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Do National Ecological Civilization Pilot Zones improve public environmental satisfaction? Evidence from China

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Existing studies on the effectiveness of the National Ecological Civilization Pilot Zones (NECPZs) have largely concentrated on objective outcomes such as green innovation and ecological efficiency, while paying limited attention to public environmental satisfaction, which represents a critical subjective indicator of governance performance. This study draws on multi-year data from the Chinese Social Survey and employs a staggered difference-in-differences model to systematically assess the impact of NECPZs on public environmental satisfaction in pilot provinces and to uncover the underlying mechanisms. The results show that the implementation of NECPZs significantly enhances public environmental satisfaction. This effect operates primarily through two channels: improving air quality and fostering public participation in environmental governance. Moreover, the heterogeneity analysis indicates that the positive effect of NECPZs on public environmental satisfaction is more pronounced among individuals who use the internet more frequently, likely because they are better able to access environmental information and perceive policy improvements. In contrast to previous studies that highlight the amplifying effect of Internet-based media on public environmental dissatisfaction, this study demonstrates its positive effect on public environmental satisfaction. This study offers practical implications for policymakers, highlighting that greater transparency, stronger information disclosure, and broader citizen participation are crucial for enhancing public environmental satisfaction and ensuring the long-term legitimacy and sustainability of ecological policies.

KEYWORDS

National Ecological Civilization Pilot Zones, public environmental satisfaction, internet use, air quality, public participation

1 Introduction

With rapid economic growth and accelerated industrialization, China has faced increasing pressure on resources and the environment, as problems such as air pollution, water contamination, and land degradation have continued to deteriorate, posing severe challenges to the sustainable development of the economy and society (Liu and Diamond, 2005; Zhang and Wen, 2008; Song et al., 2017). Against this backdrop, the central government has progressively elevated ecological civilization to a strategic priority within the national development agenda, emphasizing the integrated advancement of economic, social, and environmental objectives. Since the 18th National

Congress of the Communist Party of China, ecological civilization has been incorporated into the national "Five-in-One" overall framework, marking the first time that environmental governance has risen to the level of a national development strategy and demonstrating new features of top-level design and coordinated promotion.

To advance this strategy through institutional arrangements, the National Ecological Civilization Pilot Zones (NECPZs) policy was subsequently introduced. Its core objective is to explore resource-conserving and environmentally friendly development pathways through institutional design, and to construct an ecological governance framework that can be replicated and scaled up nationwide, thereby reconciling economic growth with environmental protection (State Council of PRC, 2016a). In 2015, building upon the accumulated experience of local ecological civilization practices, the central government officially proposed the establishment of unified national pilot zones for ecological civilization, aiming to integrate fragmented local initiatives and strengthen institutional development. By December 2024, China had designated four NECPZs in batches. This policy not only represents China's institutional practice in implementing the 2030 Agenda for Sustainable Development, but also reflects the country's proactive efforts, as a major emerging economy, to contribute a "Chinese approach" to global sustainable development governance.

As the ecological civilization agenda has advanced, existing studies have primarily evaluated the effectiveness of the National Ecological Civilization Pilot Zones (NECPZs) through objective performance dimensions such as carbon reduction, green innovation, and ecological efficiency (Lee and Nie, 2023; Liu et al., 2023; Chai et al., 2024). However, much less attention has been paid to citizens' subjective perceptions. Prior research indicates that such perceptions are not only shaped by objective environmental conditions but also feed back into governmental incentives and policy choices, thereby shaping governance practices (Shen and Saijo, 2008; Zheng et al., 2014; Yuan et al., 2023). Failing to consider this dimension may lead to an incomplete evaluation of policy effectiveness, especially regarding how the NECPZs cultivate public support and enhance policy legitimacy.

Public satisfaction serves as a key indicator of citizens' subjective perceptions, reflecting both government performance and policy effectiveness (Bouckaert and Van de Walle, 2003; Kampen et al., 2006). Beyond evaluation, it underpins political trust, a cornerstone of regime legitimacy. To sustain this legitimacy, authoritarian governments such as those in Vietnam, Jordan, and China have increasingly institutionalized mechanisms for collecting and responding to citizen feedback (Robinson, 1998; Malesky and Schuler, 2010; Truex, 2017).

This study therefore examines whether the NECPZs have improved public environmental satisfaction, understood as individuals' subjective evaluation of surrounding environmental quality. Using data from the Chinese Social Survey (CSS) and a staggered difference-in-differences (DID) design, we provide the first causal evidence on the policy's impact from the perspective of public perception, thereby supplementing existing assessments that focus only on objective outcomes.

The remainder of this paper is structured as follows. Section 2 reviews and critically assesses the existing literature on the National Ecological Civilization Pilot Zones and public environmental satisfaction. Section 3 develops the research hypotheses. Section 4 outlines the data and empirical methodology. Section 5 reports the empirical results. Section 6 presents the conclusions and policy implications of the study, summarizing the main findings, theoretical contributions, and practical insights.

2 Literature review

2.1 Factors influencing public environmental satisfaction

Although citizen satisfaction with public services has been widely examined, studies focusing specifically on public environmental satisfaction remain limited. As a crucial dimension of governance performance, public environmental satisfaction is shaped by many of the same determinants that influence overall satisfaction.

First, the quality and performance of public services play a significant role in shaping citizen satisfaction (Swindell and Kelly, 2000). Service quality is typically assessed by the extent to which service objectives are fulfilled, shaping citizens' perceptions and evaluations of government performance (Charbonneau and Van Ryzin, 2012; Favero and Meier, 2013). Nevertheless, some scholars challenge this assumption, arguing that service quality may not significantly correlate with satisfaction (Stipak, 1979).

Second, citizen expectations are widely regarded as a key determinant of satisfaction (Van Ryzin, 2004). According to the expectation-disconfirmation model, individuals assess public services not only based on their actual experiences but also by comparing those experiences with their pre-existing expectations (Van Ryzin, 2004; 2013; Zhang et al., 2022). When service performance surpasses expectations (positive disconfirmation), satisfaction tends to rise; conversely, when performance falls short (negative disconfirmation), satisfaction typically declines (Van Ryzin, 2013; Chen et al., 2022). Empirical support for this model has been found across a range of national and regional contexts (Grimmelikhuijsen and Porumbescu, 2017; Noda, 2019; Chen et al., 2022). Building on this framework, Favero and Kim (2021) distinguish between normative expectations and predictive expectations, showing that the former negatively correlates with satisfaction, whereas the latter exhibits only a weak statistical relationship.

Third, citizen satisfaction is also shaped by media. Prior studies demonstrate that media plays a pivotal role in shaping perceptions of governance outcomes (Pan et al., 2022). State-controlled media not only enhances satisfaction with government performance (Stockmann and Gallagher, 2011), but also mitigates the negative influence of informal or "grapevine" news (Zhu et al., 2013). By contrast, media independent of government control, or not sourcing content from official channels, tends to exert a negative impact on citizen satisfaction (Zhang and Guo, 2021). With the rising political salience of social media, however, scholarly consensus remains elusive. Some scholars contend that social media strengthens satisfaction by fostering government–citizen communication and engagement (Al-Omoush et al., 2023), whereas others argue that its absence of traditional filtering mechanisms may amplify negative

information and erode satisfaction (Hu et al., 2019). Overall, these findings indicate that both the type of media and the nature of the information disseminated are critical in shaping public perceptions of government performance.

Finally, both public participation and government responsiveness play important roles in shaping citizen satisfaction. Li et al. (2023) show that involvement in co-production activities such as waste sorting and environmental advocacy improves satisfaction with local environmental services, although it has no significant effect on perceptions of services provided by the central government. Nie and Wang (2023) further examine the impact of response types, finding that action-oriented responses (those aimed at solving problems) and explanatory responses (those providing policy clarification) positively influence satisfaction, whereas referral responses (those that redirect issues to other agencies) are negatively associated with public evaluations.

Taken together, these studies suggest that service quality, citizen expectations, media, public participation, and the nature of governmental response all significantly shape how citizens evaluate public service delivery. These insights offer a theoretical foundation for analyzing how the establishment of NECPZs may affect public environmental satisfaction in China.

2.2 Literature on the evaluation of NECPZs and comparative international perspectives

Although a growing body of literature has examined the performance of ecological civilization pilot policies, the focus has primarily remained on objective, quantifiable indicators related to environmental and economic outcomes. Existing studies on the NECPZs commonly adopt quasi-experimental methods, including Difference-in-Differences (DID), Propensity Score Matching-DID (PSM-DID), and the Synthetic Control Method (SCM), to identify their causal effects on eco-efficiency, green innovation, and total factor productivity. For instance, Chai et al. (2024) show that NECPZs significantly enhance regional eco-efficiency through mechanisms such as stricter environmental enforcement and the promotion of green innovation. Similarly, Lee and Nie (2023) report a notable increase in green patent applications, particularly in less-developed cities. Zhang et al. (2025) further demonstrate that the policy reduces city-level carbon emission intensity and facilitates industrial structure upgrading. By contrast, Fan et al. (2021) find that the Water Ecological Civilization Pilot policy exerted a short-term suppressing effect on green productivity, highlighting potential trade-offs in policy implementation. While these studies deepen our understanding of the ecological and economic effects of NECPZs, they rarely engage with the broader societal dimensions emphasized in international research.

Internationally, research on major environmental governance policies, such as the European Union Emissions Trading System (EU ETS) and the U.S. Clean Air Act, has examined not only ecological and economic outcomes (Aldy et al., 2022; Basaglia et al., 2024), but also public perceptions, social acceptance, and policy legitimacy (Gawel et al., 2014; Wei et al., 2021; Johansson and Derelius, 2022). At the urban and community level, European eco-city and sustainable community initiatives offer additional insights. Stockholm's Hammarby Sjöstad, through its integrated "urban metabolism" system linking energy, water, and waste flows, has substantially reduced environmental burdens while enhancing residents' environmental awareness (Joss, 2011; Pandis Iverot and Brandt, 2011). Freiburg's Vauban district, in turn, illustrates how citizen participation is crucial for ensuring policy legitimacy and long-term sustainability (Scheurer and Newman, 2009). Collectively, these studies suggest that the effectiveness of environmental governance depends not only on quantifiable ecological and economic performance but also on broad societal recognition and acceptance. By contrast, scholarship on China's NECPZs has remained predominantly oriented toward ecological and economic outcomes, with relatively little attention to social dimensions. However, public environmental satisfaction serves both as a crucial feedback mechanism for government performance and as a key indicator of social acceptance and policy legitimacy, making it indispensable for assessing the effectiveness and long-term sustainability of NECPZs as institutional experiments.

3 Theoretical analysis and hypothesis

The establishment of NECPZs is a key initiative in China's ecological civilization reform, aimed at exploring green development paths and continuously improving ecological and environmental quality. Although the policy does not explicitly target public environmental satisfaction, the public's perception of environmental changes and their subjective evaluation have become crucial indicators of governance effectiveness in the process of ecological improvements (Bouckaert and Van de Walle, 2003). Based on this, the paper examines whether the construction of NECPZs influences public satisfaction with environmental governance by improving air quality perceptions and enhancing information dissemination. Drawing on existing research, two key aspects are analyzed: first, the direct perception of air quality changes may affect public satisfaction; second, media dissemination may influence public recognition of governance effectiveness, thereby shaping their satisfaction.

3.1 Air quality and public environmental satisfaction

Among various environmental issues, air pollution is the most likely to attract public attention due to its visibility and perceptibility (Peng et al., 2019). Air quality directly impacts daily life, and the public can easily perceive its improvement or deterioration through visual, olfactory, and other senses (Ajmani et al., 2016). These perceptual experiences not only influence public evaluations of government performance but also directly contribute to individuals' overall environmental satisfaction (Li et al., 2020; Zhu et al., 2023). Previous studies have shown that the air quality in one's place of residence is a key determinant of public environmental satisfaction (Zhang et al., 2020b).

Beyond such perceptual mechanisms, a substantial body of empirical research has reinforced the critical role of air quality in shaping subjective wellbeing and evaluations of environmental governance. Cross-national studies consistently demonstrate that

improvements in ambient air quality significantly enhance life satisfaction and individual happiness (Welsch, 2006; Luechinger, 2009). Evidence from China further reveals that deteriorating air conditions undermine residents' mental health, lower happiness, and increase their willingness to pay for environmental improvements (Zhang et al., 2017a; Zhang et al., 2017b; Zheng et al., 2019). Collectively, these findings corroborate the close linkage between air quality and public satisfaction, underscoring that air quality constitutes a salient channel through which environmental policies shape public perceptions of governance outcomes.

Against this background, improving air quality has been explicitly identified as a central policy objective in the provincial "Implementation Plans" of the NECPZs. For example, Fujian aims for over 90% of days with good air quality in 23 cities by 2020 (State Council of PRC, 2016b); Jiangxi targets a 92.8% proportion of good air quality days in cities at the county level and above (State Council of PRC, 2017b); and Guizhou stipulates that all prefecture-level cities meet the second-level air quality standard, with county-level cities maintaining over 95% of good air quality days (State Council of PRC, 2017a). To achieve these ambitious goals, pilot provinces adopted stricter environmental regulations and intensified pollution-control measures. Given these explicit commitments, it is reasonable to expect that the implementation of the NECPZs enhances public environmental satisfaction primarily through improvements in air quality.

H1: The establishment of the NECPZs enhances public environmental satisfaction in pilot provinces.

3.2 Internet usage and public environmental satisfaction

Public evaluations of environmental governance are shaped not only by direct perceptions of environmental quality but also by the broader influence of media communication (Hansen, 2011). Yet, the moderating role of internet and media usage in this process remains debated. On the one hand, some studies contend that greater internet penetration increases citizens' exposure to negative information about pollution, thereby amplifying dissatisfaction with environmental governance (Zhang et al., 2019; Tang et al., 2021). On the other hand, other research indicates that online platforms can function as channels for enhancing policy transparency and strengthening government–citizen communication (Tolbert and McNeal, 2003; Bertot et al., 2010), which in turn improves public environmental satisfaction (Nie and Wang, 2023). Moreover, government-controlled media may help counterbalance the influence of negative information on public attitudes (Zhu et al., 2013; Pan et al., 2022), thereby improving overall environmental satisfaction.

In the context of the NECPZs, provincial governments have actively emphasized ecological communication and information disclosure, such as holding regular press conferences, operating official new media accounts, and organizing outreach activities. These initiatives enable individuals who use the internet more frequently to access information about environmental governance achievements more easily, thereby fostering more favorable perceptions of policy outcomes (Fan, 2024). Moreover, high-frequency internet users are not only recipients of environmental information but also active participants in the policy process. They are more likely to engage in online policy discussions, provide feedback, or join government-initiated environmental campaigns (Sun et al., 2025b), and prior research suggests that public participation generally enhances environmental satisfaction (Li et al., 2023). Building on this reasoning, the following hypothesis 2 is proposed.

H2: The positive impact of NECPZ establishment on public environmental satisfaction is more pronounced among individuals who frequently use the internet.

4 Research design

4.1 Data source

The measures of public environmental satisfaction and individual characteristics are derived from the Chinese Social Survey (CSS), a nationally representative household survey administered by the Institute of Sociology, Chinese Academy of Social Sciences. The CSS employs probability sampling and face-to-face interviews across all 31 provinces, autonomous regions, and municipalities in mainland China, with each wave covering approximately 7,000–10,000 households. The survey data are preserved and made accessible through the Chinese Social Quality Data Archive (http://csqr.cass.cn/), from which the dataset used in this study was downloaded. The CSS data have been widely adopted in empirical research (Ren and Zou, 2019; Huang, 2025). This study utilizes four cross-sectional waves (2013, 2017, 2019, and 2021), excluding the 2015 wave due to missing key regional identifiers. After listwise deletion of observations with missing values on relevant variables, the final analytical sample comprises 2,842 respondents.

4.2 Variable definitions

4.2.1 Dependent variable: public environmental satisfaction

The dependent variable, public environmental satisfaction, is derived from the following item in the CSS questionnaire:

> "On a scale from 1 to 10, how satisfied are you with the environmental conditions in your place of residence? 1 means very dissatisfied, and 10 means very satisfied."

Respondents rate their satisfaction based on their personal perceptions. This type of subjective evaluation is widely used in the existing literature (Li et al., 2020; Tang et al., 2020).

4.2.2 Independent variable: National Ecological Civilization Pilot Zones

The key independent variable is a binary indicator identifying whether a province participates in the NECPZs program. Provinces selected for NECPZs designation were chosen based on strong ecological foundations and high environmental carrying capacity,

TABLE 1 Variable definitions and descriptive statistics.

Variable name	Definition	Mean	Std. Dev	Min	Max
Satis	Public environmental satisfaction (1 = very dissatisfied, 10 = very satisfied)	6.819	2.347	1.000	10.000
NECPZ	NECPZ treatment dummy (1 from the year after NECPZ designation, 0 otherwise)	0.309	0.462	0.000	1.000
Gender	Gender dummy (1 = male, 0 = female)	0.494	0.500	0.000	1.000
Party	Chinese Communist Party membership (1 = member, 0 = non-member)	0.090	0.287	0.000	1.000
Edu	Educational attainment (1 = no education, 2 = primary, 3 = junior high, 4 = high school, 5 = college or above)	2.777	1.193	1.000	5.000
Marriage	Marital status (1 = married, 0 = otherwise)	0.826	0.379	0.000	1.000
Age	Age at the time of CSS interview	48.076	13.378	18.000	70.000
Ln_ind	Log of individual income	9.393	1.456	5.991	13.816
Ln_hou	Log of household income	10.254	1.646	6.685	16.118
Hukou	Hukou type (1 = rural, 0 = urban)	0.752	0.432	0.000	1.000
SES	Self-assessed Socioeconomic Status (1 = very low, 5 = very high)	3.806	0.935	1.000	5.000
Ln_gdppc	Log of provincial *per capita* GDP	10.743	0.398	10.003	11.685
Sec_ind_share	Share of secondary industry in provincial GDP	0.405	0.075	0.191	0.536
Urban_rate	Provincial urbanization rate	0.531	0.086	0.379	0.697

making them distinct from non-participating provinces in key baseline characteristics.

Before the formal establishment of NECPZs, the central government launched preliminary initiatives to explore institutional innovations in ecological governance. In 2013, six ministries—including the National Development and Reform Commission—jointly issued the Guidelines on the Construction of National Ecological Civilization Demonstration Zones (Trial) to encourage localized experimentation. In 2014, five provinces—Fujian, Jiangxi, Guizhou, Yunnan, and Qinghai—were selected as the first batch of provincial-level demonstration zones. Among them, Fujian, Jiangxi, and Guizhou were later officially established as NECPZs. Given their similar mandates and ecological foundations, Yunnan and Qinghai serve as suitable control provinces. Accordingly, the treatment group includes Fujian, Jiangxi, Guizhou, and Hainan, while the control group consists of Yunnan and Qinghai.

Given the typical lag between the official establishment of a NECPZ, the rollout of its corresponding policies, and observable changes in public environmental satisfaction, the treatment variable in this study is coded as 1 starting from the year after a province's designation as an NECPZ, and 0 otherwise. For example, since Fujian was established as an NECPZ in 2016, the treatment variable takes a value of 1 from 2017 onward, and 0 for all preceding years.

4.2.3 Control variables

Following prior research (Guriev et al., 2021), this study controls for a range of individual and household characteristics that may influence public environmental satisfaction. Specifically, the control variables include gender, age, hukou type, educational attainment, marital status, party affiliation, the logarithm of individual income, the logarithm of household income, and self-assessed socioeconomic status. In addition, this study also controls for several province-level variables, including the logarithm of provincial GDP *per capita*, the share of the secondary industry in provincial GDP, and the proportion of urban population in each province. Variable definitions and descriptive statistics are provided in Table 1.

4.3 Model specification

The Difference-in-Differences (DID) approach is a widely used quasi-experimental method to estimate the causal effects of policy interventions or exogenous shocks by comparing the outcome changes between a treatment group and a control group over time. The key identification assumption is the parallel trends assumption: in the absence of the treatment, the outcome trends of the treatment and control groups would have been similar.

However, the standard DID model assumes that the treatment is implemented simultaneously for all treated units. This condition is violated in our context, as China's National Ecological Civilization Pilot Zones (NECPZs) were established in different provinces at different times (a staggered adoption design). To address this issue and avoid potential biases (e.g., from comparing early-adopters to late-adopters as controls), we adopt a staggered DID model, which is the current best practice for evaluating treatments with variation in timing (Sun and Abraham, 2021; Baker et al., 2022).

Following recent literature (Lee and Nie, 2023), the baseline regression model is specified as follows (Equation 1):

$$Satis_{i,t} = \beta_0 + \beta_1 NECPZ_{i,t} + \lambda X_{i,t} + \gamma Z_{i,t} + \varepsilon_{i,t} \quad (1)$$

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TABLE 2 The impact of NECPZs on public environmental satisfaction.

Variable	Order probit			Marginal effects	
	(1)	(2)	(3)	(4)	(5)
NECPZ	0.173***	0.172***	0.189***	−0.0105***	0.0164***
	(0.043)	(0.045)	(0.069)	(0.004)	(0.006)
Gender		0.034	0.016	−0.000	0.001
		(0.040)	(0.040)	(0.002)	(0.004)
Party		0.178***	0.173**	−0.010**	0.015**
		(0.069)	(0.068)	(0.004)	(0.006)
Edu		−0.041*	−0.039*	0.002*	−0.003*
		(0.023)	(0.023)	(0.001)	(0.002)
Marriage		−0.028	−0.014	0.001	−0.001
		(0.054)	(0.053)	(0.003)	(0.005)
Age		0.000	0.001	0.000	0.000
		(0.002)	(0.002)	(0.000)	(0.000)
Ln_ind		0.014	0.019	−0.001	0.002
		(0.016)	(0.016)	(0.001)	(0.001)
Ln_hou		0.010	−0.002	0.000	−0.000
		(0.013)	(0.013)	(0.001)	(0.001)
Hukou		0.129**	0.134**	−0.007**	0.012**
		(0.052)	(0.053)	(0.003)	(0.005)
SES		−0.254***	−0.247***	0.0137***	−0.0214***
		(0.023)	(0.023)	(0.002)	(0.002)
Ln_gdppc			1.975***	−0.109***	0.172***
			(0.407)	(0.025)	(0.037)
Sec_ind_share			6.217***	−0.345***	0.541***
			(1.475)	(0.087)	(0.131)
Urban_rate			−7.129***	0.395***	−0.620***
			(2.421)	(0.140)	(0.215)
N	2,842	2,842	2,842	2,842	2,842
Pseudo R^2	0.001	0.016	0.021	0.021	0.021

Robust standard errors are in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.

Where: $Satis_{i,t}$ represents the environmental satisfaction of individual i in year t. $NECPZ_{i,t}$ is our key treatment variable. As justified in Section 4.2.2, it is a binary indicator that switches from 0 to 1 starting from the year following a province's designation as an NECPZ, and remains 1 thereafter. This coding accounts for the implementation lag and ensures our model captures the policy's effect rather than its announcement. $X_{i,t}$ denotes a vector of individual- and household-level control variables, whereas $Z_{i,t}$ represents a set of province-level covariates; $\varepsilon_{i,t}$ is the error term.

5 Empirical results

5.1 The impact of NECPZs on public environmental satisfaction

Table 2 presents the ordered probit regression results estimating the impact of NECPZ establishment on public environmental satisfaction. Columns (1), (2), and (3) report results from progressively more comprehensive models: Column (1) presents the baseline specification without any control variables; Column (2) includes individual- and household-level control variables; Column (3) further adds province-level control variables to the model in Column (2). Across all three specifications, the estimated coefficient on the treatment variable (NECPZ) is positive and statistically significant at the 1% level, indicating that the establishment of NECPZs significantly enhances public environmental satisfaction in pilot provinces. Thus, Hypothesis 1 is supported.

To further assess the extent to which the establishment of NECPZs improves public environmental satisfaction, a marginal effects analysis was conducted. The results are reported in Columns (4) and (5) of Table 4. The findings show that, following the inclusion of a province in the NECPZs program, the probability of respondents rating their environmental satisfaction as "3" decreases by 1.05%, while the probability of selecting "8" increases by 1.64%. This shift indicates that the policy has led to a concentration of satisfaction scores at higher levels, reflecting an improvement in individuals' subjective perceptions of their residential environment. Therefore, the marginal effects analysis provides additional evidence that NECPZs establishment contributes to enhancing public environmental satisfaction.

Using the model in Column (3) as a reference, the associations between individual characteristics and public environmental satisfaction are further examined. Party membership and rural hukou have significant positive associations with satisfaction levels. In contrast, Both individuals' educational attainment and their self-assessed socioeconomic status show a significant negative association with environmental satisfaction. Other factors, including gender, marital status, age, individual income, and household income, show no statistically significant effects. At the provincial level, GDP *per capita* and the share of the secondary industry in provincial GDP are significantly positively associated with public environmental satisfaction, whereas the urbanization rate exhibits a significant negative association.

5.2 Heterogeneous effects of NECPZs: the role of internet use

While the baseline results indicate that NECPZs generally improve public environmental satisfaction, this effect may vary across different population groups. Given the growing importance of the internet in shaping public perceptions of environmental issues (Hu et al., 2019; Huang, 2025), we examine whether the policy impact differs by individuals' frequency of internet use.

To test for this heterogeneity, we conduct a subgroup analysis based on respondents' internet usage frequency. Internet usage is

TABLE 3 Heterogeneous effects of NECPZs: the role of Internet use.

Variable	(1)	(2)
	High-frequency	Low-frequency
NECPZ	0.291***	−0.120
	(0.105)	(0.158)
Gender	−0.039	0.229*
	(0.083)	(0.123)
Party	0.221**	0.138
	(0.112)	(0.245)
Edu	−0.030	−0.033
	(0.052)	(0.075)
Marriage	−0.088	0.085
	(0.099)	(0.165)
Age	0.004	−0.000
	(0.004)	(0.006)
Ln_ind	0.001	−0.078
	(0.041)	(0.057)
Ln_hou	−0.047*	0.033
	(0.027)	(0.039)
Hukou	0.096	0.059
	(0.097)	(0.145)
SES	−0.225***	−0.295***
	(0.051)	(0.069)
Ln_gdppc	0.374	1.037***
	(0.267)	(0.383)
Sec_ind_share	−1.304**	−0.767
	(0.542)	(0.758)
Urban_rate	−0.020	−2.469
	(1.302)	(1.864)
N	684	319
Pseudo R^2	0.024	0.027

Robust standard errors are in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.

measured using a CSS survey question: "How often do you engage in the following activity online—browsing political news?" Response options include: "Almost every day" = 1, "Several times a week" = 2, "At least once a week" = 3, "At least once a month" = 4, "Several times a year" = 5, and "Never" = 0. Respondents who selected "Almost every day" or "Several times a week" are categorized as high-frequency internet users; all others are classified as low-frequency users. Based on this classification, we perform separate regressions for the two groups. The results are presented in Table 3.

As shown in Table 3, for individuals with high-frequency internet use, the estimated coefficient of NECPZ is 0.291 and statistically significant at the 1% level, indicating that the policy significantly improves environmental satisfaction within this group. In contrast, for individuals with low-frequency internet usage, the coefficient of NECPZ is 0.120 and not statistically significant, suggesting that the policy has no significant effect on environmental satisfaction for this subgroup. These findings support Hypothesis 2.

This heterogeneity may stem from the critical role of the internet in information dissemination and public perception. On one hand, the government increasingly relies on digital media platforms to communicate achievements in environmental governance. Citizens who frequently browse political news online are more likely to be exposed to information about NECPZs initiatives, leading to more favorable evaluations of the policy's effectiveness. On the other hand, the internet offers channels for public engagement in environmental governance, allowing citizens to voice concerns, file complaints, or participate in discussions on social media (Sun et al., 2025a). Such enhanced transparency and interactivity may increase trust and identification with government actions, thereby boosting satisfaction.

In contrast, individuals who seldom use the internet have limited access to policy-related information and fewer avenues for engagement. As a result, they may lack sufficient awareness or opportunities to form clear subjective evaluations, leading to an insignificant policy effect on their satisfaction. Thus, internet usage frequency moderates the relationship between NECPZs establishment and public environmental satisfaction, and indirectly validates "information dissemination" and "public participation" as potential mechanisms through which the policy exerts its influence.

In addition, the moderating role of internet use may also reflect broader disparities in information accessibility across regions and social groups (Di et al., 2024). In areas with better digital infrastructure and higher levels of socioeconomic development, individuals are more likely to access timely and reliable environmental information through online platforms (Hargittai, 2001; Norris, 2003), thereby reinforcing the positive policy effect on environmental satisfaction. By contrast, residents in less-developed or rural regions may face limited internet penetration and weaker channels of information disclosure, which constrain their ability to perceive and evaluate policy outcomes (Sun et al., 2025b). Similarly, individuals with lower levels of education or income may lack the resources or digital literacy necessary to fully utilize internet-based participation channels (Hargittai, 2010). These contextual differences suggest that the heterogeneous effect of internet use is not only driven by individual frequency of online activity but is also embedded in structural variations in information accessibility, which further conditions how the public perceives and responds to environmental governance. This interpretation is consistent with the literature on the digital divide, which shows that disparities in digital infrastructure and socioeconomic status shape individuals' access to and use of online information (Norris, 2003; Van Deursen and Van Dijk, 2014).

5.3 Robustness test

5.3.1 Parallel trend test

An important prerequisite for applying the Difference-in-Differences (DID) approach in policy evaluation is the parallel

trend assumption, which requires that prior to the implementation of the NECPZ policy, there were no significant differences in the trends of public environmental satisfaction between the treatment and control provinces.

Following existing literature (Lee and Nie, 2023), the following model is constructed to test for parallel trends (Equation 2):

$$Satis_{i,t} = \beta_0 + \sum_{k=-4, k\neq -2}^{k=4} \beta_k policy_{i,k} + \lambda X_{i,t} + \gamma Z_{i,t} + \varepsilon_{i,t} \quad (2)$$

where $policy_{i,\,k}$ is a set of dummy variables indicating the number of years relative to the official establishment of the NECPZ in province i. Specifically, when $k < 0$, $policy_{i,\,k}$ denotes k years before implementation; $k = 0$ represents the implementation year; and $k > 0$ captures the *k*th year after implementation. It is worth noting that $k \neq -2$ because the original dataset excludes the 2015 wave of CSS data. The base period is set to five or more years before the policy.

Our focus is on the estimated coefficients β_k, which reflect the dynamic impact of NECPZ establishment on public environmental satisfaction over time. If the β_k values for the pre-treatment years are statistically indistinguishable from zero, the parallel trend assumption is considered satisfied.

Figure 1 plots the estimated coefficients over time. The horizontal axis denotes years relative to NECPZ implementation, and the vertical axis displays the corresponding coefficient estimates, with dashed lines representing the 95% confidence intervals. When $k < 0$, the coefficients are statistically insignificant, indicating that there is no systematic difference in the trend of public environmental satisfaction between the treatment and control groups before the implementation of NECPZs. The parallel trend assumption is therefore satisfied.

When $k > 1$, the coefficients become significantly positive, indicating that the establishment of NECPZs has significantly enhanced public environmental satisfaction, albeit with a certain time lag. This finding is consistent with the results of the baseline regression. The observed lagged effect may stem from the multi-stage nature of the policy implementation process. Specifically, it takes time for policy measures to be rolled out, environmental improvements to take effect, and for the public to recognize these changes and translate them into more favorable evaluations.

5.3.2 Placebo test

To assess the robustness of the baseline regression results and address concerns that the observed treatment effect may result from random shocks or unobserved confounders, a placebo test is conducted. This approach simulates counterfactual treatment assignments to evaluate whether statistically significant effects could arise purely by chance.

In each of 1,000 simulation iterations, four pseudo-treated provinces are randomly drawn from a pool of 25 provinces, excluding the actual treated units and the two designated control provinces. These pseudo-treated provinces, combined with the two true control provinces, form a synthetic sample for re-estimating the DID model. The resulting placebo treatment coefficient is recorded for each iteration.

Figure 2 displays the distribution of the estimated coefficients from the 1,000 placebo regressions. The black dashed line marks the actual DID estimate (0.229). As shown, most placebo estimates are centered around zero, whereas the true estimate lies in the far-right tail of the distribution. This pattern offers compelling evidence that the observed treatment effect is unlikely to be driven by random variation, thereby reinforcing the robustness of the estimated policy impact of NECPZs.

5.3.3 Other robustness test

To test the robustness of the main findings, this study treats public environmental satisfaction as a cardinal variable and re-estimates the baseline models using OLS regression. The results for Columns (1)–(3) of Table 4 show that, for the full sample, the coefficient on the treatment variable (NECPZ) is 0.281 and statistically significant at the 5% level. In the subsample of respondents with high-frequency internet use, the coefficient increases to 0.589 and statistically significant at the 1% level. However, for respondents with low-frequency internet use, the coefficient is statistically insignificant. These results are consistent with the Ordered Probit estimates in both significance and direction, providing further evidence for the robustness of the main conclusions.

In addition, as a robustness check, this study incorporates cohort-specific time trends into the DID model. While the event-study results already support the parallel trends assumption (Figure 1), the staggered adoption of the NECPZs policy raises the possibility that provinces from different adoption cohorts may follow distinct long-term trajectories. Column (4) of Table 4 reports the estimates when cohort-specific time trends are included. This specification serves as an alternative to the conventional two-way fixed effects model, which did not yield stable results in our setting. The findings remain consistent with the baseline estimates, suggesting that the identified policy effects are not driven by heterogeneous pre-existing trends across cohorts.

To provide a concise overview, Table 5 summarizes the two hypotheses and their validation status based on the empirical analyses. As shown, both H1 and H2 are supported, confirming the robustness of our theoretical expectations.

5.4 Mediation analysis

While the baseline results confirm that the establishment of NECPZs significantly enhances public environmental satisfaction, it remains essential to explore how this effect is realized. To investigate the underlying mechanisms, this section conducts a mediation analysis, drawing on the earlier theoretical discussion and proposed hypotheses. Specifically, the analysis examines whether the observed improvements in public satisfaction are driven by two key channels: environmental quality and public participation.

To empirically examine these mechanisms, the effects of NECPZs on a series of mediating indicators are analyzed. The detailed estimation results are presented in Table 6 and discussed in the following subsections. Data on air quality and environment-related proposals submitted to the National People's Congress (NPC) and Chinese People's Political Consultative Conference (CPPCC) are primarily obtained from the China Environment Yearbook, while data on environmental complaints are collected from official releases published on the website of the Ministry of Ecology and Environment.

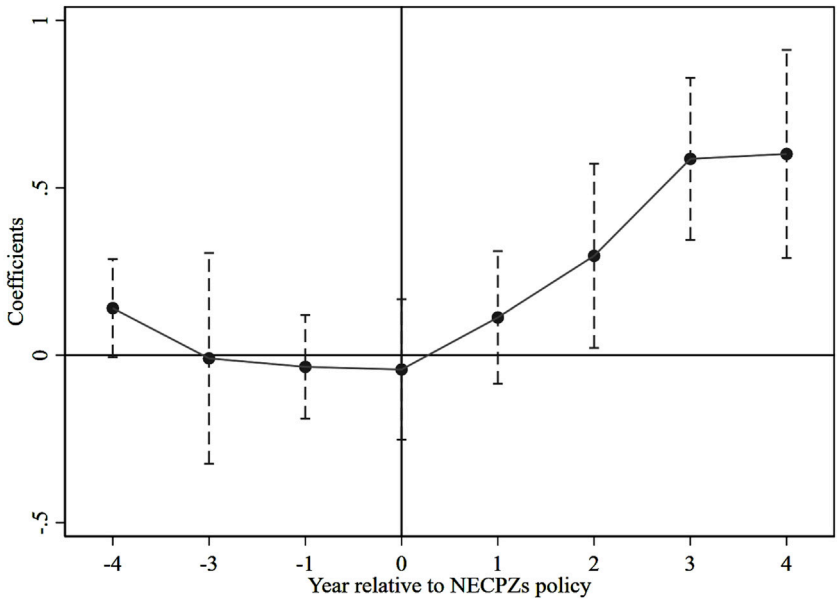

FIGURE 1
Parallel trend test.

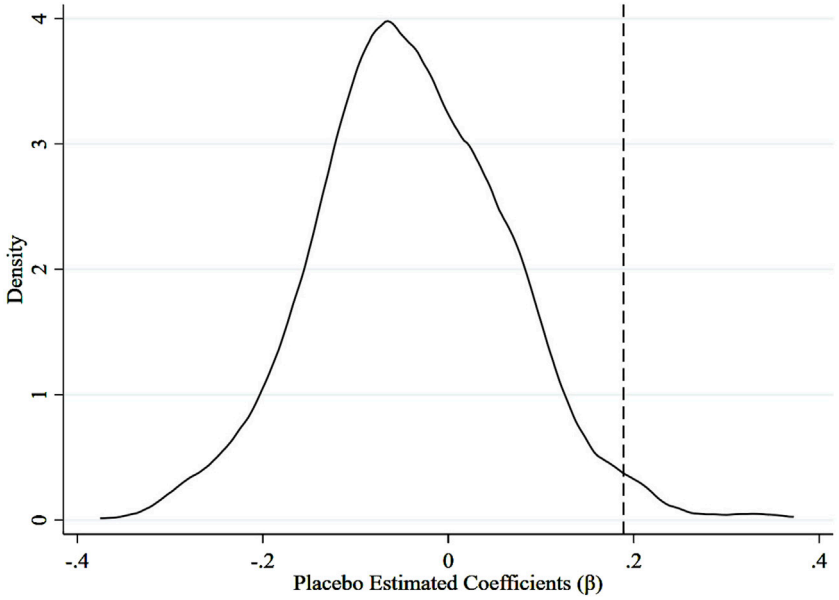

FIGURE 2
Placebo test.

5.4.1 The mediating role of air quality

The analysis first examines the mediating role of air quality. Columns (1), (2), and (3) of Table 6 report regressions where the dependent variables are, respectively, the logarithm of total SO_2 emissions, *per capita* SO_2 emissions, and PM2.5 concentrations for each province-year. In columns (1) and (2), the estimated coefficients on the treatment variable (NECPZ) are −0.275 and −0.003, both statistically significant at the 5% level. These results indicate that NECPZs significantly reduce total and *per capita* SO_2 emissions, thereby improving air quality and enhancing public satisfaction. These findings are consistent with those of Li et al. (2020).

Similarly, in column (3), PM2.5 levels are employed as an alternative proxy for air quality, and consistent results are obtained. The negative and statistically significant coefficient further suggests that NECPZs improve public satisfaction by reducing air pollution. The

10.3389/fenvs.2025.1676321

TABLE 4 Other robustness test: OLS estimations and cohort-specific time trends.

Variable	(1)	(2)	(3)	(4)
	Full sample	High-frequency	Low-frequency	Cohort trends
NECPZ	0.281**	0.589***	−0.287	0.363***
	(0.129)	(0.202)	(0.327)	(0.091)
Gender	0.079	−0.056	0.529**	0.011
	(0.090)	(0.167)	(0.262)	(0.040)
Party	0.382***	0.411*	0.123	0.175**
	(0.143)	(0.214)	(0.477)	(0.068)
Edu	−0.079	−0.008	−0.019	−0.041*
	(0.050)	(0.106)	(0.150)	(0.023)
Marriage	−0.053	−0.192	0.200	−0.011
	(0.120)	(0.199)	(0.344)	(0.053)
Age	−0.001	0.007	−0.002	0.001
	(0.004)	(0.008)	(0.012)	(0.002)
Ln_ind	0.042	−0.011	−0.157	0.017
	(0.035)	(0.082)	(0.118)	(0.016)
Ln_hou	−0.008	−0.079	0.086	−0.001
	(0.030)	(0.058)	(0.088)	(0.013)
Hukou	0.264**	0.178	0.055	0.128**
	(0.116)	(0.194)	(0.296)	(0.053)
SES	−0.578***	−0.442***	−0.605***	−0.246***
	(0.049)	(0.103)	(0.136)	(0.023)
Ln_gdppc	0.859***	0.690	2.066***	−0.447
	(0.307)	(0.540)	(0.749)	(1.024)
Sec_ind_share	−1.055*	−2.712**	−1.350	6.474***
	(0.612)	(1.086)	(1.580)	(1.600)
Urban_rate	−3.215**	0.272	−4.886	−3.308
	(1.441)	(2.654)	(3.781)	(2.805)
_cons	1.565	2.621	−9.847	
	(2.677)	(4.676)	(6.769)	
N	2,842	684	319	2,842
R^2/Pseudo R^2	0.069	0.091	0.106	0.022

Columns (1)–(3) re-estimate the baseline specification using OLS, instead of ordered probit. Column (4) reports results from the DID, model with province fixed effects and cohort-specific linear time trends (cohort × year). Robust standard errors are in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.

TABLE 5 Summary of hypotheses and validation results.

Hypothesis	Statement	Evidence	Validation
H1	The establishment of the NECPZs enhances public environmental satisfaction in pilot provinces	Table 2. The impact of NECPZs on public environmental satisfaction	Supported
H2	The positive impact of NECPZ establishment on public environmental satisfaction is more pronounced among individuals who frequently use the internet.	Table 3. Heterogeneous effects of NECPZs: the role of Internet use	Supported

TABLE 6 Mechanisms tests.

Variable	(1)	(2)	(3)	(4)	(5)
	$lnSO_2$	SO_2_pc	PM2.5	Complains	Proposals
NECPZ	−0.275**	−0.003**	−3.115***	0.779*	0.933**
	(0.133)	(0.001)	(0.945)	(0.411)	(0.432)
Controls	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
N	102	102	96	54	83
R^2	0.990	0.921	0.982	0.672	0.709

Robust standard errors are in parentheses. *p < 0.1, **p < 0.05, ***p < 0.01.

consistency of results across different air quality indicators reinforces the robustness and credibility of the conclusion.

5.4.2 The mediating role of public participation

This study classifies public engagement in environmental protection into two forms: direct participation and indirect participation. Direct participation is proxied by the annual number of environmental complaints lodged by citizens through telephone hotlines, online platforms, and social media channels such as WeChat. Indirect participation is measured by the total number of environment-related proposals submitted to the NPC and CPPCC with a 1-year lag. As noted in previous research, "Environmental proposals submitted to the NPC and CPPCC reflect public opinion on environmental governance. Once adopted and incorporated into legislation, such proposals fulfill the ultimate objective of public participation in environmental governance" (Tu et al., 2021).

Columns (4) and (5) of Table 6 report the regression results for the mediating role of public participation. In Column (4), the coefficient on NECPZ is 0.779, statistically significant at the 10% level, indicating that the establishment of NECPZs was associated with an increase in environmental complaints by the public. In Column (5), the coefficient on NECPZ is 0.933 and significant at the 5% level, indicating that NECPZs led to a significant increase in the number of environmental proposals submitted in the subsequent year.

It is worth noting that the increase in both environmental complaints and the number of environment-related proposals submitted to the NPC and CPPCC following the implementation of NECPZs does not indicate public dissatisfaction. Rather, it reflects several positive effects brought about by the policy. On the one hand, public awareness of environmental issues has increased and citizens have become more proactive in participating in environmental governance. Moreover, both direct participation (such as environmental complaints) and indirect participation (such as submitting environment-related proposals to the NPC and CPPCC) have become more accessible, enabling citizens to express their environmental concerns more effectively. In addition, government responsiveness, such as the mandated handling of environmental complaints within a specified time, has strengthened public trust in environmental governance and contributed to higher levels of environmental satisfaction. Overall, the regression results on public participation indicate that the establishment of NECPZs has enhanced public environmental satisfaction by improving participation mechanisms and increasing policy responsiveness.

5.4.3 Further discussion on the mechanisms

The empirical results in Sections 5.4.1 and 5.4.2 confirm that both air quality improvement and public participation serve as significant transmission channels through which the NECPZs policy enhances public satisfaction. Building on these findings and related literature, three further insights are provided.

First, the nature of the "public participation" mechanism deserves elaboration. The concurrent increase in both environmental complaints (a direct and sometimes confrontational channel) and NPC/CPPCC proposals (an indirect and institutionalized channel) suggests that the NECPZs policy does not merely provoke narrow local resistance to environmental issues in one's immediate surroundings. Instead, it fosters a more diversified and institutionalized form of civic engagement. This indicates the emergence of a feedback loop where public concerns are not only voiced but also incorporated into formal political processes, thereby enhancing public environmental satisfaction.

Second, it is important to consider the interplay between the two mechanisms. They are likely mutually reinforcing rather than independent. Tangible improvements in air quality can build initial public trust in the government's environmental commitment, which in turn motivates citizens to engage more proactively through formal channels. Conversely, effective public participation can lead to more targeted and publicly supported regulations, further improving environmental quality. These mutually reinforcing dynamics generate both objective improvements and subjective recognition, thus jointly raising public environmental satisfaction.

Finally, while our model estimates the average effects, existing studies suggest that the impacts of environmental policies may vary across regions and groups (Di et al., 2023; Dou and Guan, 2023). The air quality mechanism may be more salient in provinces where industrial pollution is the primary concern, whereas the participation mechanism may be more pronounced in regions with higher socioeconomic development. At the group level, Zhou and Xiong (2025) demonstrate that individuals with higher socioeconomic status are better positioned to engage in environmental protection behaviors owing to their superior access to resources and environmental education. These patterns

imply that the two mechanisms operate differently across contexts: in pollution-intensive regions, improvements in air quality may provide the most visible gains in public environmental satisfaction, while in more developed regions, participatory channels may play a greater role by enabling civic engagement. Although testing these heterogeneities lies beyond the scope of the present study, future research with more granular data could explicitly examine how the NECPZs policy functions across different regions and demographic groups.

6 Conclusion and policy implications

This study provides a systematic assessment of the National Ecological Civilization Pilot Zones (NECPZs) from the perspective of public environmental satisfaction, drawing on four waves of nationally representative data from the Chinese Social Survey and employing a staggered difference-in-differences approach. The empirical results demonstrate that the implementation of the NECPZs significantly enhances public environmental satisfaction in pilot provinces. Mechanism analysis shows that this effect is driven by improvements in air quality and the strengthening of public participation mechanisms. Furthermore, the heterogeneity analysis indicates that the effect is more pronounced among individuals with higher frequencies of internet use, underscoring the importance of information dissemination and participatory channels in shaping public environmental satisfaction.

Moreover, our findings contribute to broader international debates on how personal and environmental experiences shape public perceptions. Prior research reveals that this link is far from straightforward. Some studies suggest that direct encounters with environmental problems heighten concern and pro-environmental behavior (Spence et al., 2011; Zaval et al., 2014), whereas others indicate that such experiences do not necessarily generalize into broader attitudes (Mutz, 1993; Suls et al., 2013). These mixed findings underscore the complexity of translating objective environmental improvements into public perceptions, and highlight the value of systematically examining subjective perceptions in policy evaluation. Our study contributes to this literature by showing, in the Chinese context, that environmental policies such as the NECPZs can significantly enhance public environmental satisfaction through both environmental quality improvements and participatory mechanisms.

This research advances the literature in two important ways. To begin with, it evaluates the policy effects of the NECPZs from the perspective of public environmental satisfaction, thereby moving beyond the traditional focus on objective indicators such as ecological efficiency and green innovation. By highlighting the importance of public subjective perceptions in assessing environmental policies, this study offers a new perspective for comprehensively evaluating policy outcomes. In addition, it challenges the prevailing view that increased internet use amplifies public dissatisfaction with environmental governance. While existing literature generally suggests that digital media may magnify negative information and trigger discontent (Zhang et al., 2020a), this study finds that following the establishment of the NECPZ, individuals who frequently use the internet actually report higher levels of environmental satisfaction. This counterintuitive finding underscores the potential of digital platforms to facilitate effective policy communication and foster trust, thereby enriching the theoretical understanding of the relationship between media use and policy evaluation.

Building on these findings, the study also yields several context-specific and practical policy implications for improving environmental governance in China and other developing countries:

First, in the process of policy design and implementation, governments should give equal attention to tangible environmental outcomes and participatory governance processes. The experience of the NECPZs demonstrates that while reducing pollution is necessary, it is not sufficient to fully enhance public environmental satisfaction. Governments must also establish accessible and effective channels for public participation, such as robust complaint-handling mechanisms and formal avenues for policy input, in order to translate environmental improvements into higher levels of environmental satisfaction among citizens.

Second, the pronounced differences in public environmental satisfaction between high- and low-frequency internet users highlight the critical role of the digital divide in environmental governance. Governments should not only make active use of digital media such as official social media accounts and mobile applications to disseminate information on policy progress and environmental achievements, but also diversify communication channels through television, radio, community bulletins, or face-to-face engagement to reach low-frequency internet users. Such efforts are intended not merely to enhance publicity, but more importantly to ensure equitable access to information, enabling all citizens to perceive and appreciate the benefits of environmental policies.

Third, this study also offers valuable lessons for other developing countries. Ecological policies are more effective when they simultaneously achieve improvements in objective environmental quality and enhancements in subjective public satisfaction. To this end, it is essential to ensure transparency and openness in information flows and to encourage broad-based citizen participation through diverse channels. Such measures not only strengthen the legitimacy of governance but also enhance public support and recognition for long-term sustainability reforms.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

YD: Methodology, Data curation, Conceptualization, Software, Writing – original draft, Investigation, Formal Analysis. SQ: Resources, Writing – review and editing, Project administration, Visualization, Validation. YL: Funding acquisition, Supervision, Writing – review and editing.

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