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The Impacts of Socioeconomic Development on Rural Drinking Water Safety in China: A Provincial-Level Comparative Analysis

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Abstract: In China, achieving rural drinking water safety—meaning access to a safe, affordable, sufficient, and sustainable drinking water supply—remains a key challenge for government agencies and researchers. Using cross-sectional data at the provincial level, in this paper we examine the impacts of socioeconomic development on drinking water safety in rural China. Using a theoretical framework called Pressure-State-Response (PSR), existing data were organized into state and pressure indicators. Canonical Correlation Analysis was then used to analyze provincial-level relationships between the indicators. Significant drinking-water-safety-related differences were found across provinces. Our analyses suggest that, overall, China's recent and rapid socioeconomic development yielded substantial benefits for China's rural drinking water safety. However, this same development also negatively impacted rural drinking water safety via increased groundwater over-abstraction, reductions in water supply, and environmental contamination. The paper closes with a discussion of implications and options for improving drinking water policy, management, and regulation in rural China.

Keywords: water safety; China; water policy; Pressure-State-Response; Canonical Correlation Analysis

1. Introduction

In China, rural drinking water safety (RDWS) can be understood to mean reliable access to a safe, affordable, sufficient, and sustainable drinking water supply. At a global level and in China, RDWS is fundamental to people's health and social development [1,2]. While China's central and provincial governments continue to invest heavily in expanding rural water infrastructure, there remains a substantial water supply infrastructure and management disparity between urban and rural areas, one which continues to negatively impact many of China's rural residents [3,4]. In addition to an overall lack of rural public water supply capacity, other factors also threaten the maintenance and further expansion of RDWS in China, such as water resource shortages, microbiological and other contaminants, economic volatility, climate change impacts, and substandard drinking water treatment and supply management [5–9].

In China, the government evaluates the "safety" of rural drinking water from a number of standpoints: quality, quantity, the level of convenience, and the assurance rates. In this framing, drinking water is safe as long as (1) water quality is compliant with the State's Sanitary Standards for Drinking Water; (2) at least ~40–60 L should be available per person per day; (3) the round trip time for manual water fetching should less than 10 min; and (4) the water supply assurance rate (i.e., the proportion of days with sufficient water supply per year) is higher than 95%.

RDWS has been the focus of numerous research studies in China. Some of this work focused on RDWS monitoring and evaluation and the use of assorted qualitative and quantitative methods at provincial- or county-level scales [10–13]. Other RDWS research often focused on the impacts of water (drinking water especially) on sustainable socioeconomic development goals [14], or water supply, equity, and basic needs (often with a focus on northern areas of China where water resources are particularly scarce) [15]. Water scarcity that is thought to be caused by urbanization has also been examined in the RDWS context, work which spurred recommendations for increased investments in drinking water source protection, use efficiency, and conservation efforts [16,17]. Research-informed RDWS policy recommendations already suggested include developing new technical measures, adjusting current water pricing approaches, and improving water utility management [18–21].

As a result of the disproportionate focus on rural drinking water safety, frequent reliance on insufficient sample sizes, and a general lack of attention to the theoretical underpinnings inherent in RDWS, a number of gaps remain unaddressed. In this paper, we used province-level data and a theoretical framework called Pressure-State-Response (PSR), to explore the impacts of socioeconomic development on RDWS in China. In addition to identifying and quantifying the impacts of socioeconomic factors on rural drinking water safety at a provincial level, we also offer a number of policy proposals which may be used to further improve RDWS in China.

2. Materials and Methods

2.1. Theoretical Framework

The Pressure-State-Response (PSR) framework was first presented by the Organization for Economic Co-operation and Development (OECD) in 1993 [22]. PSR is a framework for use with environmental and sustainable development indicators, and can also be used to reveal relationships between human activities and environmental impacts [23,24]. There are three kinds of indicators in the PSR framework: environmental pressures indicators, environmental condition/state indicators, and societal response indicators.

In this study, the components underlying RDWS were treated as state indicators. Pressure indicators were defined as socioeconomic factors known to impact RDWS based on previous research [25–27]. Response indicators were framed in terms of RDWS-related policies and management methods which would be expected to maintain or improve RDWS [28]. Our PSR framework is outlined in Figure 1.

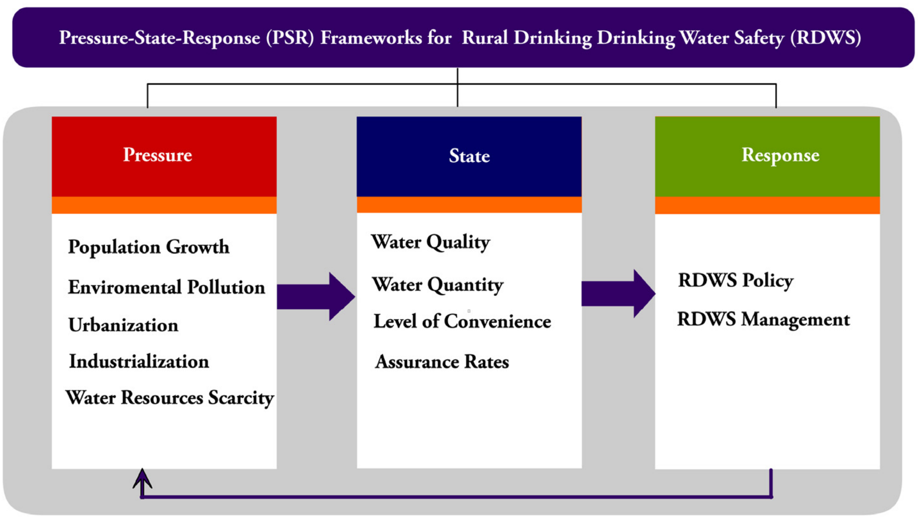

Figure 1. Pressure-State-Response (PSR) Framework for rural drinking water safety (RDWS).

2.2. Indicator Selection and Data Sources

The basic principles for indicator selection were comprehensiveness, accuracy, accessibility and independence, defined as follows: Comprehensiveness means the indicator covers all aspects of the PSR framework; accuracy means the indicator has a widely accepted definition and measurement is reliable; accessibility means the data is relatively easy to obtain; and independence means that the indicators are each unique (i.e., multiple indicators do not measure the same underlying constructs). Based on the national definition of safe rural drinking water, these four selection criteria were used to select four state indicators and twelve pressure indicators, based on 2006 cross-sectional data (2006 data were used because it was the most recent national survey data available at the time of analysis). The names, sources, and definitions of these indicators are listed in Table 1.

Table 1. RDWS related indicators included in the study.

Indicator	Indicator Definition	Data Source/s
State Indicators:		
Rural Popularization Rate of Tap Water (RPRTW)	RPRTW indicates the proportion of the population drinking tap water in rural areas via measuring the number of people in rural areas with access to tap water per 100 residents.	China National Health Yearbook
Total Eligible Rate of Rural Drinking Water Quality (TERRDWQ)	TERRDWQ indicates the proportion of rural drinking water samples in conformity with national drinking water standard in the total tested water samples in 2006 National Rural Drinking Water and Environmental Health Status Survey.	National Rural Drinking Water and Environmental Health Status Survey
Percentage of Households with Difficulty in access to Drinking Water (PHDDW)	PHDDW indicates the proportion of households with difficulty in accessing drinking water in total survey populations in the Second National Agricultural Census in China.	2nd National Agricultural Census in China
Percentage of Towns Covered by Centralized Water Supply (PTCCWS)	PTCCWS indicates the proportion of towns covered by centralized water supply in the total surveyed towns.	2nd National Agricultural Census in China
Pressure Indicators:		
Per-capita Water Resources * (PWR)	PWR was calculated by provincial water resource amount divided by the provincial total population.	China Statistical Yearbook
Total Volume of Water Supply (TVWS)	TVWS means the provincial total water supply in one year.	China Statistical Yearbook
Gross Domestic Product per Capita (GDPPC)	GDPPC is a measure of the total output that takes gross domestic product (GDP) and divides it by the number of people.	China Statistical Yearbook
Rural Per Capita Annual Net Income (RPCANI)	RPCANI is an average of total annual income per capita.	China Statistical Yearbook
Percentage of the Contribution to GDP from Primary and Secondary Industry (PCPSI)	PCPSI is a measure of the total contribution of secondary and tertiary industry divided by the GDP.	China Statistical Yearbook
Urbanization Rate (UR)	UR is defined as the proportion of total population residing in urban areas of the province.	China Statistical Yearbook
Population Density (PD)	PD is a measurement of population per unit area.	China Statistical Yearbook
Rate of Natural Increase (RNI)	RNI is the crude birth rate minus the crude death rate.	China Statistical Yearbook
Water Consumption of 10 thousand RMB GDP (WQ/GDP)	WQ/GDP means the total water consumption for every 10 thousand RMB worth of GDP produced.	China Statistical Yearbook
Water Consumption per Capita (WCPC)	WCPC is measure of the total water consumption divided by the total population.	China Statistical Yearbook
Discharge Standard-meeting Rate of Industrial Wastewater (DSRIW)	DSRIW is defined as the proportion of wastewater discharge amount in the total industrial wastewater discharge.	China Statistical Yearbook
Proportion of Towns with Sewage Treatment (PTST)	PTST is measure of the total town number with sewage treatment divided by the total town number.	China Statistical Yearbook

* **Note:** Water resources are defined as the total amount of groundwater and surface water.

2.3. Data Analysis

2.3.1. Index and Clustering Analysis

The four status indicators, all assessed on a scale of 0–100, are: Rural Popularization Rate of Tap Water (RPRTW), Total Eligible Rate of Rural Drinking Water Quality (TERRDWQ), Percentage of Households with Difficulty in access to Drinking Water (PHDDW), and Percentage of Towns Covered by Centralized Water Supply (PTCCWS). To summarize these four status indicators, a rural drinking water safety index (RDWSI) was calculated by using equal weights (as the four standpoints in rural water safety frameworks are equally important) to aggregate the values of the four indicators to describe the RDWS in province level (Equation (1)).

$$RDWSI = [RPRTW + TERRDWQ + (100 - PHDDW) + PTCCWS] \div 4 \quad (1)$$

A provincial-level comparative analysis was conducted based on these index values. Clustering analysis (using R software) was also used to analyze regional differences between state indicators [29]. Hierarchical clustering was performed using the least similarity coefficient method under Euclidean distance.

2.3.2. Canonical Correlation Analysis (CCA)

Since the state and pressure indicators have multiple dimensions, Canonical Correlation Analysis (CCA) was used to better understand the complex relationships between these various dimensions [30]. CCA helps reveal relationships between multiple dependent variables and multiple independent variables by inferring information from cross-covariance matrices. In this study, we had two vectors: $U = (U_1, ..., U_n)$ for pressure indicators and $V = (V_1, ..., V_m)$ for status indicators. CCA identifies linear combinations of U_i and Y_j which have maximum correlations with each other.

The Canonical Correlation Coefficient (CCC) seeks vectors a and b such that the variables a′U and b′V maximize the correlation. The random variables U and V are the first pair of canonical variables. The correlation coefficient (λ) of U and V was called first CCC. Then, one seeks vectors maximizing the same correlation, subject to the constraint that they are not correlated with the first pair of canonical variables; this yields the second pair of canonical variables and second CCC.

An R package called CCA was used for this analysis [31]. RDWS related indicators were divided into several subgroups according to their representations of socioeconomic factors. Gross Domestic Product per Capita (GDPPC), Rural Per Capita Annual Net Income (RPCANI), and Percentage of the Contribution to GDP from Primary and Secondary Industry (PCPSI) were attributed to the economic factor subgroup; Urbanization Rate (UR), Population Density (PD), and (Rate of Natural Increase) RNI were attributed to subgroup on social development; Per-capita Water Resources (PWR), and Total Volume of Water Supply (TVWS) were classified as water resource indicators; and Water Consumption of ten thousand RMB GDP (WQ/GDP) and Water Consumption per Capita (WCPC) was used for the consumption factors. CCA analysis was used to evaluate the relationship between subgroups of various stress indicators and status indicators. A Barlett chi-square test [32] was used to test the significance of the CCC and the probability values (Table 2).

Table 2. Canonical Correlation Coefficient between RDWS variable sets and pressure indicators sets.

First Set	Second Set	Canonical Correlation Coefficient	Proportion	Probability Value
Economic factor subgroup (GDPPC, RPCANI, and PCPSI)	RDWS	$\lambda_1 = 0.86$ $\lambda_2 = 0.26$ $\lambda_3 = 0.12$	0.938 0.003 0.001	<0.0001 0.996 0.982
Subgroup of social development indicators (UR, PD, and RNI)	RDWS	$\lambda_1 = 0.21$ $\lambda_2 = 0.10$ $\lambda_3 = 0.08$	0.835 0.002 0.001	<0.0001 0.899 0.964
Subgroup of environmental indicators (PTST, DSRIW)	RDWS	$\lambda_1 = 0.89$ $\lambda_2 = 0.56$ $\lambda_3 = 0.27$	0.895 0.003 0.001	<0.0001 0.995 0.920
Water resource indicator subgroup (PWR, TVWS)	RDWS	$\lambda_1 = 0.71$ $\lambda_2 = 0.49$ $\lambda_3 = 0.16$	0.718 0.005 0.001	0.0039 0.996 0.975
Consumption factors subgroup (WQ/GDP, WCPC)	RDWS	$\lambda_1 = 0.88$ $\lambda_2 = 0.56$ $\lambda_3 = 0.12$	0.887 0.006 0.002	<0.0001 0.991 0.898

3. Results

3.1. Provincial-Level RDWS Comparisons

Figure 2 shows the spatial distributions of RDWSI at a provincial scale (Appendix A Table A1 shows the RDWSI results by province). RDWSI values ranged from 34 to 97 (with higher scores indicating relatively better or positive conditions), with Shanghai, Beijing, Jiangsu, Zhejiang, and Guangdong in the province's top 15% in RDWSI scores, while Tibet had the lowest RDWSI value. Provinces with high RDWS levels were mainly distributed in coastal developed areas in China's east. The top five provinces or municipalities in RDWSI scores were also the top five in economic terms, accounting for 28% of China's total GDP per capita in 2006.

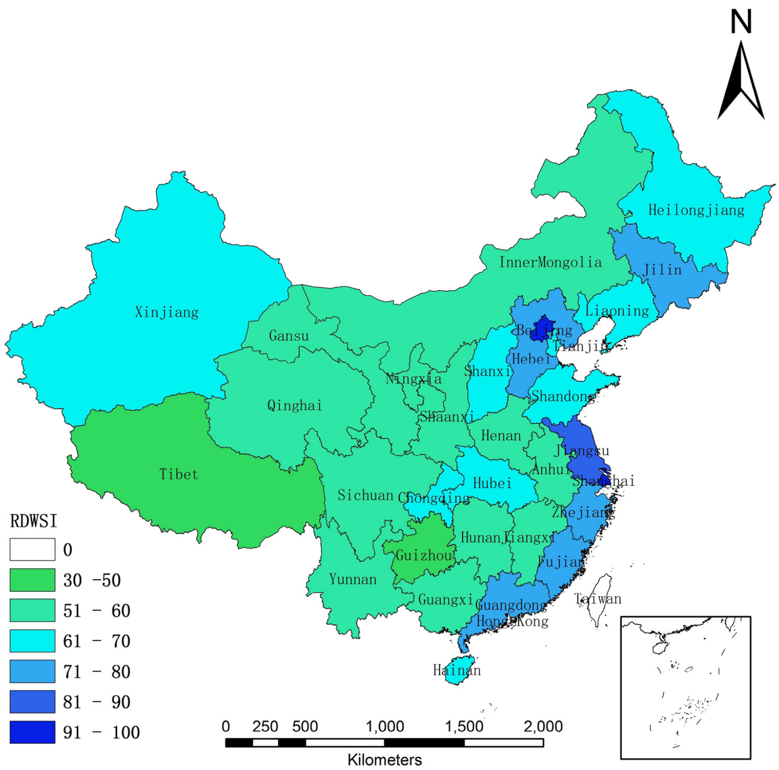

Figure 2. Provincial distribution of RDWSI in 2006.

Cluster analyses were also used for RDWS state indicators including RPRTW, TERRDWQ, PHDDW, and PTCCWS in Table 1. Cluster analysis indicated that there were five groups based on RDWS state indicators. The cut-off threshold of Euclidean distance was set to 55 to help ensure a suitable number of resulting groups. Shanghai, Beijing, and Jiangsu were in the first group, while Tibet and Qinghai were in the last group (Figure 3). The grouping results from the cluster analysis showed that the level of RDWS correlates highly with GDP.

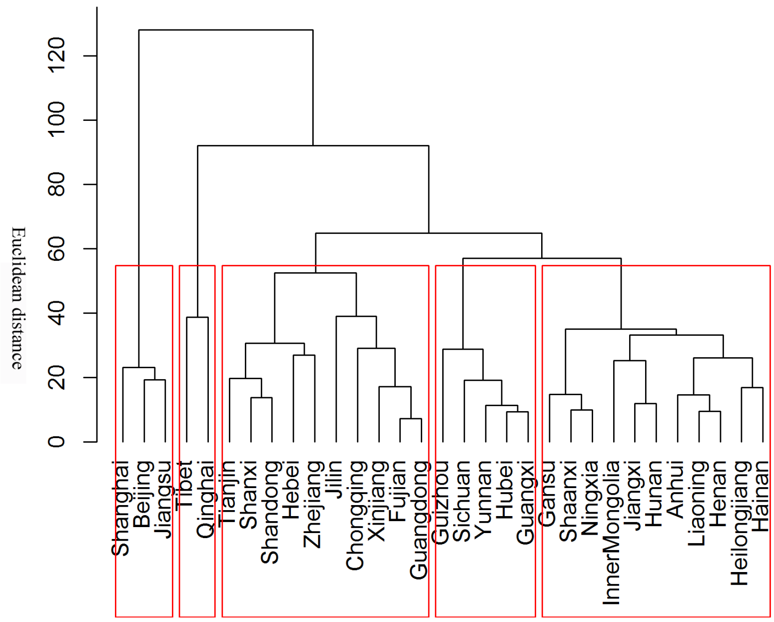

Figure 3. Cluster dendrogram of the four RDWS state indicators.

3.2. Impacts Analysis of Socioeconomic Development on RDWS

CCA results between RDWS indicators and socioeconomic indicators are provided in Table 2. There were three canonical functions for each variable set pair with their canonical correlations. The first, second, and third canonical correlations are provided in Table 3. Associations between the RDWS group and economic, social development, water resources, and consumption factors subgroups were all highly significant ($p < 0.01$). The first canonical correlation coefficients were 0.86, 0.21, 0.89, 0.71, and 0.88, respectively, and they represented 93.8, 83.5, 89.5, 71.8, and 88.7%, respectively, of total correlation between corresponding two variable sets, indicating again that there were significant relationships between these dependent and independent variables.

Formations of canonical variants corresponding to the Canonical Correlation Coefficient between RDWS sets and pressure indicators sets are listed in Table 3. For the first pair of canonical variants with significant correlation between RDWS indicators and economy development indicators, the coefficient for PHDDW (0.75) was highest within economy development indicators, while the coefficients for GDPPC (0.26) and PCPSI (0.25) within the RDWS indicators were high. This result indicates the close correlation of PHDDW with GDPPC and PCPSI, and helps explain the significant correlation between economy development indicators and RDWS indicators.

For the correlation of social development indicators and RDWS indicators, the coefficients for UR (0.52) and RNI (0.40) were high within the social development variable set, while the coefficients for PHDDW (0.70) and PTCCWS (0.33) were high within the RDWS indicators, indicating that the UR RNI subgroup of social development indicators, as well as PHDDW and PTCCWS in the RDWS set, are responsible for the significant correlation between these two variable sets.

For the correlation of environment indicators and RDWS indicators, the coefficients for PTST (0.82) was highest within the environment variable set, while the coefficient for TERRDWQ (0.75) was highest within RDWS indicators, indicating PSTS, in the environment indicators subgroup, and TERRDW in the RDWS set, accounted for the significant correlation between these two variable sets.

For the correlation of water resource indicators and RDWS indicators, the coefficient for PWR (0.82) was highest within the water resource variable set, while coefficient for PTCCWS (0.61) was highest within the RDWS indicators, indicating PWR, in the water resource indicator set, and PTCCWS, in the RDWS set, accounted for the significant correlation between these two variable sets.

Significant correlation was also revealed between water consumption factors and RDWS. The coefficient for WCPC (0.99) was the highest within the water consumption variable subgroup, while the coefficient for TERRDWQ (0.72) was highest within the RDWS indicators, indicating WCPC, in water consumption indicators, and TERRDWQ, in the RDWS set, accounted for the significant correlation between these two variable sets.

Table 3. Formation of canonical variant for significant correlation between RDWS sets and pressure indicators sets.

Groups	Formation of Canonical Variant
Economy factor subgroup and RDWS	$RDWS = 0.34 \times RPRTW + 0.16 \times TERRDWQ$ $-0.75PHDDW + 0.10PTCCWS$ $ECONOMY = 0.26 \times GDPPC + 1.18 \times PRCANI$ $+0.25 \times PCPSI$
Subgroup of social development indicators and RDWS	$RDWS = 0.18 \times RPRTW + 0.06TERRDWQ$ $-0.70PHDDW + 0.33PTCCWS$ $SociaFactor = 0.52 \times UR - 0.26 \times PD$ $-0.40RNI$
Subgroup of environmental indicators and RDWS	$RDWS = 0.1154 \times RPRTW + 0.7540 \times TERRDWQ$ $-0.2509PHDDW + 0.1598PTCCWS$ $ENVIRONMENT = 0.2547 \times DSRIW + 0.8214 \times PTST$
Water resource indicator subgroup and RDWS	$RDWS = 0.2791 \times RPRTW + 0.2892 \times TERRDWQ$ $-0.5385PHDDW + 0.6085PTCCWS$ $RESOURCE = 0.8170 \times PWR - 0.6063 \times TVWS$
Consumption factors subgroup and RDWS	$RDWS = 0.4168 \times RPRTW + 0.7164 \times TERRDWQ$ $-0.5886PHDDW + 0.0013PTCCWS$ $Consume = 1.5303 \times WQ/GDP - 0.9961 \times WCPC$

4. Discussion

4.1. Imbalanced RDWS at the Provincial-Level

When comparing RDWS levels across provinces, a substantial difference was observed between China's eastern and western regions. This difference was reflected in all aspects of RDWS. The eastern provinces scored higher than the western provinces not only for the rural water supply infrastructure but also for drinking water quality. Good water supply infrastructure likely helps to support increased reliability of water supply but also improved quality. As shown in the RDWSI distribution map (Figure 1), economically developed areas were always associated with higher levels of RDWS. This finding suggests that the level of socioeconomic development may be a reliable indicator for, and determinant of, RDWS levels.

4.2. Impacts of Socioeconomic Development on RDWS

- **Economic development and RDWS:** The CCA results indicate that GDPPC and PCPSI have a high level of influence on RDWS. The data suggest that RDWS and economic development have a positive effect on each other. This is reasonable, since investing in rural water improvement can generate direct economic benefit and contribute significantly to increased production and productivity within economic sectors [33]. Related studies suggest that for each one USD invested in water and sanitation, the return on investment is between USD 9.1 to USD 11.2 [34].

Another potential reason for this positive effect is that willingness to pay for water supply tends to increase alongside rising income levels, since the proportion of income required decreases in step [35,36]. Our analyses also suggest that economic growth has a more direct impact on rural drinking water infrastructure compared with PHDDW and PRRTW.

- **Social development and RDWS:** The impact of social development on RDWS appears to be two-sided: Some indicators, such as urbanization, had a positive effect on RDWS, while others, PD and RNI, had a negative effect. On the one hand, urbanization appears to have the effect of improving urban and rural drinking water safety infrastructure, and there is some evidence for the positive association between urbanization and nearby rural drinking water quality [37]. On the other hand, with the development of real estate and housing construction, along with the development of secondary industries, RDWS face enormous pressure from population growth and industrial structure changes.
- **Environment and RDWS:** Our analyses suggest that environmental pollution adversely impacts RDWS. As the model results show, if the pollution load discharged into an environment were to be reduced, the total pressure from environment indicators would decrease, and RDWS would in turn increase. RDWS also faces pressure—both to water quality and availability—from climate change impacts as well as from anthropogenic sources of pollution [38,39].
- **Water resource and RDWS:** Looking to the water resource indicators, we observed two opposite impacts on RDWS: PWR was positive and TVWS was negative. The model results indicate that water resource factors mainly act on PTCCWS, and these effects are positive, supporting the premise that water resource availability impacts water quantity and rates of water use. Overall, China is a water-stressed country, and the uneven distribution of water resources, both spatially and temporally, exacerbate the severity of water scarcity caused by human water consumption [20]. Water resource stress is aggravated further by poor water resource management as well as the increased use which accompanies rapid economic development and urbanization [40]. Due in part to seasonal water shortages, many rural water treatment plants have water provision rates which fall below national and provincial standards [41].
- **Water consumption factors and RDWS:** Water consumption factors also impact RDWS, mostly in a negative direction. The continuous growth of non-agricultural water use combined with ineffective control of wastewater discharges in rural areas contributed negatively to RDWS. With recent industrial restructuring [42], secondary and tertiary industries in rural areas increased, while the proportion of primary industry declined overall; this change, in turn, spurred a surge in increased rural water consumption. The low overall rate of rural wastewater treatment also contributes negatively to water production and water quality.

4.3. Potential Policy Options to Improve RDWS

The objective of using a PSR framework was not only to assess the current situation of rural water safety in China but also to identify key factors affecting RDWS in the hopes of further clarifying appropriate response measures to bolster and safeguard RDWS in the future.

- **For water resource**, having abundant water resources is clearly a helpful factor with regard to rural water supply, but it is not a prerequisite for achieving a high level of RDWS. Southwest China's Yunnan Province, for example, has abundant water resources and yet a very low level of RDWS owing to weak water supply infrastructure and relatively high rates of microbiological contamination in drinking water. Infrastructure and technical capacity building investments for rural water supply should therefore be increased, even in regions with abundant supply. The government should also work to improve the efficiency of water use. In 2015, water productivity in China was USD 15 per cubic meter on average, a level well below that of high-income countries (USD 35.80 per cubic meter) [43]. This gap means China still has a lot of room to improve water resource management and water use efficiency. Reliable water-saving measures and rigorous water pollution control should be pursued in rural China.

- **For economic and social development**, while the government should promote economic growth and guarantee stable financial support for rural water supply infrastructure construction, maintenance, and operation, the government should also revise or create policies to relieve the pressure from the excessive growth and support water saving innovations in industry and agriculture.
- **For water consumption**, insufficient water consumption and unreasonable water pricing are limiting the development of many rural water utilities. To increase water use efficiency, a more open and transparent water price formation mechanism should be established. Urban and Rural Integrated Water Supply (URIWS) in east China, such as in Zhejiang and Jiangsu provinces, improved the level of RDWS greatly [44]. URIWS may be a good option for improving the sustainable development of rural water supply elsewhere in China as well. More broadly, to support the sustainable development of the rural water utilities, especially in poor areas, direct financial support should be given by the governments at all levels to cover parts of utility operation costs.
- **For water pollution**, improved water source protection should be a top priority, and additional regulations should be developed to further this objective. Other measures, such as consolidating water quality monitoring among government agencies, better regulating and controlling point-sources of pollution, and strengthening the wastewater discharge permit system, should also be considered. Leveraging RDWS as a means to fight against water pollution is especially important for provinces in the Huaihe River Basin, such as Anhui, Shandong, and Henan provinces. The level of RDWS in these provinces does not align with their levels of socioeconomic development. Water quality problems (such as nitrate and high chemical oxygen demand) likely due to water pollution may explain this apparent mismatch. China's government has proposed an Action Plan for Prevention and Control of Water Pollution [45], which is an action guide for national efforts against water pollution, and this may prove to be helpful in this regard.

Overall, we suggest that it may be beneficial to establish a Rural Water Safety Guarantee System (RWSGF). Such a RWSGF would consist of the following components: a comprehensive environmental law system to be mobilized for water source protection, drinking water quality management, and water pollution prevention; a strong and comprehensive technical support system for rural water supply construction and management; reasonable market regulation mechanisms to guide water resource development and water price formation; and a comprehensive, multi-agency aligned, water quality management system to cover rural water supply, from source to tap.

4.4. Limitations

CCA was used in this study to describe the relationships between research factors and the target variable group. Although there are complicated mutual interactions in all the study indicators, we did not consider the interactions between all research indicators. For example, social and economic development indicators have some synergistic effects; in addition, they both have an influence on environment and water consumption in the model. A larger sample size, based on county-level data as an example, would be needed if such mutual interactions were to be considered. In addition, the PWS indicator (water resource availability per person by province) would have be more accurate if calculated using data for rural populations and corresponding water resources consumption only; however, such data were not available and so we opted to use combined rural-urban population and water resource data in order to calculate the indicator.

5. Conclusions

Through these analyses, we identified substantial differences in rural drinking water safety (RDWS) between China's eastern, middle, and western regions; disparities were evident not only in rural water supply infrastructure but also in other aspects of RDWS, such as water quality and access. China's rapid socioeconomic development yielded great benefits for China's rural drinking water safety, but byproducts associated with this development, such as water shortages, environmental pollution, and excessive water demand, seriously threaten current and future RDWS in much of the country. Based on our findings, we suggest it may be beneficial to establish a Rural Water Safety Guarantee System (RWSGF). Such a RWSGF would consist of the following components: a comprehensive environmental law system to be mobilized for water source protection, improved drinking water quality management, and water pollution prevention; a strong and comprehensive technical support system for rural water supply construction and management; reasonable market regulation mechanisms to improve water resource distribution and water price formation; and finally, a comprehensive, multi-agency aligned, water quality management system to cover rural water supply, from source to tap.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Rural drinking water safety index (RDWSI) by province in 2006.

Province	RDWSI	Province	RDWSI	Province	RDWSI	Province	RDWSI
Beijing	90.02	Shanghai	97.82	Hubei	60.68	Yunnan	57.08
Tianjin	68.76	Jiangsu	89.99	Hunan	57.34	Tibet	34.68
Hebei	71.06	Zhejiang	79.44	Guangdong	72.78	Shaanxi	53.49
Shanxi	66.62	Anhui	58.44	Guangxi	56.60	Gansu	52.61
Inner Mongolia	53.62	Fujian	71.58	Hainan	63.28	Qinghai	53.51
Liaoning	62.38	Jiangxi	56.19	Chongqing	66.31	Ningxia	54.12
Jilin	70.98	Shandong	69.31	Sichuan	57.95	Xinjiang	67.03
Heilongjiang	67.40	Henan	58.35	Guizhou	49.95	-	-

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