frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 11 January 2024
DOI 10.3389/fenvs.2023.1335569

OPEN ACCESS

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RECEIVED 09 November 2023
ACCEPTED 22 December 2023
PUBLISHED 11 January 2024

CITATION
Jiang T, Gao H, Chen G, Dai X, Xu W and Wang Z (2024), The complexity of environmental policy implementation in China: a set-theoretic approach to environmental monitoring policy dynamics.
Front. Environ. Sci. 11:1335569.
doi: 10.3389/fenvs.2023.1335569

The complexity of environmental policy implementation in China: a set-theoretic approach to environmental monitoring policy dynamics

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The implementation of environmental monitoring policies is of great significance in reducing pollution and improving the ecological environment. This study looks at three dimensions of Sabatier's policy environment framework: the tractability of the problem, the ability of the statute to structure implementation, and non-statutory variables, explores in detail the complex configuration of technology availability, change required, financial resources, implementing officials, public support, and socio economic conditions. The results based on data from 30 provinces in China identify four different combinations of conditions that match "Opinions on Deepening the Reform of Environmental Monitoring and Improving the Quality of Environmental Monitoring Data" environmental monitoring policy implementation: "priority governance" means that the change required is the most important variable in high-pollution provinces, "money talks" suggests that financial resources are a more important condition in north-western provinces, "coordinated implementation" is associated with non-statutory variables such as public support and socio-economic conditions being neither sufficient nor necessary conditions; and when both the ability of the statute and nonstatutory variables were identified as necessary conditions, as in the capital city, this is termed the "comprehensive strategy".

KEYWORDS

public policy, environmental monitoring policy implementation, fs-QCA, policy implementation process, configuration combination

1 Introduction

In recent years, China's rapid economic development and environmental pollution problems have become increasingly prominent, and the implementation of environmental monitoring policies is of great significance in reducing pollution and improving the ecological environment. The Chinese government has issued a series of environmental protection policies and regulations, of which environmental monitoring policy is an important part, and its implementation is directly related to the implementation of environmental protection policies. In addition, the continuous progress of environmental monitoring technology and the accumulation of environmental monitoring data provide more possibilities and challenges for the implementation of

environmental monitoring policies. Not only that, the international community is increasingly concerned about environmental issues, and the study of China's environmental monitoring policy implementation also needs to consider the trends and requirements of international environmental governance. Therefore, an in-depth study on the implementation of China's environmental monitoring policy will help improve the environmental monitoring policy system, enhance the effectiveness of the implementation of environmental monitoring policy, and promote the practical advancement of environmental protection.

Studying environmental monitoring policy implementation and evaluating its determinants is an important topic in public policy research (Swanson et al., 2001; Vesterager et al., 2016; Howes et al., 2017; Zhang and Yao, 2018). Sabatier and Mazmanian (1980) proposed a policy implementation framework by examining the stages of different factors and the achievement of statutory objectives. A series of studies followed their original research and studied the effects of factors such as stakeholder participation, economic conditions, technology and human resources (Challies et al., 2017; Klaster et al., 2017; Teodoro et al., 2018). Another strand of the literature studied implementation strategies and focussed particularly on the influence of different conditions (Ingram, 1990; Matland, 1995; Li et al., 2023). A number of variables such as interest group pressure (Lundin, 2007; Sharp et al., 2011), central government support (Zhan et al., 2014), and implementing officials (Sabatier, 1986) have been analysed.

The majority of recent studies have used case analysis to indicate whether the framework in question has been successfully applied (Sabatier, 1986). A key problem with much of the literature on environmental monitoring policy implementation is that the conclusions drawn from case studies are inspiring but have limited generalizability (Wang, 2016; Wang and Zhou, 2022). Second, conventional statistical analysis is limited when attempting to test the complex causal relations among explanatory variables (Fiss, 2011). Although scholars have begun to focus on individual policy implementation variables (Tuokuu et al., 2018), more research is needed to cover the effects of various combinations of conditions. Third, most empirical research on the variables involved in policy implementation has been based on the US or European countries, and we know little about whether this framework is applicable to developing countries such as China.

With the continuous promotion of ecological civilisation construction in various countries, the breadth and depth of the implementation of various types of environmental policies are continuously extended, and in this process, the factors affecting the implementation of environmental policies can not be ignored more and more. The policy implementation framework based on Sabatier scholar has been widely applied in many fields such as agriculture, education, medical care, laws and regulations. For example, Yang and Huang (2022) explored the historical evolution of rural teacher supplementation policy based on the Sabatier policy implementation framework, and Foley, 2015 scholar explored the practice differentiation of the implementation of poverty subsidy policy in township secondary schools based on the Sabatier framework model in the context of education poverty alleviation (2015). In the field of agriculture, Montefrio and Sin., 2021 explored the effectiveness of the implementation of the policy based on the practice of facility-based agriculture policy on the farms and the landing situation, for example, (2021). In addition, Li et al., 2022 scholars explored the influencing factors of poverty alleviation policy implementation in poverty-stricken areas based on the policy implementation framework (2022); in the medical field, Gauthier-Beaupré et al., 2023 explored the evolution of medical and health policies based on the evolution and development of Sabatier's framework (2022). Comprehensively, it is not difficult to find that the Sabatier policy implementation framework is a good guide for scholars to understand the influencing factors affecting policy implementation. However, with the passage of time and the change of application scenarios, it is not yet known whether the Sabatier policy implementation framework is suitable for exploring the effectiveness of environmental monitoring policy implementation in the Chinese context. Most of the existing studies have been conducted on the basis of the original framework, and there is no answer to the question of whether there are interactions between the influencing factors and whether their combination and configuration have an impact on policy implementation.

Based on this, this article attempts to further the study on environmental monitoring policy implementation by developing configuration theories for policy implementation. We use a set-theoretic approach. Fuzzy set qualitative comparative analysis (fs-QCA) enables us to address equifinality, conjunctural causation, and asymmetric relations among explanatory variables (Meuer and Rupietta, 2017). In addition, this article is based on the cases of 30 Chinese provinces in 2016, which provides an opportunity to test the factors and framework developed for analysing Western societies.

2 Theoretical framework

Although an enormous amount of research has been conducted on policy implementation, there are few synthetic theories that integrate most of the approaches. The top-down and bottom-up perspectives of policy implementation offer different explanations for implementation strategies. Scholars examining commitment-oriented hypotheses scholars have sought to identify the best way to move from a policy proposal to successful implementation (DeLeon and DeLeon, 2002). The top-down approach emphasizes centrally defined policy intentions and their hierarchical execution (Treib, 2006). Sabatier and Mazmanian (1980) performed a pioneering study on public policy implementation and developed a conceptual framework that consists of the tractability of the problem, the ability of the statute to structure implementation, and non-statutory variables. Sabatier (1986) furthered this research by explaining that each of the policy stages can affect subsequent stages, and he then proposed the six sufficient and generally necessary conditions for effective policy implementation: clear objectives, adequate theory, legal structure, effective implementing officials,

political and public support and stable socio-economic conditions (Wang et al., 2022).

In contrast, the bottom-up perspective contends that street-level bureaucrats represent the key factor in monitoring policy implementation (Hjern, 1982). By arguing that the top-down perspective research focuses mainly on rigorous models but has a misplaced focus, the bottom-up perspective assumes that environmental monitoring policy implementation should combine freedom and capacity for action (Sevä and Jagers, 2013). The main difference between the two perspectives is whether policy implementation needs to be included in policy formulation (DeLeon and DeLeon, 2002). In line with previous policy implementation research, in this article, we define environmental monitoring policy implementation as environmental monitoring laws being translated into implemented programs.

The reasons for selecting the Sabatier and Mazmanian (1980) policy implementation process as the major theoretical framework in this article were as follows. Firstly, an increasing number of studies have found that Chinese policies are generally formulated by the central government, while local officials simply implement the policy (Manion, 1991; Zhou, 2010; 2017), and the Communist Party of China always provides overall leadership and coordinates the efforts of all involved. Additionally, in such a governing system, the top-down perspective will help us to illustrate the factors involved in the policy implementation process. Secondly, the framework analyses the interactions among different factors throughout the policy implementation process, which is the focus of the present article. By identifying the complex causal relations involved in environmental monitoring policy implementation, this framework provides the basic foundation for this study and offers opportunities for further modifications.

While Sabatier and Mazmanian (1980) illustrated in considerable detail why the tractability of the problem, the ability of the statute to structure implementation and non-statutory variables affect policy implementation, this article outlines these aspects only briefly and instead focuses on explaining how the policy implementation framework differs across the three stages. To further develop the theory of environmental monitoring policy implementation, I provide further details on these three aspects with respect to the Chinese cultural context, as explained in the following sections. Firstly, I suggest different explanations for the six necessary variables for monitoring policy implementation. Secondly and more importantly, I introduce a framework based on set theory that accounts for the causal complexity of environmental monitoring policy implementation.

2.1 Tractability of the problem

The tractability of the problem is probably the most commonly studied variable in the public policy implementation literature. The tractability of the problem consists of the aspects of problems affecting the ability of policy implementers to achieve the policy's objectives and concerns the inherent nature of the problem involved (Lester and Bowman, 1989). The tractability of the issue refers to the explicitness of the issue with respect to the policy, which is addressed in statutory objectives (Ma, 2008). It concerns social problems instead of governmental programs or governments *per se*, and social problems can affect the ability to implement an environmental policy with respect to an individual variable or in the aggregate. The summary index of tractability includes four variables, namely, technical theory and technology, target group behaviour, the percentage of the target group, and the extent of behavioural change required (Sabatier and Mazmanian, 1980). The framework employed in this article holds that factors affecting the ability to implement policy can be divided into two aspects. The first is technology availability, which concerns developing the necessary technology to enable target groups to achieve the desired objectives. The second aspect is the extent of behavioural change required.

2.2 Technology availability

The typical assumption in the literature is that some time is required to develop the necessary level of technology availability to implement environmental policy. For example, being able to reduce in sulphur emissions is contingent upon having the technology needed for removing sulphur from the emissions of power plants. Technical problems could lead to implementation failure, such as mechanical malfunctions (Matland, 1995; Zhang et al., 2022). Firms in China that pass compulsory cleaner production audits and evaluations have demonstrated their ability to overcome technological difficulties. A study on the effect of technology availability in the context of hazardous waste control demonstrated that effective implementation is based on finding reliable and applicable technology (Lester and Bowman, 1989; Zeb et al., 2023). We therefore expect that in the absence of the specific technologies required, the target group's behaviour will not achieve the program objectives. Firms that pass compulsory cleaner production audits and evaluations demonstrate technology availability because these companies have the ability to overcome technological difficulties.

2.3 Change required

The change required represents how extensive the amount of behavioural change required by target groups is. In this context, "micro-issues" refer to rare situations and imply only negligible costs, while "macro issues" related to frequently occurring situations and impose substantial requirements on the target group (Thomann et al., 2019). The goal of reducing the number of heavy-pollution days provides an example of the visibility of and the importance attached to statutory objectives. The greater the number of heavy-pollution days, the more difficult implementing such a policy will be (Sabatier and Mazmanian, 1980); the basic hypothesis here, of course, is that the greater the number of heavy-pollution days in a province, the more substantial the behavioural change necessary to reduce them will be. However, some polices that demand substantial behavioural change seem to be implemented quite smoothly

(O'Toole, 1986). In such a case, the "noncompliance delay effect" would have a greater impact on policy implementation than the degree of behavioural change required (Durant, 1984).

2.4 Ability of the statute to structure implementation

According to the Sabatier and Mazmanian (1980) policy implementation process framework, the ability of the statute to structure implementation is the fundamental category in determining the success of the policy implementation. The ability of a statute to affect policy implementation includes the extent to which different variables structure the implementation process, such as the financial resources available to the implementing agency and the implementing officials being committed to the statutory objectives.

2.5 Financial resources

Financial resources concern the amount of funding local environmental protection boards (EPBs) receive from local governments or superior agencies. Obviously, money is important for any program. For example, money is important to purchase environmental monitoring equipment and hire the staff involved in the implementation process, technical analysis, program administration and monitoring. Research has shown that cutbacks in environmental expenditures have negative implications for hazardous waste control (Lester, 1986). It is necessary to have a threshold level of funding available to achieve policy objectives, and traditionally, the operationalization of financial resources is measured by the total financing the government provides to the provinces (McFarlane, 1989). To measure the financial resources invested in environmental policy, this study considers environmental investment needed in an area divided by gross domestic product (GDP). In the Chinese context, investment in environmental pollution treatment is an important way for local EPBs to obtain funding. I also include a financial resource among the statutory variables.

2.6 Implementing officials

A top-down perspective suggests that the implementing agencies and officials being committed to statutory objectives is important for achieving these policy targets. The bottom-up perspective contends that identifying the micro-level contextual factors at the local level is also important for policy outcomes (Matland, 1995). The implementing officials represent the micro-level that directly affects target groups. Street-level bureaucrats, first-line managers, and middle managers are the three main groups involved in implementation (Gassner and Gofen, 2018).

In other words, the actors involved in the policy implementation process must understand the policy to understand how to implement it. Implementing officials need to translate formal policy decisions into daily tasks before being able to directly deliver multiple policies (Gassner and Gofen, 2018). In the present work, the implementing officials variable measures the extent to which the policy implementors understand the statutory objectives, which requires solid legal and technical knowledge. In most environmental policy programs, for example, the target groups are not particularly familiar with legal issues and do not generally have a specific target to pursue in their activities. By contrast, implementing officials are intermediary agents that guide firms and help them to translate legislative goals into actual action. Implementing officials need to interact with the target groups, and a number of programs require officials who are familiar with and confident in the statutory objectives. Implementing officials being familiar with environmental policy and having the related skills are critical, and the effort needed to issue an environmental monitoring certificate is considerable.

2.7 Non-statutory variables

Given the assumption that local EPBs attempt to achieve certain goals, we should not only focus on the statutory variables but also consider the non-statutory variables. In other words, variables exogenous to the policy implementation process can determine the successful implementation of public policy. According to Sabatier and Mazmanian (1980), some important variables influence policy implementation, including the relevant socio-economic conditions, media attention, public support, business groups' attitudes, and political support. There are at least two important processes that contribute to the dynamism inherent in implementation. First, successful program implementation demands political support and cooperation or acceptance by many people. Second, the effect of changes in socio-economic and technological conditions influence the reservoir of support for objectives among stakeholders. This article focuses on public support and socio-economic conditions as aspects of the non-statutory variables.

2.8 Public support

There are three types of general public support that can influence policy implementation: public opinion, general constituents, and support for particular policy positions (Sabatier and Mazmanian, 1980). The general public can influence policy implementation because public opinion can affect the political agenda (Burstein, 2003). Greater public support for EU environmental policy played a large part in determining the outcomes of political issues in Europe (Jordan, 1999). Our research focuses on public opinion and its interaction with local EPBs. The official telephone hotline and complaint letters from citizens could easily drive the policy implementation team's monitoring priorities. Moreover, increased citizen complaints and media exposure prompt accelerated policy implementation to avoid criticism (Zhan et al., 2014). General public support can influence environmental monitoring policy implementation through the reporting of polluting activities, including complaint letters and reports through social network reporting platforms. It is easier for citizens to report polluting activities through the WeChat messages

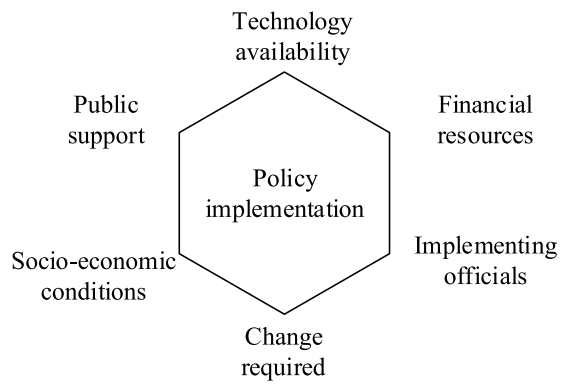

FIGURE 1
Research frame diagram. This is a figure. Schemes follow the same formatting.

forwarded to the responsible local EPBs. The support from interest groups and political facilitate "administrative implementation", and the Chinese general public increased its support for environmental monitoring policy implementation from 2000 to 2006 (Zhan et al., 2014).

2.9 Socio-economic conditions

Obviously, socio-economic conditions can substantially affect environmental monitoring policy implementation since some local governmental leaders care more about industrial development or economic growth. Given the weak authority of local environmental officials in China, it is difficult to implement environmental policy when local governmental leaders care more about economic growth (Lieberthal, 1997). When a local government's top priority is economic development, it will likely be reluctant to give enough support for local EPBs, as economic development targets sometimes conflict with environmental protection (Zhan et al., 2014). In China, local governments have different policy targets because of differences in socio-economic conditions across regions, which may lack the motivation to fully implement environmental policy (O'Brien and Li, 2017). GDP (total or *per capita*) is one of the most popular performance indicators used in regional rankings (Xu, 2011).

2.10 The causal complexity of environmental monitoring policy implementation

As Sabatier and Mazmanian (1980) illustrate in their detailed explanations of the three aspects, the combined effects of the tractability of the problem, the ability of the statute to structure implementation and non-statutory variables are decisive for the policy implementation. In other words, environmental monitoring policy implementation is affected by the different combinations of these three aspects. Sabatier (1986) explains that each of stage can affect subsequent stages. Based on this framework for the policy implementation process, it has been suggested that identifying these variables is a useful approach to analysing environmental monitoring policy implementation. This results in five stages of the implementation process that are affected by the specific variables. However, I argue that the skeletal flow diagram does not fully capture the causal complexity of environmental monitoring policy implementation, which is why I develop a more elaborated conceptual framework (see Figure 1).

This framework of environmental monitoring policy implementation is rooted in set theory, which implies that, according to set theory, policy implementation consists of six variables: technology availability, change required, financial resources, implementing officials, public support and socio-economic conditions (Sabatier and Mazmanian, 1980). To explain these six core variables in set theory, I refer to the example of studying environmental monitoring policy implementation.

First, policy implementation is not simply the opposite of failed implementation. "Policy implementation is constrained by changing organizational environments and varied local settings in the real world" (Zhan et al., 2014), which implies asymmetric causal relations between the variables and environmental monitoring policy implementation. This is why the framework is based on the causal asymmetry assumption: the reason that environmental monitoring policy implementation succeeds is not simply the opposite of what explains implementation failure.

Second, it is easier for us to examine the different variables and examine how their interplay affects environmental monitoring policy implementation via the framework. That policy implementation emerges from the intersection of different variables as appropriate preconditions is the basic idea of conjunctural causation (Ragin, 2014). In contrast to previous research, which classifies policy implementation by focusing on the full range of implementation activities (such as the different stages of the policy implementation process), the combinations of conditions of the framework conjointly cause environmental monitoring policy implementation. While the initial framework consisting of the three aspects has already been tested with respect to conjunctural causation, such attempts have been limited to individual variables, by contrast, I attempt to identify the diffident combinations of technology availability, change required, financial resources, implementing officials, public support and socio-economic conditions through a new framework. Based on the above theoretical framework, environmental monitoring policy implementation can reflect a variety of combinations of various types of variables involved and not be limited to individual ones. Furthermore, the framework assumes that the relationships between environmental monitoring policy implementation and the six variables are diverse instead of simply having an interactive effect, as argued in the initial framework. In contrast to the stage-based analysis, where three categories of variables affect the different stages of the policy implementation, the different combinations of the six variables considered here are used in the empirical investigation of environmental monitoring policy implementation.

Third, this article attempts to reveal new explanations for environmental monitoring policy implementation based on the new framework. The empirical part of this article attempts to explain reality and applies the framework to identify which combinations of variables ensure environmental monitoring

policy implementation. Moreover, the framework is also a toolbox of policy implementation strategies that local EPBs can use when determining the set of factors they should consider. In the real world, different provinces apply different sets of strategies to implement policy, which is why I attempt to identify combinations of variables that overlap. The set-theoretic perspective adopted in this analysis unravels the causal complexity of the different combinations of variables and thereby adds value by providing new and more useful strategies for local government agencies.

3 Materials and methods

The theoretical framework for environmental monitoring policy implementation developed in this article is based on configurational theory, which argues strongly for breaking the linear paradigm (Fiss, 2007). Similar to research on the best configurations of human resource management (Huselid, 1995; MacDuffie, 1995), this article applies fs-QCA to analyse environmental monitoring policy implementation. By using Boolean algebra and finding different combinations of variables, fs-QCA could explain the key terms and provides causal complexity (Fiss, 2007; Wang et al., 2023).

This method was chosen because it is one of the most feasible ways to examine the combined effects of given variables on environmental monitoring policy implementation. The traditional linear regression model examines the variation in a single variable in isolation (Ragin and Rubinson, 2009); by contrast, fs-QCA represents a useful alternative to test asymmetric causal relations. A set-theoretic approach illustrates which different configurations of six variables, as shown in the framework, lead to environmental monitoring policy implementation. The different combinations of the six variables are called configurations (Fiss, 2011).

In the initial state of the process, the key feature of fs-QCA research needs calibration. The analysis of identifying thresholds is a semi-empirical process that meaningfully represents differences in degree and in kind among cases (Greckhamer et al., 2018). The core of the test of set-subset relationships is a truth table developed using Boolean algebra. The possible configurations of conditions have a truth table with k conditions and 2k rows. Different conditions represent different configurations. For example, some conditions may account for a large proportion of cases, while other configurations may be represented by fewer or no cases. To identify the model's validity, consistency scores report how consistently given observed configurations are related to the outcome (Greckhamer et al., 2018). In other words, high configuration consistency scores mean that the configurational model exhibits strong explanatory power for the outcome.

Generally speaking, quantitative analyses (primary or secondary data) such as traditional regression methods can solve the one-to-one causal relationship between independent variables and dependent variables, but it is difficult to see the complex causal relationship between multiple antecedent conditions in a combined configuration on the dependent variable. The fsQCA method can better solve this kind of combined configuration relationship. fsQCA method treats the research object (dependent variable) as a grouping of conditions, which helps to analyse the causal complexity problems such as multi-causal concurrency, causal asymmetry and equivalence, and it is suitable for this paper to analyse the relationship between technology availability, change required, financial resources, implementing officials, public support, and the complexity of the dependent variable. Resources, implementing officials, public support, and socio-economic conditions are suitable for this paper's study of the complex relationship between necessity and adequacy of technology availability, change required, financial resources, implementing officials, public support, and socio-economic conditions and the implementation of environmental policy.

Essentially, the aim of fs-QCA is to identify the outcome under different configurations of conditions and consists of two procedures: tests of necessity and sufficiency. Necessity means that the outcome cannot be achieved without the specific conditions, while sufficiency concerns whether a condition or conjunctural causation is a subset of the outcome (Fiss, 2011). Necessity analysis should be conducted before sufficiency analysis (Greckhamer et al., 2018). The necessity and sufficiency relations are analysed by using set-theoretic measures of consistency and coverage (Ragin, 2014). Consistency values express "the proportion of cases exhibiting the configuration that exhibit the outcome" (Greckhamer et al., 2018). Coverage measures the "proportion of cases exhibiting the outcome captured by this configuration" (Greckhamer et al., 2018).

3.1 Operationalization

Because environmental policies in China are typically formulated at the Ministry of Ecology and Environment of the People's Republic of China and implemented by local EPBs, the analysis in this article focuses on the province-level government. Measuring policy implementation is challenging, particularly it is a process for different cases. Data on the number of environmental policy monitoring files and executed cases are direct measures obtained from the China Environment Yearbook. However, the yearbook data are limited when considering the different provinces as the cases, as they cover only the year 2016 and lack information on Tibet. By simultaneously applying framework for all variables, the analysis identifies only the six variables in question and does not consider other indicators not included in the framework.

The analysis refers to 30 province-level cases in China in 2016. We selected the sample size on the basis of the six conditional variables. One rationale for choosing the year 2016 is that the Central Committee of the Communist Party of China established an environmental protection supervision committee in that year. The work of local environmental protection bureaus is heavily influenced by central government support (Zhan et al., 2014). The second reason for choosing 2016 was that the latest China Environment Yearbook, which allowed me to access the feasible combinations of different environmental monitoring policy implementation variables was issued in 2017.

The case selection is also guided by the definition of regulatory implementation. In China, there are at least two dimensions for characterizing implementation strategies (Zhan et al., 2014): the degree of formalism and cooperation with other governments. This article classifies environmental monitoring policy implementation as the number of environmental policy monitoring files divided by

TABLE 1 Operationalization of variables.

	Condition	Definition	Operationalization	Source
Implementation	Environmental monitoring (em)	The environmental laws translated into implemented programs	The percentage of the environmental monitoring policy executed divided by the environmental monitoring policy files	China Environment Yearbook 2017
Tractability of the problem	Technology availability (ta)	Technologies that can help the target groups achieve the desired objectives	The number of the compulsory cleaner production audit and evaluation firms	China Environment Yearbook 2017
	Change required (cr)	The amount of behavioural modification required of target groups	The heavy-pollution days of cities at prefecture and above	China Environment Yearbook 2017
Ability of statute	Financial resources (fr)	The amount of funding for local EPBs	The percentage of total investment for environmental pollution treatment divided by regional gross domestic product (GDP)	China Environment Yearbook 2017/China Statistical Yearbook 2016
	Implementing officials (io)	The extent to which the policy implements understand the statutory objectives	The percentage of the number of environmental monitoring staff with the certificate divided by the total staff numbers	China Environment Yearbook 2017
Non-statutory variables	Public support (ps)	Public opinion that affects the political agenda	The number of reported cases from WeChat divided by the region's total population at year-end	China Environment Yearbook 2017/China Statistical Yearbook 2016
	Socio-economic (se)	Economic development	GDP *per capita*	China Statistical Yearbook 2016

the number of executed cases; the percentage so obtained is the indicator for environmental monitoring policy implementation. Very low percentage scores across suggest that a low level of policy implementation ability with respect to the outcome in question and should be considered.

The outcome variable is the environmental monitoring policy implementation (em), which is measured based on the environmental policy monitoring files. The six different variables in the framework combined form the conditions for analysis: technology availability (ta) indicates the development of technology necessary to achieve the desired objectives; change required (cr) is measured by the number of heavy-pollution days and determines the extent of change; financial resources (fr) denotes the financial support provided for environmental protection; implementing officials (io) indicates the officials familiar with the statutes in question; public support (ps) reflects cases of polluting activities reported by the public; and socio-economic conditions (se) are measured by GDP *per capita*. Table 1 summarizes the operationalization of the data set and the data sources.

To operationalize the tractability of the problem, the first causal condition considered was technology availability. The numbers of compulsory cleaner production audits and evaluation firms were examined. A decade ago, the Chinese government passed a law named the Cleaner Production Audit to encourage companies to improve their technology. Specifically, firms that passed the compulsory cleaner production audit and evaluation consistently have higher technology availability than other firms. Measuring of the extent of behavioural change required is somewhat bit complex, and both the SO_2 and greenhouse gas emissions have been considered (Durant, 1984). The sample in the present study was selected based on the number of heavy-pollution days of cities at prefecture level and above. Having a larger number of heavy-pollution days appears very likely to threaten the successful implementation of environmental policy, as a larger number is associated with increased difficulty. For example, some provinces have more heavy-pollution days, such as Hebei, Henan and Shandong.

This article regards financial resources and implementing officials as statutory variables, and they are measured by the total investment in environmental pollution and the number of environmental monitoring staff members with the relevant certificates, respectively. It is obvious that during the policy implementation process, money is necessary to hire staff and conduct technical analysis. Given the unbalanced economic development in China, I use the percentage of total investment in environmental pollution treatment divided by regional GDP to measure financial resources (McFarlane, 1989). A high percentage indicates substantial financial resources. Because the number of environmental monitoring staff members varies across provinces, I measure implementing officials using the percentage of the number of environmental monitoring staff with a certificate divided by the total number of staff numbers. A high percentage is thus associated with the staff being highly familiar with the relevant legislation.

To operationalize non-statutory aspects, this study measures the percentage of the number of reported cases from WeChat divided by a region's total population at year-end and GDP *per capita* (Zhan et al., 2014). This information was obtained from China Environment Yearbook 2017 and China Statistical Yearbook 2016. However, because GDP indicator does not capture sufficient information about different provinces' economic conditions, I operationalize socio-economic conditions using GDP *per capita* (Xu, 2011). We expect that provinces with high GDP *per capita* belong to high socio-economic condition groups. The provinces located in western regions always have poor socio-economic conditions relative to other provinces.

How do combinations of technology availability, change required, financial resources, implementing officials, public support and socio-economic conditions influence environmental

TABLE 2 Anchors for calibration.

Causal conditions and outcome	Calibration		
	Fully in	Crossover point	Fully out
Implementation (em)	0.80	0.67	0.47
Technology availability (ta)	648.000	236.000	66.500
Change required (cr)	599.500	396.500	126.500
Financial resources (fr)	0.0361	0.024	0.011
Implementing officials (io)	0.923	0.730	0.392
Public support (ps)	1.156	0.753	0.464
Socio-economic (se)	105,970.000	79,811.500	48,992.500

monitoring policy implementation? Although it is difficult to identify all environmental policies, it is possible to analyse environmental monitoring policies in China. Environmental monitoring policy implementation was operationalized in terms of the percentage of policies designated for environmental monitoring divided by the number of environmental monitoring policy files on these policies.

3.2 Calibration strategy

The first step of fsQCA analysis is calibrating the outcome and the causal conditions to determine their fuzzy set membership scores. The calibration is based on a certain number of thresholds or anchors and translates the raw numerical data into set membership scores (Duşa, 2018). There are three principles for effective calibration: first, clearly define the outcome and causal conditions; second, designate sensible thresholds or anchors; and third, transparently report the chosen thresholds (Greckhamer et al., 2018). Table 2 shows the anchors of the sets according to the basic principles of calibration. The software employed in the analysis of the raw numerical data was the Set Method packages in R software, which yielded a fuzzy calibrated condition (Duşa, 2018). This article uses the "direct method" approach to calibration, which means that the new value is a continuous number between 0 and 1 (Ragin, 2009). The thresholds have different types, where "Fully in" denotes complete inclusion in this set, "Crossover" is the crossover point, and "Fully out" is the threshold for complete exclusion; the three numbers are the actual threshold values (Duşa, 2018). For example, the label "Implementation (em)" measures the environmental monitoring policy implementation in a given province. In other words, a province with percentage scores below the crossover point of 0.67 might still engage in implementation, but the province is more out than in. Based on the existing calibration standards, this study set the intersection calibration standards for technology availability, change required, financial resources, implementing officials, public support, and socio-economic conditions to the 0.5 per centile and the full membership calibration standard to the 0.95 per centile. Conditions to the 0.5th percentile for the intersection calibration criterion, the full membership calibration criterion to the 0.95th percentile, and the full non-membership calibration criterion to the 0.05th percentile. The specific calibration anchors for each variable are shown in Table 3.

4 Results

4.1 Analysis of necessity for the outcome

The optimal approach for this study was to use the fs-QCA software, which contains the "Truth Table Algorithm" to conduct fuzzy-set analysis. The first step was to test whether a single variable was necessary for the outcomes. The minimal consistency threshold for necessity was set at 0.9 (Ragin, 2009). Neither the presence nor the absence of any of the 4 conditions is a necessary condition for the presence of good policy implementation outcomes. Necessity testing was conducted for the antecedent conditions and their negations of different transformation modes to eliminate the risk of missing necessary conditions in the parsimonious solution. Table 4 shows the results of the necessity analysis using fsQCA3.0 software. Based on the requirement that the consistency level of necessary conditions should be greater than 0.9, none of the conditional variables in this study could constitute a necessary condition for policy implementation. However, our fs-QCA analyses suggest that the absence of public support and the absence socio-economic conditions are the necessary conditions for policy implementation; of course, these two conditions are supersets of the outcome, meaning that policy implementation cannot be achieved without them.

4.2 Analysis of environmental monitoring policy implementation

Next, we tested sufficiency with a truth table representing all logically possible combinations of different variables. The design of the truth table was based on the Quine-McCluskey algorithm. The environmental monitoring policy implementation outcome was considered sufficient if the raw consistency value was above 0.8 (Ragin, 2009). For example, a value of 0.8 suggests that 80% of the cases with specific configurations are effective. The test of sufficiency for the environmental monitoring policy implementation outcome represents 64 logically possible combinations of the six variables.

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TABLE 3 Set member scores after calibration.

Province	Implementation	Technology availability	Change required	Financial resource	Implementing officials	Public support	Socio-economic
Anhui	0.257	0.322	0.019	0.330	0.475	0.003	0.021
Beijing	0.981	0.039	0.019	0.655	0.971	0.763	0.987
Chongqing	0.070	0.035	0.013	0.029	0.916	0.009	0.116
Fujian	0.404	0.083	0.013	0.021	0.885	0.722	0.380
Gansu	0.963	0.034	0.013	0.163	0.263	0.030	0.007
Guangdong	0.092	0.016	0.013	0.013	0.021	0.991	0.365
Guangxi	0.274	0.111	0.013	0.056	0.376	0.022	0.018
Guizhou	0.914	0.027	0.013	0.044	0.698	0.003	0.012
Hainan	0.162	0.022	0.013	0.025	0.002	0.004	0.033
Hebei	0.995	0.381	0.990	0.074	0.181	0.040	0.029
Heilongjiang	0.082	0.016	0.022	0.058	0.593	0.025	0.023
Henan	0.918	0.292	0.999	0.034	0.301	0.056	0.028
Hubei	0.188	0.109	0.033	0.107	0.984	0.006	0.091
Hunan	0.999	0.550	0.016	0.020	0.849	0.005	0.039
Inner Mongolia	0.648	0.036	0.016	0.594	0.113	0.007	0.323
Jiangsu	0.150	0.995	0.080	0.043	0.544	0.045	0.872
Jiangxi	0.975	0.065	0.015	0.182	0.431	0.028	0.023
Jilin	0.977	0.029	0.019	0.017	0.818	0.034	0.077
Liaoning	0.360	0.161	0.034	0.028	0.391	0.024	0.059
Ningxia	0.887	0.024	0.013	0.877	0.991	0.373	0.042
Qinghai	0.897	0.016	0.013	0.408	0.999	0.002	0.030
Shaanxi	0.991	0.037	0.276	0.164	0.892	0.043	0.060
Shandong	0.882	0.578	0.783	0.060	0.380	0.020	0.258
Shanghai	0.016	0.023	0.014	0.024	0.644	0.125	0.984
Shanxi	0.984	0.083	0.136	0.981	0.341	0.074	0.014
Sichuan	0.387	0.016	0.067	0.034	0.995	0.005	0.022
Tianjin	0.036	0.028	0.029	0.009	0.202	0.592	0.981
Xinjiang	0.920	0.023	0.037	0.873	0.652	0.014	0.023
Yunnan	0.934	0.080	0.013	0.043	0.994	0.005	0.009
Zhejiang	0.083	0.652	0.014	0.098	0.382	0.316	0.640

Table 5 is the part of the truth table that contains only rows with sufficient empirical evidence. In other words, each row covers at least one case in this truth table.

In this analysis, positive cases are set to true while negative cases, indifferent cases and remainders are set to false to find the most complex solution. We used standard analysis after the truth table was constructed because this procedure can provide complex, intermediate and parsimonious solutions (Ragin, 2009).

To resolve the limited diversity and counterfactual problems, we assumed that the variables present as directional expectations for all conditions expect change required (cr) and socio-economic conditions. Some provinces faced difficulties due to the amount of change required, and as discussed above, the more behavioural change is required, the more difficult successful environmental monitoring policy implementation; however, some polices that require substantial behavioural change seem to be implemented quite smoothly (O'Toole, 1986). This is why I base my assumption on the directionality of the change required based on the presence or absence of other factors. For socio-economic conditions (se), because local government leaders are critical and influence

TABLE 4 Analysis of necessity for the outcome.

Conditions	Consistency	Coverage
Technology availability (ta)	0.195	0.695
Change required (cr)	0.210	0.978
Financial resources (fr)	0.343	0.984
Implementing officials (io)	0.685	0.691
Public support (ps)	0.130	0.517
Socio-economic (se)	0.174	0.464
Absence of Technology availability (~ta)	0.890	0.618
Absence of Change required (~cr)	0.830	0.551
Absence of Financial resources (~fr)	0.757	0.551
Absence of Implementing officials (~io)	0.436	0.598
Absence of Public support (~ps)	0.922	0.627
Absence of Socio-economic (~se)	0.925	0.687

Note: Necessity condition analysis. On behalf of the fuzzy variables in bold (ta, cr, fr, IO, ps, se) and the fuzzy variable (~ta, cr, fr, ~~IO, ~ps, ~se).

environmental monitoring policy implementation, I make no assumptions for this condition. Based on theory and common sense, I expect technology availability (ta), implementing officials (io), financial resources (fr), and public support (ps) to contribute to the outcome when present. In other words, the absence of a requisite technology hinders successful environmental monitoring policy implementation. Having implementing officials who understand the policy, environmental expenditures, and public support for environmental policy positively influence implementation. The intermediate solution was obtained based on the above assumptions.

The intermediate solution has a consistency value of 0.958 and explains 55.587% of the cases that are coded as environmental monitoring policy implementation. This represents a comprehensive explanation of environmental monitoring policy implementation by using the six different variable combinations. Based on this, Table 6 shows formula for the intermediate solution. The discussion section will provide further details on the explanations of the intermediate solution.

4.3 Robustness tests

This paper examines the robustness of pathways that produce high environmental monitoring policy implementation effects. QCA is an ensemble theory approach that is regarded as robust when slight changes to the operations, with subset relationships between the resulting outcomes, do not change the substantive interpretation of the study's findings. QCA is a set theory approach that is based on the idea that the results of a policy implementation are not necessarily the same as the results of a policy implementation. Based on this, this study examines the four aspects of (adjusting raw consistency) adjustmentraw consistency value; changed condition crossover point; altering the operationalisations and comparative analysis of the results of the policy implementation, respectively. Robustness of the results. In the first robustness test, the same seven indicators for environmental monitoring policy implementation are included, but the raw consistency value is altered. The raw consistency value of environmental monitoring policy implementation in the original analysis was set at 0.80. In the alternative calculation, while we altered the raw consistency value to 0.85, the analysis of the conditions yielded the same configurations as the original analysis. The truth table also covered the same cases. Table 7 provides details on the configurations and results.

In the second robustness test, we changed the socio-economic conditions (se) crossover point from 79,811.5 to 81,529.6. The World Bank categorizes the world's economies into four income groups based on GNI *per capita*. The thresholds for low, lower-middle, upper-middle, and high by income are $1,025, $4,035 and $12,475, and the exchange rate between the USD and the CNY was $1 to ¥6.6423 in 2016. We set a new crossover point based on the percentage of GDP *per capita* of $8,117.27 and GNI *per capita* of $8,250 in 2016. Table 8 shows that altering the thresholds did not change the conclusions.

Generally, the robustness tests also change the operationalization of public support to the percentage of the number of reported cases from letters and visits divided by the region's total population at year-end (LV). Table 9 shows that altering the operationalizations does not significantly change the results of the analysis.

4.4 Analysis of no environmental monitoring policy implementation

Table 10 shows the intermediate solution for the outcome of no environmental monitoring policy implementation. The configurations observed in the case of no environmental monitoring policy implementation are different combinations than those observed in the case of environmental monitoring policy implementation, which also demonstrates the robustness of the environmental monitoring policy implementation configurations.

5 Discussion

The intermediate solution analysis for the environmental monitoring policy implementation outcome suggests 4 paths. This leads to four configurations of the hexagon, which reflect the various combinations of the variables influencing environmental monitoring policy implementation. The configurations are named as follows: 1) priority governance, 2) money talks, 3) coordinated implementation, and (4) comprehensive strategy.

Table 11 shows the four configurations of environmental monitoring policy implementation. The first row of this table provides a graphical illustration based on the Boolean expressions of each variable composing the hexagon. The chart that reports 1 and 0 values indicates the presence and absent absence of the variables according to the intermediate solution. While in some combinations, are of the variables all sufficient for causing high implementation, the prime combinations can be simplified; an "r" that lies between the values 1 and 0 means that the finding is logically redundant. When we observe the intermediate position, the variables might be either present in or absent from

TABLE 5 Truth table for the environmental monitoring policy implementation outcome.

Technology availability	Change required	Implementing officials	Financial resources	Socio-economic	Public support	No.	Implementation	Raw consist	PRI consist	SYM consist	Cases
0	1	0	0	0	0	2	1	1.000	1.000	1.000	Hebei, Henan
1	1	0	0	0	0	1	1	1.000	1.000	1.000	Shandong
0	0	1	1	1	1	1	1	0.979	0.967	0.967	Beijing
0	0	1	1	0	0	2	1	0.976	0.961	0.961	Ningxia, Xinjiang
0	0	0	1	0	0	2	1	0.970	0.947	0.947	Shanxi, Inner Mongolia
1	0	1	0	0	0	1	1	0.867	0.685	0.685	Hunan
0	0	1	0	0	0	9	0	0.703	0.596	0.628	Jilin, Heilongjiang, Hubei, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Qinghai
0	0	1	0	0	1	1	0	0.690	0.137	0.144	Fujian
0	0	0	0	0	0	6	0	0.656	0.477	0.492	Liaoning, Anhui, Jiangxi, Guangxi, Hainan, Gansu
1	0	1	0	1	0	1	0	0.624	0.217	0.217	Jiangsu
0	0	1	0	1	0	1	0	0.598	0.296	0.296	Shanghai
1	0	0	0	1	0	1	0	0.553	0.179	0.179	Zhejiang
0	0	0	0	0	1	1	0	0.462	0.073	0.073	Guangdong
0	0	0	0	1	1	1	0	0.361	0.052	0.052	Tianjin

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TABLE 6 Intermediate solution formula for the environmental monitoring policy implementation outcome.

Sufficient paths, connected by logical OR[a]	Consistency	Cov.r[b]	Cov.u[b]
CR*se	0.985	0.206	0.110
FR*se	0.984	0.306	0.198
TA*IO*se	0.895	0.168	0.051
cr*IO*FR*PS	0.985	0.090	0.037

Notes: Capital letters indicate presence; small letters indicate absence; and *denotes logical AND., Cov. r[b] means raw coverage; Cov.u[b] means unique coverage.

TABLE 7 Intermediate solution formula for the environmental monitoring policy implementation outcome (0.85 consistency).

Sufficient paths, connected by logical OR[a]	Consistency	Cov.r[b]	Cov.u[b]
CR*se	0.985	0.206	0.110
FR*se	0.984	0.306	0.198
TA*IO*se	0.895	0.168	0.051
cr*IO*FR*PS	0.985	0.090	0.037

Notes: Capital letters indicate presence; small letters indicate absence; and *denotes logical AND., Cov.r[b] means raw coverage; Cov.u[b] means unique coverage.
Solution coverage: 0.546; Solution consistency: 0.958.

TABLE 8 Intermediate solution formula for the environmental monitoring policy implementation outcome (new thresholds).

Sufficient paths, connected by logical OR[a]	Consistency	Cov.r[b]	Cov.u[b]
CR*se	0.986	0.207	0.111
FR*se	0.984	0.305	0.198
TA*IO*se	0.889	0.167	0.051
cr*IO*FR*PS	0.985	0.090	0.037

Notes: Capital letters indicate presence; small letters indicate absence; and *denotes logical AND. Cov.r[b] means raw coverage; Cov.u[b] means unique coverage.
Solution coverage: 0.547; Solution consistency: 0.957.

TABLE 9 Intermediate solution formula for the environmental monitoring policy implementation outcome (new operationalization).

Sufficient paths, connected by logical OR[a]	Consistency	Cov.r[b]	Cov.u[b]
CR*se	0.985	0.206	0.110
FR*se	0.984	0.306	0.217
TA*IO*se	0.895	0.168	0.051
cr*IO*FR*LV	0.983	0.077	0.037

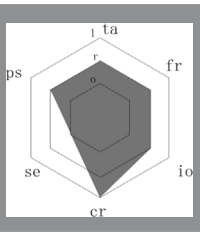
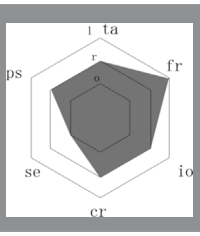
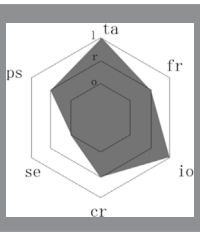
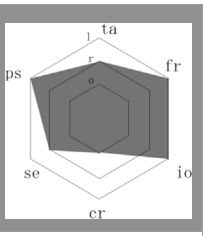
Notes: Capital letters indicate presence; small letters indicate absence; and *denotes logical AND., Cov.r[b] means raw coverage; Cov.u[b] means unique coverage.
Solution coverage: 0.546; Solution consistency: 0.958.

TABLE 10 Intermediate solution formula for the no environmental monitoring policy implementation outcome.

Sufficient paths, connected by logical OR[a]	Consistency	Cov.r[b]	Cov.u[b]
cr*fr*ps*SE	0.894	0.326	0.144
ta*cr*fr*PS*se	0.954	0.157	0.055
ta*cr*fr*io*SE	0.917	0.226	0.031

Notes: Capital letters indicate presence; small letters indicate absence; and *denotes logical AND.
Cov.r[b] means raw coverage; Cov.u[b] means unique coverage.
Solution coverage: 0.440; Solution consistency: 0.913.

TABLE 11 The complexity of environmental monitoring policy implementation.

Policy implementation (connected by logical OR)				
Configuration	Priority governance	Money talks	Coordinated implementation	Comprehensive strategy
Sufficient path	CR*se	FR*se	TA*IO*se	cr*FR*IO*PS
Most typical	Hebei, Henan, Shandong	Xinjiang, Shanxi, Ningxia, Inner Mongolia	Hunan	Beijing
Uncovered	Shanxi, Jilin, Jiangxi, Gansu, Yunnan, Guizhou, Qinghai			

Notes: 0 indicates absence; 1 indicates presence; and r indicates logically redundant TA (technology availability), CR (change required) FR (financial resources), IO (implementing officials), PS (public support), SE (socio-economic conditions).

environmental monitoring policy implementation. However, they are not necessary to ensure the outcome because of the logical minimization. Since some cases are not explained by the hexagons, in the last row, the table reports the cases that are not covered by the solution formula but have high environmental monitoring policy implementation.

The first configuration of the hexagon is referred to as "Priority Governance". The results of the first set of data show that the value of CR is 1, which represents the existence of the core condition; the value of se is 0, which represents the existence of the edge condition, and the value of ps,ta,fr, io is located between 0 and 1, which is a non-essential condition, i.e., it is logically redundant. Thus, CR*se is the Sufficient path, in addition, the results also show that Hebei, Henan, Shandong are the typical provinces that conform to this path in the context of China's environmental policy implementation. Since provinces in this group prioritize solving pollution problems and are characterized by a combination of substantial change required and poor socio-economic conditions related to environmental monitoring policy implementation. Such efforts are supported by substantial numbers of heavy-pollution days for cities at the prefectural level and above, which represent the foundational drivers of environmental monitoring policy implementation in China. The typical cases of environmental monitoring policy implementation are Hebei, Henan, and Shandong. These cases are difficult to interpret under the framework because the mixed tractability results nevertheless yield substantial environmental monitoring policy implementation; however, the basic hypothesis of Sabatier and Mazmanian (1980) is "the greater amount of behavioral change required, the more problematic successful implementation will be". Typical cases showing this configuration of the hexagon are the Hebei, Henan, and Shandong–all of which are provinces with cities at the prefecture level and above with a high number of heavy-pollution days–and they illustrate the amount of behavioural change required to stimulate environmental monitoring policy implementation under Chinese conditions. This result can be explained by the Chinese governing system, specifically, the dual leadership of the local EPBs and the "One-vote negation system" for local government. For local EPBs, environmental monitoring policy implementation is often subject to contradictory demands, vertically from the central government and horizontally from local governments. Although the amount of behavioural change required is substantial and other variable resources are limited, combinations of these variables may still encourage the environmental monitoring policy implementation. For local government, a possible motivation is that the greater pressure from the central government results in implementation agencies attempting to collaborate to secure other resources associated with perceived environmental monitoring policy implementation. By contrast, the limited pressure experienced in provinces with fewer heavy-pollution days requires more combinations of other variables, as discussed above.

The second configuration - "Money makes the Devil work". From the results of the second set of data, it can be seen that the value of FR is 1, which represents the existence of core conditions; the value of se is 0, which represents the existence of marginal conditions, and the values of ps,ta,cr, io are located between 0 and 1, which are non-essential conditions. Thus, FR*se is the Sufficient path. In addition, the results of the study show that in the context of China's environmental policy implementation, Xinjiang, Shanxi, Ningxia, Inner Mongolia are the typical provinces that conform to this path. Combined with the actual situation of the above provinces in China, the provinces mobilize financial resources, namely, they are characterized by a combination of substantial financial resources and lower socio-economic conditions. In other words, environmental monitoring policy implementation can be influenced by investment in environmental pollution treatment. Compared with the other configurations of the environmental monitoring policy implementation, the variables in this category intensively use environmental investments, as the name of the configuration suggests. The configuration includes almost all cases located in north-western China, and the only uniquely covered province—Shanxi—is also located in the northern part of China. Most cases of environmental monitoring policy implementation need not include many variables at once, as this configuration indicates. Regarding socio-economic conditions, it seems that poor regions spend substantial amounts of money on environmental monitoring policy implementation. This is similar to the viewpoints of some previous scholars in the field of environmental monitoring policy, in which Sadik-Zada and

Ferrari., 2020 scholars pointed out that the structural composition of the economy and the level of economic development (or the government's financial resources) are the main, but not the only, factors affecting the effectiveness of the implementation of a country's environmental policy (2020). Generally speaking, the lower the socio-economic conditions of a region, the greater the level of pollution, on the contrary, will be relatively large, which also increases the region's investment in the environment.

The third configuration of environmental policy implementation is called "coordinated implementation". From the results of the third set of data in Table 11, it can be seen that the value of TA and IO is 1, which is the core condition of this path; the value of se is 0, which is the edge condition of this path, and the value of ps,fr, cr is located between 0 and 1, which is the non-essential condition of this path. Thus, TA*IO*se is the Sufficient path, in addition, we can find that Hunan is a typical province that meets this path from the data. This configuration is named "coordinated implementation" because of the high technical availability, more familiarisation of the implementing officials with the policy, and lower socio-economic conditions. This configuration is more complex because it includes both the operability of the problem and the ability to organise the implementation of the regulation. Due to the combination of high technology availability, implementation officials who are more familiar with the policy, and lower socio-economic conditions. This configuration is more complex because it includes the aspects of both the tractability of the problem and the ability of statute to structure implementation. Regarding the technology availability and implementation officials in particular, it seems that promoting compulsory cleaner production audit and evaluation firms and training environmental monitoring staff are needed to ensure environmental monitoring policy implementation. That the Communist Party of China consistently provides overall leadership and coordinates the efforts of all involved can explain why coordinated implementation can lead to environmental policy effectiveness. This is the case in Hunan, the province with the highest environmental monitoring policy implementation. Since the officials can monitor the progress of the audit and evaluation and are familiar with the monitoring policies, environmental monitoring policy implementation can be influenced by the intervention of street-level bureaucrats. In addition, similar to previous studies, the environmental Kuznets curve developed by Sadik-Zada and Gatto, 2023 scholars shows that high-quality environmental monitoring policy implementation and governance outcomes can be achieved in selected developing countries with average socio-economic conditions. "Growth before governance" is no longer the common paradigm for environmental governance (2023). Therefore, it is a somewhat useful configuration of the hexagon for improving environmental monitoring policy implementation in China.

From the results of the fourth set of values in Table 11, it can be observed that FR, IO and PS have a value of 1 and therefore are the core conditions of this pathway, while cr has a value of 0 and therefore represents the marginal conditions of this pathway. Ta and se have values between 0 and 1 and are the non-necessary conditions of this drywell. From this, cr*FR*IO*PS is the Sufficient path, in addition, we can find from the data that Beijing is the typical province that meets this path. The name is based on the assumption that environmental monitoring policy implementation relies on a combination of less change being required, implementing officials who are relatively familiar with the legislation, having substantial financial resources and possessing sustained public support. A typical case where the hexagon is in this configuration is Beijing, the capital of China. Furthermore, the central government, together with ministries and commissions, is located in Beijing. The approval of the central government supports and the substantial resources provided by the various ministries which results in environmental monitoring policy implementation even though little change is required for Beijing. However, this is a specific and irrational combination, and it is difficult for other provinces to secure the same resources and support. Therefore, the hexagon representing this configuration is not stable, but it nevertheless leads to environmental monitoring policy implementation.

6 Conclusion

This paper applies the fs-QCA qualitative research methodology to categorise the antecedent variables affecting the implementation of environmental monitoring policies in China, and explores the impact of the combined configurational effects of these variables on the effectiveness of policy implementation. Specifically, based on the policy implementation process framework (Sabatier and Mazmanian, 1980), this study analytically examines the effects of different combinations of technology availability, change required, financial resources, implementing officials, public support, and socio-economic conditions on the implementation of environmental monitoring policies, following an assessment of 30 provinces in China. Among them, the four hexagonal configurations proposed in this paper provide new explanations for the reasons for differences in environmental monitoring policy implementation in different provinces.

Our study provides considerable insights into the implementation of environmental monitoring policies and confirms previous findings in the literature on the variables involved in the policy implementation process. It is not difficult to find from previous studies that most scholars have ignored the impact of the combined configuration effect of antecedent variables of policy implementation on the effectiveness of policy implementation based only on case studies. Although our results differ slightly from those in the Sabatier and Mazmanian (1980) framework, it could nevertheless be argued that these differences are due to the Chinese governance system and the country's socio-economic conditions. Apart from this slight disagreement, the results in this work confirm the variables that should be considered in environmental monitoring policy implementation by using more sophisticated methods. Initially, we believed that Western theories could be applied to China. However, a more careful analysis revealed that the application of Western policy research requires localization and contextualization. The discussion of the findings revealed that no specific variables in the hexagon alone can influence environmental monitoring policy implementation. Several provinces attempt to consider the tractability of the problem and the extent of behavioural change required, such as Hebei, Henan and Shandong. Those with poor economic performance, including Xinjiang, Shanxi, Ningxia and Inner Mongolia, require more financial resources related to environmental monitoring policy implementation, possibly because of their economic structure and geographic location. However, the highest level of environmental monitoring policy implementation demands technology availability and implementation officials to

ensure that it is effective, for example, in Hunan. By absorbing nationwide resources, the capital of China, Beijing, demonstrates that implementing officials, financial resources, social-economics and public support influence environmental monitoring policy implementation. Further study of the different variable combinations would help provinces improve environmental monitoring policy implementation.

A number of limitations may have influenced the results of this study, which seems reasonable. First, this paper uses provincial data with a duration of 1 year, while the policy implementation process is dynamic. Therefore, future research could use dynamic panel data with a time horizon of many years to better explore the differential impact of group effects of multiple factors on the effectiveness of policy implementation at different points in time. Second, another possible research limitation is that the antecedent variables selected in this paper do not cover all the variables involved in the Sabatier framework. This is so because the fs-QCA approach requires a limitation on the number of antecedent variables. Therefore, future research should expand the sample size to include more influential factors that may affect the effectiveness of environmental monitoring policy implementation, thus making the study more systematic and standardised. Finally, the collection and design development of secondary data is a challenge for our study. In future studies, the survey and interview work with the relevant population demographics and environmental monitoring policy implementers should be strengthened to enhance the reliability of the findings.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

TJ: Conceptualization, Writing–original draft. HG: Conceptualization, Writing–review and editing. GC: Data curation, Writing–review and editing. XD: Formal Analysis, Writing–review and editing. WX: Formal Analysis, Writing–review and editing. ZW: Methodology, Writing–review and editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. This work was supported by the Key Project of the National Social Science Fund of China (Grant No. 23AGL001).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Burstein, P. (2003). The impact of public opinion on public policy: a review and an agenda. *Political Res. Q.* 56 (1), 29–40. doi:10.1177/106591290305600103

Challies, E., Newig, J., Kochskämper, E., and Jager, N. W. (2017). Governance change and governance learning in Europe: stakeholder participation in environmental policy implementation. *Policy Soc.* 36 (2), 288–303. doi:10.1080/14494035.2017.1320854

DeLeon, P., and DeLeon, L. (2002). What ever happened to policy implementation? An alternative approach. *J. public Adm. Res. theory* 12 (4), 467–492. doi:10.1093/oxfordjournals.jpart.a003544

Durant, R. F. E. (1984). EPA, TVA and pollution control: implications for a theory of regulatory policy implementation. *Public Adm. Rev.* 44, 305–315. doi:10.2307/976076

Duşa, A. (2018). *QCA with R: a comprehensive resource*. New York, NY: Springer International Publishing.

Fiss, P. C. (2007). A set-theoretic approach to organizational configurations. *Acad. Manag. Rev.* 32 (4), 1180–1198. doi:10.5465/amr.2007.26586092

Fiss, P. C. (2011). Building better causal theories: a fuzzy set approach to typologies in organization research. *Acad. Manag. J.* 54 (2), 393–420. doi:10.5465/amj.2011.60263120

Foley, A. (2015). Sexuality education policy implementation in two rural midwestern school districts. *Sex. Res. Soc. Policy* 12, 347–358. doi:10.1007/s13178-015-0205-x

Gassner, D., and Gofen, A. (2018). Street-level management: a clientele-agent perspective on implementation. *J. Public Adm. Res. Theory* 28 (4), 551–568. doi:10.1093/jopart/muy051

Gauthier-Beaupré, A., Kuziemsky, C., Battistini, B. J., and Jutai, J. W. (2023). Evolution of public health policy on healthcare self-management: the case of Ontario, Canada. *BMC Health Serv. Res.* 23 (1), 1–5. doi:10.1186/s12913-023-09191-3

Greckhamer, T., Furnari, S., Fiss, P. C., and Aguilera, R. V. (2018). Studying configurations with qualitative comparative analysis: best practices in strategy and organization research. *Strateg. Organ.* 16 (4), 482–495. doi:10.1177/1476127018786487

Hjern, B. (1982). Implementation research—the link gone missing. *J. public policy* 2 (3), 301–308. doi:10.1017/S0143814X00001975

Howes, M., Wortley, L., Potts, R., Dedekorkut-Howes, A., Serrao-Neumann, S., Davidson, J., et al. (2017). Environmental sustainability: a case of policy implementation failure? *Sustainability* 9 (2), 165. doi:10.3390/su9020165

Huselid, M. A. (1995). The impact of human resource management practices on turnover, productivity, and corporate financial performance. *Acad. Manag. J.* 38 (3), 635–672. doi:10.5465/256741

Ingram, H. (1990). Implementation: a review and suggested framework. *Public Adm. state Discip.*, 462–480.

Jordan, A. (1999). The implementation of EU environmental policy; a policy problem without a political solution? *Environ. Plan. C Gov. Policy* 17 (1), 69–90. doi:10.1068/c170069

Klaster, E., Wilderom, C. P. M., and Muntslag, D. R. (2017). Balancing relations and results in regional networks of public-policy implementation. *J. Public Adm. Res. Theory* 27 (4), 676–691. doi:10.1093/jopart/mux015

Lester, J. P. (1986). New federalism and environmental policy. *J. Fed.* 16 (1), 149–166. doi:10.2307/3330181

Lester, J. P., and Bowman, A. O. M. (1989). Implementing environmental policy in a federal system: a test of the Sabatier-Mazmanian model. *Polity* 21 (4), 731–753. doi:10.2307/3234721

Li, G., Jiao, Y., Li, J., and Yan, Q. (2022). Spatiotemporal evolution and influential factors of rural poverty in poverty-stricken areas of guizhou province: implications for

consolidating the achievements of poverty alleviation. *ISPRS Int. J. Geo-Information* 11 (11), 546. doi:10.3390/ijgi11110546

Li, X., Wang, Q., Shi, R., Wang, X., Zhang, K., and Liu, X. (2023). Impact of cooperative innovation on the technological innovation performance of high-tech firms: a dual moderating effect model of big data capabilities and policy support. *Big Data*. doi:10.1089/big.2022.0301

Lieberthal, K. (1997). China's governing system and its impact on environmental policy implementation. *China Environ. Ser.*, 1, 3–8.

Lundin, M. (2007). Explaining cooperation: how resource interdependence, goal congruence, and trust affect joint actions in policy implementation. *J. Public Adm. Res. Theory* 17 (4), 651–672. doi:10.1093/jopart/mul025

Ma, Z. (2008). *The integration of cumulatginive environmental impact assessments and state environmental review frameworks*. Minneapolis and St. Paul, MN, United States: University of Minnesota.

MacDuffie, J. P. (1995). Human resource bundles and manufacturing performance: organizational logic and flexible production systems in the world auto industry. *ilr Rev.* 48 (2), 197–221. doi:10.1177/001979399504800201

Manion, M. (1991). Policy implementation in the People's Republic of China: authoritative decisions versus individual interests. *J. Asian Stud.* 50 (2), 253–279. doi:10.2307/2057208

Matland, R. E. (1995). Synthesizing the implementation literature: the ambiguity-conflict model of policy implementation. *J. public Adm. Res. theory* 5 (2), 145–174. doi:10.1093/oxfordjournals.jpart.a037242

McFarlane, D. R. (1989). Testing the statutory coherence hypothesis: the implementation of federal family planning policy in the states. *Adm. Soc.* 20 (4), 395–422. doi:10.1177/009539978902000401

Meuer, J., and Rupietta, C. (2017). Integrating QCA and HLM for multilevel research on organizational configurations. *Organ. Res. Methods* 20 (2), 324–342. doi:10.1177/1094428116665465

Montefrio, M. J. F., and Sin, H. L. (2021). Between food and spectacle: the complex reconfigurations of rural production in agritourism. *Geoforum* 126, 383–393. doi:10.1016/j.geoforum.2021.09.008

O'brien, K. J., and Li, L. (2017). Selective policy implementation in rural China. *Brill*, 437–460. doi:10.1163/9789004302488_017

O'Toole, L. (1986). Policy recommendations for multi-actor implementation: an assessment of the field. *J. public policy* 6 (2), 181–210. doi:10.1017/S0143814X00006486

Ragin, C. C. (2009). *Redesigning social inquiry: fuzzy sets and beyond*. University of Chicago Press.

Ragin, C. C. (2014). *The comparative method: moving beyond qualitative and quantitative strategies*. Oakland, CA, United States: Univ of California Press.

Ragin, C. C., and Rubinson, C. (2009). The distinctiveness of comparative research. *SAGE Handb. Comp. Polit.* 13, 34.

Sabatier, P., and Mazmanian, D. (1980). The implementation of public policy: a framework of analysis. *Policy Stud. J.* 8 (4), 538–560. doi:10.1111/j.1541-0072.1980.tb01266.x

Sabatier, P. A. (1986). Top-down and bottom-up approaches to implementation research: a critical analysis and suggested synthesis. *J. public policy* 6 (1), 21–48. doi:10.1017/S0143814X00003846

Sadik-Zada, E. R., and Ferrari, M. (2020). Environmental policy stringency, technical progress and pollution haven hypothesis. *Sustainability* 12 (9), 3880. doi:10.3390/su12093880

Sadik-Zada, E. R., and Gatto, A. (2023). Grow first, clean up later? Dropping old paradigms and opening up new horizons of sustainable development. *Sustainability* 15 (4), 3595. doi:10.3390/su15043595

Sevä, M., and Jagers, S. C. (2013). Inspecting environmental management from within: the role of street-level bureaucrats in environmental policy implementation. *J. Environ. Manag.* 128, 1060–1070. doi:10.1016/j.jenvman.2013.06.038

Sharp, E. B., Daley, D. M., and Lynch, M. S. (2011). Understanding local adoption and implementation of climate change mitigation policy. *Urban Aff. Rev.* 47 (3), 433–457. doi:10.1177/1078087410392348

Swanson, K. E., Kuhn, R. G., and Xu, W. (2001). Environmental policy implementation in rural China: a case study of Yuhang, Zhejiang. *Environ. Manag.* 27, 481–491. doi:10.1007/s002670010164

Teodoro, M. P., Haider, M., and Switzer, D. (2018). US environmental policy implementation on tribal lands: trust, neglect, and justice. *Policy Stud. J.* 46 (1), 37–59. doi:10.1111/psj.12187

Thomann, E., Trein, P., and Maggetti, M. (2019). What's the problem? Multilevel governance and problem-solving. *Eur. Policy Anal.* 5 (1), 37–57. doi:10.1002/epa2.1062

Treib, O. Implementing and complying with EU governance outputs. (2006). doi:10.12942/lreg-2006-1

Tuokuu, F. X. D., Gruber, J. S., Idemudia, U., and Kayira, J. (2018). Challenges and opportunities of environmental policy implementation: empirical evidence from Ghana's gold mining sector. *Resour. Policy* 59, 435–445. doi:10.1016/j.resourpol.2018.08.014

Vesterager, J. P., Frederiksen, P., Kristensen, S. B. P., Vadineanu, A., Gaube, V., Geamana, N., et al. (2016). Dynamics in national agri-environmental policy implementation under changing EU policy priorities: does one size fit all? *Land Use Policy* 57, 764–776. doi:10.1016/j.landusepol.2015.05.014

Wang, Q., Gao, Y., Cao, Q., Li, Z., and Wang, R. (2023). What kind of configuration can facilitate the digital transformation?: a fsQCA and NCA study of SMEs. *Journal of Organizational and End User Computing (JOEUC)* 35 (1), 1–20. doi:10.4018/JOEUC.334110

Wang, Q., Shi, R., Zhang, F., Wang, X., and Gao, Y. (2022). How organizational psychological ownership affects corporate green operations-Based on a social exchange theory perspective. *Front. Psychol.* 13, 985017. doi:10.3389/fpsyg.2022.985017

Wang, Q. J., and Zhou, J. (2022). *Study on ecosystem evolution and governance of the maker space*. Beijing, China: Chinese People's Publishing House.

Wang, W. (2016). Exploring the determinants of network effectiveness: the case of neighborhood governance networks in Beijing. *J. Public Adm. Res. Theory* 26 (2), 375–388. doi:10.1093/jopart/muv017

Xu, C. (2011). The fundamental institutions of China's reforms and development. *J. Econ. literature* 49 (4), 1076–1151. doi:10.1257/jel.49.4.1076

Yang, C., and Huang, C. (2022). Quantitative mapping of the evolution of AI policy distribution, targets and focuses over three decades in China. *Technol. Forecast. Soc. Change* 174, 121188. doi:10.1016/j.techfore.2021.121188

Zeb, F., Wang, Q., and Shahjehan, A. (2023). Hypocrisy is the tribute that vice pays to virtue: dynamics of perceived organization hypocrisy and job embeddedness in the hospitality industry. *Front. Psychol.* 13, 1036320. doi:10.3389/fpsyg.2022.1036320

Zhan, X., Lo, C. W. H., and Tang, S. Y. (2014). Contextual changes and environmental policy implementation: a longitudinal study of street-level bureaucrats in Guangzhou, China. *J. Public Adm. Res. Theory* 24 (4), 1005–1035. doi:10.1093/jopart/mut004

Zhang, K., Wang, Q., Wang, X., and Zhang, F. (2022). The impact of policy perception on technology transfer from boundary-spanning perspective-empirical evidence from Chinese technological enterprises. *Front. Psychol.* 13, 974436. doi:10.3389/fpsyg.2022.974436

Zhang, T., and Yao, H. (2018). The improvement on the implementation level of environmental policies is demanded in China. *Environ. Sci. Pollut. Res.* 25, 36035–36038. doi:10.1007/s11356-018-3620-8

Zhou, X. (2010). The institutional logic of collusion among local governments in China. *Mod. China* 36 (1), 47–78. doi:10.1177/0097700409347970

Zhou, X. (2017). *The institutional logic of governance in China: an organizational approach*. Beijing: SDX-Joint Publishing Company.