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Research Article

Karst Concerns: Understanding Resident Perceptions on Water Pollution Management in Guizhou, China

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Abstract.

Water pollution is a critical global concern with profound implications for public health and well-being. This study delves into the perspectives of residents and environmental protection department staff in Karst regions of Guizhou Province, China, examining their perceptions of government-led water pollution management. Surveying 384 residents and conducting interviews with 5 environmental protection professionals, the research employs both descriptive and inferential statistical analyses. Findings highlight household and construction/domestic waste as key contributors to water pollution, significantly impacting urban living. The study underscores the necessity for comprehensive government intervention to address pervasive water pollution issues. Notably, diverse demographics exhibit distinct perceptions toward water pollution control, emphasizing the need for tailored awareness campaigns. Recommendations include refining central government strategies, clarifying the roles of local governance entities and the market, and prioritizing targeted environmental education to foster a more effective approach to water pollution prevention and control.

Keywords: Karst regions, water pollution perception, mass participation

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1. Introduction

Water is the source of life, the need of life, the basis of production and ecology. Improving water conservancy, eliminating water disasters, protecting and treating polluted water are fundamental to people's livelihood and social stability. Guo et al. (2019) mentioned that the State Council officially issued the water pollution prevention and control action plan [1], which defined the overall requirements, work objectives and work objectives of water pollution prevention and control [2]. The plan contains 10, 35 and 238 measures for water pollution prevention and control, which provides an action plan and important guidance for the next stage of national water environment management, and an action plan and key approaches for the next stage of national water resources and environment management. Guo (2017) water resources is a basic and strategic resource [3]. However, the comprehensive influence of the growing population and economic activities, the

increasing water pollution and water environment damage, and the changing climate has highlighted the serious vulnerability of water resources. Water resources have become a key factor in the development of many countries, regions or cities, and the related research on water has also become the focus of common concern of scholars at home and abroad. Zhang (2018) the rational development and utilization of water resources in Guizhou plays an important role in promoting the social and economic development of Guizhou [4]. However, due to industrial development and human life and other reasons, some water resources in Guizhou have been polluted. There are many underground karst caves and strong connectivity between the surface and underground. Once the water quality is polluted, it is difficult to controlled. The problems of water pollution have led to the loss of biodiversity in Guizhou and the difficulty of water use for residents and industries, which has hindered the economic development of Guizhou to a certain extent. This research aims to explore resident perception on water pollution prevention and control in karst regions of Guizhou.

2. Literature review

In recent years, Guizhou Province has adhered to the “Three Rivers” master plan, made a thorough fight against water pollution, further consolidated the excellent water ecological environment, and constantly formulated and updated a number of local regulations and local government rules and regulations related to water resources protection [5]. For instant, Zheng (2019) studied the water resources protection legislation in Guizhou Province and put forward some suggestions [6]. It is not only analyzing the current situation of water resources protection legislation in Guizhou but also studies the feasibility of local legislation on water resources protection [7].

Water pollution management encompasses a range of strategies and practices designed to address water pollution by both preventing its occurrence and controlling its effects. The primary goal is to protect water quality and safeguard aquatic ecosystems, human health, and the environment. This management approach typically involves two main aspects: water pollution prevention and water pollution control [8].

Water pollution prevention aims to stop pollutants from entering water bodies in the first place. This approach is considered the most effective and cost-efficient way to manage water pollution. Additionally, Water pollution control involves managing pollutants that have already entered water bodies to mitigate their impact. This approach is necessary because some pollutants may already be present due to historical pollution or the limitations of prevention measures. Effective water pollution management requires a

combination of both prevention and control strategies. By adopting a holistic approach, authorities can work towards maintaining clean and healthy water resources for the benefit of both ecosystems and human populations.

The multi-party cooperative governance model of water pollution prevention and control in China has not yet been formed, and the environmental problems caused by excessive responsibility setting are outstanding, which does not show the legislative concept of ecological balance [9]. Based on the theory of environmental justice, drawing lessons from the national pollutant discharge elimination system in the Clean Water Act of the United States, and combining with the practical case of water pollution control by Coca-Cola Company to solve the environmental injustice problem, this research puts forward the "water harmony" governance model under the legal system of water pollution prevention and control, that is, individuals, enterprises or organizations can offset their own water pollution through wastewater recycling, water saving and emission reduction for a period of time, so as to realize "zero discharge of sewage" and achieve "balance of payments" of sewage discharge [10].

Residents of cities facing acute water pollution problems might harbor heightened concerns and expectations from their local authorities. This could stem from direct experiences of polluted water sources or witnessing the consequences of inadequate pollution management. On the contrary, individuals residing in cities with effective water pollution control measures may exhibit a more positive perception of government involvement. Higher-income areas may demand advanced pollution control technologies, while economically disadvantaged communities may prioritize basic access to clean water [11]. Thus, this research proposed:

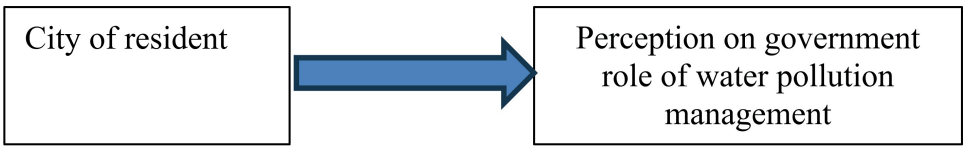

Figure 1: Research hypothesis.

This research tests residents' perceptions and the city's water quality, as data was collected in ordinal manner thus hypothesis should be stated that;

H1: there is a relation between the city of residence and perceptions of government efficiency in water pollution management.

3. Research methodology

This research studies perceptions on regional water pollution management among residents of typical karst regions in Guizhou Province, China. This survey method takes the public as the survey object, and sets relevant questions to understand the public's views on the government's water pollution prevention and control.

3.1. Population, sample size, sampling

According to the distribution of karst regions and water environment in Guizhou Province, the survey samples are from residents in Zunyi, Tongren, Anshun, Bijie, Liupanshui and other places. According to the population statistics of Guizhou in 2022, the total number of people in the five places is about 22.14 million, including about 30% of the elderly and patients under the age of 18 and unable to take care of themselves. Therefore, the total number of survey samples is about 15.5 million. The proportion of men and women in Guizhou is 51.1% / 48.9%. Therefore, the statistical sampling formula is adopted:

The equation presented is a crucial tool in statistical sampling theory, enabling the determination of the necessary sample size (n) for a given population (N) under specific conditions. By substituting specific values into the formula (e.g., n = 15,500,000, z = 1.96, p = 0.511, and e = 0.05), the calculated sample size is approximately 384. This means that, under the specified conditions, a sample size of 384 is sufficient to make statistically valid inferences about the population with a 95% confidence level and a 5% margin of error.

3.2. Research instrument

Survey questionnaire design. The questionnaire on water pollution prevention and control in karst regions in Guizhou Province was distributed to residents in Zunyi, Tongren, Anshun, Bijie, Liupanshui and other cities on www.wjx.cn. Obtain the true and reliable data filled in the survey samples in karst areas, and analyze the different understandings of people of different ages and different educational levels on the responsibility of local governments for water pollution control.

3.3. Data collection

As the survey is targeted at specific areas, the survey samples are from residents in Zunyi, Tongren, Anshun, Bijie, Liupanshui and other places. The questionnaire was distributed online from May 2022 to August 2022 to ensure the authenticity of the questionnaire. The questionnaire was completed anonymously. The questionnaire was collected after the study. A total of 384 questionnaires were received, and 6 invalid questionnaires were eliminated. 378 valid questionnaires were collected. The effective rate of the effective questionnaire was 98.4%.

3.4. Data analysis

The survey data underwent rigorous analysis employing Excel and SPSS software, with coded samples for statistical interpretation. The initial phase focused on profiling respondents by age, gender, residence, and education, encompassing categorical and numerical data. This involved frequency distribution, measures of central tendency, and variability assessments. Subsequently, scrutiny centered on public perception of government water pollution control. Evaluation criteria encompassed satisfaction, policy effectiveness, and overall opinions, involving frequency analysis and measures of central tendency and variability. The third phase employed chi-square tests, probing gender, age, education, and city's impact on public perception. This statistical approach involved organizing data into a contingency table, revealing associations between categorical variables.

4. Research Findings

This section is mainly to make a descriptive analysis of the questionnaire, understand the water pollution prevention and control situation of the government in Guizhou karst regions and analyze the views of the masses.

4.1. Basic information of respondents

Table 1 reveals that among the 378 respondents, 221 were male, accounting for 58.47% of the total number of respondents; 157 women, accounting for 41.53% of the total. It also shows that men are more concerned about water pollution than women.

TABLE 1: Respondent profile.

Variable	Categories	frequency	percentage
Gender	Male	221	58.47%
	Female	157	41.53%
Age	25 and below	65	17.2%
	26-35	136	35.98%
	36-45	109	28.84%
	46 and above	68	17.99%
Residence city	Zunyi	74	19.58%
	Tongren	123	32.54%
	Anshun	74	19.58%
	Bijie	62	16.4%
	Liupanshui	45	11.9%

In terms of age, residents aged 25-55 were the main participants in the questionnaire survey, accounting for 35.98% in 25-35 years old, 28.84% in 35-45 years old, and 14.29% in 45-55 years old. It shows that the post-80s and post-90s have become the main force of the society, and they have shown great concern for the occurrence of various problems and the problems of water environment pollution and people's livelihood.

In the region, the targeted survey was conducted based on the samples of prefecture level cities in typical karst areas, including Zunyi accounting for 19.58%, Tongren accounting for 32.54%, Anshun accounting for 19.58%, Bijie accounting for 16.4%, and Liupanshui accounting for 11.9%. Among them, Tongren is the city with the highest quality of reclaimed water environment in these cities. There may be some reasons for the highest attention.

4.2. Resident perception toward water pollution

1) Perception of resident on water pollution problem in the city

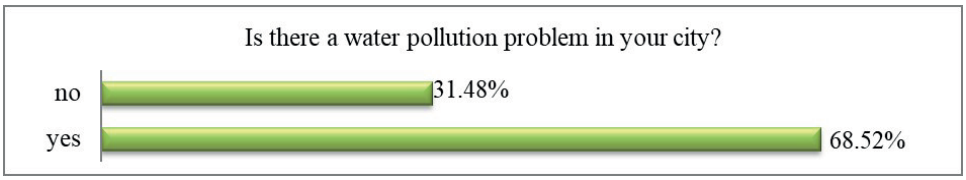

Figure 2: Perception on water pollution.

All 378 respondents, up to 259, believed that the city they lived in had water pollution problems. This also fully illustrates the importance and necessity of water pollution control in karst areas (Figure 2).

2) Perception on the local government attaches importance to water pollution

Table 2: Perception on local government values the degree of water pollution.

subject	category	Do you think the local government attaches importance to water pollution?					total
		make much account of	commonly	importanc	Unclear and uncertain	Neglect	
What is your city?	Liupanshui	6 (13.3%)	12 (26.7%)	20 (44.4%)	4 (8.9%)	3 (6.7%)	45
	Anshun	13 (17.6%)	20 (27%)	28 (37.8%)	7 (9.5%)	6 (8.1%)	74
	Bijie	11 (17.7%)	13 (21%)	19 (30.6%)	7 (11.3%)	12 (19.4%)	62
	Zunyi	19 (25.7%)	15 (20.3%)	33 (44.6%)	3 (4.1%)	4 (5.4%)	74
	Tongren	31 (25.2%)	40 (32.5%)	34 (27.6%)	11 (8.9%)	7 (5.7%)	123
total		80	100	134	32	32	378

The analysis of different city governments' stance on water pollution reveals distinct perspectives. In Zunyi, situated in the Wujiang River Basin, 25.7% believe the local government prioritizes water pollution, attributed to domestic sewage discharge and cage farming causing Wujiang River contamination. Tongren, a vital precious metal production zone, faces challenges in treating mine wastewater. The survey indicates 25.2% recognize the city's commitment to addressing water pollution, aligning with the reality of untreated mine discharge. Both cases underscore the critical need for innovative water treatment solutions, emphasizing the alignment between public perception and the tangible environmental challenges faced by Zunyi and Tongren.

4.3. Resident suggestion on government water pollution management

1) Perception on government organized water pollution prevention and control

The government should strengthen the environmental protection supervision of enterprises, and the way more recognized by the people is to establish a stricter supervision mechanism. The proportion reached 50.53% in the three items (Figure 3). The remaining two items were 26.98% and 22.49% respectively. It shows that the recognition of these two items is relatively low.

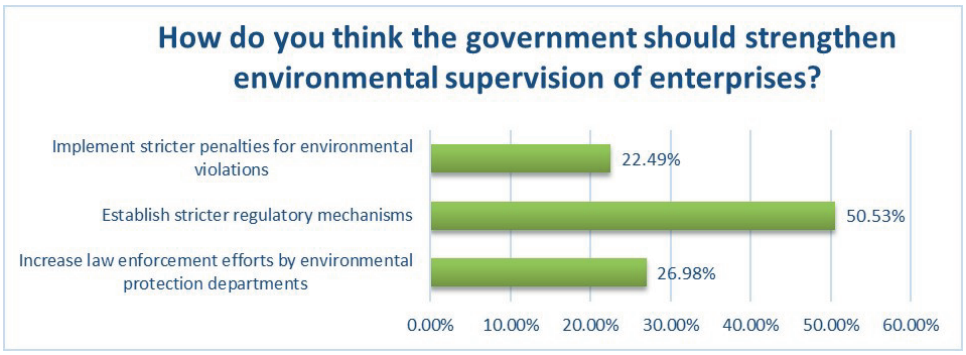

Figure 3: Perception on government organized water pollution prevention and control.

2) Perception on government organized water pollution prevention and control

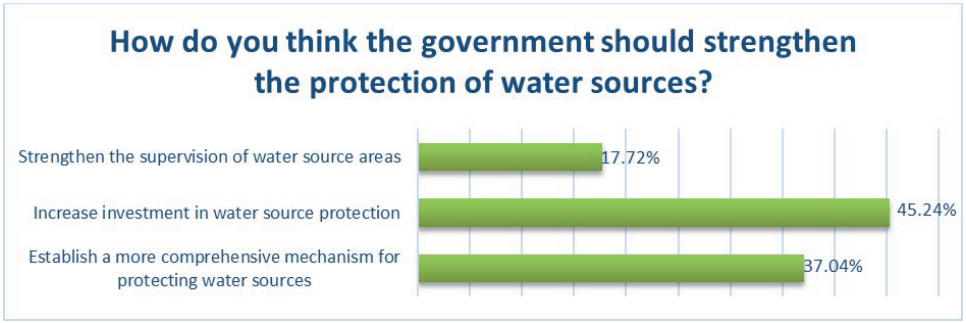

Figure 4: Perception on government organized water pollution prevention and control.

In terms of how the government should strengthen the protection of water sources, people generally believe that the investment in water source protection should be increased, accounting for 45.24%. It shows that the government's investment in this area should be relatively small, so the masses pay more attention to the protection investment in this area. The second is 37.04%, establishing a more perfect water source protection mechanism (Figure 4).

3) Perception on government should strengthen in water pollution prevention and control

In assessing government priorities for water pollution prevention and control, 71.69% of respondents advocate reinforcing water pollution monitoring and supervision, emphasizing the need for robust oversight. Given Guizhou's comparatively modest economy and limited resources, there's reluctance to divert attention from economic aspects to ecological concerns (Figure 5).

4) Perception on important personal approach to water pollution prevention and control

It is generally believed that the most important way for individuals to prevent and control water pollution is not to disturb the waste, accounting for 39.42%, which can

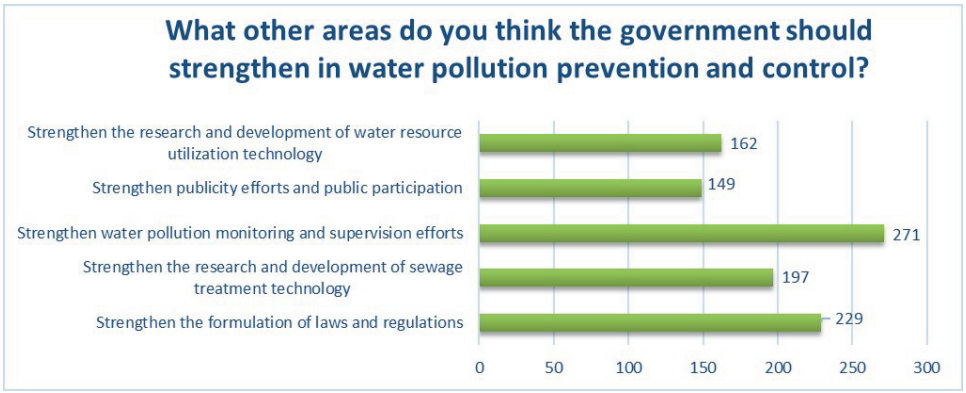

Figure 5: Perception on government should strengthen in water pollution prevention and control.

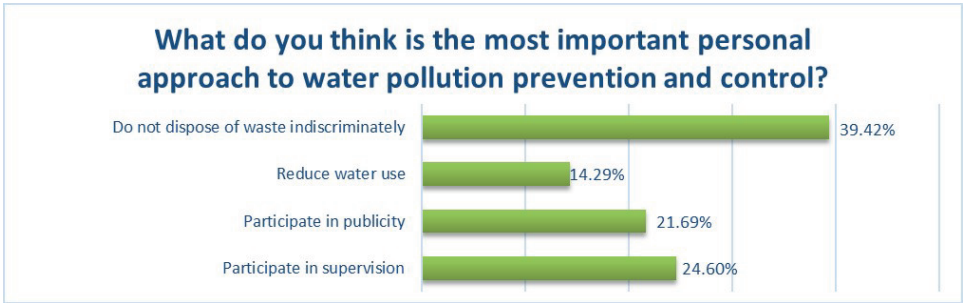

Figure 6: erception on important personal approach to water pollution prevention and control.

be done anytime and anywhere in people's lives, and is fully practical. The minimum requirement is to reduce water consumption, which accounts for 14.29%, indicating that the masses are not willing to accept this practice.

4.4. Comparative expectation of difference resident city on the role of government on water pollution management.

This section uses inferential statistics to compare perception of resident city on the role of government on water pollution management.

Resident in Tongren has a largest proportion that believes their city has a water pollution problem, where Bijie resident has largest proportion that does not agree that believes their city has a water pollution problem, Pearson Chi-Square proved that there is statistically significance among perception of resident city of their resident city on water pollution problem. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on water pollution problem in their city.

Resident in Tongren has a largest proportion that believes Establish Stricter Regulatory Mechanisms., where Liupanshui resident believe that Implement Stricter Penalties

Table 3: Compare perception of resident City on Water Pollution Problem.

		A water pollution problem in your city		Total
		No	Yes	
Resident City	Zunyi	24	50	74
	Tongren	43	80	123
	Anshun	24	50	74
	Bijie	15	47	62
	Liupanshui	13	32	45
Total		119	259	378
Pearson Chi-Square	2.419	P-Value	0.659	

Table 4: Compare perception of resident city on government strengthen environ supervision of enterprises?

		The government should strengthen environ supervision of enterprises?			Total
		Implement Stricter Penalties for Environmental Violations.	Establish Stricter Regulatory Mechanisms.	Increase Law Enforcement Efforts by Environmental Protection Departments.	
Resident City	Zunyi	17	38	19	74
	Tongren	24	60	39	123
	Anshun	21	37	16	74
	Bijie	11	37	14	62
	Liupanshui	12	19	14	45
Total		85	191	102	378
Pearson Chi-Square	6.916	P-Value	0.546		

for Environmental Violations, Pearson Chi-Square proved that there is statistically significance among perception of government should strengthen environ supervision of enterprises. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role to strengthen environ supervision of enterprises.

Resident in Zunyi has a largest proportion that believes government should increase Investment In Water Source Protection, where this city resident agree that government should strengthen the supervision of water source areas, Pearson Chi-Square proved that there is statistically significance among perception of resident city of their resident

Table 5: Compare perception of resident city on government role to protection of water sources?

		The government should strengthen the protection of water sources?			Total
		Strengthen the supervision of water source areas.	Increase investment in water source protection	Establish a more comprehensive mechanism for protecting water sources.	
Resident City	Zunyi	9	30	35	74
	Tongren	14	58	51	123
	Anshun	16	37	21	74
	Bijie	17	26	19	62
	Liupanshui	11	20	14	45
Total		67	171	140	378
Pearson Chi-Square	15.501	P-Value	0.050		

City on Water Pollution Problem. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on strengthen the protection of water sources.

Table 6: Compare perception of resident City on Government Should Strengthen Research and Development In Water Pollution Prevention And Control.

		The government should strengthen research and development in water pollution prevention and control.		Total
		No	Yes	
Resident City	Zunyi	21	53	74
	Tongren	43	80	123
	Anshun	19	55	74
	Bijie	20	42	62
	Liupanshui	16	29	45
Total		119	259	378
Pearson Chi-Square	2.540	P-Value	0.637	

Resident in Anshun has a largest proportion to agree that The Government Should Strengthen Research and Development in Water Pollution Prevention And Control., where Zunyi resident has largest proportion that does not agree so, Pearson Chi-Square proved that there is statistically significance among perception of resident city of their resident City on the statement that Government Should Strengthen Research and Development in Water Pollution Prevention And Control. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of

resident and perception on government role on strengthen research and development in water pollution prevention and control.

Table 7: Compare perception of resident City on Government Should Strengthen Its Effort In Water Pollution Prevention Control.

		The government should strengthen its effort in water pollution prevention control.		Total
		No	Yes	
Resident City	Zunyi	43	31	74
	Tongren	88	35	123
	Anshun	40	34	74
	Bijie	37	25	62
	Liupanshui	30	15	45
Total		238	140	378
Pearson Chi-Square	7.703	P-Value	0.103	

Resident in Tongren has a largest proportion agree that Government Should Strengthen Its Effort in Water Pollution Prevention Control., where Liupanshui resident has largest proportion that does not agree so, Pearson Chi-Square proved that there is statistically significance among perception of resident city that Government Should Strengthen Its Effort in Water Pollution Prevention Control. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on strengthen its effort in water pollution prevention control.

Table 8: Compare perception of resident City on Government Should Strengthen Monitoring in Water Pollution Prevention Control.

		The government should strengthen monitoring in water pollution prevention control.		Total
		No	Yes	
Resident City	Zunyi	19	55	74
	Tongren	37	86	123
	Anshun	22	52	74
	Bijie	20	42	62
	Liupanshui	9	36	45
Total		107	271	378
Pearson Chi-Square	2.524	P-Value	0.640	

Resident in Tongren has a largest proportion to agree that The Government Should Strengthen Monitoring in Water Pollution Prevention Control., where Anshun resident has largest proportion that does not agree so, Pearson Chi-Square proved that there is statistically significance among perception of resident city that Government Should Strengthen Monitoring in Water Pollution Prevention Control.Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on strengthen monitoring in water pollution prevention control.

Table 9: Compare perception of resident City on government should strengthen monitoring in water pollution prevention control.

		The government should strengthen monitoring in water pollution prevention control.		Total
		No	Yes	
Resident City	Zunyi	1	73	74
	Tongren	2	121	123
	Anshun	1	73	74
	Bijie	4	58	62
	Liupanshui	0	45	45
Total		8	370	378
Pearson Chi-Square	7.159	P-Value	0.128	

Resident off cities has agree government should strengthen monitoring in water pollution prevention control, Pearson Chi-Square proved that there is statistically significance among perception of resident city of their perception that government should strengthen monitoring in water pollution prevention control. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on strengthen monitoring in water pollution prevention control.

Resident in Anshun has a largest proportion that believes the government should strengthen monitoring in water pollution prevention control., where Bijie resident barely believed so, Pearson Chi-Square proved that there is statistically significance among perception of resident city on the government role to strengthen monitoring in water pollution prevention control. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on strengthen monitoring in water pollution prevention control.

Table 10: Compare perception of resident City on government should strengthen monitoring in water pollution prevention control.

		The government should strengthen monitoring in water pollution prevention control.		Total
		No	Yes	
Resident City	Zunyi	23	51	74
	Tongren	47	76	123
	Anshun	32	42	74
	Bijie	29	33	62
	Liupanshui	21	24	45
Total		152	226	378
Pearson Chi-Square	4.944	P-Value	0.293	

Table 11: Compare perception of resident City on Local Water Pollution Control Investment.

		aspect of local water pollution control investment.				**Total**
		Equipment investment	**Technical investment**	**Manpower investment**	**Capital investment**	
Resident City	Zunyi	9	10	24	31	74
	Tongren	27	20	40	36	123
	Anshun	13	17	27	17	74
	Bijie	15	8	24	15	62
	Liupanshui	9	12	12	12	45
Total		73	67	127	111	378
Pearson Chi-Square	15.220	P-Value	0.230			

Resident in Bijie has a largest proportion that believes that government should consider aspect of Local Water Pollution Control Investment is Manpower Investment., where Zunyi resident barely believed that government should consider equipment Investment, Pearson Chi-Square proved that there is statistically significance among aspect of local water pollution control investment.Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government role on aspect of local water pollution control investment.

Resident in Tongren has a largest proportion that the government's measures in water pollution prevention and control is very effective., where Anshun resident does not agree that believes that the government's measures in water pollution prevention and control is very ineffective, Pearson Chi-Square proved that there is statistically

Table 12: Compare perception of resident City on Government's Measures in Water Pollution Prevention and Control.

		The government's measures in water pollution prevention and control.				Total
		Not very effective	Invalid	Effective	Very effective	
Resident City	Zunyi	14	10	30	20	74
	Tongren	20	30	37	36	123
	Anshun	17	22	15	20	74
	Bijie	13	15	23	11	62
	Liupanshui	15	11	13	6	45
Total		79	88	118	93	378
Pearson Chi-Square	20.022	P-Value	0.067			

significance among perception of resident city of their resident City on the government's measures in water pollution prevention and control. Hypothesis 1 is rejected, as empirical evidence indicates that no statistically significance difference between city of resident and perception on government's measures in water pollution prevention and control.

5. Conclusion and Recommendation

This research studies perceptions on regional water pollution management among residents of typical karst regions in Guizhou Province, China. This section analyzes the results of the previous section and assumes the impact of development, discusses and summarizes relevant suggestions, in order to better enable the government to serve the people.

The provincial government in this region has played a leading role. From the perspective of specific measures, they mainly include improving river water quality, strengthening the control of Source water protection areas, building sewage treatment plants and pipe networks, strengthening the utilization of reclaimed water and recycled water, controlling industrial pollution sources, controlling agricultural non-point source pollution, strengthening groundwater protection, controlling urban black and odorous water bodies, and strengthening relevant publicity, education and information dissemination. Secondly, the general public is a more important component. The public is the target of government services, and only by effectively understanding their needs and opinions can we better solve problems.

City of resident differences does not play a role in the perception of water pollution prevention control. Legislation based on public participation suggestions can effectively promote the effectiveness of local water pollution control. Due to different environmental factors in different regions, the public is more aware that the local environment can be tailored to local conditions, which can fully mobilize the functions of local governments to improve.

The government should firmly grasp the focus of public participation in water pollution prevention and control, make practical efforts and achieve results, mobilize the enthusiasm, initiative, and creativity of the general public, and promote the construction of an ecological environment community where everyone is responsible, responsible, and enjoyed. The direct embodiment of the principle of ensuring the people's participation in Popular sovereignty is an important means of strengthening supervision. But even under the public led environmental protection system, the government's guidance must be the pioneer of this activity, with the government serving as the channel and the people guiding the water. What the masses can do is to provide some suggestions to help the government make such changes, thereby playing a role in guiding the masses. To ensure that the government can better solve the water pollution problem in Karst Plateau areas according to local conditions.

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