard farmland project is the township government. The property rights of small-scale farmland and water conservancy infrastructures belong to the township governments, and they are fully responsible for the durable operation and management of these facilities."*

And therefore, the top-down administrative nature of WUAs, initiated and steered by public authority, can be conveniently co-opted by the township government to establish uniform management of water resources and to improve irrigated agricultural productivity. Based on the political calculus, the government was eager to bureaucratize WUAs into quasi-public institutions, which they can assign specific tasks to tighten administrative control over irrigation and strengthen food security (Lam et al., 2021).

The bureaucratic modality in Y village is not a unique case and has been widely promoted across the county, which highly relies on governmental staff for water fee collection and the maintenance of irrigation infrastructure. It represents a trend of re-centralization of government control in grassroots irrigation governance, dismantling the state-reinforced villagers' self-governance of WUAs both in name and in practice. The advantages of bureaucratizing WUAs include timely maintenance of irrigation facilities and transparency in water fee collection and payment under fiscal audits. In addition, under the strict procedure of governmental audits, the expenditure of water fees is monitored and the end is kept at break even. Some townships with a large group of water users, such as Yang township, even has a surplus of maintenance funds from the collected water fees every year.

However, the disadvantage is that villagers need to recharge their water IC cards at the government office during working hours on weekdays, with cash only, which may limit their access to water and disrupt farming schedules during critical seasons. More ironically, it places a significant administrative burden on the government and strains its personnel and financial resources. For example, the Gui township water station, consisting of a director and five technician employees, is responsible for the management of a total of 514 project wells. Due to geological reasons, some of the project wells have collapsed in recent years. Over 20 of these wells were newly-built in 2023, each of which cost around 15,000 *yuan* with funding from the county's water bureau. In addition, it undermines the empowerment of local communities. By re-centralizing control, villagers show less concern for these government-drilled project wells, as is concerned by Mr. Wei from the water station. He stated that some villagers did not take care of these wells when using machines for agricultural operation in the field. They were even reluctant to pay for the man-made damaged facilities as they assumed that the government should take on the responsibility for all aspects of repairs and maintenance. The reliance on the government for public goods provisions leads to a lack of enthusiasm for participating in the governance of irrigation affairs among villagers, which weakens community bonds and the sense of collective responsibility for shared common-pool resources.

6.4.2 The self-governing modality: X village

In contrast to the top-down policy design of WUAs, an alternative model of self-governing irrigation commons is discovered in X village. This self-governing modality, different from the bureaucratization of WUAs for the management of government-backed project wells, is spontaneously initiated by folk villagers themselves rather than organized by the semi-administrative village committee.

X village, located at the lowest reach of the branch canal that delivers water from the Laomo River, has a total of 1580 registered population with 800 permanent residents. The village covers an area of 2200 *mu* of farmland, cultivating 1800 *mu* of wheat, 1500 *mu* of rice, and around 700 *mu* of maize or garlics across two seasons[21]. Because of its relatively low-lying topography, there are no project wells in the village as the government assumed it has good access to canal water.

However, the irrigation schedule in X village is poorly timed and often lacks sufficient water supply during the sowing season. Located in the downstream, X village has experienced delayed and inadequate water flows for several times when it is its turn to irrigate, particularly during dry seasons. During June 2024 when the county suffered from a heatwave and scarce rainfall, Mr. Qiao, the village committee party secretary, had urged the water station for three times to open the regulation gate promptly in case of missing the farming schedule. He even sent villagers from the public welfare positions to guard a small culvert upstream in case the water was cut off by the upper village. The unreliable water supply led to a land transfer of 700 *mu* with over 200 households involved in 2018, coordinated by the village committee. The land was transferred to four large producers at an annual rate of 800 *yuan* per *mu*, among which three were from the local villages, while another one from the nearby township.

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[21] Source: interviews with the village committee leader, June 2024.

In response to the instability of canal water supply, the villagers have taken matters into their own hands. In groups of seven or eight people, they have collectively contributed to the construction of 13 electromechanical wells for groundwater irrigation in 2022. Each well, costing over 10,000 *yuan*, irrigates an area of 70 to 100 *mu* of farmland. These wells, powered by electricity to pump and transport groundwater, are privately owned by the beneficiary households. Two local plumbers in the village are responsible for operation and water fee collection by charging water IC cards at a rate of 0.7 *yuan* per kilowatt-hour. After deducting the agricultural electricity cost of 0.54 *yuan* per kilowatt-hour, the remaining funds are used to cover the labor costs for operating and maintaining these wells. In the event of any broken issues, the investors again collectively pool money for repairs and maintenance.

The self-governing modality in X village, in contrast to the state-reinforced promotion of WUAs, emerged from the folk water practices in response to the late-arriving of water via the communal canal irrigation system. Echoing Scott's (2017) analysis of farmers' agency in highland communities but not in a scene of avoiding state's control, the villagers have intentionally self-organized themselves to ensure a thriving agricultural livelihood. The decision is driven by two main factors. The first and foremost driving force is the constraints of the material environment, such as the unfavorable location in the downstream that has led to a delay of water supply. Under such a disadvantaged environment, people in X village did not want to passively rely on the heavens and wait for water ("*dengtiankaoshui*" in Mr. Qiao's own words).

The second and related driving force stems from the villagers' desire for irrigation mechanization. Interviews and casual talks with X villagers indicate that they have noticed the convenience of electromechanical wells brought by the governmental projects in other villages, which made it labor-saving for the left-behind elderly and women to irrigate their farmland promptly and conveniently with their water IC cards taped on the electrical box. And thus, they would like to keep up with the pace of agricultural modernization and enjoy the benefits of irrigation mechanization. A household producer in her seventies with around 10 *mu* of farmland informed me that:

> *"Water flow in the canal was quite limited…We used to rely on the shallow-dug well built by the village committee for irrigation, carrying heavy and oil-consuming diesel engines to pump water…Now I am too old to carry these machines… The mechanized irrigation [electromechanical well] is very prompt and handy [with a smile in her face]."*

This informal self-governing model, initiated by grassroots practices, suggested that self-governing needs not to be formally organized following the institutional design principles as the Ostrom school advocates. It involves the participation of villagers by giving them control over their irrigation resources to some extent. This sense of ownership can also lead to better maintenance and management of the wells. As Mr. Qiao once noted that "People cherish the wells they have invested in, but not the public ones." The process of collective investment and management can strengthen community bonds and cooperation among villagers, fostering a sense of unity and shared purpose.

However, this model is not without its challenges. Not all villagers are able to participate due to financial constraints or other reasons, leading to a potential exclusion within the community between those who have invested and those who have not. It is reported that there is still 600 *mu* of farmland that is not covered by the well irrigation and has to rely on canal irrigation. Those excluded individuals may either transfer their land and give up farming or find alternative and often individual irrigation solutions. Furthermore, the long-term sustainability of the self-governance model is uncertain. Especially with the aging of well facilities, it will face more complex governance issues, including rising well-drilling and maintenance costs, and a shortage of maintenance personnel.

6.4.3 The self-dependent modality: M village

Distinct from the bureaucratic and self-governing modalities mentioned above, M village represents an individualized and self-dependent approach to water management in groundwater irrigation, a model prevalent in many villages in rural China along with the development of affordable technologies, such as tubewells and diesel or gasoline pumps.

M village, situated in the middle reach of the Laomo River, has a registered population of 1800 and nearly 3000 *mu* of farmland that is dedicated to the cultivation of wheat and rice across two cropping seasons. Like X village, M village has not received any government-sponsored project wells yet. And the availability of surface water for irrigation in the village is also significantly limited by delayed irrigation schedules, particularly during dry seasons when canal water flow is minimal.

In response to both water shortage and untimely supply of canal water, most villagers have to rely on big, concrete wells for irrigation. These wells are approximately 6 to 7m deep, and were constructed by the village committee decades ago (see Figure 6.7). They are crucial for meeting agricultural schedules, especially for rice seedling transplantation. However, as the groundwater table continues to decline, extracting water from these wells using diesel engines has become increasingly difficult and time-consuming. During my site visits to M village in June 2024, a smallholder in his fifties expressed these concerns. He told me that there was no water available in the canal when he started to transplant rice seedlings, as it was not the village's turn to access the canal irrigation water. Consequently, he had to resort to using his diesel engine to pump water from the collective well. Yet the successive dry weather led to a deeper groundwater table in the well and increased time and costs associated with groundwater irrigation. Moreover, due to a lack of management and maintenance by the village committee, some of the concrete wells are no longer in use and are blocked up.

Figure 6.7. An old concrete well built by the village collective.

Source: Author, June 2024.

In addition to the collective wells, villagers have adopted various strategies to navigate water constraints and sustain their agricultural livelihoods in a less organized way. Over the past three years from 2022 to 2024, groups of five to six villagers have jointly financed the drilling of their own vacuum tubewells, each costing around 2,000 *yuan*, with a diameter of 15cm and reaching a depth of 40m. These small tubewells are not equipped with electrical boxes and underground pipelines, necessitating the use of personal diesel or gasoline engines to pump water from the wells, which is then transported to the fields via removable hoses. These wells are secured with locks, and each contributing household has a key for access during irrigation needs (see Figure 6.8). A smallholder with 4 *mu* of farmland was weeding in the field when I passed by. He told me that:

> *"I used water from the tubewell to transplant rice seedlings last week, and I have irrigated the paddy field four times within a week because of the dry weather…Canal water didn't come until last night."*

Figure 6.8. The private vacuum tubewell invested by villagers.

Source: Author, June 2024.

This mode of groundwater irrigation governance, although highly individualized, reflects the villagers' proactive efforts to flexibly navigate water access and maintain agricultural production, without waiting for bureaucratic processes or collective decisions. However, this self-dependent model is in lack of coordination to some extent. Although some groups of villagers have contributed to the construction of private tubewells at a relatively low cost, they do not specify any responsibility for the maintenance and operation, as the focus shifts from public goods to individual interests. This limitation may lead to the early decay of the infrastructure as time goes by. Moreover, the adoption of varied irrigation solutions has led to discrepancies in farming schedules. Some growers who rely on free canal irrigation transplant their rice seedlings a week later than those who rely on groundwater irrigation, highlighting the diverse approaches to water management within the village. During my site visits to M village in June 2024, I found that some smallholders just began to transplant rice seedlings with the late-arriving of canal water, while their neighbors had irrigated the paddy fields four times within a week after transplantation, using labor- and oil-consuming groundwater irrigation (see Figure 6.9).

Figure 6.9. A woman grower was transplanting rice seedlings in the field.

Source: Author, June 2024.

6.4.4 Summary of three groundwater irrigation governance modalities

Three groundwater irrigation governance modalities have been identified in Gui township: bureaucratic, self-governing, and self-dependent. The features of each modality are summarized in Table 6.3.

Table 6.3. Summary of three groundwater irrigation modalities.

Management modality	Infrastructure ownership	Operation & maintenance arrangement	Emerging dynamic	Village sample
Bureaucratic	Township government	The water station is responsible for project wells	Political imperatives and government's calculation	Y village
Self-governing	Beneficiary households	Contributed by folk villagers and operated by local plumbers	Needs of and desires for mechanized irrigation	X village
Self-dependent	Collective and private	Various individual irrigation solutions	Parochial interests and agricultural livelihoods	M village

The bureaucratic modality of groundwater irrigation as exemplified in Y village transfers the ownership of irrigation facilities from the state-reinforced WUAs to the township government, and the repairs and maintenance of project wells are taken over by the water station, a public institution of the township government fully funded by the public finance. This emerging structure is contingent on the government's calculation under political imperatives of agricultural modernization and the associated national food security, rather than the immediate needs of the users.

In contrast, the self-governing modality in X village features private ownership of the electromechanical wells by beneficiary peasant households, with self-appointing local plumbers responsible for the operation and maintenance of these infrastructures. This approach is driven by folk water practices in response to the needs of and desires for mechanized irrigation for a thriving agricultural community, though it may encounter governance and sustainability challenges in the long run.

Lastly, the self-dependent modality in M village is characterized by a blend of collective and private ownership, where smallholders within the village navigate water accesses through various irrigation solutions such as pumping water from big, old wells drilled by the village collective and drilling private tubewells in small groups. This individualized modality is usually motivated by self-interest and the pursuit of individual agricultural livelihoods, which has a lower degree of organization and coordination.

6.5 Discussion and conclusion

This chapter examines the shifting dynamics of grassroots irrigation governance in both canal and groundwater irrigation systems, revealing how these transformations reflect broader changes in state-society relations in the interrelationship between water infrastructures, associated organization forms, and governance practices. Zooming in on Gui township—a traditional agricultural area reliant on a conjunctive use of surface water and groundwater—it uncovers a paradoxical trend: while the canal irrigation system exhibits an apparent, secular decline in delivery capacity and collective management, the groundwater irrigation system displays a coexistence of the recentralization of government intervention alongside grassroots self-governance and self-dependent adaptive strategies. These findings cast serious doubts on the central tenets of neo-institutional policy prescriptions, particularly the promotion of WUAs as a universal model for participatory irrigation management. Instead, they reveal an institutional diversity shaped by the complex interaction of state-led formal institutions and informal community-driven practices. This duality underscores the need for a more nuanced understanding of how diverse and hybrid irrigation governance modalities coexist to combat water challenges and sustain agricultural production. This chapter advances two main arguments.

First, China's grassroots irrigation governance challenges prevailing doctrines that prioritize local self-governance while underestimate the state's role in managing common-pool resources. While Elinor Ostrom's (1990, 2005) framework of polycentric governance emphasizes decentralized, community-based solutions, her model—derived largely from small, homogeneous communities—neglects the critical influence of state intervention in shaping resource governance (Viet Thang, 2017). This Western-centric perspective fails to account for the political realities of many Asian contexts, where participation is often encouraged and organized by the state rather than organic. Sarker (2013) offers a more fitting alternative with his concept of "state-reinforced self-governance", observed in Japan's irrigation systems where a strong state provides financial, technological, and legal support to local self-management. Similarly, China's WUAs were not grassroots initiatives but were imposed through top-down government mandates, often alongside small-scale farmland infrastructural projects. As Section 6.3 demonstrates, these associations remained nominal, dominated by village elites, and ultimately failed to address the disorder and contestation of the communal canal irrigation system arising from rural de-collectivization. This divergence in institutional origins profoundly influences how governance organizations and institutional arrangements evolve and change in response to the varying and contextual dynamics.

Second, it emphasizes the need to examine institutional change and institutional diversity within specific sociopolitical, economic, and environmental contexts. Irrigation governance does not operate in isolation; rather, it is embedded within broader governance structures and shaped by context-specific dynamics. As Section 6.4 illustrates, China's agricultural modernization and food security agendas have dismantled the formal planning of WUAs at the local level, bureaucratizing WUAs into parastatal institutions to reinforce governmental control over irrigation management. This shift has transferred the ownership and management authority of irrigation infrastructures from village collectives to township governments, ostensibly to enhance responsiveness and accountability. This finding resonates with Lam et al. (2021), who observed a similar bureaucratization of irrigation associations in Taiwan, where state intervention tightened control to align with policy priorities.

Yet, in contrast to the formal and top-down planning of WUAs, Gui Township also exhibits an informal self-governing modality emerging from folk water practices. As shown in the section 6.4, faced with canal water shortages, peasant households have collectively invested in electromechanical wells, developing re-organized and adaptive management strategies to sustain agricultural livelihoods. These folk practices reflect local people's worldviews, beliefs, and material needs, illustrating how communities navigate water scarcity outside formal institutional frameworks. This contextual dynamic of grassroots self-governance resonates with Pia's (2024) reinterpretation of Mao's "mass line" ("*qunzhongluxian*" in Chinese) as a potent organizing principle for climate and environmental collective action. Rather than outright resistance, marginalized rural communities engage in socio-material practices that renegotiate state-society relations in everyday struggles over water access (ibid.). This perspective highlights the agency of local actors and everyday practices in shaping irrigation governance, offering critical insights into China's evolving hydraulic society.

To conclude, these findings challenge prescriptive, one-size-fits-all institutional designs, demonstrating instead the coexistence of formal state interventions and informal folk practices in rural China. The next chapter moves to examine the formation and operation of hybrid water market institutions, using a case study of the agricultural-to-industrial water rights trade in Tancheng County. This analysis will further elucidate the co-evolving and embedded state-market relations in China's water governance, where water is simultaneously treated as the public, private, and common good—a tension reflective of broader transformations under agricultural modernization and environmental neoliberalism.

Chapter 7 The agricultural-to-industrial water rights trade under state-directed marketization

7.1 Introduction

Agricultural modernization can't be understood in isolation from industrialization and urbanization. The agricultural sector, consuming over 70% of the total water supply (FAO, 2017), has long been perceived as unproductive and needs to improve irrigation efficiency, in order to spare water available to be reallocated for industrial and domestic uses (World Bank, 2022). In parallel with the application of advanced, water-saving technologies and infrastructures, international development agencies and national governments have introduced and promoted water markets as a water reallocation institution to mediate competing water demands and increase water-use efficiency (SDG 6.4)[22] and productivity. Through the water market mechanism, water is treated as an economic good and can be traded and transferred to higher-value uses with maximized economic returns and end-use efficiency in the non-agricultural sectors (Bauer, 2004; Garrick et al., 2018).

Critical scholars have investigated water market reforms across a range of place-specific contexts, challenging the market environmentalism doctrine that frames neoliberal water market as a cost-recovery measure and a win-win solution for growth-compatible sustainability (Anderson and Leal, 2001). They conceptualize these institutional arrangements as "neoliberalization of nature," wherein water is naturalized, depoliticized, and appropriated to serve political and economic interests, and often have led to accumulation by dispossession and exacerbated social-environmental inequalities in line with the logic of capital (Castree, 2008a; Bakker, 2009; Budds and Loftus, 2023). The

[22] SDG target 6.4 states that "By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity."

scholarly debate, however, has predominantly focused on the dichotomy between water as a commodity and water as commons, as Bakker (2007) puts it, with discussions often framed within a state/market or public/private binary (Paerregaard and Andersen, 2019). Far less research has been conducted on the functioning and evolution of hybrid water market models, which integrate state (re)regulation and market-based mechanisms. These hybrid models question the assumption that water markets should be developed de novo based on a Western free-market paradigm. Instead, they underscore the need for a nuanced examination of how existing water reallocation institutions can be adapted to the particular social-political and economic circumstances (Bakker 2002, 2003b; Wu, 2020).

China's water policies and pilot water trading projects have been characterized by a complementary mix of strong government control and market-based toolkits (Jiang et al., 2020; Sheng and Webber, 2019; Sheng et al., 2020; Svensson et al., 2021). Despite this recognition, there is a lack of understanding of how this hybrid governance model operates in practice and how it is shaped by the underlying political, economic, and environmental dynamics, particularly in response to competition for limited water resources between the agricultural and industrial sectors, as well as across levels of central and local governance. This chapter is going to examine the hybrid water market institution that enables the reallocation of water from agriculture to industry within China's centralized political and institutional context. Drawing on a case study of agricultural-to-industrial water rights trade in Tancheng county, this chapter aims to first unpack the complex interplay among a diverse set of stakeholders with different interests and levels of influence power, including the central government, local governments, market actors, and peasant farmers. By analyzing how these various parties navigate and shape the state-directed process of water marketization, it aims to provide nuanced insights into mechanisms and implications of the state-market synergy in China's evolving water governance landscape.

Following the introduction, section 7.2 retells the cutdown of total water use quotas since

2021 under the centrally planned water allocation system, which initiated the ad hoc water rights trade in Tancheng county so as to reconcile water abstraction permits requested by the industrial sector within the newly imposed limits. Section 7.3 details the bargaining process and the resulting compromises on water volumes, water prices, and trading terms between the county's Water Resources Bureau and the local water supply company. Section 7.4 presents the administrative and government-led measures put in place to support and sustain this water market transaction, with an aim to meet increasing industrial water demands while simultaneously to ensure agricultural production and safeguard rural communities. This chapter concludes with a discussion of the state-market synergy in the China' hybrid water governance model, which follows the logic of the local state to achieve multiple policy objectives and to strike a balance between competing use of water across sectors.

7.2 The initiation of cross-sectoral water rights trade

The agricultural-to-industrial water rights trade in Tancheng county is an adaptation tailored to the local context rather than a universally applicable model for the expansion of water markets nationwide. The development of the water market in this specific case involves a number of stakeholders, including the MWR, the Huai River Basin Commission, the Water Resources Department of Shandong province, the county's Water Resources Bureau, the water supply company, chemical industrial enterprises, the irrigation district, and peasant communities. This section starts with the initiation of the water rights trade in Tancheng county, highlighting the dynamic interplay among water bureaucrats at the central, river basin, provincial, and county levels. This initiative emerged as a flexible alternative to allocate the limited water supply under the cap to its most efficient and productive uses. Subsequent sections further explore the complex interactions between the county's water bureaucrats, the local water supply company, industrial enterprises with water demands, and peasant farmers.

7.2.1 Cutting down total water-use quotas by the central and provincial government

The initial water allocation system is centrally planned in China. Under this system, water resources are state-owned, and the rights to use these resources (as "water quotas") are allocated by river basin commissions to various provinces. The provinces, in turn, allocate the water quotas to local governments in a hierarchical manner (Shen and Speed, 2009). This centralized approach to water allocation is complemented by a cap on the total water use, which means that water quotas at the county level are administratively controlled by the upper levels of governments (see Chapter 4.3.1 for details).

The emergence of cross-sectoral water rights trading in Tancheng county was prompted by increasingly stringent control over total water-use quotas by the central and provincial governments. In 2021, the Water Resources Department of Shandong province, in collaboration with four other functional departments, issued a water conservation plan for the years 2021 to 2025. This provincial plan was developed to execute the National Action Plan for Water Conservation (NDRC and MWR, 2019) and aimed to establish a water-saving benchmark across the country. It set up specific targets for the total, industrial, agricultural, and domestic water use, with a focus on building a water-saving society at the county level. This plan put forward to cap the total water use across the province at 28.922 billion m^3 by 2025. Subsequently, in 2022, the MWR further refined this target by reducing the total water-use cap to 24.11 billion m^3 (see Table 7.1).

Table 7.1. Targets for water-saving in Shandong province from 2021 to 2025.

Target / Proposer	Total water-use quotas (billion m^3)	Water use reduction per 10,000 *yuan* of GDP (%)	Water use reduction per 10,000 *yuan* of industrial added value (%)	Irrigation water efficiency
Water Resources Department of Shandong province	28.922	10	5	0.651
Ministry of Water Resources	24.11	16	10	0.651

Source: Shandong Provincial Water Resources Department (2021); MWR and NDRC (2022). Note: These targets were set based on the 2020 values.

The newly imposed total water-use cap for Shandong province was then distributed layer by layer in a hierarchical manner, with each level of government receiving a portion of the quota. As a result, Tancheng county experienced a significant reduction in its allocated water-use quota. Specifically, the county's water-use quota was reduced by over 70 million m^3, dropping from 237.28 million m^3 in 2020 to a consistent 162.39 million m^3 from 2022 to 2025, given the reason that the actual water consumption in Tancheng had not approached the previous water-use cap (see Table 7.2).

Previously, Tancheng county had enjoyed a surplus of nearly 90 million m^3. However, under the new cap, the margin is slender, with only less than 10 million m^3 separating the cap from actual water consumption. Consequently, the total water abstraction permit for the county's three irrigation districts was decreased from 169 million m^3 to 143.2 million m^3, amounting to a total reduction of 25.8 million m^3 (see Table 7.3). In the industrial sector, the total water abstraction permit has been maintained at approximately 9.38 million m^3, which falls within the allowable range of the total water-use cap. However, this newly-imposed cap on industrial water use has constrained the development of new, water-intensive industries within the county.

Table 7.2. Total water-use cap and total water consumption in Tancheng.

Year	Total water-use cap/ million m^3	Total water consumption/ million m^3
2020	237.28	144.55
2021	/	152.27
2022	162.39	152.07
2023	162.39	159.84

Source: Data are collected from the annual notice on the control targets for water resources management issued by the Linyi Water Resources Bureau. Note: The total water use includes the use of surface water, groundwater, and non-conventional water sources such as recycled water. The Linyi Municipal Water Resources Bureau did not manage to officially issue the notice on the new total water-use cap in 2021.

Table 7.3. Annual water abstraction permit of irrigation districts in Tancheng.

Year	Lizhuang irrigation district	Matou irrigation district	Qingquansi irrigation district	Total
2020	45	76	48	169
2021-2025	45	66	32.2	143.2
Reduction	0	10	15.8	25.8

Source: Data are collected from interviews with government officials from the county's Water Resources Bureau. Unit: million m^3.

7.2.2 Accommodating water abstraction permits by the county government

Like many other agricultural counties in China, Tancheng has undergone rapid industrialization and urbanization over the past few decades. In particular, its Economic Development Zone formed a chemical cluster gathering major enterprises in the chemical industrial park in 2018 (see Chapter 4.4.3 for details).

The abrupt reduction in annual water-use quotas in the county has posed great challenges to water supply management in light of growing water demands driven by economic development. During a series of group discussion meetings and semi-structured interviews conducted between July 2023 and June 2024, water bureaucrats in the county consistently voiced their profound frustration and dissatisfaction with the reduction in total water-use quotas. Mr. Liang, a government official from the county's water resources bureau, personally expressed his concerns to me during a car ride to a field visit. He complained that:

> *"Even though Tancheng has a great water storage capacity of 220 million m^3 with 16 dams on its two major transboundary rivers, we can't use the stored water in our jurisdiction under the total water-use cap…Water is indispensable for development. The reduction of water quotas is all about dealing with the performance evaluations from upper-level governments. It is unreasonable just like tying our own hands and feet, without considering the actual need of local economic development."*

The cutting down of total water-use quotas, in particular, had a direct impact on the Water Group Co., Ltd., a state-owned enterprise responsible for industrial and domestic water supply in the county. The company started to build a surface water plant in 2019, with the intent to serve the needs of 81 industrial companies in the chemical industrial park. This newly-built water plant, which cost a total investment of 215 million *yuan*, occupies a land area of 2.03 hectares and is designed to deliver water from the Yi River, transporting it through a 21-kilometer network of water pipelines (see Figure 7.1). The purpose of this new facility was to supplement the capacity of the company's three existing groundwater plants, which supply both drinking water and water for industrial purposes.

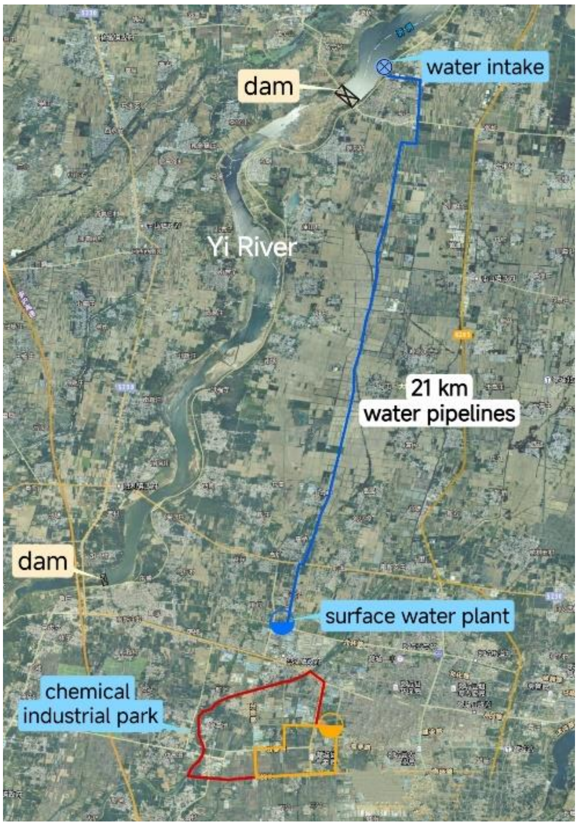

Figure 7.1. Map of the surface water plant.
Source: Water Group (2022), reproduced by the author.

At first, the Water Group planned to obtain a water abstraction permit to legally deliver water from the Yi River, and had reported this urgent need many times to the county's Water Resources Bureau. Acknowledging the importance of transitioning from groundwater to surface water for a sustainable industrial supply, the water bureau, actively supported the company's application for the permit, liaising with higher-level authorities. Nevertheless, the water abstraction permit was not approved until September 2020, when the surface water plant had been established and was undergoing trial operations. Subsequently, with the finalization of the reduced water-use quotas in 2022, the prospect of obtaining additional water-use rights through new water abstraction permits became unviable for the Water Group.

In response to the constraints imposed by the water quotas, the Water Resources Bureau had no other choice but explored the possibility of water market transaction. The initiative of water rights trade aimed to reallocate water from Lizhuang irrigation district to the surface water plant, thereby supporting the water needs of the industrial companies in the chemical industrial park. An official from the county's water bureau informed me during the group discussion in July 2023 that:

> *"We have to find a way out since there is no quota for surface water anymore. The irrigation district has 45 million m^3 of water quotas per year, among which 22 million m^3 are actually used. Therefore, we could reallocate the water-use quota among sectors within the cap of total water use, transferring 10 million m^3 to the industrial sector out of 45 million m^3 in the irrigation district."*

The agricultural-to-industrial water trade was proposed in March 2022, when the county's Water Resources Bureau communicated its needs and expressed interest in water rights trading to the Huai River Basin Commission. As the governing body for managing transboundary water of the Yi River, the Huai River Basin Commission places a great emphasis on the establishment of water markets within the basin, regarding water rights trading as a crucial strategy to enhance the economic and efficient use and distribution of water resources. Consequently, the Huai River Basin Commission enthusiastically supported the cross-sectoral water rights trade in Tancheng county, designating it as a pilot project to be showcased and promoted. Following the Commission's approval of the water rights trading scheme in June and the subsequent water resources evaluation report in November, the water rights trading agreement was formally signed in December 2022 between the county's Water Resources Bureau and the Water Group. This transaction marked the first and most substantial cross-sectoral water trade in terms of volume within the Huai River Basin (China Water Exchange, 2022).

To sum up, the water rights trade in Tancheng was not proactively planned and initiated by the county government, but emerged as an ad hoc and adaptable strategy to navigate the constraints of the total water-use cap and to satisfy local water demands under the central planning water allocation system. Conventionally, the county's water bureaucrats are more inclined towards applying for new water abstraction permits, an administrative approach to water allocation that remains firmly under governmental control. The Huai River Basin Commission and the county's Water Resources Bureau were the primary drivers of this water rights trade, each with their own motivations. The Huai River Basin Commission sought to establish a showcase example that would encourage the development of water markets as a means to optimize water allocation within the basin. Meanwhile, the county's Water Resources Bureau aimed to secure water abstraction permits for industrial use to support local economic development. Additionally, the bureau was keen to shift the water use structure away from its heavy reliance on groundwater for drinking and industrial purposes by endorsing and maintaining the operation of the surface water plant constructed by the Water Group.

As a result of these efforts, the proportion of groundwater consumption in the industrial sector has seen a dramatic decrease since 2020 when the surface water plant was on a trail operation, falling from nearly 99% to approximately 68%. While domestic drinking water consumption has continued to rely exclusively on groundwater over the years (see Figure 7.2).

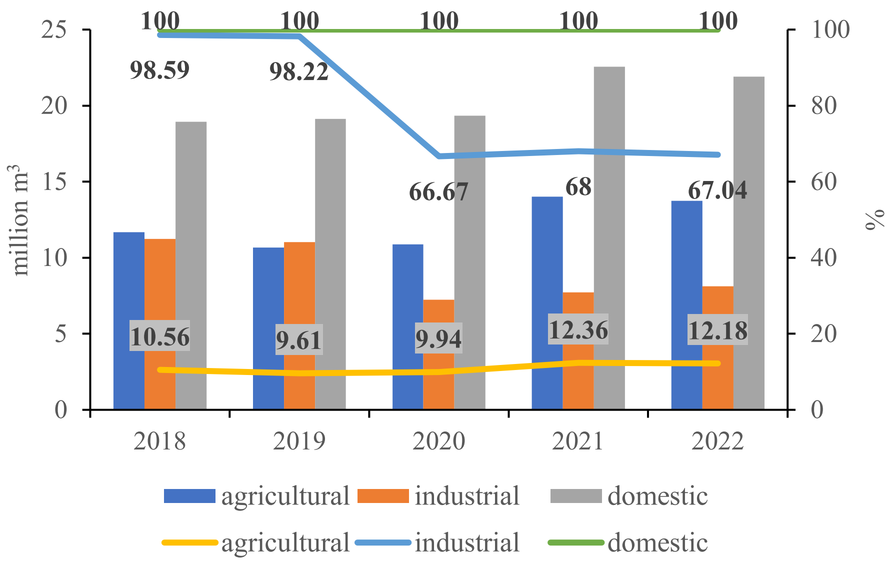

Figure 7.2. Volume and proportion of groundwater consumption in Tancheng.

Source: Linyi Water Resources Bureau (2018 to 2021); Tancheng Water Resources Bureau (2022).

This section illustrates the initiation of the agricultural-to-industrial water rights trade in Tancheng county, showing the varying degrees of influence and levels of interest among water bureaucrats at different tiers of the Chinese administrative structure. It is crucial to note, however, that the provision of irrigation water must be secured to maintain agricultural productivity and ensure food security, a priority that is particularly significant in a traditional agricultural county like Tancheng. The subsequent section explores the interaction between the county government and the market actors to reconcile the water supply needs of agricultural production with the water demands of industrial development.

7.3 Bargaining and compromise between the two trading parties

The water rights trade in China is distinct from its global counterparts, characterized by significant government interventions and a lack of competitive market dynamics (Speed, 2009; Moore, 2015). The state plays a pivotal role in navigating the blurred lines between water as an economic good and a public good, striving to balance the competing demands for water from the agricultural and industrial sectors. The Water Group in Tancheng county had a keen interest in the agricultural-to-industrial water rights trade, as it was the only way to obtain water for its newly-built surface water plant. Yet, it found itself with limited bargaining power and encountering regulatory constraints imposed by the county government. The Water Resources Bureau, acting on behalf of its affiliated irrigation district office, managed to establish a ceiling on water volumes, regulate the water pricing, and enact a short trading period for the water rights transaction after extensive bargaining, negotiation, and compromise with the Water Group. This section respectively presents the intricate interaction between the two trading parties, detailing the bargaining and compromise made regarding water volumes, water prices, and the duration of the trading period of this cross-sectoral water rights trade.

7.3.1 Capped and regulated volume of water transfer

To balance agricultural production and industrial development, the county's Water Resources Bureau capped and regulated the trading water volume in three ways. First, the trading volume of water required by the Water Group was significantly reduced. When the Water Group proposed the construction of the surface water plant project in 2019, the intended water abstraction scale was set at 40.15 million m^3 per year, calculated to meet the freshwater demand of 36.18 million m^3 for the chemical industrial park by the year of 2022 (see Table 7.4). However, the feasibility of this volume was called into question once the water abstraction permit was transformed into a water rights trade, given the fact that the annual water-use quota for Lizhuang irrigation district was only 45 million m^3. Mr. Liang, a government official from the county's water resources bureau, emphasized the bureau's obligation and pressure to support agricultural production and national food security, particularly in Tancheng, one of the main agricultural-producing counties across the whole country.

Table 7.4. The planning water use of the chemical industrial park.

	Initial plan/ million m^3	**Final agreement/ million m^3**
Industrial consumption	29.95	8.75
Water plant consumption and water transmission losses	3.62	0.80
Water supply network leakage	2.61	0.45
Total	36.18	10

Source: Water Group (2019, 2022).

Following a series of negotiations and discussions, the two parties arrived at a compromise. To reconcile the demands of agricultural production with industrial growth, the Water Resources Bureau opted to prioritize water supply for the H Coal Company, the largest enterprise in the chemical industrial park and a key contributor to the county's tax revenue (see Figure 7.3). It was estimated that the company's water consumption would rise to 10 million m^3 by 2025 following its expansion plans. Consequently, the agreed-upon water rights trading volume was set at 10 million m^3 per year, which would replace the H Coal Company's original groundwater abstraction permit.

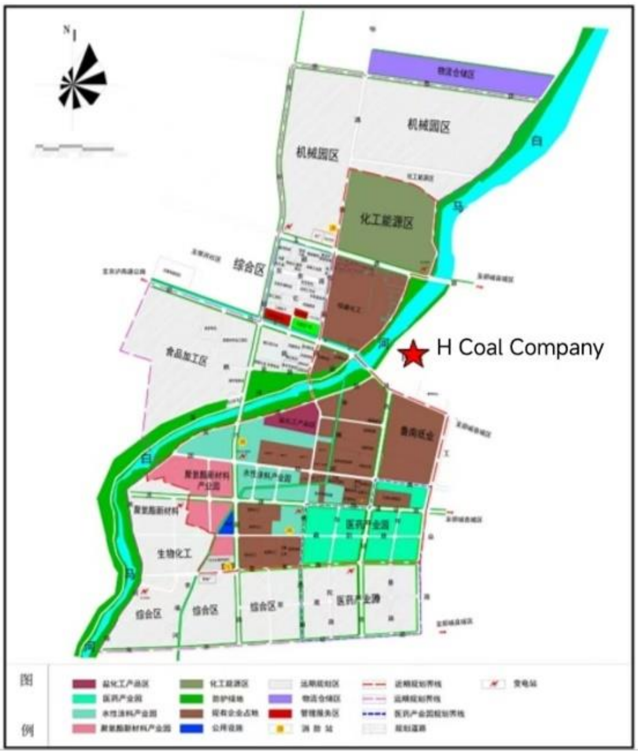

Figure 7.3. Location of H Coal Company in the chemical industrial park.

Source: Overall Development Plan of the Chemical Industry Park in Tancheng Economic Development Zone (2013-2020), provided by government officials during the fieldwork.

Second, the quantity of the trading water is monitored to prevent over-extraction by the county government. Since 2017, the county's Water Resources Bureau has progressively invested in a remote water meter reading system to enhance water resources management. This system facilitates intelligent measurement, real-time online monitoring, and data analysis for all water abstractors through advanced information and communication technologies. By 2023, the county had spent 3.13 million *yuan* to install 296 sets of meters, thereby monitoring the water usage of 228 companies (see Table 7.5). According to the water trading agreement, the Water Group is obligated to install water meters throughout the water acquisition and usage process. And the Water Group must ensure the proper operation and regular calibration of these measurement and monitoring facilities to maintain their reliability and integrate them with the county's remote water meter reading system.

Table 7.5. Installation of the remote water reading system in Tancheng.

Year	Number of monitoring set	Number of company	Investment/ million *yuan*
2017	21	3	0.37
2019	196	164	1.57
2020	55	51	0.76
2022	24	10	0.43
Total	296	228	3.13

Source: Tancheng Water Resources Bureau (2022).

Third, the county's Water Resources Bureau has ceased to renew groundwater abstraction permits for individual industrial enterprises within the coverage area of the public water supply network. The bureau gradually blocked up the private wells belonging to approximately 80 industrial companies that fell within the service area of public water plants. Notably, due to the operation of the surface water plant, the H Coal Company's annual groundwater abstraction permit, which allowed for 5.8 million m^3, was eventually terminated in 2024.

While the Water Resources Bureau exercises considerable control over water volumes, the establishment of administered water price has proven to be a more contentious issue among the trading parties, which is going to be explored in the next subsection.

7.3.2 Administered and noncompetitive water pricing

In contrast to the metered water price determined by supply and demand in a free market system, the water price for agricultural-to-industrial water rights trading in Tancheng county is entirely set by the government. This price comprises three components: the water resources tax, the water supply price charged by governmental conservancy projects, and the transaction fee for the water trade. Specifically, according to the water market transaction arrangement (China Water Exchange, 2022), the Water Group is obligated to pay a water resources tax of 0.4 *yuan*/m^3 to the county's taxation bureau for the cost of extracting surface water that is owned by the state, an engineering project fee of 0.035 *yuan*/m^3 to the Huai River Basin Commission, and a transaction fee of 0.1 *yuan*/m^3 to the county's water bureau for claiming water-use rights from the irrigation district. Unlike the first two components, which are basic water prices, the transaction fee for water trading serves as a token compensation to the irrigation district. It doesn't compensate rural households directly but is designated for subsequent renovations and water-saving projects constructed by the county government, such as lining channels to reduce seepage and enhancing the efficiency of irrigation water utilization.

The transaction fee has been a point of contention for the Water Group, a state-owned enterprise with profit-orientation. This was evident during a focus group discussion in June 2024, held in the governmental building with stakeholders from the Water Resources Bureau and the Water Group. Mr. Quan, the CEO of the Water Group responsible for establishing the surface water plant and the associated water trade, appealed for the waiver of the transaction fee to the water bureaucrats. He highlighted that the surface water plant project had incurred a total financing loan of 215 million *yuan*, and the annual transaction fee of 1 million *yuan* would further exacerbate the company's financial burden. He stated that:

> *"We've invested a total of 215 million yuan in this project. The county government contributed a small portion, while the majority of the funding came from bank loans and financing…Only when industrial enterprises operate efficiently will there be increased water consumption and consequently higher revenue from water fees. The thing is—the current economic climate is tough…"*

In response, Mr. Liang, representing the Water Resources Bureau, insisted the necessity of the transaction fee, arguing that the Water Group did not originally possess the water-use rights and had acquired them from the irrigation district, which required compensation for the loss of its water quotas and support for improving irrigation efficiency. The presence of an observer, myself, precluded any further debate between the two parties. However, this scenario underscores the limited acceptance of the concept of "water market" at the local level, at least in Tancheng county. Water abstractors, such as the Water Group, are more accustomed to obtaining water through administrative abstraction permits, a traditional and common method that does not entail additional market transaction fees.

During my follow-up visit to the surface water plant in July 2024, the CEO and managers of the Water Group further complained about the high operational cost when showing me around the surface water plant. The surface water plant, as they introduced, consists three major projects: the water intake pumping station, the water purification plant, and water transmission and distribution pipelines (see Figure 7.4). Our on-site tour commenced at the water intake pumping station, which is located at a depth of 8m underground. Here, four 160 kW pumps extract water from the intake at the Yi River. The water is then channeled through a 21-kilometer pipeline to the water purification plant, where it undergoes a comprehensive treatment process including precipitation, filtration, and disinfection before being ready for distribution.

Mr. Quan, the CEO of the Water Group, detailed the financial implications of these operations and explained that the total water supply cost amounted to 2.32 *yuan*/m^3, encompassing the raw water price, electricity costs, chemical treatments, and labor expenses. Despite the Water Group's tiered water supply pricing for industrial enterprises, which ranges from 2.38 *yuan*/m^3 to 2.6 *yuan*/m^3, Mr. Quan highlighted the challenge of achieving cost recovery for the project's investment and loans in the short term. Based on a cost-benefit analysis, the Water Group had not yet paid the transaction fee of the water rights trading to the county's water bureau by 2024, the second year after the cross-sectoral water rights transaction.

(a) The water intake pumping station.

(b) The water purification plant.

(c) Water transmission and distribution pipelines.

Figure 7.4. Major projects of the surface water plant.

Source: Author, July 2024.

7.3.3 Short and flexible term of water trading

So far, I have illustrated the interaction between the county's Water Resources Bureau and the Water Group, both of whom were interested in the water transfer but exerted varying levels of influence over the trading water volume and water prices. Although the negotiation over water prices was contentious, the agreement on a three-year trading period was comparatively less controversial, leading to a pragmatic consensus between the two parties.

Contrasting to permanent or long-term water rights transfers, the cross-sectoral water trading pilot in Tancheng was designed to last for three years, from 2023 to 2025, as outlined in the transaction agreement. This timeframe was constrained by the expiration of the current water abstraction permit for the irrigation district in 2025. Additionally, the Water Resources Bureau was uncertain about future policies regarding the total water-use quotas during the 15th five-year plan period (2026-2030), which could either tighten or relax controls. This short-term arrangement afforded the county government the flexibility to respond to changing circumstances. As committed by the Water Resources Bureau, the county government would try its best to guarantee the Water Group's water-use rights after the expiration date, either assisting the Water Group in obtaining extra water abstraction permits or maintaining the water trading mechanism. Mr. Liang articulated the government's stance, saying that:

> *"We plan to support the Water Group to expand the surface water plant project, gradually replacing groundwater with surface water for domestic drinking water consumption…There are three options to acquire water depending on the situation. First, priority will be given to seeking more total water-use quotas from higher authorities. Second, within the limit of total water-use cap, more surface water quotas will be obtained by gradually shutting down private groundwater wells. Third, on the premise of further improving irrigation efficiency and ensuring food production, the current water rights trading between agriculture and industry will be ongoing."*

To sum up, this section details the bargaining and compromise on the trading volume, water prices, and the trading period between the county's Water Resources Bureau and the Water Group, each with differing interests, values and influences on the cross-sectoral water rights trade. The next section will further illustrate the administrative backups that enable and maintain the water market while safeguard rural communities in spite of limited peasants' participation in the water transaction process.

7.4 Enabling and safeguard measures for water rights trading

As shown in the cross-sectoral water rights trade, the roles of irrigation districts and peasant farmers are notably less prominent compared to those of water bureaucrats and market actors, even though they should have been involved as one of the trading parties. The irrigation district office, functioning as a subordinate agency of the county's Water Resources Bureau in the Chinese political and institutional setting, followed the directives and guidance issued by the water bureau. Meanwhile, peasant households were neither directly included in nor consulted about the transaction process. This exclusion was primarily due to the fact that irrigation water was often distributed administratively to townships or villages at most, rather than to individual households based on their landholdings, as depicted in Chapter 6.3. In terms of stakeholder interest and influence, irrigation districts and peasant households had the least impact on the cross-sectoral water rights trading.

However, rural communities were not dispossessed by the water market as scenarios often seen in neoliberal-transforming countries (Budds, 2004; Urteaga-Crovetto, 2016; Hoogesteger, 2018). Instead, they were supported by state interventions accompanied by market mechanisms. This section begins by illustrating the compensation to the irrigation district through government-led infrastructural projects. It then discusses the administrative reallocation of water for irrigation in times of droughts. Finally, it addresses the unregulated and free access to groundwater for agricultural production, which, somewhat paradoxically, enabled the agricultural-to-industrial surface water trade to a certain extent.

7.4.1 Compensation through government infrastructural projects

The local governments in China recognize the importance of a stable water supply in attracting investment and maintaining economic growth, while also striving to minimize the negative impact on agriculture (Nickum, 2010). In addition to the transaction fee paid by the water supply companies to compensate the irrigation district, the Chinese government has also financed the construction of water conservation projects, such as canal lining, directly from its own budgets (Moore, 2015). This is particularly evident in Tancheng, a leading agricultural-producing county, where the county government navigates a delicate balance between safeguarding agricultural and industrial interests to meet national policy objectives of food security and economic development.

In Chapter 5, I have elaborated on the small-scale farmland and water conservancy projects, notably the high-standard farmland project, which is mainly led by the agricultural bureau. In parallel, the Water Resources Bureau is specifically responsible for the management of irrigation districts and the implementation of the Irrigation District Supporting and Water-saving Renovation Project. These projects are designed to reduce water seepage and enhance irrigation efficiency through measures such as lining canals, dredging ditches, reconstructing canal supporting infrastructures, and equipping with information engineering technologies.

For example, according to officials at the Water Resources Bureau, Tancheng's three medium-sized irrigation districts, established in the late 1950s and early 1960s, have undergone several rounds of renovations since 1990s, including the upgrade of all its 16 storage dams. The most comprehensive and recent renovation initiative commenced in Matou irrigation district in 2023 and was set to extend to the other two irrigation districts in 2024 (see Table 7.6). The projected investment is substantial and is fully funded by government budgets at various levels, with the national government contributing 50%, the provincial government providing 20%-30%, and the county government covering the remaining 20%-30%.

Table 7.6. Current irrigation district supporting and water-saving renovation project in Tancheng.

Year	Irrigation district	Estimated investment/million *yuan*
2023	Matou	300
2024	Lizhuang	460
2024	Qingquansi	500

Source: interviews with governmental officials from the county's Water Resources Bureau, 2023-2024.

In summary, the government's investment in irrigation district projects plays a vital role in mitigating the water loss in the agricultural sector brought by water market transfers. This investment has supplemented the often delayed and inadequate market-based compensation provided to the irrigation districts, such as the transaction fee ought to be paid by the Water Group. It has also promoted more efficient water use within agriculture and ensured the physical capacity for future water transfers by enhancing irrigation infrastructures and technologies. In local officials' parlance, the high-standard farmland project and the irrigation district supporting and water-saving renovation project have lined most of the earthen canals over the years, significantly reducing transmission losses and consequently lowering the irrigation district's actual water consumption. However, the discourse of "water-saving" remains questionable. As I will illustrate in the section 7.4.3, instead of actually saving agricultural water, more groundwater has been used without regulation and monitoring of the agricultural wells, thereby challenging the long-term sustainability of agricultural production.

7.4.2 Administrative water reallocation in times of droughts

Apart from the previously discussed government-led water conservation projects, the Chinese government also resorts to administrative command and control to manage water reallocation during emergencies. This administrative approach to water reallocation is an indispensable complement to the operation of water markets, preventing rural communities from the potential water grabbing by industrial capital.

As detailed in the section 7.2.2, the water transaction agreement between the agricultural and industrial sectors in Tancheng was formulated and executed under the regulatory oversight of the Huai River Basin Commission. In addition to the water transaction agreement, the Huai River Basin Commission (2023) also issued an administrative approval for water abstraction permits associated with this water rights trade by the Water Group. This approval further stipulated the priority of government authority in the reallocation of the trading water volume in the event of uncertainty or water crisis. The Water Group was obligated to comply with the directives made by the Water Resources Bureau regarding the restriction of water abstraction during periods of extreme weather, such as prolonged droughts, and when there are inadequate environmental flows. This mandate ensures that the government retains the power to intervene and reallocate water resources in the best interest of the public and the environment, thereby maintaining a balance between industrial needs and the preservation of irrigation water supplies.

> *"**Article Five** Your company should take water in accordance with the water allocation and management of the Yi River. In case of major droughts or when the ecological flow at the downstream does not meet the standards and other special circumstances occur, your company should comply with the water administrative department's legally made decisions to restrict water intake. If water intake affects the legitimate rights and interests of third parties, your company should provide compensation in accordance with relevant regulations."*

The emergency administrative water reallocation in China is orchestrated through the national mobilization in a top-down approach. The MWR has established a comprehensive set of protocols for flood and drought management, which includes monitoring, early warning systems, and emergency response actions for river basin commissions and local water administration departments. When the MWR activates an emergency response for flood and drought prevention and control, which is categorized into four levels of severity: Grade IV (the lowest), Grade III, Grade II, and Grade I (the highest), the relevant river basin commissions and local water management authorities are tasked with immediately initiating emergency response measures at the appropriate level and executing unified and coordinated water reallocation from major rivers and water infrastructure projects (MWR, 2022).

For example, in response to a persistent heatwave and dry conditions in Northern China in 2024, the MWR activated a Grade IV drought emergency response across eight provinces, including Shandong, on June 12 (see Figure 7.5). The directive emphasized the need for water reallocation, well drilling, and other measures to secure irrigation water for summer crops and to ensure a safe drinking water supply for both urban and rural residents.

Figure 7.5.Grade IV drought emergency response in Northern China.

Source: Shandong Radio and Television, 13 June 2024.

In Tancheng, the county government particularly the Water Resources Bureau and the Agriculture and Rural Affairs Bureau, proactively launched a county-wide “drought defense campaign.” It is reported that since the emergency response was triggered, a total of 69 water reallocation directives have been issued, diverting 16.23 million m^3 of water to irrigation districts and reallocating 8.3 million m^3 of water for drought resistance. To meet the water demands for summer planting and cultivation, the county government also applied for an additional 5 million m^3 of irrigation water-use quotas from the municipal government (Song et al., 2024).

7.4.3 Unregulated and free access to groundwater for agricultural production

The last and crucial factor that enables the cross-sectoral water rights trade and ensure agricultural water supply is the unregulated and free access to groundwater for agricultural production. Ironically, this practice is obscured by the prevailing discourse of agricultural modernization, while undermines the goal of sustainable groundwater development that the water trading aims to achieve.

First, the regulation of groundwater withdrawal from agricultural wells often escapes the oversight of fragmented government agencies (see Figure 7.6). The Agriculture and Rural Affairs Bureau of the county government, which leads the current high-standard farmland project, primarily focuses on building more wells to enhance agricultural productivity. While the Water Resources Bureau is mainly responsible for canal irrigation and industrial and drinking water supply. Therefore, project wells built by the agricultural bureau are metered only for electricity, not water, and do not require water abstraction permits from the water bureau, which is a mandate for industrial and domestic water uses in urban areas. Furthermore, the integration of the Water Station into the agricultural service center at the township level for operation and maintenance of small-scale farmland irrigation infrastructures has further weakened groundwater regulation.

Although the water station is tasked with charging electricity bills and maintaining these wells, it lacks comprehensive oversight of the actual amount of groundwater used for agricultural production.

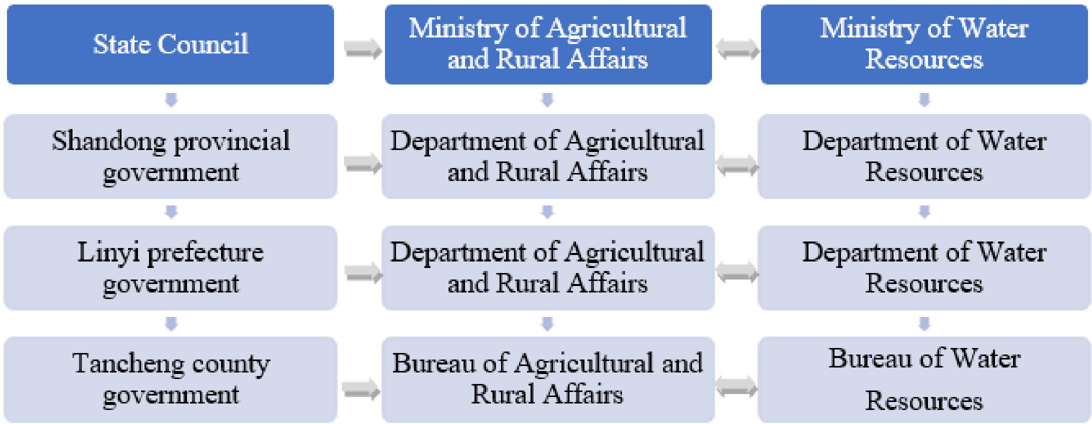

Figure 7.6. The matrix structure of governmental administration.
Source: produced by the author.

The absence of management over agricultural groundwater by both the agricultural and water bureau has resulted in a lack of regulation on agricultural wells. A preliminary investigation by the Water Resources Bureau in 2022 found that a total of 5,494 agricultural wells with a diameter of more than 20cm were in use. The volume and proportion of groundwater consumption in the agricultural sector had increased to over 12%, reaching around 13 million m^3 of the total agricultural water consumption by 2022 (Tancheng Water Resources Bureau, 2022). The actual groundwater usage in practice significantly exceeds the figures recorded by the government, as many wells used for agricultural production do not equip with water meters, resulting in a lack of precise and available data on the actual agricultural groundwater usage.

Second, the regulatory vacuum of groundwater for irrigation has led to an expansion of small private wells on farmland. With no mandatory groundwater abstraction permissions for agricultural wells, small private wells have been increasingly built to supplement project wells, driven by the demand for a stable irrigation water supply. For example, a family farm, located within the Lizhuang irrigation district, has invested to build over 10 private wells on 26 hectares of farmland in addition to project wells, each costing about 2,000 *yuan*. This kind of private well is relatively easy-equipped with a borehole, a pump, an electrical box, and a removable hose through which groundwater is delivered (see Figure 7.7). Supported by a reliable water supply from private wells, the farm owner changed to grow rice, a crop with a higher water requirement, instead of corn that is less demanding of water.

Figure 7.7. The easy-equipped private well.

Source: Author, August 2023.

Small-scale and privately operated tubewells with a diameter of less than 20cm, which are not officially recorded, are also widespread in greenhouse agriculture within the Lizhuang irrigation district. Both the government and business enterprises have invested in the establishment of numerous greenhouses as part of poverty alleviation initiatives. These plots of farmland were traditionally used for food crop production, but due to their low economic returns, the village collective transferred the land from individual households and built greenhouses for the cultivation of vegetables, fruits, and flowers, leveraging subsidies from the government's poverty alleviation projects.

Q village in the Miao township, for example, has approximately 2,400 *mu* of farmland, of which 1,700 *mu* were used for growing food crops and 200 *mu* were dedicated to greenhouse planting. The village committee acquired the land from individual villagers to construct 44 greenhouses, each spanning around 4 *mu*, for the cultivation of tomatoes and eggplants. These greenhouses were built in 2015 with the support of a government poverty alleviation project, which provided a subsidy of 30,000 *yuan* per greenhouse. According to the interview with Mr. Jin, the village party secretary of the Q village, 10 greenhouses received irrigation water from a shallow-dug well built by the village committee, while each of the remaining greenhouses was equipped with a private tubewell by the greenhouse operator (see Figure 7.8). These agricultural wells are exempt from the requirement for water abstraction permits, and the groundwater they provide is free of charge, with only the cost of electricity paid by the growers.

Figure 7.8.The private tubewell in the vegetable greenhouse.

Source: Author, July 2023.

The Q village is not an exceptional case in Tancheng county. The ready availability of groundwater via private tubewells has facilitated the rapid expansion of greenhouse agriculture across the county over years. By 2022, the total area dedicated to greenhouse cultivation (including smart, sunlight, plastic, small, and medium arch greenhouses) had surged to 2888 hectares. Approximately 1500 hectares are used to plant vegetable, while 740 hectares are allocated to strawberry growing (see Figure 7.9).

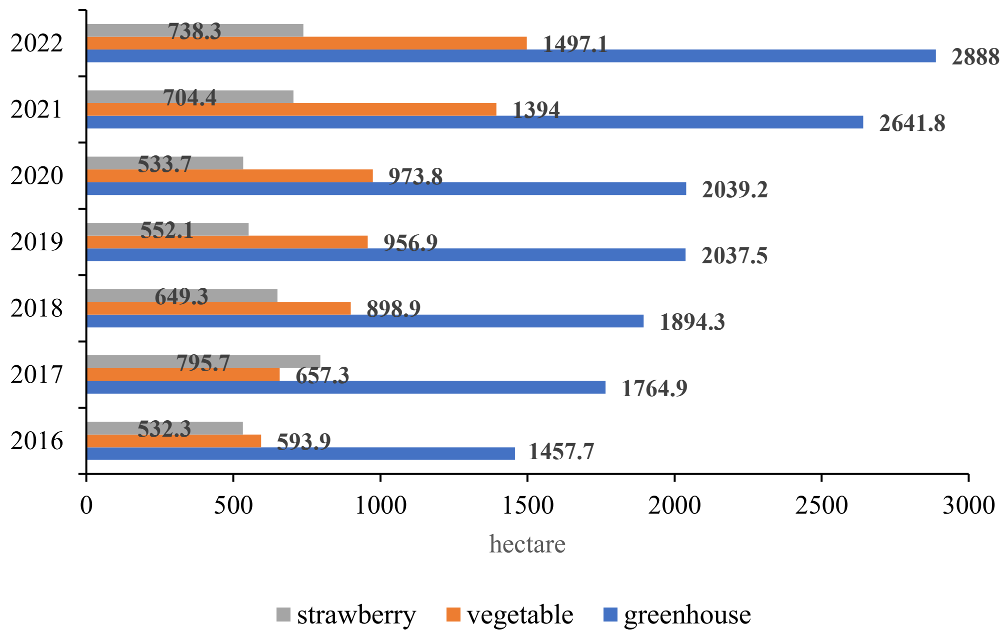

Figure 7.9. Area of greenhouse agriculture in Tancheng.

Source: Statistics Bureau of Tancheng (2017 to 2023).

The unregulated expansion of agricultural wells and excessive groundwater extraction have led to land subsidence, rendering farmland low-lying and poorly drained. In July 2023, there was a day-long period of intense rainfall when I visited a vegetable production base covering an area of 80 hectares with over 100 greenhouses in the county. Each greenhouse has small private tubewells drilled with a diameter of 6cm and a cost of 1200 *yuan* including pumps. With hundreds of tubewells across the entire base, the lower terrain of this region weakened its drainage capacity and thus it was easily flooded, forcing individual households to use their diesel engines to continuously pump water off their land during heavy summer rains (see Figure 7.10). The manager of the vegetable production base informed me that:

"The production base has been flooded twice in recent years. The losses were covered by the government's agricultural insurance in the previous two years, but it is not any more now… The risks [of floods] are very high."

Figure 7.10. The diesel engine used to pump water off the greenhouse.

Source: Author, July 2023.

The unregulated and free use of groundwater for agricultural production, along with the expansion of greenhouses as a form of modern irrigated agriculture, has played a pivotal role in the county's water governance. By reducing reliance on surface water, these practices have facilitated the partial substitution of groundwater for surface water in the industrial sector—particularly through agricultural-to-industrial water rights trades. However, this shift has come with hidden costs: the proliferation of agricultural wells and increasing groundwater extraction have led to overconsumption beyond officially reported levels. Consequently, these trends undermine the government's claims of promoting "water-saving" agricultural modernization and sustainable development.

7.5 Discussion and conclusion

This chapter investigates the intricate dynamics of the formation and operation of China's water market by examining a case study of the agricultural-to-industrial water rights trade in Tancheng county. It unpacks the complex interplay among a diverse array of stakeholders with varying degrees of interest and influence throughout the trading process, including water bureaucrats at both the central and local government levels, the water supply company, industrial enterprises, irrigation districts, and peasant communities. These stakeholders can be categorized based on their diverse interests and the influence they wield over this water rights trade, as illustrated in Figure 7.11. There is a non-linear relationship between the influence and interest held by these stakeholders, which shows the diffusion of power and the emergence of agencies in the process.

Neither the MWR nor the Water Resources Department of Shandong province involved and expressed particular interest in this cross-sectoral water rights trade; however, they exerted significant influence over its occurrence through the regulation of total water-use quotas. Although Water Resources Bureau of Tancheng county had the least influence on water allocation compared to its counterparts at the upper levels, it expressed the highest interest in the reallocation of water to the industrial sector for local economic development through the water market transaction. In liaison with the Huai River Basin Commission, it was able to wield great power, as both the seller and the regulator, over the water supply company and industrial enterprises, in order to protect the interests of the irrigation district and rural communities that had the lowest power and influence.

Drawing on a context-specific analysis of the political, economic, and environmental conjunctures, this chapter moves beyond a traditional and dichotomous notion of commons versus commodity or state verse market. This narrow approach often fails to illuminate the nuanced sociopolitical and economic processes that configure the hybrid governance systems in practice. The chapter advances three key arguments.

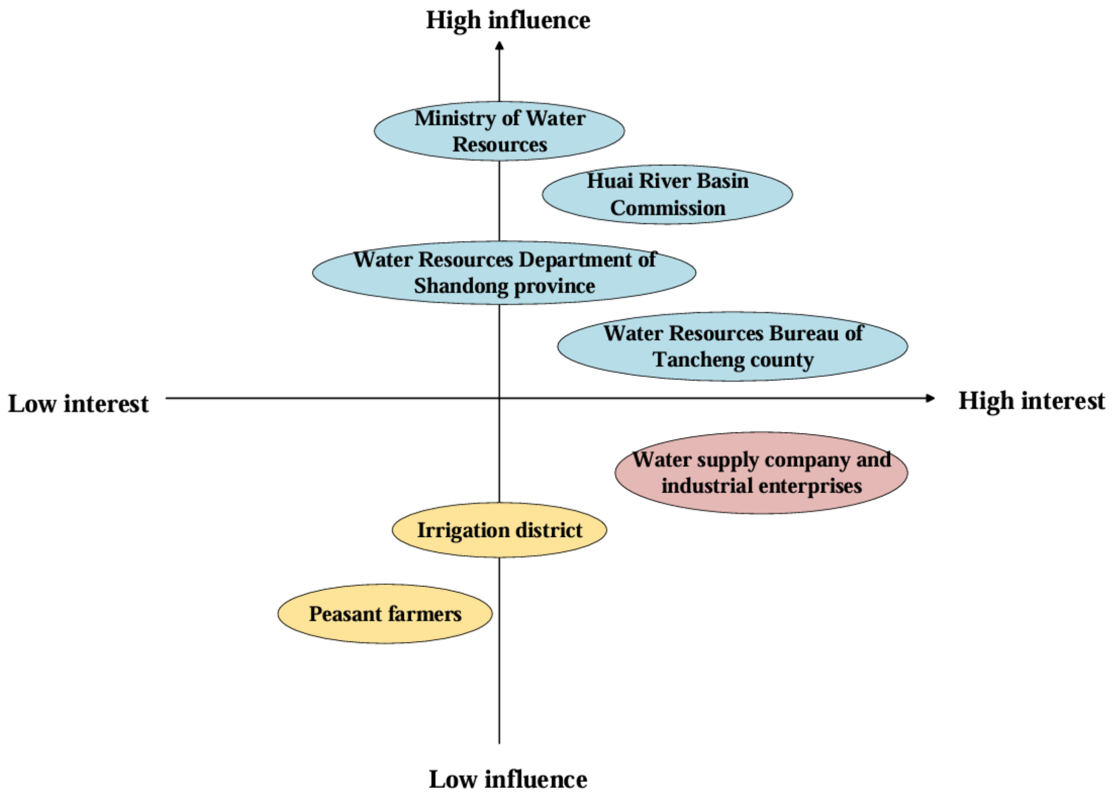

Figure 7.11. Stakeholders involved in the water rights trade.

Source: drawn by author. Note: The blue ellipses represent the water bureaucrats at various levels (the central, the river basin, the provincial, and the county); the red ellipse represents the water supply company (the Water Group Co., Ltd.) and enterprises within the chemical industrial park. The yellow ellipses represent the Lizhuang irrigation district and peasant households that it serves.

First, this chapter posits that water, by virtue of its essential and life-sustaining nature, defies simplistic categorization as either a pure commodity or a straightforward common good (Paerregaard and Andersen, 2019). Instead, it operates within a hybrid governance framework that combines administrative control with market-based mechanisms. The introduction of water marketization does not necessarily imply a wholesale "retreat" of the state; rather, the state and market are concomitant, with the state playing a significant role in the Chinese context (Wu, 2008; Jiang et al., 2020).

In the specific case of agricultural-to-industrial water rights trading in Tancheng county, both the buyer and the seller are state and parastatal entities. This stands in contrast to neoliberal water markets, where private property rights of water are often held by the traders. In Tancheng, the rights being traded are water-use quotas allocated by the county government within the centrally planned water allocation system. The county government assumes a pivotal role in the division and reallocation of these water-use quotas through market transactions. The state-directed water market transaction is marked by several distinctive features: they are subject to capped water volumes, operate under non-competitive water pricing, and are confined to a short-term trading period (see section 7.3).

Second, the chapter argues that the hybrid process of water rights trading, which I refer to as "state-directed marketization", is contingent upon the specific political-economic conjunctures faced by the local government. As shown in the section 7.2, the county government initiated the cross-sectoral water rights trading as an experimental and patchwork solution to bypass the stringent control of water abstraction permits imposed by the central water allocation planning from the top-down political hierarchy. While this water rights trade also created space for the local government to address the growing water demands of economic development within the confines of the total water-use cap.

Similar to China's market reforms, which have followed an ad-hoc process known as "directed improvisation" allowing for flexibility and local experimentation (Ang, 2016), the adoption of water market institutions is not driven by a preplanned institutional design but rather by the need for practical solutions. In other words, the development of the water market is a politically expedient choice for both central and local administrations. One of the stated objectives of establishing a water market is to introduce flexibility into the existing water allocation system, offering an adaptable means to cope with interannual variability in water supply and to mitigate the rigidities of the state-granted, fixed-use, and nontransferable water abstraction permits. This expediency explains why the current trading prices and trading volumes in water markets remain low and limited (Speed, 2009; Moore, 2015).

Third, this chapter argues that state interventions and market mechanisms are synthesized in China following the logic of the local state, navigating the blurred lines between water as an economic, public, and common good. In contrast to neoliberal water market systems in Western countries, where the logic of capital prevails in water management and allocation (Loftus and Budds, 2016; Budds and Loftus, 2023), China's selectively adapted water markets under administrative control embody a state-centric utilitarian approach to balance multiple competing values and interests of use in water allocation. As Wu (2008) puts it, strong government control over the market in China is not merely a legacy of state socialism but a pragmatic response to the impasses of marketization. This statecraft transcends the pursuit of capital accumulation and serves a range of extra-economic objectives (Xu, 2020; Han and Rogers, 2023).

The case of water trading in Tancheng county exemplifies this point. On one hand, it addresses the rising water demand from the industrial sector as part of local strategies for economic growth. On the other hand, it facilitates agricultural modernization and rural development without squeezing out and marginalizing the agricultural sector (see Section 7.4). Financial compensation is extended to the irrigation district to mitigate the impact of reduced water availability stemming from the water market transaction. Governmental investments and revenues generated from transaction fees are channeled back into irrigation infrastructure renovation projects, thereby enhancing water use efficiency on farms. Although rural households are typically excluded from direct participation in the trading and decision-making processes, they stand to benefit indirectly from improvements to irrigation infrastructure. In times of severe droughts, the state also supersedes market mechanisms, employing administrative command and control to reallocate water. This action demonstrates the state's commitment to protecting rural communities and agricultural production in the face of uncertainty. The state's capacity to coordinate and accommodate competing political, economic, and social interests underscores the selective, pragmatic, and context-sensitive nature of water market adaptation in China.

Chapter 8 Hydrosocial reconfigurations amid China's state-led agricultural modernization

8.1 Introduction

In this thesis, I interrogate the co-constitution of agricultural modernization and water governance in China. By analyzing the transformations of water governance through technological and infrastructural development, institutional and organizational shifts in irrigation management, and the operation of water markets (see Figure 8.1), I address three central questions: (1) How is agricultural water allocated, accessed, and managed at the grassroots level, and which actors shape these processes? (2) Through what mechanisms is power exercised and materialized via water? (3) What intended and unintended consequences arise from these dynamics, and how do they influence broader development objectives? Employing a political ecology framework of "hydrosocial reconfigurations", this thesis uncovers a hybrid form of water governance at the county and grassroots level in the process of China's state-led agricultural modernization. Through a localized, multi-scalar analysis, I reveal how power is channeled and negotiated among central and local governments, rural communities, and market actors, highlighting tensions between top-down developmental agendas and grounded practices.

This discussion chapter synthesizes key findings on the evolving dynamics of water governance and hydrosocial reconfigurations under China's state-led agricultural modernization. Section 8.2 unpacks the hybrid nature of China's water governance with mixed features of formal and informal institutions, top-down state directives and market-based mechanisms, and bureaucratic administration and localized folk practices. Section 8.3 then explains the governance logics driving this hybridity, focusing on three interrelated mechanisms: the multiplicity of the Chinese state, the two-way embeddedness of local governments and rural societies, and the pragmatic state-directed marketization of water. This chapter ends with reflections on China's state-led agricultural modernization as a hydrosocial project, revealing how water serves as both a catalyst for and a contested outcome of political and socio-ecological change.

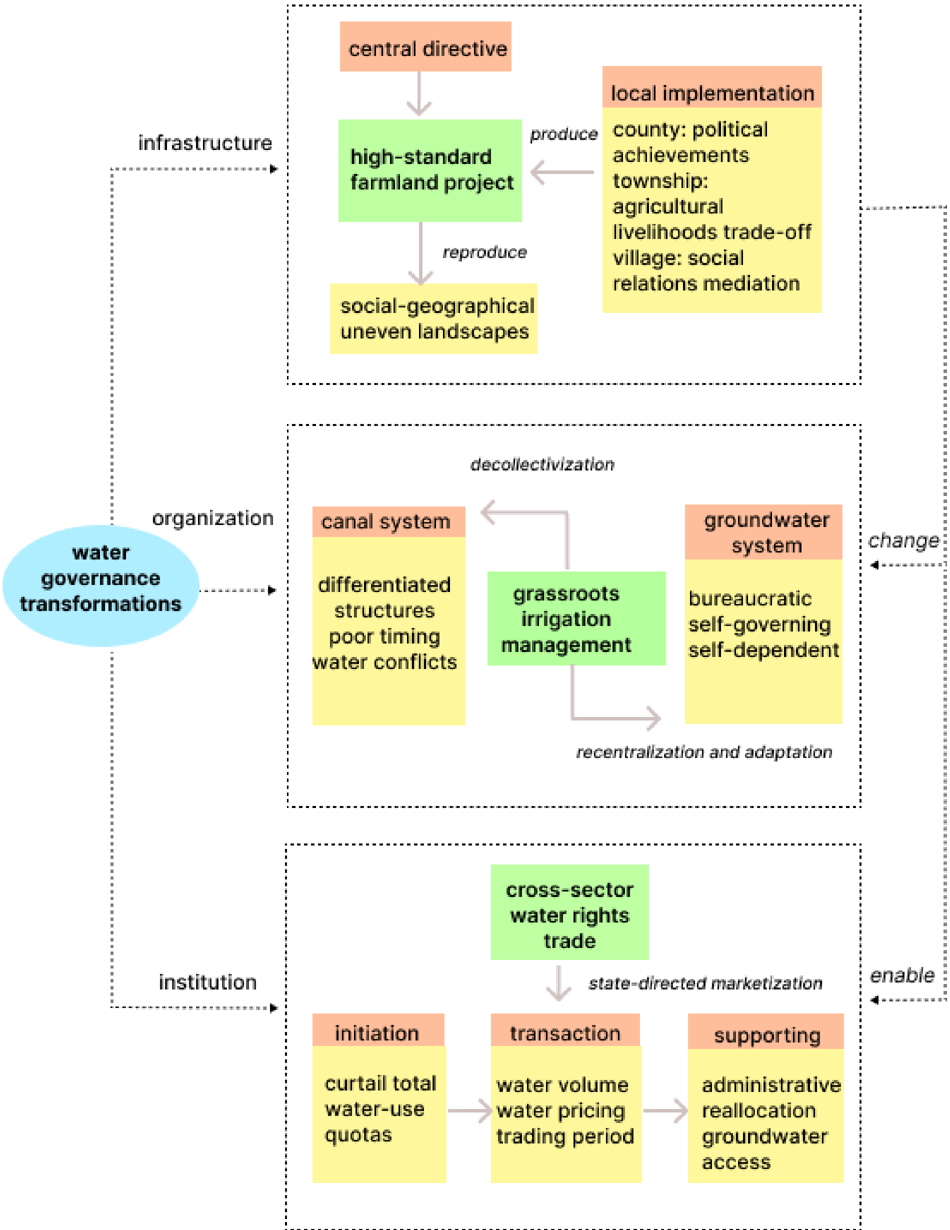

Figure 8.1. Roadmap of the thesis.

8.2 A hybrid form of water governance

Agricultural modernization has become a political agenda since the founding of the People's Republic of China in 1949, when technological advancements in agriculture were mobilized to fuel industrial growth and consolidate state power (Hazell, 2009). Since the 2000s, this agenda evolved into an unprecedented wave of agricultural and rural modernization aimed at addressing systemic challenges of agricultural productivity, national food security, and enlarging urban-rural development gaps (Ye, 2015).

China's uniqueness lies not in exceptionalism but in its state-led approach to agrarian change. Unlike many African and Latin American contexts, where foreign capital and global markets predominantly drive agricultural transformations (Allan et al., 2012; Woodhouse, 2012b; Van Eeden et al., 2016), the Chinese state has leveraged its strong institutional capacity to direct policy foci and financial resources toward agricultural modernization and rural revitalization. Shifting focus from the centre to the locality, this thesis argues that the implementation of this state-led development paradigm at county and grassroots levels has produced a hybrid form of water governance, blending formal and informal institutions, public and private actors, state directives and market mechanisms, and government administration and folk practices.

As shown in Chapter 5, the construction of small-scale irrigation infrastructures through centrally-directed initiatives has produced uneven outcomes due to localized adaptations by county and township governments, village committees, large producers, and smallholders. These stakeholders navigate competing priorities through both formal and informal tactics: adhering to standardized project designs while leveraging bureaucratic networks and social relations to advance political or economic interests. This reveals how top-down initiatives fracture into contested, context-specific implementations.

The canal and groundwater irrigation systems, as demonstrated in Chapter 6, show the coexisting trends of de-collectivization, re-centralization, and individualization in irrigation management. While township governments recentralize government control over state-funded irrigation facilities, self-governance persists for collectively owned infrastructures through the formation of tubewell-owning partnerships. At the same time, smallholders develop informal, individualized practices to combat water constraints and to sustain agricultural livelihoods.

The operation of agricultural-to-industrial water rights trading, as analyzed in Chapter 7, illustrates the complementation rather than contradictions of state control and market mechanisms in China's water market system. With capped water volumes, administered water prices, short-term trading periods, and administrative backups during dry conditions, this quasi-market system frees up water as an economic good for industrial development while maintaining its public-good attribute for rural livelihoods.

These hybrid water governance forms emerge from China's unique political economy, where dialectics of state/collective/private ownership and plan/market logics are institutionally embedded. Far from accidental, such hybridity embodies the hydrosocial reconfigurations shaped by state-led agrarian modernization. What mechanisms drive and sustain this hybrid water governance? How do power dynamics between state, market, and rural society actors shape its evolution? The following section theorizes these logics through China's contextual particularities, moving beyond Western-centric notions of the "hydraulic state" and "neoliberalizing water" to foreground how developmental and hydraulic imperatives work in practice.

8.3 Logics and mechanisms of hybrid water governance

China's agricultural modernization and water governance diverge sharply from neoliberal paradigms, where agrarian change is driven by capitalist accumulation and market logics. Here, the state remains the primary architect of transformations. However, this thesis resists reductive analyses of the Chinese state as a monolithic, unidirectional force, as often depicted in existing scholarship. While recognizing the enduring influence of technological and institutional legacies of state's efforts (Pietz, 2015), I adopt an actor-oriented and agency-structure approach to interrogate how power is enacted through the everyday practices of diverse actors.

In Tancheng county, these actors include the county government and its agricultural and water bureaus, township governments and water stations, the state-owned water supply company, industrial enterprises, and rural households. Their mundane engagements—negotiating the access, allocation, and management of water and reconciling state mandates with local realities—reveal that the state authority is neither absolute nor static but continually reshaped through grassroots interactions. The resulting hybrid water governance reflects broader socio-political reconfigurations: central-local tensions recalibrated through policy implementation, state-society relations redefined by contingent collaborations, and state-market boundaries blurred through strategic accommodations.

8.3.1 Multiplicity of the state's agendas

Existing literature on hydraulic states and hydraulic missions often portrays the "state" as centralized and consistent authority, emphasizing the state's capacity to deploy infrastructural and bureaucratic techniques to order both landscapes and societies for its modernization agenda (Akhter and Ormerod, 2015; Rogers et al., 2016; Rusca et al., 2018; Menga and Swyngedouw, 2018). The traditional "hydraulic state" model in China posits rigid central control over the construction and management of imperial waterworks such as flood control dykes, canals, and irrigation systems (Wittfogel, 1957). Under such reductive analyses, the state's modernization agenda is perceived as fixed and singular, with the process of advancing the agenda seen as unidirectional, that is, from the state to society in a top-down manner, where local governments such as county and township governments acting as agents of the central state. The premise of unchanging authoritarianism overlooks critical nuances in contemporary water governance reforms. As Mertha (2008) suggested, we have to invert Wittfogel's top-down paradigm to understand the decentralized complexity and institutional diversity of China's water transformations.

This thesis unpacks the state's varying forms and functions by interrogating how local state actors—county and township governments—strategically reinterpret and navigate national agricultural modernization agendas. Through a case study of the high-standard farmland project in Tancheng, I demonstrate how the county and township governments have adopted various strategies in the construction of small-scale irrigation infrastructures. Proactive townships leverage the initiative to secure political capital, establishing demonstration zones to showcase the achievements in agricultural modernization. Conversely, anti-project townships prioritize the diversity of local agricultural livelihoods over standardized grain production. This spectrum of response reveals the state not as a monolith but as a negotiated arena where local actors recalibrate central directives to accommodate specific context dynamics within their territorial jurisdictions.

These findings align with Xu's (2020) analysis of the variegated but integrated intra-state variations due to the state's dual functions: advancing economic development while maintaining social stability. This thesis advances this understanding by further articulating the multifaceted and sometimes contradictory nature of the state's modernization agendas, which leads to unintended socio-political and environmental outcomes. Multiple policy goals—agricultural productivity, national food security, poverty alleviation, rural revitalization and environmental sustainability—are contingently negotiated and reproduced within local socio-political and economic contexts. For example, the case study of Tancheng exemplifies how state-led irrigation infrastructure initiatives reshape grassroots governance through paradoxical outcomes. While the transfer of management authority to township administrations ostensibly enhances professionalism, responsiveness, and accountability, it simultaneously entrenches bureaucratic control, marginalizing traditional community-led irrigation practices. This shift generates uneven geographies of water access: state-backed groundwater-fed irrigation investments, mediated by coalitions of local bureaucrats, land managers, and private drilling firms, systematically prioritize large producers over smallholders. Such infrastructural "modernization" entrenches socio-ecological inequalities, as unregulated well-digging proliferates to meet short-term productivity targets, enabling agricultural-to-industrial water trading while against long-term water sustainability.

Through the lens of hydrosocial reconfigurations, I argue that the state's agendas are neither clear-cut nor singular; instead, they are often diverse and competing. The state-led development operates not as a unidirectional imposition, but rather as a dynamic coproduction process where local strategies and everyday practices coexist with and constrain the exercise of state power, thereby diverging policy goals from its original intentions (Wang et al., 2018; Lamb et al., 2022).

8.3.2 Two-way embeddedness of the state and rural society

Mainstream commons scholarship often presumes that common-pool resources can be sustainably managed through universalized, decontextualized, and ideal-type lists of institutional design principles and "best practices". Such frameworks tend to romanticize self-governance, positioning civil society as a "third way" for resource governance, ostensibly independent from state and market actors (Ostrom 1990, 2005). While in the Chinese context, the relationships between the state and rural society are often embedded, fluid, and contingent (Spires, 2011; Wang and Liu, 2022). This thesis challenges conventional binaries separating state and society, arguing instead for their mutual embeddedness in rural water governance.

On one hand, China's experience demonstrates the alternative approach defined as "state-reinforced self-governance" by Sarker (2013), where a financially, technologically, legally, and politically strong state support water users in the management of irrigation commons. China's state-led development projects signify an extension of state authority into rural areas, introducing water users associations (WUAs) through its bureaucratic system and extensive engineering projects. Yet these ostensibly participatory institutions, promoted as a modern governance model through top-down directives, clash with the realities of a de-collectivized, hollowing-out countryside. In Tancheng, WUAs overlap with existing village committees and have been gradually merged into township water stations to tighten bureaucratic control of irrigation management.

On the other hand, I also find adaptive social institutions emerging from localized, folk practices for the use and maintenance of private wells. In X and M villages in Gui township, Tancheng county, farmer households have formed informal well-owning partnerships to gain access to groundwater, sharing costs for construction, operation, and maintenance in groups. Due to unstable and untimely canal irrigation under dry conditions, this new form of cooperation and adaptation becomes a necessity for rural societies, coexisting with the state-managed irrigation system instead of challenging or resisting it. These cooperative management institutions are grounded in people's worldviews, beliefs, and knowledge to do with water, combating climate change and driving for agricultural modernization. Unlike the rigid, rule-bound models championed by mainstream commons studies, their governance evolves organically from the interplay of smallholder agency, technological access, ecological constraints, and the political economy of production. Nevertheless, whether these flexible institutional arrangements are durable networks or not remains to be seen, as they are constantly reconfigured and hybridized with rules in use adapted to dynamic socio-ecologies.

This study illustrates how state-driven irrigation modernization operates through a dialectical relationship with rural communities. The development initiatives to improve water governance simultaneously shape and are reshaped by local knowledge, livelihood priorities, and adaptive responses to climate pressures. Such two-way embeddedness of state and society in the Chinese context challenges the one-size-fits-all models for grassroots irrigation governance. It articulates the diversity and adaptation of social institutions and organizations that emerge from the interplay of context-specific socio-political structures, resource constraints, and grassroots agency.

8.3.3 Pragmatism of the state-directed marketization

Contesting the global trend of "market environmentalism," which promotes various types of market-oriented water reforms to reconcile economic growth with environmental sustainability, scholarship on the neoliberalization of nature/water has critiqued its depoliticized and normative analyses. This body of literature emphasizes how such apolitical approaches neglect power relations and politics, highlighting the contextually contingent institutional practices that emerge from localized adaptations and negotiations within particular political-economic dynamics, regulatory arrangements, and power geometries (Castree, 2006; Castree, 2008b; Brenner et al., 2010; Budds and Loftus, 2023).

However, the scholarly debate remains anchored in a dichotomy between “commons” and “commodity” or “state” and “market” (Bakker, 2007; Paerregaard and Andersen, 2019), framing the neoliberalization of water as a form of capital accumulation by dispossession (Castree, 2008a; Bakker, 2010). While scholars increasingly recognize that market-oriented reforms rarely produce “free market” systems but establish hybrid forms of neoliberal governance with different degrees of state reregulation (Bruff, 2014; Baer, 2014), less is known about how such hybridization process unfolds in practice. This study addresses this gap by interrogating the mechanisms and power dynamics underpinning state-directed marketization in China’s water sector, offering a nuanced analysis of how neoliberal-induced water governance is reconfigured within distinct political-institutional contexts.

In contrast to neoliberal water market systems, which emphasize minimal state intervention, China’s water market operates through hybrid governance arrangements with an integration of administrative control and market mechanisms. As we can see in the case of cross-sectoral water rights trading in Tancheng, where transactions occur exclusively between state and parastatal actors, rather than private entities and without public participation. Crucially, the traded “rights” are not private property, as is typical in neoliberal contexts, but state-allocated water-use quotas administered through a centrally planned water allocation system. The county government retains decisive authority, orchestrating the division and reallocation of these quotas via market-based transactions. These transactions, however, are tightly constrained by state power: they operate within capped water volumes, adhere to non-competitive pricing structures, and remain subject to command-and-control regulatory measures that prioritize administrative objectives over market rationales.

While previous studies position China’s hybrid water market system as a product of deliberate state planning aimed for the enhancement of state legitimacy (Sheng and Webber, 2019; Sheng et al., 2020), this study further argues that its development stems instead from pragmatic expediency rather than premeditated institutional design. This perspective aligns with Speed's (2009) assertion that the establishment of water markets is the result of fragmented, ad hoc initiatives rather than systematic institutional attempts. For instance, China's first cross-regional water rights trading between Dongyang and Yiwu administrative governments originated as a local experiment without formal legal authorization, yet it gained traction through tacit support from the MWR (Jiang et al., 2019). Such cases illustrate that state-directed marketization evolves dynamically through iterative interactions between local states and market actors within particular political-economic conjunctures.

The co-evolving process mirrors China's broader "directed improvisation" approach to market reforms, where strategic central guidance coexists with localized experimentation and adaptive flexibility (Ang, 2016). Similarly, the water market system provides a flexible alternative for the locality to accommodate interannual water supply variability. By enabling localized adjustments to centrally allocated water-use quotas, it mitigates the rigidity of top-down planning of water allocation and functions as a pragmatic compromise born of necessity rather than ideological commitment.

The concomitant adaptation of water market under administrative control reflects a state-centric utilitarian approach to balancing multiple and competing values and interests in water allocation and water use. As Wu (2008) contends, strong government control is not simply a legacy of socialist planning economy but a pragmatic reaction to the impasse of marketization. By integrating government control with market toolkits, the Chinese state cultivates capacities to coordinate divergent interests, from economic efficiency to social equity and environmental constraints, in particular to accommodate the diversity of localities. This explains why China's water market adaptations remain selective, pragmatic, and contextually contingent: they are calibrated instruments of governance, not ideological commitments to market logics.

8.4 Reflections on agricultural modernization through a water lens

China's water sector has undergone a paradigm shift from centralized "water management" to "water governance" with multiple actors involved. The emergence of hybrid water governance, alongside its underlying hydrosocial reconfigurations, complicates the apolitical, modernist-oriented, and techno-centric governance model promoted in national policy discourses. This hybrid and dynamic water governance system operates as both a catalyst for and a check on development agendas, simultaneously enabling and constraining China's state-led agricultural modernization with significant political, social, and environmental consequences.

On one hand, the transformations of water governance drive China's state-led agricultural modernization through distinct political rationalities without displacing smallholders. In contrast to neoliberal contexts where capitalist modes of production and accumulation drive agrarian change through market logics, the Chinese state plays a dominant role in the agricultural modernization process to address urban-rural development disparities (Ye, 2015). The central government, wielding strong state capacities, has channeled substantial investments into rural infrastructure including irrigation, water supply, and electrification. With focused policy attention and substantial resources being allocated to the countryside, it has resulted in measurable improvement in agricultural productivity, peasant incomes and rural livelihoods (Huang et al., 2006; Xiao et al., 2022).

The dominant and supporting role of the Chinese state challenges the conventional assumption of "accumulation by dispossession," which sets it apart from most African and Latin American countries where weak state regimes have fostered large-scale, capital-intensive land and water exploitation by foreign direct investment (Allan et al., 2012; Woodhouse, 2012b; Van Eeden et al., 2016). Unlike land, which is limited, fixed, and subject to transfer between users, water is fluid, renewable, and can be harnessed through hydraulic infrastructure development. In spite of an inherent scale bias in resource distribution, the heavily state-invested irrigation infrastructures remain accessible to most rural households and help them stay productive. More importantly, these infrastructures have complemented rather than replaced traditional irrigation methods, enabling smallholders to sustain agricultural production amidst rural outmigration. As discovered in Chapter 6, there are various ways to access and govern agricultural water. China's land tenure system further mitigates land dispossession risks associated with modern irrigation infrastructure, where land remains collectively owned by rural communities, and peasant households retain their land contract rights while transferring land use rights to large growers (Zhang and Donaldson, 2008). This system has allowed smallholders to preserve their landholdings and diversify their livelihoods though wage labor, non-farm employment or specialized farming in addition to receiving land rents (Zhang, 2012; Gu, 2022; Wilmsen et al., 2024).

On the other hand, water plays an agential role in the reproduction of state-led agricultural modernization with unintended consequences, reinforcing and transforming existing power dynamics and social relations. The agency of water challenges anthropocentric perspectives dominant in political economy, which often view labor as a transformative process while overlooking the distinct material properties of non-human elements (Benton, 1989). A humanist conception of agency—rooted in nature-society dualism—fails to acknowledge the political subjectivity of socio-natures like water (Bakker, 2010). Unlike land, water is a flow resource that is interconnected, difficult to bound spatially, and characterized by blurred boundaries. It is neither a neutral background nor a passive biophysical resource for human exploitation. Instead, it acts as a political subject within agricultural modernization, both transformed by and constraining political-economic evolution (Bakker, 2002). Modernization, therefore, involves more than technological or institutional change; it fundamentally regenerates water-society relations through the hydrosocial cycle.

For example, Chapter 5 reveals that the uneven geographies of water infrastructure investment across social strata and spatial areas have reshaped the competitive strengths between large producers and smallholders. While large producers benefit from exclusive access to infrastructures and preferential water prices, smallholders outside of the project area face higher costs and labor burden to secure irrigation water. These irrigation infrastructures, once adopted in rural societies, have institutional momentum to reshape grassroots irrigation governance by shifting management authority toward township administrations, ostensibly to improve professionalism, responsiveness and accountability, as shown in Chapter 6. Moreover, the widespread and unregulated use of agricultural wells to access groundwater has enabled the agricultural-to-industrial water rights trade as discussed in Chapter 7. However, it has also inadvertently encouraged excessive groundwater extraction, prioritizing immediate policy outcomes of agricultural productivity and industrial development over enduring water sustainability. This is particularly evident in the use of electromechanical wells by large producers to access water in a pervasive and unregulated manner, which has led to land subsidence and poor drainage.

Through the lens of water and hydrosocial reconfigurations, this study advances a nuanced understanding of power dynamics in the interplay of water, development, and power in Chinese rural society, demonstrating that China's state-led agricultural modernization has aligned with a technocratic developmentalism in pursuit of high-modernist ideals while produced varied socio-political and environmental impacts. These implications show an alternative development pathway and power dynamics in China, contributing to rethinking "modernization" in a critical, non-linear, and context-sensitive way.

Chapter 9 Conclusion

9.1 Main insights from the study

There are three main insights drawn from this study. First, it argues that agricultural modernization and water governance mutually affect and constitute one another. This thesis articulates the dialectical relationship between agricultural modernization's influence on water governance and water's agential role in the modernization process. Techno-centric agricultural modernization has shaped specific technological and managerial approaches to water governance. In turn, water transformations have restructured water-society relations within a social and material matrix of infrastructures, organizations, institutions, and power dynamics, thereby reshaping agricultural modernization.

Second, it demonstrates that China's water governance embodies a hybrid amalgamation of practices and institutional arrangements, producing both intended and unintended political, social, and environmental outcomes. Water transformations—manifested through the development of small-scale farmland irrigation infrastructures to access water, state-reinforced self-governing organizations to manage water, and quasi-market institutions to reallocate water between agricultural and industrial sectors—combine formal and informal, modern and traditional, state-directed and market-oriented, and governmental and folk practices at local and grassroots levels. While the hybrid water governance enables the state to advance modernization agendas such as agricultural productivity, food security, and rural revitalization, it also results in the centralized government control over grassroots irrigation governance, socially and geographically uneven water accesses among irrigators, and an unregulated expansion of agricultural wells and excessive groundwater extraction.

Third, it employs the theoretical lens of ‘‘hydrosocial reconfigurations’’ to reconceptualize water in a relational and dialectical approach, unpacking the state-market-society relations underpinning hybrid water governance in China’s state-led agricultural modernization. It reveals the complex exercise of state power on the ground, where local governments strategically navigate central multifaceted policy agendas, mutually embed themselves within dynamic rural societies, and pragmatically adopt market-based mechanisms to mediate competing water demands between agricultural and industrial sectors.

9.2 Research contributions

This research contributes to both agrarian studies and critical water studies, addressing the underrepresentation of China in existing academic literature. In particular, it advances the bridge of agrarian political economy and political ecologies of water.

First, this thesis brings water back into agrarian studies by centering water as a critical dimension in discussions of agrarian change. While classical political economy literature often emphasizes human-driven narratives of rural transformations, where capital and labor dominate natural landscapes while hiding away ecology within the agrarian question (Taylor, 2015), I acknowledge that water governance can’t be analyzed independently of broader shifts in agrarian political economies (Barker and Molle, 2004). This research demonstrates the interconnectedness and mutual constitution of water and agricultural modernization. The assumption of sufficient and effective agricultural water use in pursuit of modernization entails new forms of governance that change both organizations and institutions of water-use practices and water technologies designed to support them. These modernist affiliations embedded in the policy discourses of water governance, in turn, reshape agricultural production, rural structures, and power relations in the localized socio-environmental processes, both enabling and constraining agricultural modernization.

These research findings align with increasing ecological critiques of agrarian capitalism and calls to “green the agrarian question” with an environmental dimension included (Bernstein, 2009; Gerber and Veuthey, 2010). Scholars have articulated how capitalist production transforms human-nature relations, challenging the productivist paradigm of intensive, commercialized agriculture centered on land and soil (Moore, 2015; Xu and Ye, 2021). However, agrarian change analyzed through water remains under-researched, despite water’s role as an essential means of production and its entanglement with land, food, and energy in rural livelihoods (Mehta et al., 2012). My research advances existing knowledge by unpacking water governance transformations and hydrosocial relations in rural China, demonstrating the state’s multifaceted modernization agendas and the state-society-market synergies navigated by local governments to enrol and protect rural communities from “accumulation by dispossession”.

Second, a water-centric dimension not only sheds light on distinct modernization processes and power dynamics, but also opens up new theoretical forums for critical agrarian studies by bridging them with the political ecologies of water and development. Mainstream water policy models and institutions predominantly justify water exploitation and governance for economic and social progress under the pretext of modernist visions (Worster, 1985; Scott, 1999; Swyngedouw, 2004; Kaika, 2006; Robbins, 2012). Baker (2013), for example, argues that the expansion of hydrology as a scientific discipline has framed water governance as a technocratic project to “manage water for human benefit” at all scales by hydraulic bureaucracies, promoting technological fixes and market mechanisms as universal solutions or panaceas. This apolitical and technocratic understanding of water governance also dominates China’s national policy discourses and its agricultural modernization agendas.

Moving beyond water’s biophysical reductionism, this research reconceptualizes the role of water in a relational and dialectical approach, proposing the theoretical framework of “hydrosocial reconfigurations” to critically analyze the political and social aspects of water governance in practice. As political ecologists suggested, water is not an inert object to be governed, but a power-laden medium in the social realm that actively reshapes water-society relations within specific spatiotemporal contexts (Swyngedouw, 1999; Linton and Budds, 2014).

Unlike neoliberal settings, where capitalist modes of production and accumulation recompose water into a frontier of appropriation through the interplay of capital, power, and science, this study advances a nuanced understanding of power dynamic in rural China. Here, state-led agricultural modernization aligns with technocratic developmentalism, pursuing high-modernist ideals while generating distinct hydrosocial relations with varied socio-political and environmental consequences. These reconfigurations are driven by state logic rather than capital logic, as local governments strategically and pragmatically navigate central imperatives and market-based toolkits in everyday practices within dynamic rural societies. This thesis disentangles the politics of "apolitical" water governance and reinterprets the socio-natural relationship between water and the "modernist ideal" in the China's agrarian context.

9.3 Limitations and future research agendas

This study, while providing critical insights into the interplay of water governance and agricultural modernization, has limitations that invite further scholarly engagement.

First, the meso-level case study methodology adopted in this thesis provides a comprehensive view of water governance transformations unfolding in a traditional agricultural county. Future studies are encouraged to dive deeper into the micro-level investigations at the household scale, using survey data to elucidate how these water transformations affect individual worldviews, behavior practices, and livelihood strategies related to agricultural production and irrigation. For instance, this study has identified adaptive well-owning partnerships in some villages that are not covered by state-backed infrastructural projects. It is interesting to further examine why villagers initiate such partnerships and what factors have enabled them to do so? Who is excluded from these arrangements and how their exclusion reinforces or challenges existing social hierarchies? And how these informal arrangements interact with formal governance structure? The micro-level data could help to identify marginalized groups such as the poor elderly and female-headed households, and reveal how power asymmetries within villages mediate access to water, offering insights into grassroots resilience and vulnerability that are often obscured in macro- and meso-level analyses.

Second, while this study acknowledges climate change as a critical dynamic, it does not fully disentangle its profound impacts on water-related practices and agrarian livelihoods. Future research should adopt a climate-water-agriculture nexus to capture the dialectical interplay of climate change, agrarian transitions, and water transformations. For example, future studies warrant to investigate how severe dry weathers amplify competitive strengths between large producers and smallholders in the access to and use of agricultural water. Drought-induced water scarcity may disproportionately burden smallholders with higher irrigation costs and labor demands, accelerating land consolidation or outmigration. Although Tancheng has reported moderately good groundwater recharge in years of adequate monsoon rains, it is necessary to track its long-term groundwater table fluctuations under increasingly frequent extreme droughts and unregulated well drilling practices, which risk irreversible aquifer depletion.

In addition, it is interesting to explore the paradox of “too much water” in climate-adaptive governance. This study notes that poorly drained farmland, exacerbated by land subsidence from excessive use of agricultural wells, heightens flood risks during intense summer rains. Future research could analyze how flooding disrupts agricultural practices, alters crop choices, or triggers shifts in land tenure, as well as how state and community responses to floods reconfigure hydrosocial relations.

9.4 Concluding remarks

As I was commuting to the fields of Tancheng during my fieldwork, a banner standing still on the farmland caught my eye. It is written with bold red Chinese characters of "On the Field of Hope" against a sea of golden wheat. This phrase, drawn from a Chinese song celebrating renewed livelihoods following the reform and opening up in the 1980s, not only conveys the longstanding state discourse of agricultural modernization and rural development, but also expresses the aspirations of local hardworking people for a better agrarian future. On a personal note, it reminds me of wonderful fieldwork experiences on the earth of my homeland and encourages me to continue studying such an important and promising topic on the socio-ecology of agrarian change.

I would like to conclude this thesis with a quote from Paul Robbins (2012: 3-4). This comment critiques the anthropocentric framing of agrarian change that reduces water to a biophysical resource harnessed by human grand designs. Instead, it emphases the co-constitution of agrarian change and hydrosocial reconfigurations that this thesis aims to address. I believe that attentions to the socio-political nature of water and inherent politics and power dynamics are important if we are to contribute to sustainable and just water transformations!

> "This, I think, may make a small contribution to helping us all break from an image of a world where the human and the non-human are disconnected, a fiction that remains so stubborn a part of our modern reasoning that it is as difficult to unimagine as it is to picture a world without patriarchy or class. I believe, however, that an alternative picture, where nature and society are undivided, is as much an act of remembering as one of inventing."

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Appendix A. Participant pseudonyms and demographic information

Coding	Name	Gender	Township	Semi-structured interview/Casual talk (S/C)
CG-1	Liang	Male	Tan	S
CG-2	Huai	Male	Tan	S
CG-3	Jin	Male	Tan	S
CG-4	Bao	Male	Tan	C
CG-5	Wang	Male	Tan	S
CG-6	Feng	Male	Tan	C
CG-7	Yan	Female	Tan	C
TG-1	Guo	Male	Yang	S
TG-2	Wu	Male	Yang	S
TG-3	Xu	Female	Yang	C
TG-4	Zhi	Male	Hua	S
TG-5	Yao	Male	Hua	C
TG-6	Chang	Male	Hong	S
TG-7	Fang	Male	Gui	S
TG-8	Wei	Male	Gui	S
WC-1	Quan	Male	Ma	S
WC-2	Song	Male	Ma	C
WC-3	Chen	Male	Ma	C
HC-1	Cheng	Male	Hua	S
HC-2	Xue	Male	Hua	C
HC-3	Fu	Male	Hua	C
HC-4	Han	Male	Hong	S
LP-1	Li	Male	Tan	S
LP-2	Wang	Male	Gang	S
LP-3	Liu	Male	Gang	S
LP-4	Lan	Male	Miao	S
LP-5	Huang	Male	Yang	C

LP-6	Xu	Male	Yang	S
LP-7	Yong	Male	Yang	S
LP-8	Gao	Male	Hong	S
LP-9	Li	Male	Hua	S
LP-10	Wan	Male	Chong	S
LP-11	You	Male	Gui	S
LP-12	Qiu	Female	Quan	C
VC-1	Sun	Male	Hua	C
VC-2	Qiao	Male	Gui	S
VC-3	Song	Male	Gui	S
VC-4	Liu	Male	Gui	S
VC-5	Zhang	Male	Gui	S
VC-6	Lei	Male	Yang	S
VC-7	Liang	Female	Yang	S
VC-8	Yang	Male	Miao	S
VC-9	Jin	Male	Miao	S
SF-1	Xie	Male	Gui	S
SF-2	Ma	Male	Gui	C
SF-3	Wang	Male	Gui	C
SF-4	Zhang	Male	Gui	C
SF-5	Lou	Female	Gui	C
SF-6	Zhang	Female	Yang	S
SF-7	Si	Female	Yang	S
SF-8	Gao	Male	Yang	C

Note: CG=county government official and staff, TG=township government official and staff, WC=water supply company, HC= Hydraulic engineering company, LP=large-scale producer (e.g. agribusiness companies, family farms, farmers' professional cooperatives, and large households), VC=village cadre, SF=smallholder farmer.

Appendix B. Guiding topics and questions for interview

<u>County government officials and staff:</u>

1. Area and distribution of farmland and permanent basic farmland?
2. Farmland and water conservancy projects:
   a) Their construction period, investment, and ownership?
   b) Who are responsible for the investment, construction, and maintenance?
   c) How to distribute amongst townships?
   d) What are the social, economic, and environmental outcomes?
3. Any financial incentives and support for large-scale agricultural producers?
4. Water supply and water consumption:
   a) What are the sources for water supply?
   b) The amount and proportion of water used in the agricultural, industrial, and domestic sectors?
   c) What are the annual total water use caps and how they have changed over years?
5. Agricultural water distribution and pricing:
   a) How to allocate agricultural water for irrigation amongst townships?
   b) How to price agricultural water?
   c) How is the agricultural water pricing reform going on?
   d) Any water-saving incentives or subsidies?
6. Groundwater use and regulation:
   a) How to apply for groundwater extraction permits for agricultural and industrial wells?
   b) Who have the approval authorities?
   c) Any supervision measures and remediation actions for groundwater over-extraction?
7. How the cross-sector water rights trading is implemented?

Township government officials and staff:

1. Farmland and water conservancy projects:
    a) Their construction period, investment, and ownership?
    b) Who are responsible for the investment, construction, and maintenance?
    c) How to distribute amongst villages?
    d) What are the social, economic, and environmental outcomes?
2. Land transfer:
    a) How many land areas?
    b) How much per *mu* and for how long?
    c) To whom the farmland is transferred and for what purposes?
    d) Who are involved in the land transfer process?
    e) The number and scale of large agricultural producers?
3. Irrigation operation and management:
    a) How the agricultural water is distributed among villages and households? And by whom?
    b) What are the rules for irrigation scheduling? Who sets these rules?
    c) How irrigation water fees are collected? What are the changes?
    d) Who are responsible for the operation and maintenance of farmland irrigation infrastructure?
4. How the water users association operates? Who are the members? What are the rules for decision-making?
5. Any water use conflicts between upstream and downstream townships/villages? How have they been resolved?

Water supply or engineering companies:

1. Why to build the surface water plant?
2. The cross-sector water rights trading with the irrigation district:
    a) Who initiated it and why?
    b) What is the water volume being traded?

    c) What is the trading price?
    d) What other investment costs?
3. How water is priced within and beyond the public water supply networks?
4. How to participate in the construction, management, and operation of farmland water conservancy projects?

Large-scale agricultural producers (including agribusiness companies, family farms, professional cooperatives, large households, etc.)**:**

1. Basic information: farmland scale, crops, labor, agricultural machinery, etc.
2. Land transfer:
    a) How many land areas?
    b) When did you start to transfer land?
    c) How much per *mu* and for how long?
    d) Relationships with governments, village committees, and farmer households in the process?
3. How to irrigate for large-scale operations? What are the primary water sources? Any capital and technological investments?
4. What are the cost and benefit for upscaled farming? What are the irrigation costs for different crops?
5. How to participate in the construction, management, and operation of farmland water conservancy projects?
6. Have you ever received any government subsidies or project incentive funds?

Village committee cadres:

1. Basic information: population, migration, farmland scale, crop structure, collective economic income, etc.
2. Land transfer:
    a) How many land areas?
    b) How much per *mu* and for how long?

c) To whom the farmland is transferred and for what purposes?

3. Irrigation practices:
    a) What are the primary water sources for irrigation? In particular, how many land areas are groundwater-fed?
    b) How the agricultural water is distributed among farmer households?
    c) What are the rules for irrigation scheduling? Who sets these rules?
    d) How irrigation water fees are collected? What are the changes over years?
4. How many agricultural wells in total? How deep are they and how much do they cost? Who owns these wells?
5. Who are responsible for the operation and maintenance of farmland irrigation infrastructure?
6. How the water users association operates? Who are the members? What are the rules for decision-making?
7. Are there any water use disputes between upstream and downstream villages/farmer households? How have they been resolved?
8. What are the impacts of government projects or policy changes on village irrigation governance?

Smallholders (including the elderly, women irrigators, etc.):

1. Basic information: household structure, income sources, farmland scale, crop structure, land transfer, etc.
2. How do you access water for irrigation? Is it convenient and available for you?
3. What are the cost and benefit for farming? In particular, how much is the irrigation cost per season?
4. Any water use conflicts with large producers or other smallholders? How have they been resolved?
5. What are the impacts of government projects or policy changes on your agricultural production and rural livelihoods?

Appendix C. Consent form

Research topic: Agricultural modernization and the transformation of water governance in Shandong, China.

Researcher: Caixia Man, PhD student from the University of East Anglia and Southern University of Science and Technology

Dear Participant,

Thank you for participating in this research project! Before the study begins, please carefully read and confirm the following terms:

1. I voluntarily agree to participate in this study and provide relevant information, personal experiences, and perspectives.
2. I understand that I can pause or withdraw from this study at any time without facing any negative consequences.
3. I consent to being audio-recorded, video-recorded, and photographed throughout the study. I acknowledge that audio recordings will be transcribed into written transcripts for the researcher's analysis.
4. The researcher will securely store all audio, video, and photographic materials to prevent unauthorized access or leakage. All collected data will be used only for academic research and no other purposes.
5. My personal identity will remain strictly confidential. With my explicit consent, the researcher may use excerpts of conversation segments to authentically present research findings.
6. I agree to review and verify the analysis with the researcher, and I will receive feedback on the research findings upon completion of the study.

Signature: ....

Date: ....

Appendix D. Quota for Agricultural Water in Shandong Province (DB37/T 3772—2019)

Table 1. Irrigation quotas for wheat, corn, and rice.

Crop	**Reliability of irrigation**	**Irrigation quota/ m^3 per *mu***				
		I zone	II zone	III zone	IV zone	V zone
Wheat	P=50%	180	232	220	160	158
	P=75%	207	258	245	195	187
Corn	P=50%	43	90	77	40	40
	P=75%	65	116	103	65	65
Rice	P=75%	420	446	478	420	
	P=85%	446	478	510	446	

Table 2. Adjustment coefficient of agricultural water quotas.

Condition		**Water conservancy zone**				
		I zone	II zone	III zone	IV zone	V zone
Type of water engineering	Earthen canal	1	1	1	1	1
	Lined canal	0.98	0.95	0.95	0.92	0.92
	Pipeline convey	0.88	0.87	0.87	0.85	0.85
	Sprinkler irrigation	0.75	0.75	0.75	0.70	0.70
	Drip irrigation	0.65	0.65	0.65	0.63	0.63
Method of water extraction	Gravity	1	1	1	1	1
	Lifting	0.95	0.95	0.95	0.94	0.94
	Groundwater	0.94	0.94	0.94	0.93	0.93
Scale of irrigation district	Large	1.12	1.12	1.12	1.11	1.11
	Medium	1.08	1.08	1.07	1.06	1.06
	Small	1	1	1	1	1

Note: 1) Shandong is divided into five water conservancy zones based on the natural environment, river basin, agricultural production conditions, and other factors affecting agricultural water use: Southwest (I zone), Northern (II zone), Central (III zone), Southern (IV zone), and Eastern (V zone). 2) The reliability of irrigation refers to the probability that water supply in an irrigation district can be met over years. 3) The adjustment coefficient reflects the degree of impact that different types of water engineering, methods of water extraction, and scales of irrigation districts have on the irrigation quota under reference conditions.