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METHOD

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A framework to examine the potential social influence of scientists and nongovernmental organizations in marine conservation

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Abstract

Effective marine conservation requires science-based decisions and strong support from the public and local communities. Understanding the potential social influence of scientists and nongovernmental organizations (NGOs) in marine conservation is key, yet this aspect has been underexplored in conservation social science. In this study, we created a simple index of potential social influence (PSII) for scientists and NGOs, initiating an analytical framework to identify key variables correlated with the PSII and their underlying pathways. We illustrated this framework using China as a case study, where marine conservation advancement is urgently needed. Our results indicated that many of the variables we identified were correlated with the PSII, even though some are rarely mentioned in the related literature. Notably, both communication capability and annual funding positively impacted the potential social influence of scientists and NGOs, albeit through different pathways. This study provides valuable insights to enhance marine conservation efforts in China and addresses a critical research gap in assessing social influence on nature conservation.

KEYWORDS

conservation social science, environmental literacy, NGO, pathway analyses, policy advocacy, science communication

Plain language summary

Protecting our oceans, which serve as an important life-support system for humans, presents a significant challenge that needs both science-based conservation decisions and strong support from multiple stakeholders. However, marine conservation strategies often prioritize environmental and ecological goals above social factors and human dimensions, even though these elements are essential to successful conservation efforts. Scientists and nongovernmental organizations (NGOs) play vital roles in science communication and conservation practices and significantly influence the decision-making of various stakeholders, including policymakers, conservation managers, and the public. Therefore, understanding the potential social influence of scientists and NGOs on marine conservation, as well as identifying the driving factors behind this influence, is critical for enhancing their impact on societal attitudes and achieving more efficient marine conservation and other successful outcomes. In this context, we present China as a case study to introduce a new

framework for identifying the factors and potential causal pathways that affect the social influence of scientists and NGOs on the decision-making processes of multiple stakeholders in marine conservation. Our research showed that both communication capability and annual funding have strong positive effects on the potential social influence of scientists and NGOs in marine conservation, despite being through different pathways. This finding highlights the importance of these factors in achieving social influence. The novel framework we propose provides a new approach for global researchers to examine the social influence of scientists and NGOs in nature conservation. Ultimately, this framework aims to facilitate science-based conservation policymaking and actions, helping to achieve the targets of the Kunming-Montreal Global Biodiversity Framework.

1 | INTRODUCTION

The ocean is our life-support system, providing diverse ecosystem services that are critical to human survival and well-being (Palumbi et al., 2009; Sala et al., 2021). There is a growing urgency to protect our ocean as our marine footprints are expanding and intensifying (Jouffray et al., 2020; O'Hara et al., 2021). Facing this global challenge, the United Nations (UN) has made numerous efforts to protect our ocean, particularly in the last few decades (e.g., Aichi Targets by 2020, SDG 14—Life Below Water by 2030). More recently, in December 2022, the COP15 to the UN CBD endorsed the Kunming-Montreal Global Biodiversity Framework, which sets 23 new and ambitious targets for 2030 and 2050 (Convention on Biological Diversity [CBD], 2022).

To meet the new marine conservation targets, we will need science-based conservation decisions and robust enforcement through broad collaborations among multiple stakeholders (Jolibert & Wesselink, 2012; Laurance et al., 2012; Rossbach et al., 2023). Marine conservation strategies often prioritize environmental and ecological goals above social factors and human dimensions, despite the latter being crucial drivers of successful conservation outcomes (Bennett, 2019; Bennett et al., 2017). Currently, global marine conservation efforts face significant challenges (Katsanevakis et al., 2015), and we cannot afford to repeat the same mistakes made during the implementation of the Aichi Targets (e.g., lack of representativeness and enforcement of the protected areas) (Adenle, 2012; Tittensor et al., 2014; Watson et al., 2023). Furthermore, studies have shown that many conservation actions implemented were ineffective (Daru & le Roux, 2016; Rife et al., 2013; Turnbull et al., 2021). One of the major reasons for these inefficiencies is the lack of engagement with multiple stakeholders and the difficulty in addressing their divergent interests scientifically and sufficiently during the development of policies while also meeting conservation targets (Giakoumi et al., 2018; Jolibert & Wesselink, 2012; Redpath et al., 2013). Consequentially, many well-intentioned and ambitious policies are not endorsed by local communities and, therefore, are challenging to implement effectively on the ground (Bennett & Dearden, 2014; Rife et al., 2013).

Nevertheless, increasing the contribution of scientists and nongovernmental organizations (NGOs), both important stakeholders in marine conservation, may help to address these challenges (Berdej & Armitage, 2016; Temple et al., 2018). Understanding

Practitioner points

- Our findings suggest that increasing annual funding, communication capability, and expert consultation may enhance scientists' social influence in marine conservation. However, it is important to note that annual funding negatively influences communication capability. A probable explanation is that raising and accumulating more funds might overwhelm scientists, requiring them to allocate more time to research and less time to improving their communication skills.
- Scientists may benefit from seeking collaborations with nongovernmental organizations (NGOs) that have higher communication capacities. This partnership can help scientists become more proactive in increasing public environmental literacy through effective communication strategies.
- Academic institutions should develop reward systems that encourage scientists to engage in conservation communication and policy advocacy. These activities should be funded or valued as equally important as academic publications.
- Our findings for NGOs suggest that higher communication capability, more volunteers and participants in activities, more compliance supervising activities, and greater annual funds can eventually lead to higher social influence.

the roles, social traits, and influences of crucial stakeholders is integral for conservation success and may help to improve future engagement strategies in marine conservation (Ison et al., 2021). Scientists, through their research on marine biodiversity and conservation and their understanding of the interests of different stakeholders, can identify optimal trade-off solutions to formulate more scientific conservation plans (e.g., systematic marine spatial planning) (Ban & Klein, 2009; Ban et al., 2014). They have the opportunity to engage in government policy-making and present science-based conservation proposals to decision-makers (Choi et al., 2005). In addition, scientists can collaborate with NGOs to advocate for conservation ideas and approaches among stakeholders (e.g., community-based MPAs, adaptive stakeholder approaches) (Gray & Campbell, 2009; Sink et al., 2023), thereby promoting effective communication and seeking common ground. Likewise, by partnering with scientists, some NGOs can conduct surveys on marine ecosystems and local communities or stakeholders, raising public awareness and facilitating greater participation in conservation efforts (Cadman et al., 2020). Local NGOs can also represent community interests in government policy-making processes (Berkes, 2007). As crucial stakeholders, scientists and NGOs can influence policymakers and the public through their involvement in science communication and behavior change initiatives in marine conservation. This involvement can enhance multi-stakeholder understanding of marine conservation, their willingness to protect, their conservation behaviors, and their decision-making processes, ultimately influencing marine conservation efforts (Cadman et al., 2020; Grorud-Colvert et al., 2010; Nuno et al., 2021).

The contribution of scientists and NGOs in marine conservation largely depends on their social influence on the decision-making processes of multi-stakeholders, a topic that has been rarely discussed in the literature (Cadman et al., 2020; Ison et al., 2021). In this context, "multistakeholders" mainly refer to conservation managers (e.g., government leaders, policymakers, etc.) and the general public (e.g., local communities, consumers, etc.). Research on social influence has a long history in social psychology and conservation (St John et al., 2010; Wood, 2000). Techniques such as social network analysis and stakeholder analysis have been utilized to identify influential stakeholders and those who need to be involved in conservation efforts to achieve successful outcomes (Markantonatou et al., 2016; Vance-Borland & Holley, 2011). These approaches assist conservation managers and stakeholders in constructing communication and engagement strategies to achieve desired conservation results. However, these methods focus mainly on identifying crucial stakeholders and their relationships rather than quantifying their social influence on decision-making. Directly evaluating social influence is challenging because decision-making can be affected by various individuals or organizations. Moreover, it is difficult to separate the social influence of a scientist (or their research team) or an NGO, given their collaborative efforts in conservation initiatives. Therefore, quantifying the social influence of a person or an organization is still in its infancy (Tahamtan & Bornmann, 2020) and has rarely been done in conservation science. There is also scant knowledge about the factors associated with the social influence of scientists and NGOs in marine conservation and the underlying processes. Addressing this knowledge gap is significant as it may help scientists and NGOs improve their social influence, thereby contributing more effectively to marine conservation efforts.

With its growing influence across the marine realms, China is poised to play an increasingly pivotal role in global marine conservation, yet the country faces numerous challenges in protecting its own seas (Liu, 2013). As one of the megadiverse countries, China boasts a rich diversity of terrestrial organisms and more than 23,000 marine organisms known to science (Liu, 2013). Currently, only 3.5% of China's marine area is covered by its marine protected areas (MPAs), and these are often poorly managed (Hu et al., 2020; Zhang et al., 2017). Iconic marine species have been heavily threatened or even become functionally extinct in China's seas (Chen et al., 2009; Kang et al., 2021; Lin et al., 2022; Sadovy & Cheung, 2003). To the best of our knowledge, the number of Chinese scientists and NGOs focusing on marine conservation is minimal. This does not align well with the nation's large population size and the significant need to protect biodiversity in its vast coastal seas. In recent decades, China has carried out many national or provincial marine conservation actions and marine habitat restoration projects (Liu et al., 2020). However, partially due to a lack of scientific guidance, some of these projects have sometimes not only failed to promote conservation but have also caused irreparable damage to local marine ecosystems (Jiang et al., 2015).

Using China as an example, our study aims to illustrate a novel framework to examine the factors and potential causal pathways that may affect the social influence of scientists and NGOs upon the decision making of multi-stakeholder in marine conservation. Given the challenges of directly estimating social influence, we focus on potential social influence, evaluating who might have a greater capacity to influence governments and the general public. First, we identify research samples and define a potential social influence index (PSII) along with its potential covariates. The PSII is based on practical indicators (e.g., policy consultation and media coverage) that may serve as surrogates for potential social influence on decision-making by multistakeholders. Second, we conduct questionnaire surveys to collect data from our research samples. Third, we integrate various methods to identify the important factors associated with the

PSII of scientists and NGOs and to examine their causal pathways. Our study provides guidance for Chinese scientists and NGOs to improve their social influence in marine conservation. Additionally, it fills an essential research gap by establishing a scientific framework to study potential social influence in nature conservation.

2 | METHODS

Our study framework consists of three main phases (i.e., experimental design, data collection, and data analyses) and six specific steps (Figure 1), which we outline as follows using China as an example.

2.1 | Research sample

We identified scientists (i.e., academics, $N = 71$) and NGOs ($N = 112$) that are actively engaged in marine conservation in mainland China. Here, "scientists" are defined as professional researchers (i.e., academics) working in academic organizations. NGOs must meet the following criteria: (1) operating as a Chinese nongovernmental organization and (2) conducting marine conservation projects in mainland China (Wang & Jia, 2002). These entities were identified based on their participation in marine conservation, as evidenced by their activities, goals, or objectives. "Marine conservation" is broadly defined to include not only marine biodiversity conservation or marine ecosystem protection but also marine pollution control and developing sustainable fisheries (see details in the Supporting Information S1). Each scientist or NGO was treated as an independent sample.

2.2 | Influence indicators and variables

It is important to note that social influence on decision-making can encompass a wide range of indicators, not all of which can be easily or directly quantified. Here, we considered only those indicators that are simple, measurable, relevant, and timely (Molas et al., 2002). We selected indicators that are complementary and could evaluate the potential social influence of a specific identity (rather than multiple groups in collaboration) as accurately as possible, even though achieving precise measurements by doing so is unpractical. Based on these principles, we defined several indicators and calculated their arithmetic mean to derive a PSII for scientists and NGOs separately (Table 1).

Policy document citation is one of the most valuable indicators of the social influence of research (Tahamtan & Bornmann, 2020). However, quantifying this can be very challenging, as Chinese policy documents rarely cite their sources in

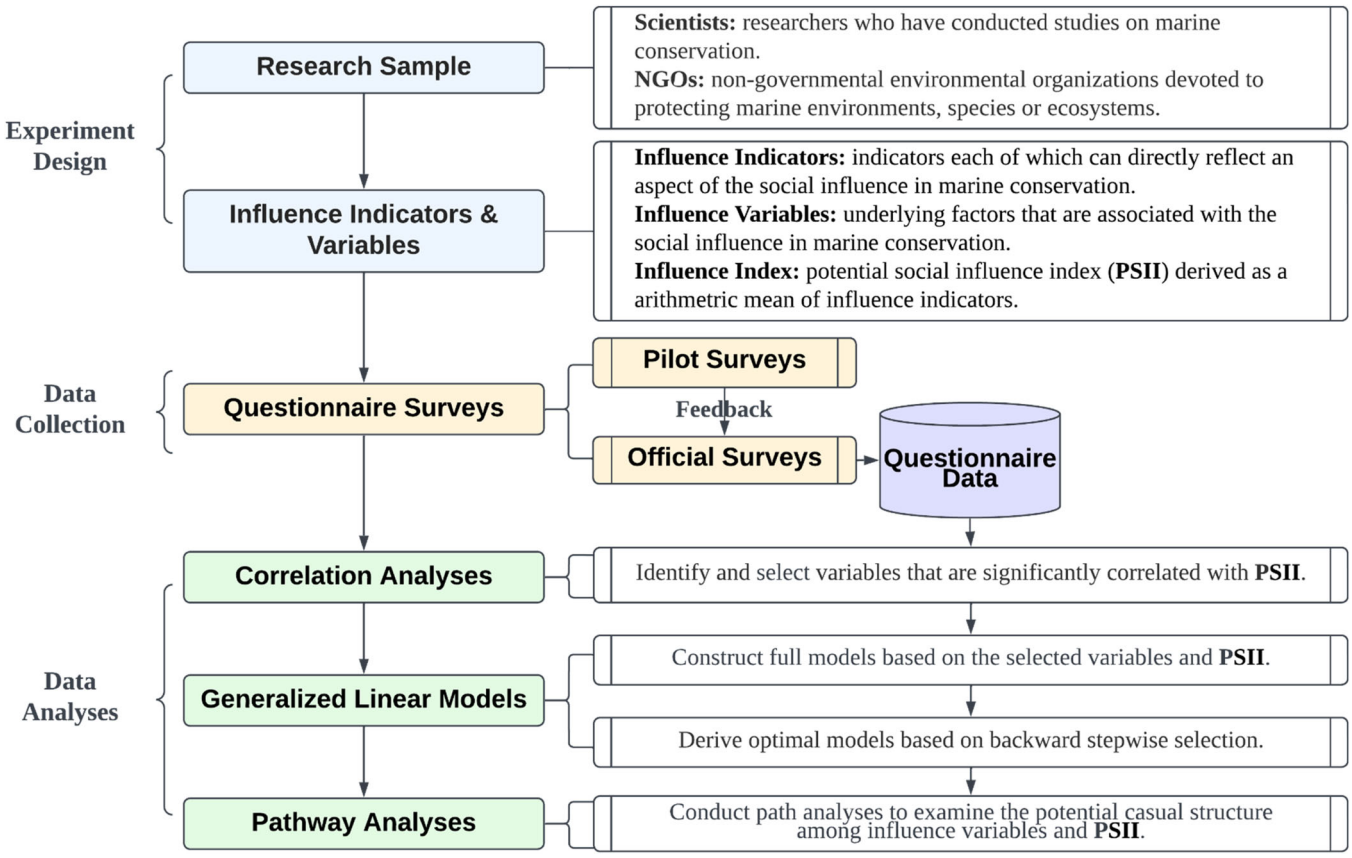

FIGURE 1 The analytical framework developed to identify relevant variables that drive the potential social influence (PSII) of scientists and nongovernmental organizations (NGOs) in marine conservation and the potential pathways.

TABLE 1 Indicators used to estimate the potential social influence index (PSII) of scientists and nongovernmental organizations (NGOs).

Indicator	Definition	Questionnaire options	Applicability
Policy consultation	The frequency of being invited by the government to participate in seminars related to marine conservation themes in recent 5 years.	1 = Never 2 = Occasionally 3 = Sometimes 4 = Usually 5 = Always	Scientists and NGOs
Policy advocacy	The frequency of advocating for marine conservation policies to the government in recent 5 years.		Scientists and NGOs
Media coverage	The frequency of accepting media interviews in recent 5 years.		Scientists and NGOs
Academic popularity	The frequency of being invited by academic conferences/forums in recent 5 years.		Scientists only

detailed reference lists. Here, we selected two practical indicators as surrogates: (1) the frequency of being invited by the government to participate in seminars related to marine conservation themes (hereafter, policy consultation), and (2) the frequency of advocating for marine conservation policies to the government (hereafter, policy advocacy). Given that these two indicators cover only the potential influence upon government decision-making, we considered two additional indicators to cover other stakeholders: (1) the frequency of accepting media interviews (hereafter, media coverage), given the impact of social media on public decision making (Bond et al., 2012); and (2) the frequency of being invited to academic forums or conferences (hereafter, academic popularity, for scientists only) (Oester et al., 2017). Among these four indicators, policy consultation and academic popularity can also serve as surrogates for trustworthiness or authority, which is an impactful factor in influencing decision-making (Moraes et al., 2019). We measured these four indicators over the past 5 years, given the principle of timeliness and feasibility. We did not introduce weights to these indicators when calculating PSII due to the lack of evidence indicating the superiority of one over another.

To identify the determinants of social influence in marine conservation, we initially selected 20 variables for scientists (Table 2) and 45 variables for NGOs (Table 3). These variables can be classified into five dimensions: (1) the profile of the leader, (2) the profile of the team, (3) the dissemination of research outputs (for scientists only), (4) communication capability, and (5) communication channels. Studies on management and organizational behavior have demonstrated that organizational commitment or performance is often correlated with various sociodemographic, management, and economic factors (Bakotić, 2022; Wang et al., 2015). Consequently, we aimed to investigate whether certain characteristics of the leader or the team (e.g., age, gender ratio, education, experiences, funding) may determine the social influence of an NGO or a research lab (i.e., scientist). We considered the dissemination of research outputs for scientists, as researchers who convert their findings into, for instance, popular science articles (targeted at the general public) and policy advice (targeted at the government) could potentially have higher social influence (Barel-Ben David et al., 2020). We also examined the communication capability of the team, given its significance in science communication and policy advocacy (Bruine de Bruin & Bostrom, 2013; Reyes-Rodríguez, 2021). We further examined whether using specific communication channels could better increase one's social influence.

2.3 | Questionnaire surveys

In social science, questionnaire surveys are commonly used to obtain self-report data, enabling scientists to quantify variables of interest that may not be measurable through other means. We designed separate questionnaires for scientists and NGOs to score the influence indicators and variables mentioned above (Supporting Information S1: Tables S1 and S2). We asked respondents to self-evaluate their social influence in marine conservation among their peers using a ranking score (used to validate our PSII). The questionnaires included three main types of questions: (1) multiple-choice questions, where respondents could select, for instance, their focal areas of marine conservation; (2) Likert scale questions with a five-level scale, ranging from 1 to 5 (Croasmun & Ostrom, 2011), where participants could choose, for instance, their frequency of policy consultation; and (3) fill-in-the-blank questions.

Before launching the official survey, we consulted and piloted the questionnaire with one scientist and three NGO leaders to refine its content (see Supporting Information S1). The revised questionnaire was distributed to the targeted respondents via email and WeChat, a popular social media platform. If no response was received within 2–3 weeks after initial contact, a follow-up contact was made. If there was still no response after two follow-up attempts, further invitations were ceased. The survey period for scientists was from August 17, 2022, to January 18, 2023, and for NGOs from August 15, 2022, to December 9, 2022. All participants were informed of the survey's purpose and consented to the collective use of their data collectively in our study, with personal and

TABLE 2 Initially defined influence variables of scientists.

Variable	Definition	Description and reference
Age	Age of the scientist	Profile of the scientist
Gender	Gender of the scientist	Profile of the scientist
Dedication	Degree of dedication to marine conservation, measured by the proportion of projects or activities focusing on marine conservation	Profile of the scientist
# of years of experience	Number of years of experience	Profile of the scientist
# of staff	Number of personnel in the research team	Profile of the team
Age of staff	Average age of core members in the research team	Profile of the team
% of females	Proportion of females of core members in the research team	Profile of the team
Annual fund	Annual fund for marine conservation projects over the past 5 years	Profile of the team. Study shows that researchers who receive research grants increase their research publications and citations by about 20% (Jacob & Lefgren, 2011), which may contribute to their increased social influence.
# of projects	Number of projects about marine conservation since he/she started to work in marine conservation	Profile of the team
Spatial scope	Major spatial scope of marine conservation projects	Profile of the team
Primary concerned area	Primary concerned area in marine conservation by the scientist and the research team	Profile of the team. Studies have shown that the attractiveness of a species greatly increases support for its conservation (Gunnthorsdottir, 2001), so scientists working in different areas within the conservation field or focusing on different species may receive varying degrees of public attention and, in turn, generate varying degrees of social influence.
Primary collaborator	Primary collaborator in marine conservation projects	Profile of the team. Collaboration can bring together multiple resources to solve problems (Fortunato et al., 2018), which is beneficial to the development of scientific endeavors. We aim to investigate the potential effect of the frequency of collaboration and the primary collaborators of scientists on their social influence.
Frequency of collaboration	Frequency of collaboration in marine conservation projects	Profile of the team. Collaboration can bring together multiple resources to solve problems (Fortunato et al., 2018), which is beneficial to the development of scientific endeavors. We aim to investigate the potential effect of the frequency of collaboration and the primary collaborators of scientists on their social influence.
Conversion rate	Proportion of research results converted to conservation outcomes	Dissemination of outputs
Popular science	Whether research outputs converted to popular science works	Dissemination of outputs
Expert consultation	Whether research outputs converted to expert consultation (such as participation in policy consultation meetings, guiding relevant conservation practices)	Dissemination of outputs
Legal proposals	Whether research outputs converted to legal proposals (such as advocating for ocean conservation policies, proposals by National People's Congress representatives)	Dissemination of outputs

(Continues)

TABLE 2 (Continued)

Variable	Definition	Description and reference
Conversion approaches	The number of conversion approaches for the scientist's research results related to marine conservation as mentioned above	Dissemination of outputs
Communication capability	Scientists believe that their ranking in terms of the capability to communicate research findings in the field of marine conservation compared with domestic scientists in the same field	Communication capability
Primary communication channel	The most important channel for the dissemination of research results related to marine conservation	Communication channel

organizational information kept confidential. For NGO participants, we requested organizational information rather than personal details. Thus, we invited only one participant (mainly the leader) from each NGO to complete the questionnaire (see Supporting Information S1).

2.4 | Correlation analyses

We conducted Spearman's rank correlation tests to identify continuous or ordered variables that were significantly correlated with the PSII and to examine correlations between the selected variables. For categorical variables, we used Kruskal–Wallis tests to determine whether there were significant differences in PSII among different groups. These analyses were conducted in R using the "stats" package (R Core Team, 2023). A correlation heat map illustrating the relationships was generated using the "ggcorrplot" package (Kassambara, 2022). To validate the reliability of PSII, we constructed linear models between PSII and the self-evaluation score for the social influence of scientists and NGOs.

2.5 | Generalized linear models (GLM)

We used Shapiro–Wilk tests to assess the normality of the PSII for scientists and NGOs, respectively, and the results indicated that both response variables followed a normal distribution. Subsequently, variables that were significantly correlated with the PSII were selected, and a GLM based on the Gaussian function was constructed with the data for scientists and NGOs, respectively. We applied a backward recursive stepwise regression to select variables based on the Akaike Information Criterion (AIC) to obtain an optimal simplified model.

2.6 | Pathway analyses

We employed the piecewise structural equation model (PSEM) to conduct a pathway analysis on the variables that potentially have a causal relationship with PSII for scientists and NGOs, respectively (Lefcheck, 2016). Unlike traditional SEM, PSEM converts each path diagram into a set of (structured) linear equations and independently estimates them, which is beneficial for fitting data with various distributions (normal or nonnormal) and sampling designs (Shipley, 2000, 2009). Furthermore, in theory, PSEM is capable of fitting smaller datasets as fitting specific component models only requires a sufficient number of degrees of freedom (Shipley, 2000), usually five times the number of variables included in each equation (Grace et al., 2015). In our PSEM, we first constructed a linear model based on the structure of the optimal GLM mentioned above. Then, for each independent variable in the optimal model, we built separate linear regression models using other variables that exhibited significant correlations and potential causal relationships with that variable. We employed the d-separation test to assess if any missing critical paths should be added or whether any additional paths should be excluded (Shipley, 2013). We used the Fisher's C and p values of the test to assess the goodness of fit, with a p-value > 0.05 indicating that the model fit is adequate (Lefcheck, 2016). We carried out these analyses in R with the 'piecewiseSEM' package (Lefcheck, 2016).

3 | RESULTS

We eventually obtained reliable data from 29 scientists and 31 NGOs (valid response rates of 41% and 28%, respectively). Although the sample sizes were small, most of their profile variables (e.g., age, years of experience) were normally distributed (Shapiro–Wilk tests, $p > 0.05$) or not significantly different between groups. These participants represented diverse groups in terms of their primary research or concerned areas and their geographic locations (see details in Supporting Information, Tables S3 and S4, Supporting Information S1: Figure S1). The PSII for scientists (mean ± SD, 2.80 ± 0.89, $N = 29$) and that for NGOs (2.95 ± 1.08, $N = 31$) were normally distributed (Shapiro–Wilk tests, $p > 0.05$). The profiles of the scientists and NGOs investigated suggest minimal

TABLE 3 Initially defined influence variables of nongovernmental organizations (NGOs).

Variable	Definition	Description and reference
Years	Number of years of experience	Profile of the team
Gender	Gender of the leader	Profile of the leader
Age	Age of the leader	Profile of the leader
Education	Education level of the leader	Profile of the leader
Government working experience	Whether the leader has government working experience	Profile of the leader. Previous studies indicate that the initial systems and resource strategies of an NGO might be strongly influenced by the institutional management experience of its founders. These systems and strategies may change as leaders gain new experience or skills (Hsu & Jiang, 2015).
Enterprise working experience	Whether the leader has enterprise working experience	
Research institute working experience	Whether the leader has research institute working experience	
Foundation working experience	Whether the leader has foundation working experience	
Community working experience	Whether the leader has community working experience	
NGO working experience	Whether the leader has NGO working experience	
Other working experience	Other working experience of leader	
Lack of experience	Lack of experience working in the aforementioned institutions	
Dedication	Degree of dedication to marine conservation, measured by the proportion of projects or activities focusing on marine conservation	Profile of the team. The higher proportion of marine conservation activities carried out by nongovernmental organizations may indicate that the organization is more dedicated to marine conservation.
# of full-time staff	Number of full-time staff	Profile of the team
# of part-time staff	Number of part-time staff	Profile of the team
# of volunteers	Number of volunteers	Profile of the team. Volunteers are vital to the sustainability of NGOs and communities (Ilyas et al., 2020).
% of females	Proportion of females in management personnel	Profile of the team
Average age of managers	Age range of management personnel	Profile of the team
Education of managers	Education level of management personnel	Profile of the team
Knowledge of natural sciences	Knowledge of natural sciences	Profile of the team. The expertise and skills of an organization in marine science, biology, ecology, and other related natural disciplines greatly contribute to its professional conduct of marine conservation activities. Additionally, the organization's ability to raise funds, manage projects, build partnerships, and associated social science expertise directly influence its capacity to effectively operate and carry out projects in the field of marine conservation.
Knowledge of social sciences	Knowledge of social sciences	
Partnership establishing capability	Partnership establishing capability	
Fundraising capability	Fundraising capability	
Project management capability	Project management capability	
Innovation capability	Innovation capability	
Annual fund	Annual fund for marine conservation projects over the past 5 years	Profile of the team. Financial are vital to the sustainability of NGOs (Ilyas et al., 2020).
# of participants	The number of participants engaged in marine conservation projects per year	Profile of the team
Spatial scope	Major spatial scope of marine conservation projects	Profile of the team

(Continues)

TABLE 3 (Continued)

Variable	Definition	Description and reference
Registration type	Registration type of the NGO	Profile of the team
Primary concerned area	Primary concerned area in marine conservation by the NGO	Profile of the team. Studies have shown that the attractiveness of a species greatly increases support for its conservation (Gunnthorsdottir, 2001), so NGOs working in different areas within the conservation field or focusing on different species may receive varying degrees of public attention and, in turn, generate varying degrees of social influence.
Primary activity area	Primary activity area for conducting marine conservation projects	Profile of the team
Primary working method	Primary methodology utilized by the NGO in carrying out marine conservation-related projects.	Profile of the team
Primary collaborator	Primary collaborator in marine conservation projects	Profile of the team
Frequency of collaboration	Frequency of collaboration in marine conservation projects	Profile of the team
Performance	Performance of the NGO in marine conservation	Profile of the team
% of conservation practice	Proportion of conservation practice in all activities	Profile of the team
% of policy advocacy	Proportion of policy advocacy in all activities	Profile of the team
% of compliance supervising	Proportion of compliance supervising in all activities	Profile of the team
% of public service	Proportion of public service in all activities	Profile of the team
% of popular science	Proportion of popular science promotion in all activities	Profile of the team
% of scientific research	Proportion of scientific research in all activities	Profile of the team
% of other activities	Proportion of other activities	Profile of the team
Primary communication channel	The most important channel for the dissemination of information related to marine conservation	Communication channel
Year of the primary communication channel putting into use	The year in which the primary communication channel was put into use	Communication channel
Communication capability	NGOs believe that their ranking in terms of communication capability in the field of marine conservation compared with domestic NGOs in the same field	Communication capability

sampling bias in the collection of samples. Both self-evaluation scores of scientists and NGOs were linearly correlated with the corresponding PSII (adjusted $R^2 = 0.58$ and 0.51; both $p < 0.001$) separately (Supporting Information S1: Figure S2).

3.1 | Variables significantly correlated with the PSII

We found that 9 out of 16 continuous or ordered variables had significant correlations with the PSII of scientists, and 14 out of 38 continuous or ordered variables with the PSII of NGOs (Spearman's correlation tests, all $p < 0.05$, Figure 2a,b, Supporting Information S1: Tables S5 and S6). The values of PSII did not significantly differ among the groups of each categorical variable (e.g., primary concerned area, primary collaborator, primary communication channel, registration type, primary activity area, primary working method, Kruskal–Wallis tests, all $p > 0.05$). Therefore, only the 9 and 14 continuous/ordered variables were further used in the following analyses.

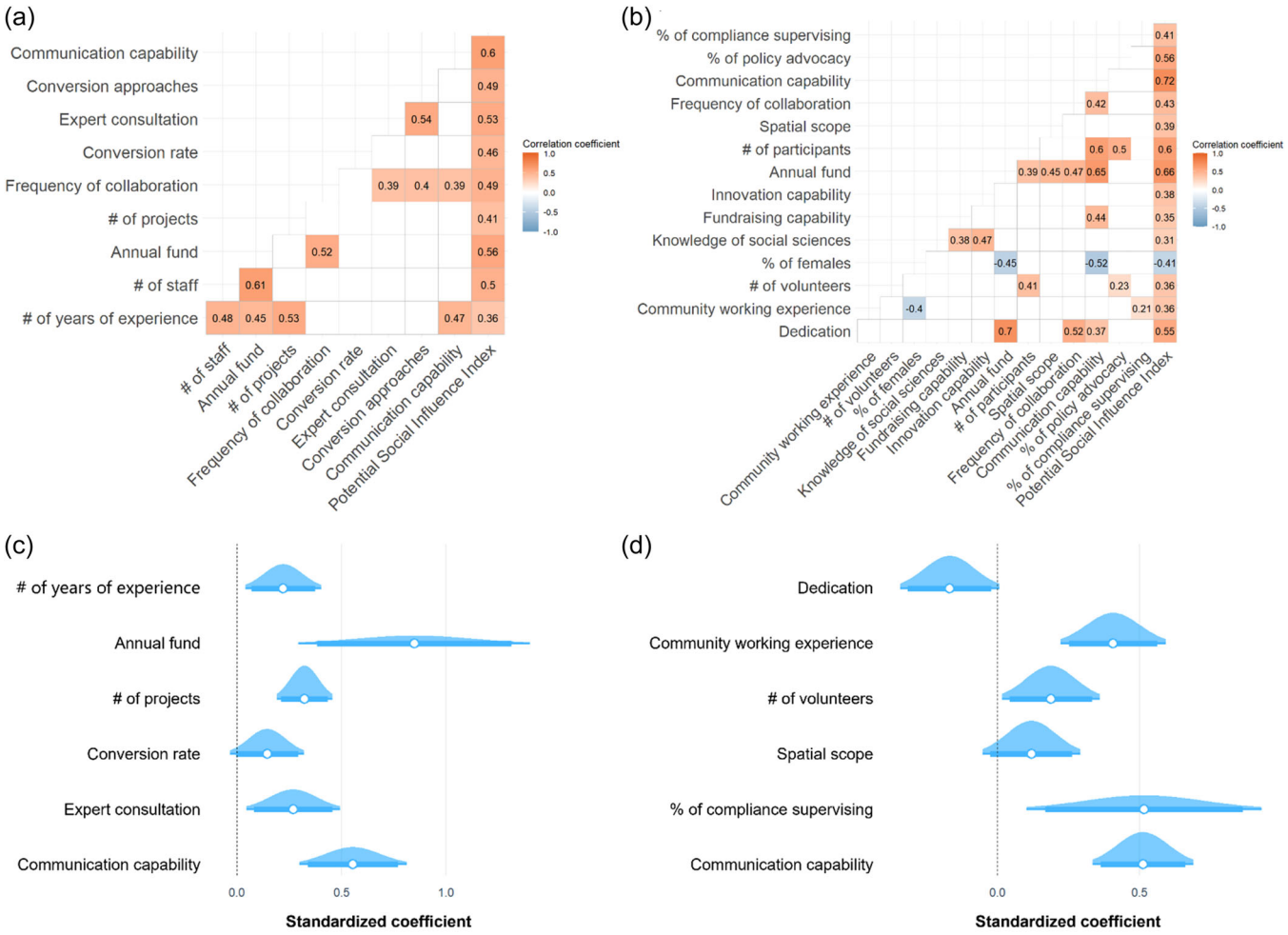

FIGURE 2 Correlation matrix of variables significantly correlated with the potential social influence index (PSII) of (a) scientists and (b) nongovernmental organizations (NGOs), respectively (orange, positive correlation; blue, negative correlation). Standardized coefficients (estimates on the *x*-axis) of the selected variables in the optimal generalized linear model (GLM) models for the PSII of (c) scientists and (d) NGOs. Standardized coefficients overlapping the dashed line 0.0 represent that the coefficient is not significant. (a) The correlation coefficients of nine variables that had significant correlations with the PSII of scientists. (b) The correlation coefficients of 14 variables that had significant correlations with the PSII of NGOs. (c, d) The standardized coefficients of six variables in the optimal GLM models for the PSII of scientists and NGOs, respectively.

3.2 | Optimal GLMs for scientists and NGOs

For the scientists' model, six out of the nine selected variables were retained in the optimal GLM ($AIC_{optimal\ model}$ vs. $AIC_{full\ model}$, 42.59 vs. 46.79; Figure 2c, Supporting Information S1: Table S7). The communication capability and expert consultation had the highest positive effects on the PSII of scientists ($\beta_{standardized} = 0.512$ and 0.516, respectively; both $p < 0.05$), followed by the amount of annual funding and number of projects ($\beta_{standardized} = 0.407$ and 0.187, respectively; both $p < 0.05$). Overall, the optimal model explained 88% of the variance in the PSII for scientists.

For NGOs, 6 out of the 14 selected variables were retained in the optimal GLM ($AIC_{optimal\ model}$ vs. $AIC_{full\ model}$, 56.13 vs. 65.81; Figure 2d, Supporting Information S1: Table S7). The community working experience (of an NGO's founder) had the highest positive effect on PSII of NGOs ($\beta_{standardized} = 0.849$, $p < 0.01$), followed by communication capability ($\beta_{standardized} = 0.555$, $p < 0.001$), the number of volunteers ($\beta_{standardized} = 0.324$, $p < 0.001$), the proportion of compliance supervising activities in all activities ($\beta_{standardized} = 0.270$, $p < 0.05$), and so on. Overall, the optimal model explained 85% of the variance in the PSII for NGOs.

3.3 | Pathways driving social influence of scientists and NGOs

The PSEM for scientists adequately fit the data (Fisher's $C = 22.08$, $p = 0.905 > 0.05$, $AIC = 350.20$, $N = 29$). Based on this model, eight pathways were statistically significant, including one added pathway suggested by the d-separation test, while six other pathways did not achieve statistical significance (Figure 3a, Supporting Information S1: Table S8). The variables communication capability, annual funding, and expert consultation had direct positive effects on the PSII of scientists ($\beta_{standardized} = 0.273$–$0.575$, all $p < 0.05$; Supporting Information S1: Table S8).

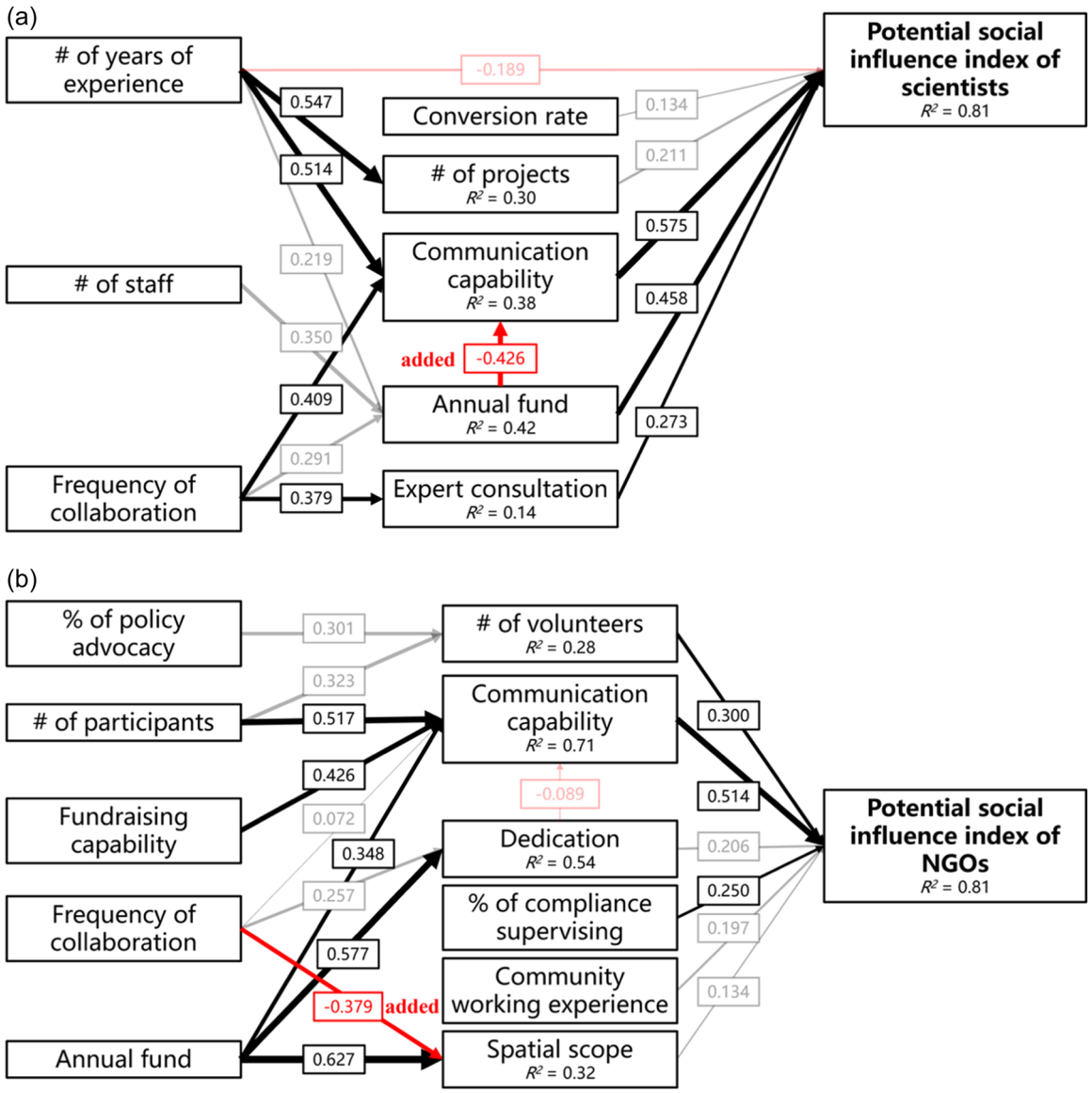

FIGURE 3 The piecewise structural equation model (PSEM) for potential social influence index (PSII) of (a) scientists and (b) nongovernmental organizations (NGOs). Big boxes represent measured variables. Small boxes with values represent the standardized regression coefficients ($\beta_{standardized}$) of the paths. Arrows represent unidirectional relationships among variables. Black arrows denote positive relationships, and red arrows negative ones. Arrows for nonsignificant paths ($p \geq 0.05$) are semitransparent. The thickness of the significant paths has been scaled based on the magnitude of the $\beta_{standardized}$, given in the associated box. The pathways detected by d-separation tests were annotated as "added."

Surprisingly, annual funding negatively influenced scientists' communication capability ($\beta_{standardized} = -0.426$, $p < 0.05$), and indirectly affected the PSII ($\beta_{standardized} = -0.245$, $p < 0.05$). Nevertheless, the total effect (direct and indirect combined) of annual funding remained positive ($\beta_{standardized} = 0.213$). The frequency of collaboration positively and strongly influenced scientists' communication capability ($\beta_{standardized} = 0.409$, $p < 0.05$) and their participation in expert consultation directly ($\beta_{standardized} = 0.379$, $p < 0.05$), and indirectly affected the PSII ($\beta_{standardized} = 0.337$, $p < 0.05$). The number of years of experience had a strong positive effect on the number of projects ($\beta_{standardized} = 0.546$, $p < 0.05$) and scientists' communication capability ($\beta_{standardized} = 0.514$, $p < 0.05$), indirectly affecting the PSII ($\beta_{standardized} = 0.296$, $p < 0.05$).

Similarly, the PSEM for PSII of NGOs also sufficiently fit the data (Fisher's $C = 40.274$, $p = 0.963 > 0.05$, AIC = 913.87, $N = 31$). We found nine pathways to be statistically significant, including one added pathway identified by the d-separation test, while eight other pathways did not achieve statistical significance (Figure 3b, Supporting Information S1: Table S9). The communication capability, the number of volunteers, and the proportion of supervision activities had significant positive effects on the PSII of NGOs ($\beta_{standardized} = 0.250$–$0.514$, all $p < 0.05$). The number of participants (engaged in NGO's activities), fundraising capability, and annual funding significantly and positively affected the communication capability of NGOs ($\beta_{standardized} = 0.348$–$0.517$, all $p < 0.05$). Annual funding directly affected the dedication, the spatial scope (of conducted marine-conservation projects), and communication capability ($\beta_{standardized} = 0.348$–$0.577$, all $p < 0.05$); it also had a significant indirect effect on

the PSII of NGOs ($\beta_{standardized} = 0.179$, $p < 0.05$). Frequency of collaboration significantly and negatively influenced the spatial scope ($\beta_{standardized} = -0.379$, $p < 0.05$).

4 | DISCUSSION

Global marine conservation requires more contribution from scientists and NGOs (Bickford et al., 2012; Cadman et al., 2020), as their social influence on multistakeholder decision-making is key in this process but has rarely been investigated. Here, to the best of our knowledge, we are among the first to conduct such research using a novel framework (Cadman et al., 2020; Vance-Borland & Holley, 2011). We provide useful indices (i.e., PSIIs) to rapidly assess the potential social influence of scientists and NGOs in marine conservation for China—a nation that urgently needs more substantial contributions from these groups to meet the CBD's new ocean targets (Jiang et al., 2015). We identified a pool of useful PSII predictors that can be used in future studies in other countries. Importantly, our research demonstrated that both communication capability and annual funding have strong positive effects on the potential social influence of scientists and NGOs in marine conservation, suggesting that these two factors play vital roles in achieving social influence (Barel-Ben David et al., 2020; Jacob & Lefgren, 2011). However, our study also showed that the pathways driving potential social influence differ between scientists and NGOs. Despite the limited sample sizes, our results represent the best current understanding of which variables influence the social impact of scientists and NGOs, and how these variables operate in a country where advancing marine conservation is urgently needed. The framework we initiated here offers insightful guidance for global studies on understanding the social influence of scientists and NGOs in nature conservation in general.

4.1 | Evaluating the social influence of scientists and NGOs in marine conservation

Evaluating the social influence of scientists and NGOs in marine conservation is challenging due to varying definitions of influence among the many different stakeholders engaged in conservation. The indicators selected to quantify influence do not equate directly to social influence but can provide some indication of implied or potential influence (Lavery et al., 2021). Theoretically, evaluating social influence upon decision-making may require long-term monitoring to establish causal relationships between the outputs of scientists and NGOs and actual changes in (1) government officials' decision-making and (2) the daily behaviors of the general public (Tahamtan & Bornmann, 2020). To address this gap, we developed simple indices, that is, PSIIs. Although the indicators used to calculate these indices are not direct measurements of influence, they reflect the potential impact upon both government policy-making and public decision-making or behavior (Bond et al., 2012; Tahamtan & Bornmann, 2020). A questionnaire embedding these indicators enables us to rapidly quantify social influence potential, providing a basis for further examination of the drivers of social influence and the underlying pathways.

We identified useful variables that correlate with the PSII in marine conservation for both scientists and NGOs, filling an essential knowledge gap in conservation social science literature. Previous studies have suggested that annual funding, communication capability, and frequency of collaboration may impact the social influence of scientists (Fortunato et al., 2018; Jacob & Lefgren, 2011). Our research provides direct evidence to support the usefulness of these variables. Additionally, we are among the first to show that other variables, such as conversion rate from research to practical conservation and the number of years of experience in conservation, are also associated with the PSII of scientists. For NGOs, likewise, we are the first to validate the usefulness of several previously suggested variables, such as the number of volunteers and annual funding (Ilyas et al., 2020). For the first time, we also find that some rarely studied variables (e.g., dedication to conservation, community working experience, fundraising capability, and innovation capability) are positively correlated with the PSII of NGOs in marine conservation, suggesting these should be considered in future studies. Interestingly, our research sample included fewer female scientists than males (Supporting Information S1: Tables S3 and S4), reflecting the gender imbalance in oceanographic subdisciplines in China and many other countries (Giakoumi et al., 2021; Legg et al., 2023). Despite this, we encourage more women to take leading roles in marine conservation to increase social equity (Giakoumi et al., 2021). Our findings show that the PSII of females (either as a scientist or a leader of an NGO) is comparable to their male peers, supporting evidence that women's engagement can improve conservation outcomes (Vollan & Henry, 2019; Westermann et al., 2005). Surprisingly, the portion of females in the management personnel of Chinese marine NGOs was negatively correlated with the PSII of the organizations. Future research efforts (including increased sample sizes) are needed to investigate this finding further.

4.2 | Mechanisms of social influence in marine conservation

Our results indicate that increasing annual funding, communication capability, and expert consultation

may enhance scientists' social influence in marine conservation. Increased funding often leads to more research publications and citations, thereby promoting social influence (Heyard & Hottenrott, 2021). Nonetheless, we show that annual funding negatively influences communication capability, which seems to contradict previous studies (Heyard & Hottenrott, 2021; Jacob & Lefgren, 2011). A probable explanation is that raising and managing more annual funding might overwhelm scientists, requiring them to allocate more time to research and less time to conservation outreach, an avenue through which scientists usually practice and improve their communication capability. Scientists often face challenges in science communication as the general public may not recognize or support biodiversity conservation efforts (Bickford et al., 2012). Therefore, scientists should seek partnerships and collaborations with more skilled communicators to proactively increase the public's environmental literacy through effective communication and outreach (Bickford et al., 2012; Pavlov et al., 2018). Through the consulting process, scientists can play a vital role in marine conservation by providing insightful suggestions (Bhola et al., 2021; Enríquez-Andrade et al., 2005). Institutional reward systems within academia should encourage scientists to conduct conservation outreach and policy advocacy, regarding these activities as being on a level with academic publications (Bickford et al., 2012). While such systems are being gradually introduced, it is too soon to evaluate their impact.

For NGOs, our findings suggest that higher communication capability, more volunteers and participants in activities, more compliance supervising activities, and increased annual funding can lead to a higher social influence. It is not surprising that communication capability is vital to the social influence of NGOs. Our quantitative findings on volunteers and annual funding are consistent with a previous qualitative study, which revealed that the strategies NGOs employ in volunteer engagement and financial sustainability are critical to their success (Ilyas et al., 2020). Larger NGOs, with more volunteers and funds, are more likely to have a higher input of resources and a broader reach, enabling them to achieve higher and broader social influence in raising public awareness of conservation issues and solutions compared to smaller NGOs. However, this does not imply that larger NGOs necessarily have higher social influence than smaller ones such as community-based NGOs, which play important roles in promoting local conservation actions. Additionally, compliance supervising activities of NGOs usually lead to the launch of significant public events (Wu et al., 2017). The broad dissemination of such events can elevate the social influence of NGOs. Unlike scientists, for whom annual funding can negatively impact communication capability, NGOs can indirectly enhance their social influence through increased funding, which positively impacts their communication capability. This is not surprising considering that NGOs predominantly focus on conservation outreach and actions rather than conducting research, which is more crucial to scientists. Therefore, more funds can allow NGOs to practice and improve communication skills across more projects.

4.3 | Usefulness and caveats of our analytical framework

We pioneered the development of a practical analytical framework that facilitates the comprehension of the social influence of scientists and NGOs in nature conservation. This framework provides valuable guidance and critical information for social influence research in relevant fields. We believe that this framework can enhance our understanding of how scientists and NGOs could increase their potential social influence in nature conservation, which may contribute to promoting science-based policymaking and encouraging NGO-involved conservation actions (Rose & Parsons, 2015; White et al., 2023). Knowledge and information disseminated or transferred through policies and media can foster positive changes in stakeholder attitudes and actions toward conservation (Lucrezi, 2022; Nguyen et al., 2023), although this may not always be the case.

Further enhancements are required to extend the applicability of our methods and framework to other related studies. First, we acknowledge that many indicators (e.g., ethnicity, privilege, or political direction) that are potentially correlated with social influence were not examined by our study. The particular indicators used in our study might be more suitable for China than other countries. Future studies should consider indicators that can be locally applicable and may involve weightings if their importance can be objectively quantified. Second, future studies employing our framework should collect more samples. When sample sizes are large enough (e.g., $n > 100$), other methods could be incorporated into our framework. For instance, principal component analysis (PCA) can be used to identify latent variables to build structural equation models (Lefcheck, 2016); mixed-effect models may also be useful to distinguish fixed effects from random effects on social influence (Mahmoodi et al., 2018). Third, academics and NGOs could possibly have a long-term impact on a specific local area that may not be reflected in policy radar, media coverage, or academic conferences. At present, our proposed framework for rapid evaluation of potential social influence does not extend to measuring these more subtle forms of influence, which may be addressed in future research. Moreover, it should be noted that social influence is not always positive and may not lead to increased conservation awareness or successful conservation outcomes (Bergman et al., 2022; Kaplan-Hallam & Bennett, 2018). Although we used a self-evaluation on social influence to verify the PSII, future research may focus on linking the PSII or its indicators with changes in

conservation behavior, awareness, and outcomes to validate the use of this index. Nevertheless, we believe that our study's framework can serve as a cornerstone to inspire more sophisticated and meaningful analyses of social influence in nature conservation.

AUTHOR CONTRIBUTIONS

Minhui Li: Data curation; formal analysis; visualization; writing—original draft. **Tien M. Lee**: Conceptualization; writing—review and editing. **Xiong Zhang**: Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; software; supervision; validation; visualization; writing—review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

All data and R code used in our analyses are available from Figshare (DOI:10.6084/m9.figshare.24076245).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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