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Effectiveness of the River Chief System in China: A Study Based on Grassroots River Chief's Behavior

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ABSTRACT

The River Chief System is an administrative model of water environment governance currently adopted in China. Under this system, the chief CPC and government leaders at various levels serve as "river chiefs" and are responsible for organizing and directing the management and protection of the rivers and lakes within their remit. This paper tries to reveal the actual effectiveness of the River Chief System based on the behaviors of grassroots river chiefs (GRCs). First-hand data about GRCs is obtained through a questionnaire survey. Whether the water environment governance target is achieved and the water quality change of the river sections in the charge of GRCs is quantitatively assessed It has been found that, except for implementing "one policy for one river" and making river patrols, the behaviors of GRCs have no positive effect on river pollution prevention and control, implying the ineffectiveness of the River Chief System. The framework design of the River Chief System should be optimized, and a system with professionals to support GRCs in performing their duties should be established. Moreover, the tendency to use environmental regulation as a mandatory policy tool should be weakened. These measures are of great practical significance to the implementation of the green development concept and the furthering of the River Chief System overall.

INTRODUCTION

As an innovative administrative model of water environment governance in the face of severe water pollution, the River Chief System in China requires chief CPC and government leaders at various levels to serve as "river chiefs" and be responsible for organizing and directing the management and protection of the rivers and lakes within their remit. Essentially, this system is implemented to enhance the overall coordination, authority and accountability of existing river management systems. Since the issuance of the *Opinions on Full Implementation of the River Chief System* by the General Office of the Communist Party of China (CPC) Central Committee and the General Office of the State Council of China in 2016, the River Chief System has shifted from a "bottom-up" self-exploration to a unified "top-down" will (Shen 2018). Taking into consideration both river/lake distribution and administrative divisions, this system puts the decentralized authority of river management into the hands of CPC and government leaders at various levels. Through a stressful interaction mechanism between leadership and responsibility where all authority is put into one hand and one chief leader is held accountable, it solves the problem of dysfunction caused by overlapping authority between water administration departments to a certain extent.

Grassroots river chiefs (GRCs) are undoubtedly the principal actors in implementing the River Chief System. For example, in Zhejiang Province, it is stipulated that the river chiefs at the county level and above should take the lead in the development of a water environment governance program with one policy for one river and that river chief at town and village levels should be responsible for the daily patrols of the river sections in their charge, with an aim to find and solve problems in a timely manner and assisting the higher-level river chiefs in their work. The term "GRCs' behaviors" refers to GRCs' performance of their daily management responsibilities for the river sections in their charge and their execution of tasks related to overall river pollution prevention and control. As a special form of environmental control, whether the River Chief System is effective in river pollution prevention and control depends directly on GRCs' behaviors. Theoretically, GRC as a single individual is both a public interest realizer and a rational value selector. GRCs' behaviors are a process where a system uses all available information and takes action. Variables such as gender, age, occupation, and personality indirectly influence behavioral intentions through behavioral attitudes and subjective norms (Ajzen & Madden 1986). From the organizational behavior perspective, concerning an individual's psychological state, there are not only positive factors such as realizing public values and performing duties but also negative factors such as hesitation when facing multiple choices, hesitation to perform job responsibilities, and doubts as to mitigating risk pressure (Sheng & Chen 2019). It is the interaction among these positive and negative factors that provides a direct value judgment on GRCs' behaviors. In general, GRCs' behaviors tend to realize a range of outcomes, including social, organizational, and individual values. In objective reality, the realization of social and organizational values is subject to some uncontrollable factors. The realization of social value can be influenced by factors such as economic and social transformation and external organizational development, and the realization of organizational values can be impacted by heavy administrative duties at the grassroots level and the strong accountability required by higher-level governments. As a result, GRCs can directly devote themselves to the realization of individual values. Especially since the implementation of the River Chief System, GRCs, under stressful assessments and inefficient incentives, can easily develop fears of taking responsibility and dare not take action. Instead, they may be eager to achieve goals or accomplish tasks that are easy, with only controllable risk and a smaller level of accountability. The original property of responsibility is ignored consequently. In terms of the external environment, the River Chief System, which runs based on a principle of local management and a mechanism for river chiefs at all levels to be held accountable, actually transfers the main responsibility for river pollution prevention and control and related great pressure to the grassroots in a top-down way. The whole framework of the River Chief System, comprising various rules regarding meetings, patrol, information reporting, work supervision, assessment, accountability, and other aspects, is often overwhelming for GRCs and can easily bring out formalism, reducing the effectiveness of the system objectively. It has been shown that, although the River Chief System has achieved initial outcomes for water pollution control, it has not significantly reduced the pollutants deep in the water, which may reveal a whitewash of local governments addressing the symptoms but not the root cause (Shen & Jin 2018). In terms of internal requirements, river pollution prevention, and control is a complex, systematic project whose principal implementers must have solid professional knowledge, a positive attitude at work, excellent comprehensive abilities, and an open mind. These requirements are unachievable for most GRCs, thus subjectively limiting the effectiveness of the River Chief System.

These facts have been shown in existing studies. Scholars have argued that, although it is possible to improve the results of river pollution prevention and control by strengthening the vertical mechanism (Zhou & Xiong 2017, Xiong 2017), the "last mile" of water environment governance is not always smooth due to the capability and action dilemmas for individuals and agencies implementing policy caused by over-reliance on authority (Gao 2019) and role overload caused by information asymmetry in the principal-agent relationship and dual roles (Wang & Cai 2011, Yan & Wang 2019). As very few quantitative analyses have been conducted on the effectiveness of the River Chief system, there is a need to obtain first-hand data about GRCs through questionnaire surveys and quantitatively assess whether the water environment governance target is achieved and water quality changes in the river sections under the charge of GRCs, thus revealing the actual effectiveness of the River Chief System based on GRCs' behaviors. This paper tries to provide some empirical support and a decision-making basis for structuring the positive incentive mechanism for GRCs' behaviors in the reconstruction of the River Chief System and thereby has great practical significance to the implementation of the green development concept and the furthering of the River Chief System overall.

STUDY DESIGN

Sample Selection

Generally speaking, grassroots river chiefs (GRCs) refer to village- and town-level river chiefs. But as stipulated in many regions, it is county-level river chiefs who are responsible for developing and implementing a water environment governance program with one policy for one river, which is the fundamental basis for the assessment and accountability of river chiefs at the county level and below. Due to this fact, county-level river chiefs are also deemed GRCs in our study. In 2022, we conducted a questionnaire survey to assess the duty performance of GRCs in 2021. The survey participants were 683 GRCs attending the professional training on the River Chief System organized by the College of Zhejiang River Chief at Zhejiang University of Water Resources and Electric Power, which is the first college of river chiefs in China. A total of 683 questionnaires were handed out, and 97.66% of them (667) were collected as valid questionnaires based on information screening and reliability assessment. Among the 667 GRCs, 628 river chiefs were from counties within prefecture-level cities Jinhua, Quzhou, and Wenzhou

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of Zhejiang Province, and the remaining 39 river chiefs were from Kongdong District (County), Pingliang City, Gansu Province. In terms of administrative level, there were 445 village-level river chiefs (66.72%), 136 town-level river chiefs (20.39%), and 86 county-level river chiefs (12.89%).

Variables

Explained Variables

To examine the effectiveness of the River Chief System, two explained variables were set, namely, whether the water environment governance target is met (OV1) and water quality change (OV2). OV1 is a binary variable with only two possible values: 0 (Yes) or 1 (No). Water quality has been divided into six grades: VI (poorest quality), V, IV, III, II and I (best quality). Grades VI, V, IV, III, II and I are assigned a value of 0, 1, 2, 3, 4 and 5, respectively. And OV2 is the water quality difference over time.

Explanatory Variables

Our core explanatory variables are a set of variables describing GRCs' behavioral characteristics. Nine behavioral variables were summarized and identified according to GRCs' duties under the River Chief System: (1) whether one policy for one river is implemented; (2) the annual number of river patrols; (3) whether records of river patrols are kept; (4) the annual number of regular work meetings; (5) communication with the public; (6) whether work training is attended; (7) whether annual tasks are disclosed; (8) whether the annual work plan is accomplished on schedule; and (9) overtime work. These nine variables are generally considered to have an effect on river pollution prevention and control. In other words, if one policy for one river is implemented, records of river patrols are kept, annual tasks are disclosed, the annual work plan is accomplished on schedule and there are more river patrols, regular work meetings, communication with the public and overtime work during a period, the River Chief System is likely to be more effective.

Control Variables

Our control variables are a set of variables describing social characteristics. The control variables are included in the study due to the fact that whether the water environment

Table 1: Definitions of variables.

Variables		Definitions
Whether the water environment governance target is met		No = 0, Yes = 1
Previous water quality		Grade VI (poorest) = 0, Grade V = 1, Grade IV = 2, Grade III = 3, Grade II = 4, Grade I (best) = 5
Current water quality		Grade VI (poorest) = 0, Grade V = 1, Grade IV = 2, Grade III = 3, Grade II = 4, Grade I (best) = 5
Change in water quality		Current water quality - previous water quality
Behavioral Characteristics	Whether one policy for one river is implemented	No = 0, Yes = 1
	Annual number of river patrols	The annual number of river patrols
	Whether records of river patrols are kept	No = 0, Yes = 1
	Annual number of regular work meetings	0 meeting = 1; 1 meeting = 2; 2 meetings = 3; 3 meetings = 4; 4 or more meetings = 5
	Communication with the public	Zero = 1; Little = 2; Frequent = 3; Much = 4; Very much = 5
	Whether work training is attended	No = 0, Yes = 1
	Whether annual tasks are disclosed	No = 0, Yes = 1
	Whether the annual work plan is accomplished on schedule	No = 0, Yes = 1
	Overtime work	Never = 1; Little = 2; Occasional = 3; Frequent = 4; Always = 5
Social characteristics	Whether the public report the problems	No = 0, Yes = 1
	Support for work from the public	None = 1; Little = 2; Some = 3; Much = 4; Very Much = 5
	Number of sewage outfalls	Number of sewage outfalls
	Number of rainwater outfalls	Number of rainwater outfalls
	Number of industrial enterprises in catchment areas	Number of industrial enterprises in catchment areas
	Number of livestock and poultry farms in catchment areas	Number of livestock and poultry farms in catchment areas

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governance target is met and water quality change is affected by some objective conditions such as the status of the public, infrastructure, industry, etc. Generally speaking, if the public can report problems or support water environment governance or if there are many rainwater outfalls, it will be easier to achieve water environment governance targets and improve water quality. On the contrary, if there are many sewage outfalls, industrial enterprises and livestock and poultry farms, the realization of the above-mentioned outcomes will be adversely affected to some extent. Definitions of the variables are shown in Table 1.

Model Setting

Most behaviors of GRCs have a significant positive effect on the achieving of water environment governance targets and water quality improvement, indicating the effectiveness of the River Chief System. Given the qualitative or quantitative characteristics of the explained variables, two regression models, a binary logistic model and an OLS model, were constructed to reveal the real effectiveness of the River Chief System.

The constructed binary logistic regression model is as follows:

$$\log it(T=1)=\alpha_0+\sum_{i=1}^{9}\left(\alpha_{1i}B_i\right)+\sum_{j=1}^{6}\left(\alpha_{2j}S_j\right)+\theta+\varepsilon \quad \ldots(1)$$

And the constructed OLS regression model is as follows:

$$\Delta Q=Q_1-Q_0=\beta_0+\sum_{i=1}^{9}\left(\beta_{1i}B_i\right)+\sum_{j=1}^{6}\left(\beta_{2j}S_j\right)+\eta \quad \ldots(2)$$

Where, T denotes the probability of having met the water environment governance target; ΔQ denotes the change in water quality; Q_0 and Q_1 denote the previous and current water quality respectively; B_i denotes the core explanatory variables, a set of variables describing behavioral characteristics; S_j denotes the control variables, a set of social characteristics variables; α_0, α_{1i}, α_{2j}, β_0, β_{1i} and β_{2j} are the corresponding regression coefficients; θ is county's fixed effect; ε and η represent random errors. A significantly positive α_{1i} or β_{1i} obtained by regression indicates that the corresponding behavior of GRCs can have a positive effect on river pollution prevention and control. Otherwise, the behavior would be a vain attempt at water environment governance.

EMPIRICAL ANALYSIS

Descriptive Statistics

The descriptive statistics for all variables are shown in Table 2. As indicated by the survey, a total of 585 GRCs (87.71%) achieved their water environment governance target. In addition, the mean previous and current water quality were 2.2969 and 3.2264, respectively, resulting in a mean water quality change of 0.9295, which suggests that the implementation of the River Chief System has led to a general improvement in water quality from Grade IV to Grade III.

For the behavioral characteristics of GRCs, 624 GRCs (93.55%) implemented one policy for one river; 602 GRCs (90.25%) made river patrol records; 511 GRCs (76.61%) attended work training; 589 GRCs (88.31%) disclosed their annual work tasks; and 488 GRCs (73.16%) accomplished their annual work plan on schedule. In addition, in the year 2021, GRCs made 3.7901 river patrols and attended 4.1244 work meetings on average. At the same time, the mean value of their communication with the public and overtime work are 3.6387 and 2.8426, respectively. It can be seen that, although GRCs made relatively few river patrols in the year, they performed their duties actively in general.

For social characteristics faced by GRCs, 250 GRCs (37.48%) received problems reported by the public and had public support for their work (3.9415); on average, there were 1.7376 outfalls (SD: 8.1862), 3.8441 rainwater outfalls (SD: 25.5761), and 4.2804 industrial enterprises (SD: 51.6797) and 0.5067 livestock and poultry farms in catchment areas (SD: 5.1209). It can be seen that not many GRCs receive reports on problems from the public, and the public is supportive of their work. As indicated by the geographic origins of questionnaire survey respondents, geographic factors such as the number of sewage outfalls, rainwater outfalls, industrial enterprises and livestock and poultry farms in rain catchment areas vary greatly.

Analysis of the River Chief System's Effectiveness

The regression results based on equations (1) and (2) are presented in Table 3 and Table 4, respectively. Column (1) are the results without including any control variables; column (2) are the results when only control variables related to the public (i.e., two social characteristics: whether there are problems reported by the public and public support for the work) are included; column (3) are the results when only control variables related to infrastructure (i.e., two social characteristics: the number of sewage outfalls and the number of rainwater outfalls) are included; column (4) are the results when only control variables related industries (i.e., two social characteristics: the number of industrial enterprises and the number of livestock and poultry farms in catchment areas) are included; and column (5) are the results when all control variables describing social characteristics are included.

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Table 2: Descriptive statistics for variables.

Variables		Sample size	Max.	Min.	Mean	Standard Variance
Whether the water environment governance target is met		667	1	0	0.8771	0.3286
Previous water quality		667	5	0	2.2969	1.2777
Current water quality		667	5	0	3.2264	1.2098
Change in water quality		667	5	-4	0.9295	0.9426
Behavioral Characteristics	Whether one policy for one river is implemented	667	1	0	0.9355	0.2458
	Annual number of river patrols	667	30	0	3.7901	4.3171
	Whether records of river patrols are kept	667	1	0	0.9025	0.2968
	Annual number of regular work meetings	667	5	1	4.1244	1.2319
	Communication with the public	667	5	1	3.6387	1.1055
	Whether work training is attended	667	1	0	0.7661	0.4236
	Whether annual tasks are disclosed	667	1	0	0.8831	0.3216
	Whether the annual work plan is accomplished on schedule	667	1	0	0.7316	0.4434
	Overtime work	667	5	1	2.8426	0.9745
Social characteristics	Whether the public reports problems	667	1	0	0.3748	0.4844
	Support for work from the public	667	5	1	3.9415	0.9027
	Number of sewage outfalls	667	164	0	1.7376	8.1862
	Number of rainwater outfalls	667	440	0	3.8441	25.5761
	Number of industrial enterprises in catchment areas	667	1224	0	4.2804	51.6797
	Number of livestock and poultry farms in catchment areas	667	125	0	0.5067	5.1209

For results shown in all columns of Table 3, the county is controlled as a fixed effect.

The results of the two regressions demonstrate that, among the behavioral characteristics, two factors, whether one policy for one river is implemented and the annual number of river patrols, have a significant positive effect on the achievement of water environment governance targets and water quality change, which is robust. In column (5) of Table 3, the average marginal effects of whether one policy for one river is implemented and the annual number of river patrols are estimated to be 0.1662 (SE: 0.0381) and 0.0224 (SE: 0.0060), respectively, both significant at 1% level; their odds ratios are 11.7682 (SE: 6.2846) and 1.3949 (SE: 0.1165), respectively, both significant at 1% level. This indicates that the probability of achieving the water environment governance target will increase by 0.1662 units or 0.0224 units for each unit increase in the extent of implementing one policy for one river or the annual number of river patrols, and the odds ratio will increase by 10.7682 units or 0.3949 units accordingly. Whether one policy for one river is implemented has a larger effect on the achieving of the water environment governance target than the annual number of river patrols. Similarly, the regression coefficients in column (5) of Table 4 shows that the effect of whether one policy for one river is implemented on water quality change is greater than that of the annual number of river patrols. It is worth noting that overtime work has a significant negative effect on water quality change, which is robust. This may be due to the fact that the work of river chiefs is usually backlogged and can only be finished during overtime hours and that environmental controls are not effectively implemented during normal working hours, resulting in some illegal pollution emissions not being stopped in time. Consequently, the higher the frequency of overtime work, the more serious the deterioration of water quality. Yan & Wang (2019) also illustrated that workload had a significant negative effect on the policy implementation of GRCs. On the contrary, overtime has no significant effect on whether the water environment governance target is met. In addition, although slightly less robust, the annual number of regular work meetings has a significant positive effect on water quality change. Among control variables describing social characteristics, whether the public reports problems have a significant negative effect on water quality change, probably due to the situation where problems reported by the public cannot be resolved in a timely manner.

To ensure the robustness of the regression results, more analyses were conducted under the following settings: first, the Probit model was used for equation (1) for re-estimation; second, as the river sections in the charge of river chiefs

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Table 3: Binary logistical regression results for the effectiveness of the River Chief System.

Whether the water environment governance target is met	(1) Logit	(2) Logit	(3) Logit	(4) Logit	(5) Logit
Whether one policy for one river is implemented	2.4661*** (0.5098)	2.4464*** (0.4581)	2.4864*** (0.5027)	2.4660*** (0.5087)	2.4654*** (0.4551)
Annual number of river patrols	0.3482*** (0.1181)	0.3339*** (0.1205)	0.3465*** (0.1159)	0.3485*** (0.1181)	0.3328*** (0.1190)
Whether records of river patrols are kept	0.5616 (0.5264)	0.5246 (0.5552)	0.5352 (0.5303)	0.5631 (0.5250)	0.5016 (0.5687)
Annual number of regular work meetings	0.3692 (0.2789)	0.3839 (0.2770)	0.3871 (0.2770)	0.3700 (0.2780)	0.4060 (0.2715)
Communication with the public	0.0226 (0.2134)	0.0047 (0.1514)	0.0229 (0.2170)	0.0214 (0.2133)	-0.0026 (0.1597)
Whether work training is attended	-0.2994 (0.7952)	-0.3430 (0.8212)	-0.2978 (0.7122)	-0.3094 (0.7737)	-0.3434 (0.7339)
Whether annual tasks are disclosed	0.0232 (0.3091)	0.0383 (0.2789)	0.0016 (0.3273)	0.0258 (0.3051)	-0.0054 (0.2826)
Whether the annual work plan is accomplished on schedule	-0.0077 (0.4121)	-0.0772 (0.3901)	0.0158 (0.4041)	-0.0062 (0.4118)	-0.0444 (0.3799)
Overtime work	0.3498 (0.2460)	0.3516 (0.2290)	0.3439 (0.2464)	0.3512 (0.2466)	0.3485 (0.2318)
Whether the public reports problems	—	-0.5331 (0.4074)	—	—	-0.5245 (0.4015)
Support for work from the public	—	0.2108 (0.2411)	—	—	0.2212 (0.2381)
Number of sewage outfalls	—	—	-0.0407* (0.0236)	—	-0.0366 (0.0251)
Number of rainwater outfalls	—	—	0.0317 (0.0254)	—	0.0338 (0.0241)
Number of industrial enterprises in catchment areas	—	—	—	0.0004 (0.0020)	-0.0012 (0.0009)
Number of livestock and poultry farms in catchment areas	—	—	—	-0.0060 (0.0108)	-0.0062 (0.0070)
Constant terms	-3.8108*** (1.0961)	-4.2500*** (0.9180)	-3.8601*** (1.0932)	-3.8097*** (1.0965)	-4.3335*** (0.9291)
The county as a fixed effect	Yes	Yes	Yes	Yes	Yes
Sample size	667	667	667	667	667
Pseudo R^2	0.3330	0.3409	0.3376	0.3331	0.3456
Likelihood	-165.8267	-163.8557	-164.6932	-165.7952	-162.6894
Correctly (%)	91.90	92.65	91.90	91.90	92.35

Note: *, ** and *** indicate significance at 10%, 5%, and 1% levels, respectively; standard errors are in parentheses; "-" is the default item.

at lower administrative levels in the same region may be part of the river sections in the charge of river chiefs at higher administrative levels, 136 town-level river chiefs and 86 county-level river chiefs were excluded from the overall sample, and only the 445 village-level river chiefs were analyzed using equations (1) and (2); and third, given provincial differences, 39 GRCs from Gansu Province were excluded from the overall sample, and only the 628 GRCs from Zhejiang Province were analyzed using equations (1) and (2).

The results of robustness tests are presented in Table 5. It is shown that, among the behavioral characteristics, two factors, whether one policy for one river is implemented and the annual number of river patrols, have a significant positive effect on the achievement of water environment governance targets and water quality change. When only 445 village-level river chiefs or 628 GRCs from Zhejiang Province are included in the overall sample, the regression results show that: the annual number of work meetings has a significant positive effect on the achieving of the water environment

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Table 4: OLS regression results for the effectiveness of the River Chief System.

Change in water quality	(1)	(2)	(3)	(4)	(5)
Whether one policy for one river is implemented	0.6017*** (0.1658)	0.6194*** (0.1716)	0.5544*** (0.1527)	0.5991*** (0.1622)	0.6215*** (0.1686)
Annual number of river patrols	0.0100* (0.0054)	0.0128*** (0.0038)	0.0123** (0.0048)	0.0097* (0.0053)	0.0121*** (0.0039)
Whether records of river patrols are kept	0.1113 (0.1285)	0.1160 (0.1223)	0.1573 (0.1324)	0.1154 (0.1282)	0.1065 (0.1214)
Annual number of regular work meetings	0.0920** (0.0403)	0.0609 (0.0399)	0.0864** (0.0399)	0.0781** (0.0395)	0.0670* (0.0403)
Communication with the public	-0.0292 (0.0355)	-0.0440 (0.0358)	-0.0403 (0.0355)	-0.0403 (0.0353)	-0.0365 (0.0361)
Whether work training is attended	0.0922 (0.1065)	-0.0524 (0.1015)	0.0811 (0.1050)	0.1023 (0.1094)	-0.0445 (0.1062)
Whether annual tasks are disclosed	-0.0081 (0.1245)	0.0276 (0.1142)	0.0131 (0.1295)	0.0349 (0.1229)	0.0308 (0.1153)
Whether the annual work plan is accomplished on schedule	-0.0903 (0.0748)	-0.0470 (0.0766)	-0.0764 (0.0753)	-0.0579 (0.0740)	-0.0655 (0.0765)
Overtime work	-0.0900** (0.0369)	-0.1143*** (0.0362)	-0.0970*** (0.0367)	-0.0894** (0.0369)	-0.1024*** (0.0364)
Whether the public reports problems	—	-0.1354** (0.0668)	—	—	-0.1347** (0.0676)
Support for work from the public	—	0.0805* (0.0455)	—	—	0.0703 (0.0461)
Number of sewage outfalls	—	—	-0.0079 (0.0091)	—	-0.0100 (0.0073)
Number of rainwater outfalls	—	—	0.0011 (0.0019)	—	0.0012 (0.0017)
Number of industrial enterprises in catchment areas	—	—	—	0.0015 (0.0013)	0.0018 (0.0013)
Number of livestock and poultry farms in catchment areas	—	—	—	0.0001 (0.0041)	0.0006 (0.0056)
Constant terms	0.2050 (0.1999)	0.2313 (0.2153)	0.2696 (0.1869)	0.2334 (0.1913)	0.2003 (0.2175)
Sample size	667	667	667	667	667
Adj R^2	0.5699	0.6239	0.5738	0.5692	0.6175
F statistic	89.37***	93.20***	75.83***	74.43***	68.31***

Note: *, ** and *** indicate significance at 10%, 5%, and 1% levels, respectively; standard errors are in parentheses; "-" is the default item

governance target in columns (2) and (3), and has a significant positive effect on water quality change in column (5); disclosure of annual work tasks has a significant positive effect on water quality change in column (4); and overtime work has a significant negative effect on water quality change in columns (4) and (5). There are two points worth noting. First, attendance in work training has a significant negative effect on the achieving of governance targets in columns (2) and (3), and has a significant negative effect on change in water quality in columns (4) and (5). A possible explanation is that the content of the training received by the river chief provides wrong guidance on work to some extent. As a result, the attendance of village-level river chiefs or GRCs from Zhejiang Province in work training leads to water quality deterioration and more difficulty in achieving water environment governance targets. Second, whether the annual work plan is accomplished on schedule has a significant negative effect on the achieving of the governance target in column (3), and has a significant negative effect on water quality change in column (4). A possible explanation is that the setting of annual tasks does not give full consideration to contingent factors. As a result, the accomplishment of annual tasks on schedule makes it harder for GRCs from Zhejiang Province to achieve the water environment governance target

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Table 5: Robustness test results.

Whether the water environment governance target is met	(1) Probit	(2) Logit	(3) Logit	Change in water quality	(4) OLS	(5) OLS
Whether one policy for one river is implemented	1.4904*** (0.2736)	2.9539*** (0.5606)	3.0266*** (0.5021)	Whether one policy for one river is implemented	0.7570*** (0.2188)	0.7616*** (0.1709)
Annual number of river patrols	0.1565*** (0.0507)	0.3515*** (0.0845)	0.4003*** (0.0999)	Annual number of river patrols	0.0215*** (0.0037)	0.0141*** (0.0043)
Whether records of river patrols are kept	0.2796 (0.3035)	-0.4960 (0.6978)	-0.3287 (0.5167)	Whether records of river patrols are kept	-0.0598 (0.1632)	-0.1400 (0.1237)
Annual number of regular work meetings	0.2098 (0.1389)	0.6675** (0.2737)	0.6833*** (0.2210)	Annual number of regular work meetings	0.0503 (0.0503)	0.1141*** (0.0405)
Communication with the public	0.0101 (0.0774)	0.1601 (0.1497)	0.1173 (0.1978)	Communication with the public	-0.0457 (0.0394)	-0.0418 (0.0371)
Whether work training is attended	-0.1538 (0.3816)	-1.3638** (0.5878)	-1.3900*** (0.5198)	Whether work training is attended	-0.7592*** (0.1164)	-0.2032** (0.0976)
Whether annual tasks are disclosed	-0.0206 (0.1608)	-0.4195 (0.3738)	-0.1668 (0.2411)	Whether annual tasks are disclosed	0.3842** (0.1543)	0.1513 (0.1161)
Whether the annual work plan is accomplished on schedule	-0.0423 (0.1966)	-0.3472 (0.3855)	-0.5845* (0.3281)	Whether the annual work plan is accomplished on schedule	-0.2479** (0.1024)	-0.1055 (0.0745)
Overtime work	0.1662 (0.1137)	0.1811 (0.1965)	0.1288 (0.2537)	Overtime work	-0.2300*** (0.0385)	-0.1294*** (0.0364)
Control variables	Yes	Yes	Yes	Control variables	Yes	Yes
Constant terms	-2.3374*** (0.5317)	-3.8665** (1.7633)	-4.0704*** (1.0339)	Constant terms	0.9519*** (0.2746)	0.2656 (0.1967)
County as a fixed effect	Yes	Yes	Yes	Sample size	445	628
Sample size	667	445	628	Adj R^2	0.8801	0.6266
Pseudo R^2	0.3408	0.3576	0.4394	F statistic	205.14***	66.86***
Likelihood	-163.8849	-95.0371	-113.4661			
Correctly (%)	91.60	93.93	94.90			

Note: *, ** and *** indicate significance at 10%, 5%, and 1% levels, respectively; standard errors are in parentheses; "-" is the default item

and causes water quality deterioration at the village level. Overall, GRCs' behaviors have no positive effect on river pollution prevention and control, and the River Chief System is not as effective as it should be.

CONCLUSIONS AND POLICY IMPLICATIONS

Except for implementing "one policy for one river" and the annual number of river patrols, the behaviors of grassroots river chiefs (GRCs) have no positive effect on river pollution prevention and control, implying the ineffectiveness of the River Chief System. Therefore, it is imperative to re-construct the River Chief System. Combining the questionnaire survey and interview results, we believe that the most pressing priority in re-construction is to structure a positive incentive mechanism for the behaviors of GRCs. The specific measures are as follows. First, the framework design of the River Chief System should be optimized. On the basis of continuing to strengthen the implementation of one policy for one river and formalize the patrol system, the government should simplify the rules regarding the meeting, information reporting, and work supervision, and establish a reasonable and effective reward and punishment system based on the achieving of water environment governance targets and water quality improvement for the river sections in the charge of river chiefs. In particular, there should be a focus on enhancing the guidance on and delivery of benefits to mobilize the enthusiasm of GRCs to perform their duties and induce the endogenous driving force for river pollution prevention and control. For example, the government can link the work performance of river chiefs with salary and promotion; elect "excellent river chiefs" according to the assessment results and set up special funds to reward them; and improve the financial system to reimburse or subsidize expenses related to the work of river chiefs. Second, a system with professionals to support GRCs in performing their

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duties should be established. Technicians can be recruited by long-term recruitment from the market or temporary transfer from functional departments to enrich the talent pool for GRCs, make up for GRCs' lack of professional capabilities and effectively improve their efficiency in performing duties. Third, the tendency of environmental regulation as a mandatory policy tool should be weakened. Environmental taxes and subsidies and emissions trading can be introduced to optimize the structure of policy tools. And non-governmental forces such as enterprises, the public, NGOs and the media can be absorbed in river pollution prevention and control to effectively alleviate the risk and pressure brought by the "responsibility contracting system" to GRCs.

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