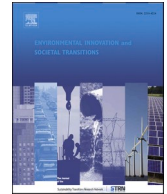




ELSEVIER

Contents lists available at ScienceDirect

## Environmental Innovation and Societal Transitions

journal homepage: [www.elsevier.com/locate/eist](http://www.elsevier.com/locate/eist)

Research article

## Pathways towards successful urban community waste management: Insight from 26 experiments in China

Shengnan Wang<sup>a</sup>, Bernhard Truffer<sup>b,c</sup>, Xuemei Bai<sup>a,\*</sup><sup>a</sup> Fenner School of Environment and Society, Australian National University, Linnaeus Way, Acton ACT, 2601, Australia<sup>b</sup> Eawag, Swiss Federal Institute of Aquatic Science and Technology, Überlandstrasse 133, CH-8600 Dübendorf, Switzerland<sup>c</sup> Faculty of Geosciences, Utrecht University, Heidelberglaan 2, NL-3584, CS, Utrecht, The Netherlands

## ARTICLE INFO

## Keywords:

Urban community waste management  
Sustainability transitions  
Sustainability experiments  
Fuzzy set qualitative comparative analysis  
Success factors  
Factor combinations

## ABSTRACT

Understanding factors influencing the outcomes of innovative community waste management experiments is crucial for improving urban waste management. Yet, there is limited evidence on what are the critical factors and how different combination, and interaction of these factors influence outcomes. This study analyses 26 community waste management experiments in Shenzhen, China, using a mixed-method approach. Through analyzing data obtained from interviews, surveys, and focus groups, we identify 19 key factors determining the success of these experiments. Through fuzzy-set qualitative comparative analysis (fsQCA), we identified three successful causal pathways: (1) committed participants supported by dedicated communities; (2) committed participants with local government backing; and (3) strong grassroots leadership supported by responsible local government. This indicates that an integration of social, organizational, and behavioral dimensions is crucial to tackle complex waste management challenges. The results also imply that policymakers and practitioners may chose alternative approaches to success, depending on their local situation.

## 1. Introduction

Municipal Solid Waste (MSW) management has become increasingly critical for mitigating urban environmental impacts, including pollution, biodiversity loss, and the depletion of landfill space and natural resources (Bai et al., 2017; De Feo et al., 2019; Hoornweg and Bhada-Tata, 2012; Stoeva and Alriksson, 2017). China, as the world's largest MSW producer, has implemented various government interventions over the last two decades, focus on waste recycling and separation at the community level. However, these efforts have yielded limited success, mainly due to overemphasis on infrastructure investment and insufficient public engagement (Cui et al., 2022; Wang and Hao, 2020). Research suggests that effective waste management requires addressing both technical issues and socio-technical factors, including multi-stakeholder engagement and individual behavioral changes (Fagan, 2003; Vergara and Tchobanoglous, 2012; Wang and Hao, 2020).

However, the joint impact of actors' behavioral and organizational factors remains underexplored. In particular, the integration of social, organizational, and behavioral dimensions, especially in managing stakeholder interests within community waste management, has not been thoroughly addressed in existing research (Arantes et al., 2020; Lishan et al., 2021; Wang et al., 2024; Zhang et al., 2019).

\* Corresponding author at: Fenner School of Environment and Society, Frank Fenner Building (141), Australian National University, Linnaeus Way, Acton ACT, 2601, Australia.

E-mail addresses: [Shengnan.wang@anu.edu.au](mailto:Shengnan.wang@anu.edu.au) (S. Wang), [Bernhard.Truffer@eawag.ch](mailto:Bernhard.Truffer@eawag.ch) (B. Truffer), [xuemei.bai@anu.edu.au](mailto:xuemei.bai@anu.edu.au) (X. Bai).

<https://doi.org/10.1016/j.eist.2025.101032>

Received 24 December 2024; Received in revised form 5 May 2025; Accepted 17 July 2025

Available online 22 July 2025

2210-4224/© 2025 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Sustainability transition studies, which examine the complex transformation processes wherein various actors and factors interact at multiple levels offer insights into the intricate interplay between technologies and institutional condition (Elzen et al., 2004; Köhler et al., 2019; Markard et al., 2012). This approach is particularly relevant for achieving sustainability transitions in waste management as it addresses not only the provision of infrastructures but also the deeply intertwined social, organizational, and behavioral dimensions that are required to reliably operate the services (Wang et al., 2024). The challenges of urban waste management are emblematic of the broader sustainability issues that arise at the nexus of rapid urbanization, environmental degradation, and evolving societal awareness.

Experimentation plays a key role in sustainability transitions by providing a protected space for potentially disruptive innovations, which do not comply with the dominant routines, rules and regulations in a sector (Hoogma et al., 2002; Sengers et al., 2021). *Sustainability experiments* —“planned initiatives that embody a highly novel socio-technical configuration likely to lead to substantial (environmental) sustainability gains” (Berkhout et al., 2010) — offer an opportunity to enable interactions among actors and factors, and by this demonstrate the feasibility of new socio-technical “configurations that work” in real-world settings (Geels, 2002; Kemp et al., 1998). To this end, several studies attempt to identify critical success factors, including socio-political contexts, resources and stakeholder collaboration (Ornetzeder and Rohracher, 2013; van den Heiligenberg et al., 2017; Wang et al., 2024).

Few studies examine how the interplay of various factors influences outcomes, even though local contextual conditions significantly shape the emergence of effective socio-technical configurations. This is problematic as factors rarely act in isolation. It is essential to analyze their interactions to understand how they collectively impact outcomes (Bai et al., 2010; Schneider and Wage-mann, 2012; Wainaina et al., 2022) and examine diverse cases to disentangle the socio-technical dimensions from spatial elements, offering deeper insights into these dynamics (Truffer et al., 2015). In particular, we need to know how specific combinations of factors can determine an experiment’s successful outcome (Bai et al., 2010). The primary purpose of this study is to explore the combinations of social, organizational, or behavioral factors that explain success or failure of community waste management experiments in different local contexts. The overarching research question therefore is: Are there distinct causal pathways to achieving success in these experiments? This leads to two sub-questions: 1) What are the determinant factors? and 2) How do these factors interact and combine to influence outcomes?

Cross-case comparative studies are important for understanding neglected factor combinations (Bai et al., 2010; Greckhamer et al., 2018). To investigate multiple causal factors from a configurational perspective across a set of case studies, this paper uses fuzzy-set qualitative comparative analysis (fsQCA) (Ragin, 2008), which will be detailed in the methodology section. We examine 26 sustainability experiments in community waste management in Shenzhen, China. These cases, set in a consistent geographical, cultural, policy, and regulatory environment, operated over one-year period, provide a unique opportunity to focus on experiment internal mechanisms that affect success or failure. The cases include both successful and unsuccessful experiments, offering a balanced view of the factors influencing outcomes. Moreover, this study contributes empirical evidence from China - a rapidly urbanizing, densely populated, and evolving socio-economic and political context under a top-down governance model. Shenzhen, a rapidly growing megacity known for its openness to innovations and civic engagement, offers a valuable ground for understanding the dynamics of community-driven sustainability efforts.

The next section reviews the literature on sustainability experiment outcomes and influencing factors. Section 3 details our methodology, including case description, data collection and analysis. This section also presents interim results, illustrating the rationale for subsequent data collection stages. Section 4 presents the findings of the fsQCA analysis. Finally, Section 5 discusses the results, and Section 6 concludes the study.

## 2. Explaining experiment outcomes and factors

The global production of waste is estimated to range between 7 and 10 billion tons annually, with approximately 70% of this waste not being recycled (Wilson et al., 2015). Consequently, the issues of waste accumulation and potential resource scarcity have been identified as critical challenges confronting human society (Hou et al., 2012). In response, waste management has garnered significant attention as a key strategy for advancing progress toward the Sustainable Development Goals (Duygan et al., 2018; Lishan et al., 2021). The effectiveness of waste management experiments hinges on how well various actors and factors are integrated, demonstrating that a configurational approach such as the one proposed by sustainability transition studies is appropriate. To explore key factors and their combinations influencing experiment outcomes, here, we first define and explain what constitutes experiment outcomes and then identify factors that have been studied by transition scholars.

### 2.1. Experiment outcomes

Defining success or failure in sustainability experiments is challenging due to their diverse contexts, goals, and priorities (Feola and Nunes, 2014). Some scholars emphasize effective internal interactions among stakeholders and impact on the environment or society as indicators of outcomes (Ornetzeder and Rohracher, 2013) while others suggest that the former is more critical (Devine-Wright and Wiersma, 2013). To assess the outcomes of sustainability experiments for the purpose of this paper, we adapt Bai et al. (2010) outcome concepts, considering four types of outcomes. The specific meanings of these outcomes in context of community waste management are:

- Ended (O1): Experiments were discontinued, with all related activities ceasing. There is no lasting impact, and the community reverts to previous practices.

- Continued in local context (O2): Experiments continue within the original community, integrating into daily routines and developing local expertise.
- Multiplied (O3): Experiment outcomes are replicated in other communities; more participants adapt and implement sustainable waste management practices in new settings.
- Upscaled (O4): Experiment outcomes are upscaled to affect broader systemic change in waste management practices, potentially influencing policy, or broader community behaviors.

In this context, we combined the latter two because they both involve expanding the scope of the experiment's impact beyond the original setting. O1 is considered unsuccessful due to its lack of lasting impact, while O2 and O3 (combination of O3 and O4) are deemed successful, indicating sustained or broader influence.

Existing literature highlights the importance of assessing both short-term achievements and long-term viability of experiments, with long-term trajectories providing a better measure of their impact (Wainaina and Truffer, 2024). For instance, concepts like “appropriation”— a process akin to adoption but involving deeper integration of experiments into daily practices (Wainaina and Truffer, 2024)—and the importance of “embeddedness” to form “positive inertia” (Irvine and Bai, 2019) underscore the significance of experiments helping to form a part of community identity. Given our empirical cases are recent experiments, we derive outcomes from short-term achievements to understand influencing factors, acknowledging the limitation in assessing long-term effects.

## 2.2. Factors influencing the outcomes of experiments

We identified 12 factors (as shown in Table 1) through a synthesis of relevant literature listing factors that may influence the outcomes of sustainability experiments. Beyond technical and financial resources, outcomes also depend on social, organizational, and behavioral factors, including stakeholder engagement, collaboration, leadership, sustained commitment, the legislative environment, regulatory commitment, and local context.

A supportive legislative environment is fundamental in facilitating sustainability experiments. Governments who provide clear, supportive regulatory frameworks significantly enhance experiments success potential. Breugh et al. (2021) emphasize that open regulatory environments foster innovation and ensure coordinated institutional settings. Similarly, Feola and Nunes (2014) highlight the importance of clear regulatory frameworks, while Forrest and Wiek (2014) point to government support as crucial. Additionally, Ornetzeder and Rohrer (2013) and Middlemiss and Parrish (2010) discuss how regulatory clarity promotes sustainability initiatives, and Brangwyn and Hopkins (2008) stress the necessity of supportive policies for community-led experiments.

Local context, including community social cohesion and governance, plays a vital role. Strong community ties and effective governance provide legitimacy and administrative support. The availability of resources such as materials, facilities, and land are also crucial. Breugh et al. (2021) note that community engagement and support are essential for success. Forrest and Wiek (2015) and van den Heiligenberg et al. (2017) emphasize the significance of local resources and governance in facilitating experiments. Feola and Nunes (2014) stress the community cohesion's role, while Ornetzeder and Rohrer (2013) and Middlemiss and Parrish (2010) highlight the importance of local resources.

Collaboration, partnerships, and networks are often critical for success. Effective collaboration among organizers and various actors facilitates knowledge sharing and idea dissemination. Breugh et al. (2021) and Middlemiss and Parrish (2010) underscore that collaborative efforts are essential for exchanging resources. Feola and Nunes (2014) highlight partnerships' role in knowledge transfer, while Forrest and Wiek (2014) discuss networks' importance in supporting experimental initiatives. explore how stakeholder partnerships can enhance development and scalability of experiments in Chinese community waste management sector.

Engaging stakeholders and addressing their diverse interests is essential. Studies by Forrest and Wiek (2014) on a carbon-neutral community experiment and by Ornetzeder and Rohrer (2013) on comparing successful experiments across nations both highlight the importance of stakeholder engagement in experimental development. Irvine and Bai (2019) further emphasize that urban sustainability experiments catering to various stakeholders are more likely to succeed.

**Table 1**

Overview of 12 main factors influencing sustainability experiments' outcomes.

Factors	Short Description
Legislative Environment	Open to regulatory changes, clear frameworks, coordinated institutions
Local Contextual Factors	Social cohesion, governance support, resources availability
Collaboration & Networks	Knowledge sharing and idea dissemination
Stakeholder Engagement	Addressing diverse stakeholder interests
Technical Factors	Ease of technology adoption and acceptance
Financial Resources	Stable financial backing throughout the experiment
Human Resources	Experienced and skilled personnel
Performance Management	Timely performance information and team management
Risk Disposition	Flexibility in addressing risks and uncertainties
Time	Accurate forecasting and optimal timing for implementation
Leadership	Strong leadership, both governmental and from core organizers, provides legitimacy, secures funding, and fosters community support
Participants' Sustained Commitment	Knowledgeable and motivated participants long-term engagement and commitment

Technical factors also influence success. The ease of technology adoption and acceptance by participants is crucial. Breaugh et al. (2021) and van den Heiligenberg et al. (2017) stress the need for user-friendly technology to ensure smooth implementation and participant engagement.

Moreover, stable financial resources are vital. Consistent funding ensures the experiment's continuity, which is crucial for achieving desired results (Breaugh et al., 2021; Forrest and Wiek, 2015). Equally important are human resources. A stable team with the necessary experience and skills is crucial for effective execution (Ornetzeder and Rohrer, 2013).

Effective performance management ensures experiments stay on track. This includes timely performance information, evaluations, and team performance management. Breaugh et al. (2021) and Forrest and Wiek (2015) highlight how performance management contributes to successful outcomes by discussing the impact of effective risk management on experiment outcomes. They also argue that addressing risks associated with stakeholder resistance, outcome uncertainties, and lack of action through a flexible approach is crucial. Accurate time management and the ability to implement different stages of the experiment in a timely manner are also vital (Breaugh et al., 2021).

Leadership is essential in providing legitimacy, facilitating funding, and ensuring the accessibility and acceptability of experiments. Effective leadership includes both government and a committed core group of organizers leadership. Effective government leaders can provide essential legitimacy, making experiments easier to attract funding and public support. They can also enact policies to facilitate experimental initiatives, streamline regulatory processes, and ensure resource availability (Breaugh et al., 2021). Moreover, Midlemis and Parrish (2010) and van den Heiligenberg et al. (2017) highlight the importance of organizers' leadership in navigating challenges, accumulating resources and adapting to changing circumstances. They emphasize the role of dedicated organizers in maintaining momentum and fostering community buy-in.

Lastly, participants' sustained engagement and commitment are essential for long-term success. Participants need to be well-informed, motivated, and willing to invest their time and effort. Hoffman and High-Pippert (2010) and Wang et al. (2025) highlight the need for continuous participant involvement to ensure the success of experiments.

While these 'factors' are primarily grounded in sustainability transitions literature, they incorporate a broad set of studies that directly examine the conditions and variables contributing to the success or failure of urban experiments, which could be applicable to community waste management initiatives. Waste management, particularly in urban contexts, is increasingly recognized as a complex socio-technical challenge that requires not only technological solutions, but also sustained community engagement, institutional coordination, and behavioral change (Duygan et al., 2018; Lishan et al., 2021). These dynamics align closely with transition-based understandings of experimentation, where success is contingent upon actor alignment, strategic learning, and contextual adaptation (van den Heiligenberg et al., 2017). Recent waste-specific research also supports the inclusion of key factors identified in this section. For example, a comprehensive systematic review by Macklin et al. (2023) highlights over 130 influencing factors on curbside recycling behavior, among them, infrastructure availability (convenience), government communication, and social norms are influential. Similarly, Qiao et al. (2024) demonstrate how local decentralized waste treatment systems can boost participation in food waste sorting, contingent on local contextual factors. Therefore, the identified conditions resonate with sector-specific findings in waste management scholarship.

While the current literature indicate that these 12 factors influence the outcomes of experiment, few studies have explored their joint impact. However, literature (Bai et al., 2010; Ragin, 2000; Schneider and Wagemann, 2012) show that factors often work in conjunction rather than isolation. Moreover, different combinations of factors may lead to similar outcomes (equifinality), and the presence or absence of an outcome may not necessarily due to the same factors (asymmetry). This complexity underscores the need for empirical testing to understand the interplay of multiple causal factors.

### 3. Material and methods

The insights gained from a set of 26 community waste management experiments in Shenzhen city in China, which is renowned for its proactive culture in community engagement, is elaborated hereafter. The different experiments were part of two citywide waste management programs and therefore operated under similar conditions. They however varied in important respects and outcomes, enabling the relative assessment of factors that led to success or failure of the experiments. In order to account for how specific combinations of conditions may lead to success, we apply the method of fsQCA. In the following, we describe cases and their selection, outline the two stages of data collection and analysis, with description of early findings which guide subsequent stages. It also introduces the fsQCA method and details its application in the empirical analysis.

#### 3.1. Case description

China's centralized government system often limits flexibility in sustainability experiments, and regional variations in government support can lead to fragmented community waste management practices (Wang et al., 2025). To align with our research objective, we choose a single city to allow us to minimize external variables and closely examine internal dynamics (Van der Heijden, 2015). Shenzhen was chosen due to its urgent need for sustainable waste management solutions, early engagement by the government with

grassroots actors, and its reputation as a hub of innovation and volunteerism (see Supplementary Note 1).

In Shenzhen, we examined 26 experiments from two programs: “Refinement”<sup>1</sup> (a set of 11 experiments, conducted in 2021–2022) and “Green Vision”<sup>2</sup> (a set of 15 experiments, conducted in 2022–2023). The city government facilitated the initiation of these two programs by securing financial support from the Vanke Foundation. The Vanke Foundation provided funding, resources, program guidance, feedback, and evaluation to Non-Governmental Organizations (NGOs), the Zero Waste Promotion Association<sup>3</sup>, and the Shenzhen Special Economic Zone School of Social Work<sup>4</sup>, which were responsible for organizing the two programs, respectively. Each ENGO was tasked with organizing project applications and selection, providing training in experiment design and implementation, conducting initial experiment reviews, offering experiment guidance, and performing expert reviews and evaluations for successful applicants who organized the experiments. Each experiment was led by one or more individuals. One experiment from the Refinement program was excluded due to its leadership structure being based in an NGO rather than an individual volunteer (details of the two programs are shown in Supplementary Note 2). Despite similar support from the government and NGOs, the experiments—all focused on sustainable waste management—produced varied outcomes, ranging from early discontinuation to local continuation or broader replication. This variation, within a shared urban and institutional setting, provided an ideal empirical basis for fsQCA, allowing for the exploration of causal complexity while minimizing external confounding variables (Ragin, 2008).

The experiments spanned diverse settings: 19 urban residential communities, 2 schools, 2 urban villages, 1 factory, 1 public park, and 1 restaurant. They targeted various groups, including households, students, workers, and catering shops, promoting waste reduction and recycling through activities like workshops, community gardens, composting, and education. This heterogeneity strengthens the generalizability of insights within the urban waste management domain. Of the 26 experiments, 8 were unsuccessful, while 18 succeed — 11 continued locally, and 7 were multiplied or scaled to other contexts. To ensure validity and reduce response bias, all experiments were monitored by the two coordinating NGOs through regular training, site visits, progress reviews, and final evaluations. Additionally, the first author conducted 11 on-site visits to directly observe activities and cross-validate interview and survey data. Detailed documentation, including activity logs, participant numbers, and funding records was also used to triangulate outcomes and strengthen the reliability of reported data. Detailed descriptions with identifiers (Experiment 1, 2, ... 26) are in Supplementary Note 2.

### 3.2. Data collection, analysis, and results

This section outlines two stages (Fig. 1 details the procedure). In the first stage, we identified 19 factors influencing experiment outcomes from the “Refinement” program. This stage also compared organizers and participants’ perspectives on experiment performance. In the second stage, we validated 19 factors using data from the “Green Vision” program. These factors were categorized into four groups for further fsQCA analysis. This research was reviewed and approved by the Humanities and Social Sciences Delegated Ethics Review Committee Chair from Australian National University under Protocol: 2021/258.

#### 3.2.1. First stage: identification of influencing factors

From December 2022 to March 2023, the first author visited 11 experimental sites and conducted 42 semi-structured interviews with experiments organizers, NGOs, government, academic and consultants (details in Supplementary Table 1.1).<sup>5</sup> The interviews explored experiment contexts, governance structures, stakeholder roles, leadership profiles, funding, activities, strategies, factors influencing experiment outcomes, and practical experiments’ outcomes. A Likert scale (1–10) was used to assess short-term achievements, leadership capacity, social connections, and participant empowerment (see Supplementary Note 3), e.g., “on a scale of 1–10, how would you rate participant empowerment?” with higher values indicate better performance.

An online survey via Wenjuanxing (<https://www.wjx.cn>) collected 250 responses from participants<sup>6</sup> across 11 experiments, assessing their perceptions of outcomes, leadership abilities, engagement levels, empowerment and their participation frequency and post-activity behaviors on a Likert scale (1–10). They also identified key factors for success through an open-ended question.

We compared organizers and participants’ assessment of experiments’ performance based on Likert scale results. We found that the organizers’ evaluations on the performances of experiments were more aligned with the practical outcomes (see Supplementary Note 3). Thus, organizers’ perspectives were prioritized in the second stage of data evaluation. English translation of the interview transcripts and survey open-ended responses were analyzed using Nvivo 12. We used a predetermined coding scheme based on 12 factors

<sup>1</sup> “深圳启动社区垃圾分类深耕细作专项行动” Shenzhen launches special Refinement Program for community waste sorting. Details can be seen from: <https://baijiahao.baidu.com/s?id=1706979119197617456&wfr=spider&for=pc>, [https://cgj.sz.gov.cn/xsmh/ljfl/pgyjh/flxc/mtbd/content/post\\_9036688.html](https://cgj.sz.gov.cn/xsmh/ljfl/pgyjh/flxc/mtbd/content/post_9036688.html)

<sup>2</sup> “绿见社区·益创未来——深圳社区环境可持续发展支持计” Green Community · Creating a Better Future — Shenzhen Community Environmental Sustainability Support Program (“Green Vision program”) <http://www.sswc.org.cn/news-81346.html> <http://sswc.org.cn/news-79935.html>

<sup>3</sup> 深圳市龙华区零废弃促进会 (Zero Waste Promotion Association) [http://www.lingfeiqi.org.cn/?page\\_id=17](http://www.lingfeiqi.org.cn/?page_id=17)

<sup>4</sup> 深圳经济特区社会工作院 (Shenzhen Special Economic Zone School of Social Work) <http://sswc.org.cn/about.html>

<sup>5</sup> The selection of the 11 experiments was guided by their representativeness of diverse pathways, different outcomes under similar socio-economic contexts and duration in Refinement Program. As noted by Ragin (2008), for a small number of cases, a minimum of 10–15 cases is recommended for meaningful analysis, and our 11 experiments align with this guideline.

<sup>6</sup> Despite variations in participant numbers across experiments, based on (Cohen J., 1988), the minimum number of 20 participants per experiment was deemed sufficient to prevent significant impact on the results.

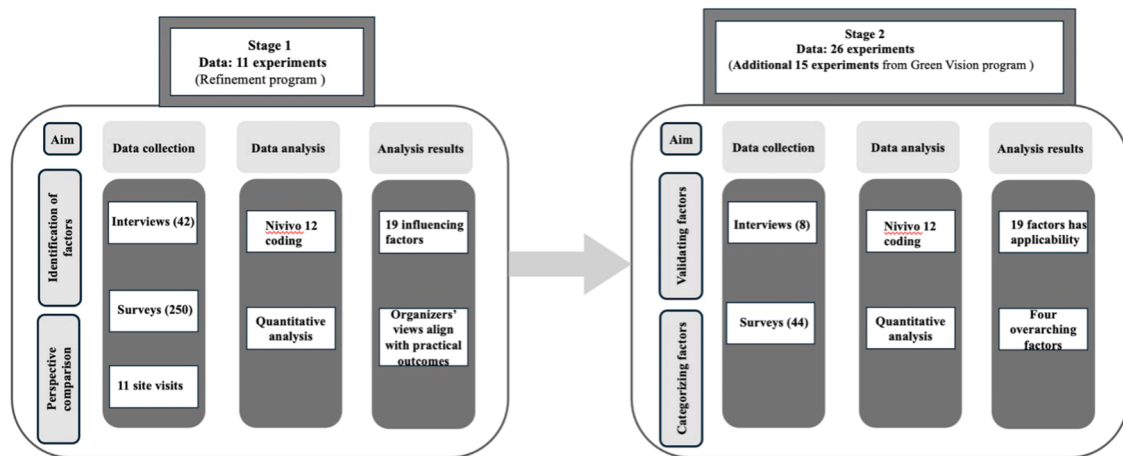


Fig. 1. Methodology procedure.

that were derived from the literature and added other factors that resulted from open coding<sup>7</sup> of survey to consider local aspects that proved important in the local contexts, and which were not explicitly covered by extant literature. The coding scheme was iteratively revised until saturation (Corbin and Strauss, 2014), allowed for a comprehensive analysis of influencing factors. This approach identified 19 factors influencing sustainability experiment outcomes. The coding structure for deriving these 19 factors is shown in Supplementary Figure 1. Supplementary Table 2 provides comprehensive explanations of each of the 19 factors.

### 3.2.2. Second stage: validating and categorizing influencing factors

In this stage, additional 15 experiments are involved from the “Green Vision” program (Supplementary Note 4 provides elaborations). Online semi-structured interviews were conducted with 8 out of the 15 experiment organizers<sup>8</sup> (Supplementary Table 1.2) to understand the outcomes, specific contexts, and internal governance of the experiments.

Surveys were conducted with organizers from all 26 experiments, using a Likert scale (1-10) to rate the importance of each factor, 10 being the most important and 1 the least important.

Statistical analysis, including average ratings and T-tests, showed no significant differences between the two groups (11 and 15 experiments’ organizers), showing the 19 factors’ applicability (see details in Supplementary Note 5).

For fsQCA preparation, the 26 organizers were asked to categorize the 19 factors into three broad groups, as the literature suggests for small-N datasets with three or four conditions (Greckhamer et al., 2013). Additionally, 18 online surveys were conducted with key stakeholders, including NGOs and government officials, gathering broader insights. In total, 44 surveys were received.

Analysis of open-ended survey responses using Nvivo 12 led to the removal of four factors<sup>9</sup> from the original 19, as they were not mentioned by participants in factor categorization. The remaining 15 factors were grouped into three categories: effective leadership of organizers, responsible local government, and participants’ long-term commitment (see grouping steps in Supplementary Figure 2). These factors encompass organizational aspects, regulatory commitment, and behavioral factors.

Integrating the existing literature review of 12 factors (Table 1) with our findings, we identified six factors—legislative environment, performance management, financial resources, risk disposition, duration, and technology adaptation from literature review—that were either consistent across our empirical cases or not applicable<sup>10</sup>. Consequently, these factors were excluded from our analysis. To better capture the influence of local context on experiment outcomes, we split the factor “responsible local government” into two: “effective local community” and “responsible local government” (see Figs. 2 and 3). This distinction enables the role examination of local facilities, cohesion, governance, and structure in shaping sustainability experiment outcomes.

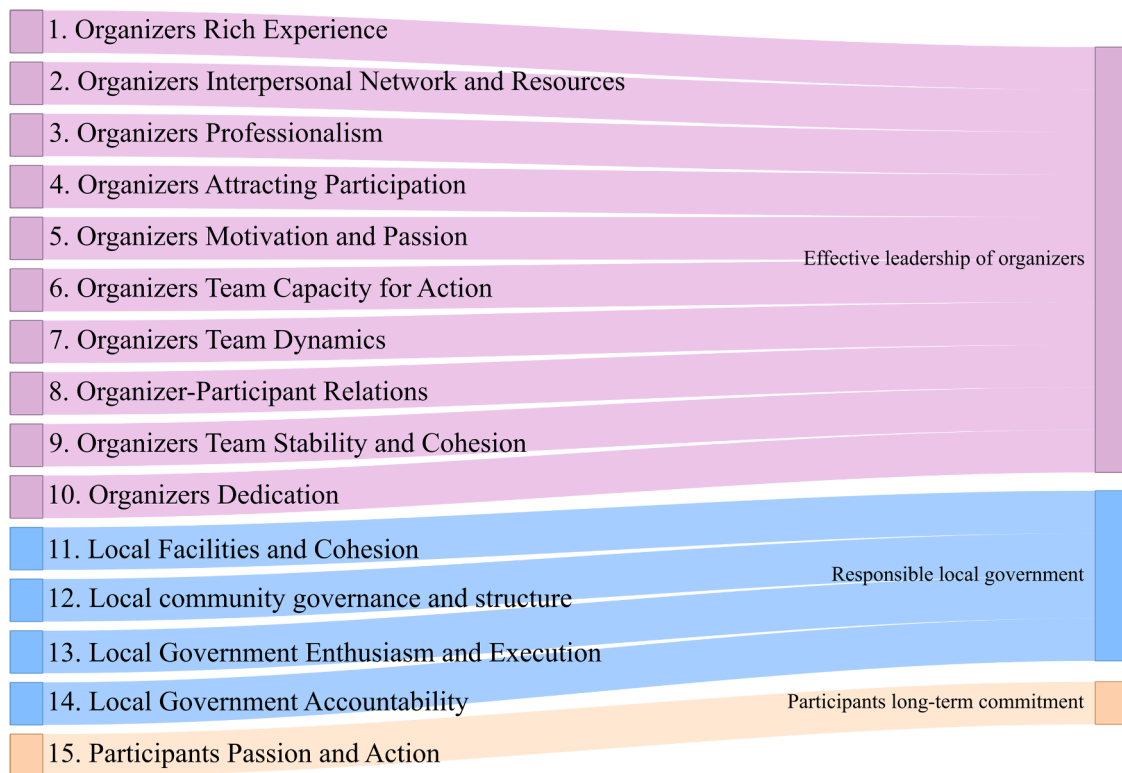
These four factors represent social, organizational and behavioral aspects, will be used as casual factors for fsQCA analysis. The definitions of these four factors, based on the literature review and our findings, are provided in Table 2 in the next section.

<sup>7</sup> Relevant factors not captured by the initial categories were coded with an “open” code, regularly reviewed, discussed, and grouped into new categories.

<sup>8</sup> With assistance from the leading NGO of this program (Shenzhen Special Economic Zone Social Work Institute), we believe the absence of interviews with the remaining 7 experiments has minimal impact as supplementary documents are available to mitigate any information gaps.

<sup>9</sup> Based on Nvivo 12 analysis of open questions about how stakeholders group the 19 factors, we removed four factors that are not mentioned in the result of the open-ended question including the size of the organizer’s team, whether the organizer is from the community (e.g., whether as a resident of the community), the community’s past relevant achievements (such as being recognized as a green community) and the scale of participant numbers.

<sup>10</sup> Technological factor was not applicable as our empirical cases did not involve technological innovations.



**Fig. 2. Results of the empirical analysis categorizing 15 explanatory factors into three overarching groups.** Four factors were excluded from the original 19 due to their absence in the second round of survey results. This figure presents the final 15 factors, grouped into three categories derived through analysis of survey responses. Factors sharing the same colour belong to the same group: Factors 1–10 belong to effective leadership of organizers, factors 11–14 belong to responsible local government, and the remaining factor belongs to participants' long-term commitment.

### 3.3. fsQCA analysis

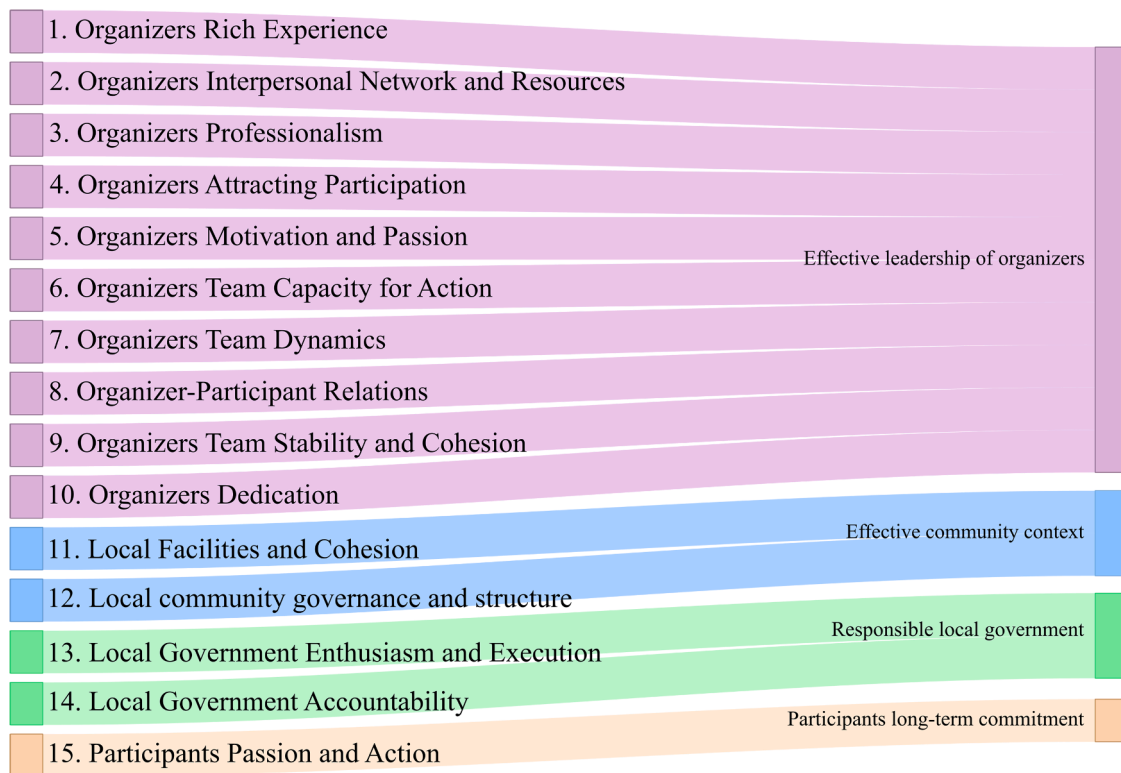
This paper employs fsQCA to investigate the four overarching factors, which are regarded as “conditions” (Fiss, 2011), influencing sustainability experiment outcomes. Grounded in Boolean algebra, fsQCA can effectively capture the complexity of causal conditions including equifinality, conjunctural causation, and asymmetry (Ragin, 2008; Ragin, 2000). Recognizing that sustainability outcomes seldom arise from a single factor (Bai et al., 2010), fsQCA simplifies logical patterns linking conditions to outcomes, evaluated by coverage (proportion of relevant observations in a configuration) and consistency (degree of support for a configuration) (Schneider and Wagemann, 2012). A detailed explanation of fsQCA is provided in Supplementary Note 6.

The fsQCA method follows a specific sequence of steps (Schneider and Wagemann, 2012), simplified here into four key steps:

First, we must define the conditions and outcomes. The four identified conditions are effective organizers, participants' commitment, responsible local government, and effective local community. While all 26 experiments analyzed in this study fall under the broader category of sustainable community waste management, they span diverse contexts such as residential neighborhoods, schools, urban villages, factories, parks, and restaurants. Each case involves distinct activities, stakeholder groups, and levels of institutional complexity. Accordingly, our analysis applied context sensitive interpretations of ‘effective community context’ that reflect the specific governance and stakeholder makeup of each experimental setting. Outcomes are categorized as successful or failed sustainability experiments. Specific definitions for these conditions and outcomes are in Tables 2 and 3, respectively.

Then for each of the cases, we must determine the set membership scores. Set-membership scores are numerical values indicating the degree to which a condition belongs to a particular experiment (Ragin et al., 2008; Schneider and Wagemann, 2012). We used a 7-value fuzzy set approach to capture fine-grained differences in membership degrees (Rasoolimanesh et al., 2023). This 7-value scale ranges from 0 to 1, denoting minimum to maximum degrees of membership, with cut-off points at 0.17, 0.33, 0.67, and 0.83 to differentiate levels of inclusion. A cross-over point at 0.5 indicates equal presence and absence of a condition (Pennings, 2009).

To develop the set membership table, Ragin et al. (2008) suggested the importance of basing decisions on the researcher's substantive knowledge. Drawing on field visits, interviews, surveys, and theoretical insights, we followed the detailed steps established in existing papers (Fiss, 2011; Pennings, 2009) and assigned a 7-value fuzzy set to four conditions for each case, as detailed in Supplementary Note 7 Table 1. Since experiments may succeed or fail to varying degrees, three outcome types (O1, O2, O3) were graded using the same fuzzy set, and their final outcome was determined by averaging the membership values of the three types. To minimize bias, all membership values were reviewed three times and validated through consultation with NGOs involved as evaluators. Further



**Fig. 3.** Results from integrating the literature review and data analysis: Final 15 factors categorized into four overarching groups for fsQCA analysis. The original categorization of three factors (refer to Fig. 2) was expanded to four by distinguishing “effective community context” as a separate group from “responsible local government.” This separation allows for a clearer understanding of the unique role of local context—such as local facilities, cohesion, governance, and structure—in shaping the outcomes of sustainability experiments. Factors are color-coded to indicate their respective groups: Factors 1–10 belong to effective leadership of organizers, factors 11–12 belong to effective community context, factors 13–14 belong to responsible local government, and the remaining factor belongs to participants’ long-term commitment, which captures both participants’ behavioral (long-term visible actions) and attitudinal dimensions (intrinsic motivation, enthusiasm, pride in environmental action).

**Table 2**  
Definitions of four overarching factors.

Conditions	Short label	Definition
Effective leadership of organizers	Effective organizers	Refers to the leadership of a core group organizers with professional knowledge, high execution capacity, and team management skills. They ensure stable human resources, facilitate collaboration, and drive the experiment toward its goals with enthusiasm and strategic engagement with local government and the community.
Participants’ long-term commitment	Participants’ commitment	Refers to sustained behavioral involvement in experiment activities (e.g., consistent recycling, volunteering, attending training sessions), alongside attitudinal factors such as motivation, enthusiasm, and alignment with the experiment’s goals. This factor captures both visible actions and internal drivers of participants that contribute to the continuity and success of the experiments over time.
Responsible local government	—	Local government here means Shequ (refers to urban neighborhood communities) operate under the jurisdiction of subdistrict offices (Jie Dao Ban Shi Chu), which are the lowest formal government entities in urban settings. Demonstrates strong execution capability, enthusiasm, and political commitment. The local government effectively implements policies, engages in community experiments, adapts to challenges, and innovates to improve systems, promoting public trust through transparency and accountability.
Effective governance and structural organization within the local community	Effective community context	Characterized by well-maintained facilities, strong social cohesion, and effective governance and organizational structures that provide legitimacy and support. Governance structures vary across different community settings due to varying stakeholder involvement and responsibilities: residential and urban villages are led by residents’ committees and homeowner associations; schools are governed by administration teams; factories have formal structures with management and environmental officers; restaurants are governed by owners; parks are managed by dedicated teams like the Bureau of Parks and Gardens.

**Table 3**  
Definitions of outcomes.

Outcomes	Set definition expectation
<b>Successful</b>	A successful outcome is characterized by the development of cohesive and functional interactions within the experiment, fostering learning that leads to achieve its short-term goals and broader impacts on sustainable community practices. This success is evidenced by the continuity of the experiment at the local level, its upscaling to larger contexts, or its replication in other settings. High success, marked by widespread diffusion and upscaling; low success, with sustained local continuity where impact remains limited.
<b>Failed</b>	Experiments have ceased operations, showing complete discontinuity.

procedures and rationales for developing the set-membership table are explained in Supplementary Note 7, and the set-membership table is shown in Supplementary Table 3.

Calibration of the set-membership values on causal conditions and outcome variables is essential to fully utilize the gradations in set membership central to fuzzy sets, ensuring accurate measurement within and across the 26 case studies (Ragin, 2008). Following Pappas and Woodside (2021), the 0.95, 0.5, and 0.05 as the three thresholds, representing fully in, crossover, and fully out respectively to cover the range of data distribution and capture cases belonging to a set to varying degree (the calibration Table and details are shown in Supplementary Table 4). We computed the 95 %, 50 %, and 5 % of our measures and use these values as the three thresholds in fsQCA software (fs/QCA (version 3.0)), following the detailed procedures in Schneider and Wagemann (2012). The calibrated Table and detailed steps are shown in Supplementary Table 5.

Secondly, we analyzed the data for necessary conditions following standard fsQCA practices. A condition is considered necessary if the outcome is unlikely to occur without it. We conducted necessity analyses of all conditions and their negation, applying a recommended consistency benchmark of  $\geq 0.9$  and taking coverage as measure of a necessary condition's relevance (Schneider and Wagemann, 2012).

Thirdly, we conducted sufficiency analyses using Ragin's (2008) truth table algorithm to identify condition combinations consistently linked to an outcome. A consistency benchmark of  $\geq 0.8$  was applied, complemented by a proportional reduction in inconsistency (PRI) score benchmark of  $\geq 0.65$  to avoid simultaneous subset relations of attribute combinations in both the outcome and its absence (Greckhamer, 2016). More explanations about truth table algorithm are shown in Supplementary Note 8.

After minimizing the truth table, a standard analysis was conducted in fs/QCA 3.0, resulting in three types of logically reduced configurations of conditions sufficient for the outcome: complex, intermediate, and parsimonious solutions (detailed in Supplementary Note 9). The complex solution is derived entirely from empirical data, while the intermediate solution refines it by incorporating easy counterfactuals—hypothetical scenarios grounded in theory or substantive knowledge (Fiss, 2011). The parsimonious solution, the simplest form, uses difficult counterfactuals, making assumptions to fill data gaps while simplifying the analysis. However, this approach risks oversimplification and reduced precision (Ragin, 2008). In our study, we distinguish core and peripheral causal conditions by integrating insights from both intermediate and parsimonious solutions, enabling a more nuanced and comprehensive interpretation (Fiss, 2011).

To assess sensitivity of our result to calibration thresholds, we conducted robustness checks by recalibrating all sets using 20th, 50th, and 80th percentile cut-off points (Fiss, 2011; García-Castro et al., 2013). Additionally, we adjusted the cut-off consistency value to 1 as a further robustness measure, ensuring stricter sufficiency conditions. Results show the identified configurations maintained a subset relationship with the original results, confirming their stability and robustness (see Supplementary Tables 10 -12).

#### 4. Results

The findings are presented in two steps. First, we outline the main causal pathways explaining the success and failure of the experiments, highlighting key configurations of factors important for establishing community waste management schemes in Shenzhen, China. Second, we illustrate how these conditions manifest in real-world examples using our qualitative data, offering practical operationalizations for policymakers and waste management practitioners.

**Table 4**  
Configurations of causal conditions leading to successful experiments.

Causal conditions	Pathway 1	Pathway 2	Pathway 3
Effective organizers			●
Participants' commitment	●	●	
Responsible local government		●	●
Effective community context	●		
Overall solution coverage	0.911251		
Overall solution consistency	0.973485		

Note: Black circles indicate the presence of a condition. Large circles indicate core conditions (present in both parsimonious and intermediate solutions), while small circles indicate peripheral conditions (present in intermediate but not parsimonious solutions). Blank spaces indicate "don't care" situations.

#### 4.1. Main causal pathways explaining success and failure: fsQCA results

In the necessity analysis (Supplementary Table 6), none of the four conditions reached the consistency benchmark of 0.9, indicating that no single condition is necessary for the experiments' success. This finding highlights the importance of considering combinations of conditions rather than focusing on individual factors in isolation for achieving successful experiments. This finding reinforces the value of fsQCA in exploring conjunctural causation, distinguishing it from traditional variable-centric approaches.

The sufficiency analysis identified combinations of conditions sufficient as causal pathways for successful sustainability experiments. Parsimonious and intermediate solutions are detailed in Supplementary Tables 7 and 8, respectively. Table 4 presents fsQCA results using Fiss's (2011) notation, showing three sufficient pathways for successful experiments:

**Pathway 1:** Participants' passion and long-term commitments is identified as a core condition, and a supportive community context as a peripheral condition.

**Pathway 2:** The development of intrinsic incentives and commitments among participants, as well as backing from responsible local government, are both core conditions.

**Pathway 3:** The presence of accountable local government continues to be a core condition, while the leadership of grassroots organizers functions as a periphery.

This study primarily reports intermediate solutions, with supplementary information from parsimonious solutions to clearly delineate core and peripheral conditions, enhancing interpretation (Fiss, 2011). The overall solution consistency is 0.973 shows that the solution was 97 % consistent with empirical evidence, demonstrating the solution's strong explanatory power (Ragin, 2008). The solution coverage of 0.911 suggests high empirical relevance, covering 91% of observed cases.

**Table 5**

Summary of key pathways for studied community waste management experiments include pathway key characteristics and detailed case illustration.

Pathways	Key characteristics	Illustrative Experiments (identifiers are in Supplementary Note 2 Table 1)	Experiments uniquely follow this pathway	Detailed case illustration
<b>First Pathway:</b> Fostering Participants' Long-Term Commitment Within a Supportive Community Context	Supportive local leadership, strong governance, accessible facilities, ongoing community engagement. Effective local context leadership and adaptability of organizers. Focus on participants' intrinsic motivation and sustained commitment.	Experiments 1, 12, 23, 17, 26, 3, 8, 9, 13, 15, 20, 21, 22, 24	Experiments 3, 13, 21, 24	Songhui Chemical Industry (Experiment 12) - Local leaders with execution capacity tailored activities to the factory's context. - Coherent governance integrated recycling into regulations and training. - Local context accessible and user-friendly facilities increased participation. - Ongoing education and volunteer networks ensured sustainability.
<b>Second Pathway:</b> Commitments Among Participants and Responsible Local Government	Local government enthusiasm, accountability, and execution capacity. Local government initiatives and adjustments based on participant feedback. Non-monetary incentives for engagement. Adaptable strategies to participant needs	Experiments 1, 12, 17, 23, 6, 8, 9, 15, 18, 20, 22, 26	Experiments 18	Xinwei Urban Village (Experiment 8) - Initially smooth activities were disrupted by a leadership change. - Later expanded to other villages with supportive officials. Ludan Community (Experiment 6) -Local government awarded certificates to families excelling in waste sorting. - Local informational videos encouraged sustained participation. Shenye Yuyuan (Experiment 1) - Collaborative 5233 community governance framework led to high compliance and effectiveness.
<b>Third Pathway:</b> Effective Grassroots Organizers Working with Supportive Local Governments	Strong grassroots leadership: emphasizing adaptability and trust-building within the community. Effective partnerships between top-down (local government) and bottom-up (grassroots) approaches. Learning-by-Doing: Encouraging flexibility, timely communication, and inclusivity in practices. Government Support: Reliance on local government for authority, resources, and legitimacy.	Experiments 1, 12, 17, 23, 8, 9, 5, 6, 11, 22, 26	Experiments 5 and 11	Songhui (Experiment 12) Organizers learn and make adaptive changes in strategy. E.g., transitioned to training core members and forming volunteer teams to enhance peer influence. Longjing Village Restaurants (Experiment 10) shows grassroots organizers encountered resistance need collaboration with local government.

Understanding factors leading to failure is as important as identifying those leading to success. Two pathways were found sufficient to lead to failure (Supplementary Table 9). The first pathway indicates that the combination of irresponsible local government, ineffective organizers, and inconsistent participant commitment will lead to failure, across varying local context. This failed pathway reflects a systemic breakdown across institutional, organizational, and individual levels. The second pathway shows that the absence of an effective community context, responsible local government, and participant commitment will also result in failure, irrespective of organizer effectiveness. The consistency of 0.99 indicates these solutions reliably predict failure, and the coverage of 0.93 suggests these conditions explain 93% of failure cases.

Together, these findings reveal that failed experiments are not simply the result of one missing element but often emerge from multiple misalignments across actor roles, community conditions, and institutional support. Unlike successful cases, which benefit from the positive reinforcement of coordinated efforts, failed cases tend to suffer from fragmented responsibilities, unclear leadership, and disengaged stakeholders. A more nuanced understanding of failure is therefore essential, not just to avoid replicating unsuccessful configurations, but to design more adaptive strategies that can withstand contextual uncertainties. This analysis complements the three success pathways presented earlier and strengthens the overall understanding of what shapes outcomes in urban waste management experimentation.

#### 4.2. Specifying the conditions: results from in-depth case analyses

The three causal pathways indicate alternative configurations of conditions that have led to success in the respective cases. Below, we elaborate on emblematic cases that illustrate these pathways. These cases were selected not only for their representativeness of the particular pathways, but also because they cover diverse contexts, including factories, residential areas, urban villages, and restaurants to better capture the study's focus on diverse causal configurations in different settings. Table 5 summarizes the key pathways and real-life examples from our community waste management experiments.

##### 4.2.1. First pathway: fostering participants' long-term commitment within a supportive community context

The first pathway to successful community waste management is observed in 14 cases with four uniquely following this pathway, demonstrating that an effective community context and participant commitment alone can lead to success (shown in Table 5). The other cases overlapped with pathways involving responsible local government and effective organizers, indicating that while this pathway is sufficient, it is not exclusively necessary. In this pathway, key elements include supportive local leadership, strong governance, accessible facilities, and ongoing community engagement at local context foster participants' intrinsic motivation and sustained commitment.

These key factors are observed in the successful waste reduction and sorting case at Songhui Chemical Industry (Songhui Industry, experiment 12). The factory, additional to manufacturing unit, has a dormitory for 500 workers, a canteen, and an office building, all producing daily waste. Sustainable waste management practices have been consistently adopted by employees even after the experiment concluded.

Firstly, this experiment involves factory leaders with strong execution capacity and local knowledge. The Human Resources Department manager coordinated activities with grassroots organizers and provided feedback based on the factory's specific situation. Organizers (interviewee 27, see Supplementary Table 1.1) noted that implementation would have been difficult without the manager. For example, activities were moved from Saturdays to Friday afternoons based on the manager's insight for better attendance, showing the value of local insight. Active participation of other Songhui Industry leaders, including the factory foreman in supervising waste separation activities and attending award ceremonies, further encouraged workers to engage in waste separation.

Secondly, the existence of a sound governance system and an organizational structure in the local community context facilitated the success. Songhui's coherent governance which entails a well-coordinated and effective system of policies, regulations, and enforcement mechanisms in the local context ensured efficient recycling practices. For example, waste separation and recycling were integrated into factory regulations and workers' training sessions. Songhui also introduced dormitory inspections with rewards to reinforce positive behaviors.

Thirdly, the ease of recycling is crucial for long-term participant commitment. Songhui provided accessible, well-marked, and conveniently located recycling facilities, increasing participation rates. Unlike the commonly used tall and heavy bins in Shenzhen (based on Interviewee 28), Songhui used light, short, and user-friendly bins.

Fourthly, community members exhibited stronger commitment when they understood the direct impact of their actions on the local environment. Ongoing education programs about the benefits and correct practices of recycling were conducted in Songhui factory, with training materials and specific responsibilities for workers and volunteers.

Lastly, Songhui developed a core team of dedicated volunteers, ensuring continuity and sustainability of the waste management practices. This internal volunteer network also reduced reliance on outside organizers, making the initiative more resilient and sustainable.

##### 4.2.2. Second pathway: commitments among participants and responsible local government

Twelve cases succeeded via second pathway, with only one case being unique to this pathway (shown in Table 5). This pathway emphasizes the importance of building participants' passion and long-term commitment through strong local government support. This suggests that the combination of supportive local government and participants commitments can independently lead to successful outcomes. It also implies that the robust local government involvement can compensate for a less effective community context (which is crucial in the first pathway). Key elements of this pathway involve government's enthusiasm, accountability, and execution

capacities in managing waste effectively. For the other successful cases which overlap with other pathways demonstrates that while strong local government and participants commitment are crucial factors, there can be other factors that will lead to success.

Local government enthusiasm is crucial for implementing innovative activities, attracting participants and fostering interest. The case of *Recycling of Abandoned Wooden Products in Xinwei Urban Village* (experiment 8) illustrates the impact of local government support. This experiment aimed to recycle, and reuse abandoned wooden furniture in community gardens, create handicraft products, and provide nature education to students. Local government support initially ensured smooth activities and high participant involvement. When a less supportive official took over, barriers like confiscation of activity rooms disrupted the experiment. The experiment later gained public attention and expanded to seven other urban villages through an exhibition of wooden handicrafts made from discarded furniture, through the effort of a supportive government official.

Supportive local government also incentivizes long-term participant involvement through recognition. The successful case of the *Promotion of Waste Sorting and Zero Waste Courses in Ludan Community* (experiment 6) highlights the effectiveness of non-monetary incentives, such as certificates of recognition awarded at special events to families excelling in waste sorting. These families helped create informational videos on effective waste sorting practices, which were used to educate other residents. According to the experiment organizer (interviewee 6, Supplementary Table 1.1), these videos, played continuously at public venues, effectively encouraged ongoing participation from residents.

Adjusting strategies based on participants' feedback is crucial. The *Build 5233 Course System for Volunteer Services to Promote Waste Reduction and Sorting in Shenye Yuyuan Community* (5322 case, experiment 1) exemplifies this approach. The local government involved residents in decision-making processes, such as determining the optimal locations for trash bins, setting collection schedules, and addressing educational needs. Regular meetings and feedback collection led to adjustments like providing pictorial instructions to accommodate varying literacy levels within the community. Furthermore, the local government and community representatives co-created the 5233 framework. It consists of five teams: the community committee, property owners' committee, property management company, research team, and volunteer team. The framework includes two volunteer groups: adults and students. It focuses on three themes: community care, custodial services, and creating a beautiful home. Finally, it uses three evaluation schemes: activity participation, individual performance, and family performance. This framework fosters cooperation, emotional exchanges, and collaborative consensus, leading to high compliance rates and enhanced waste reduction program effectiveness, demonstrating the local government's strong execution ability and commitment to public engagement.

#### 4.2.3. Third pathway: effective grassroots organizers working with supportive local governments

Eleven cases succeeded via the third pathway with two experiments 5 and 11 being unique to this pathway (shown in Table 5). These unique cases illustrate that effective grassroots organizers and supportive local government can independently lead to successful outcomes. The overlap of cases with other pathways further highlights that while grassroots leadership and local government support are critical, diverse strategies in other pathways can be equally functional in achieving desired outcomes. This pathway involves grassroots organizers providing expertise, networks, passion, and flexibility, working alongside local governments to engage communities and promote sustainable practices. Success relies on collaboration between top-down and bottom-up approaches.

Effective organizers exhibit strong leadership qualities, crucial for inclusive and accessible activities. They build trust within the community and foster a sense of ownership over waste management issues. The organizers of 11 successful cases following this pathway show common characteristics like attracting local government participation through strong interpersonal networks and a commitment to transparency and respect within their teams. Additionally, their dedication to environmental sustainability enhances public engagement.

Grassroots organizers are flexible, using a learning-by-doing approach, emphasizing timely communication and adaptability. For instance, the organizer of the Songhui case (Interviewee 27) stressed that they shifted from factory-wide information distribution to training core members and forming a volunteer team as they find peer influence more effective.

However, the success of these experiments relies heavily on local government support, as grassroots organizers often lack the necessary influence to drive change independently. A grassroots organizer (interviewee 26) from the *Waste Reduction and Sorting in Restaurants in Longjing Village Longjing street* case noted:

*"This isn't something we can do alone as volunteers. We lack authority, so we need to collaborate with the local government. Many restaurant owners were either too busy or didn't see the importance, ignoring us."*

This highlights the need for collaboration with local authorities to overcome challenges and achieve success.

Integration with local government also allows grassroots organizers to offer valuable insights based on their direct experiences and lessons learned on-the-ground. Their continuous access to on-site information and collaboration with residents are crucial for enhancing policy acceptance and effectiveness as noted by a government official (interviewee 40). Furthermore, evidence from 11 successful cases in this pathway underscores that with local government support, grassroots organizers engage residents effectively as local government provide necessary authority, resources, and legitimacy.

## 5. Discussion

These findings offer critical empirical and conceptual contributions to the field of urban waste management in China. They not only highlight the successful pathways observed in Shenzhen's community waste management but also illuminate the nuanced mechanisms at play. By engaging with concepts such as equifinality, asymmetry, and conjunctural causation, this section uncovers the intricate dynamics between social, organizational, and behavioral factors, offering a better understanding of how diverse factors converge to

shape community waste management outcomes.

### 5.1. Implications for community waste management

The first pathway highlights the importance of participants' commitment for success, with a supportive local context as a complementary factor. Leveraging contextual factors is helpful to encourage continuous participation in waste sorting. Prior research indicates that knowledge and infrastructure significantly influence pro-environmental behavior (Qiao et al., 2024; Ramayah et al., 2012; Tonglet et al., 2004). When individuals are unaware of the environmental impact of their actions, they are less likely to make moral decisions about waste management (Klößner and Matthies, 2004). Therefore, ongoing community education is crucial, which makes the consequences of unsustainable waste management widely known. Accessible recycling facilities are also critical as inadequate infrastructure can hinder proper waste practices (Zhang et al., 2019).

Empirical evidence suggests that supportive local community leadership and robust governance foster prosocial norms and moral obligations (Chan and Bishop, 2013; Huang et al., 2022). In China, these concepts can be related to "Mianzi" and "Guanxi". "Mianzi" refers to one's reputation or self-perception, influences residents' recycling behaviors through social norms and peer influence (Qin and Owen, 2021). The social pressure to maintain "Mianzi" encourages participation in recycling activities, especially within tightly knit networks characteristic of China's "acquaintance society". Similarly, "Guanxi" represents close reciprocal relationships, motivating active participation in waste separation through personal networks, beyond mere compliance (Read, 2003).

The second pathway identifies participants' commitment and responsible local government as core conditions. Local governments should support waste management efforts and consider residents' needs, as they are ultimately responsible for sustainable behavior. Understanding the attitudes and obstacles to residents' participation is crucial for implementing successful experiments. For example, government should offer essential resources and highlight exemplary behaviors to establish positive norms (Timlett and Williams, 2008).

The third pathway emphasizes collaboration between grassroots organizers and local government efforts. Effective grassroots leadership, characterized by professional knowledge, network building, passion and dedication is crucial. Our empirical evidence shows that effective grassroots organizers bridge the gap between government, NGOs, and community residents by reflecting and addressing real issues and serving the community effectively. They can also address local government insufficiency in public engagement and increase public awareness of waste management issues. Based on existing transition literature, these grassroots organizers can play a pivotal role in sustainability transitions by acting as intermediaries who connect various actors, along with their skills and resources. They facilitate citizen engagement and help align the interests of diverse stakeholders (Kivimaa et al., 2019a; Kivimaa et al., 2019b).

However, grassroots organizers alone face challenges, including limited recognition and resources (Hossain, 2018; Seyfang and Smith, 2007). They may struggle with negative public perceptions and skepticism, particularly in volunteer-based operations. Our findings on unsuccessful cases (cases 2, 10, 19) and existing literature indicate that to be successful, grassroots actors efforts often require government support (Feola and Nunes, 2014; Hossain, 2018; Seyfang and Smith, 2007; Wang et al., 2024). Institutionalizing grassroots organizers roles and enhancing professional development can significantly increase the impact of grassroots organizers (Lishan et al., 2021).

Moreover, while conducting separate fsQCA analyses for different types of experimental settings was beyond the scope of this research—primarily because residential neighborhoods make up 19 of the 26 cases—their dominance means that they appear across all three identified success pathways. For instance, of the 14 experiments that follow the first pathway, 10 are based in residential neighborhoods, and 9 out of the 12 cases in the second pathway are also residential. This widespread presence makes it difficult to draw firm comparative conclusions based solely on the frequency of specific setting types within each pathway. However, a closer examination reveals that nuanced differences in sub-types of experimental settings—such as factories, parks, urban villages, or school-community hybrids—play a critical role in shaping actor dynamics, governance configurations, and intervention strategies. For instance, Pathway 1, which emphasizes fostering participants' long-term commitment within a supportive community context, is well illustrated by Experiment 21 (community garden) and Experiment 24 (flea market initiative), where cohesive neighborhood ties, volunteer-driven action, and internal leadership created conditions for sustained behavioral change. In Pathway 2, characterized by strong participant engagement reinforced by responsive local government, cases like Experiment 6 (Ludan Village) and Experiment 1 (Shenye Yuyuan) show how government support through certification, visibility, and coordination can amplify community-driven efforts. Finally, Pathway 3, which relies on collaboration between effective grassroots organizers and supportive local government, is demonstrated in hybrid or less formally governed contexts such as Experiment 5 (Bishui Longting, a school-community initiative) and Experiment 8 (Xinwei urban village). In these settings, flexible partnerships and adaptive learning between bottom-up and top-down actors compensated for weaker formal institutions. These insights suggest that while residential settings are the most frequent, the internal diversity of community structures and governance contexts can influence which pathway is most effective.

### 5.2. Understanding causal complexity in community waste management pathways

Understanding what leads to success or failure in experiments is not always straightforward. Different conditions often need to come together, and different combinations can still result in similar outcomes. This section uses concepts like conjunctural causation, equifinality, and asymmetry to explain how these complex patterns work in practice.

Conjunctural causation means that success often depends on several conditions working together and no single factor is enough on its own (Schneider and Wagemann, 2012). In the context of the waste management pathways, conjunctural causation is evident in the

necessity of combining factors such as participant commitment, supportive local governance, and effective grassroots leadership. For instance, the first pathway demonstrates that both participant commitment and a conducive local context are essential for success but neither one is sufficient on its own. This means that the absence of one condition cannot be compensated by the presence of another in this pathway; they must work in conjunction to achieve the desired outcome.

Equifinality describes that there is more than one way to achieve success (Schneider and Wagemann, 2012). In our empirical cases, equifinality is demonstrated by the existence of three distinct successful pathways. Each pathway represents a different combination of conditions leading to effective waste management. The first pathway emphasizes the role of participants and local context, the second focuses on participants and governmental support, and the third combines grassroots organizer leadership with governmental support. This diversity in successful strategies underscores that no single formula is universally applicable; rather, different configurations of conditions can result in positive outcomes. For example, even if a local context is not particularly supportive, passionate participants combined with a proactive government can still achieve success, demonstrating that multiple “recipes” can yield the same “dish” (van der Heijden, 2019).

The concept of asymmetry in causation highlights that the presence of certain conditions may lead to an outcome, but their absence does not necessarily lead to a failure of that outcome (Schneider and Wagemann, 2012). In our empirical cases, while a condition like participant commitment may be crucial in one pathway, its absence in another does not preclude success if other supportive conditions are present. For instance, the third pathway shows that even in the absence of strong participant engagement or a conducive local environment, collaboration between effective grassroots organizers and responsible local government can still lead to successful outcomes. This asymmetry reflects the subset relationship where certain conditions are sufficient but not necessary, allowing for flexibility in achieving the desired results (Ragin, 2008).

These ideas help us better understand why some experiments succeed while others do not. The fsQCA is especially good at identifying these patterns from small to medium-sized samples. It allows us to explore how different factors work together in real-world settings. By applying these ideas to 26 experiments in Shenzhen, we extend existing work in sustainability transitions research. Past studies provide a robust framework for understanding these interactive dynamics (Geels, 2004), but this research identifies broader patterns across multiple experiments. Our findings suggest the need for greater attention to actors’ specific roles, their behavioral and organizational characteristics, and the critical importance of context-specific enablers in determining the success of urban waste management experiments (Bai et al., 2010). This flexibility suggests that policymakers and practitioners should tailor their strategies to their unique contexts, leveraging the most promising pathways available to achieve success even if some ideal conditions are not fully present.

## 6. Conclusions

This study explores pathways to success in community waste management based on 26 case studies in Shenzhen, China. Through interviews, surveys, on-site visits, and focus groups, we identified 19 influential factors and analyzed their combinations using fsQCA. Three successful pathways emerged: 1) passionate, committed participants with supportive communities; 2) committed participants backed by responsible local government; and 3) effective grassroots leadership with responsible local government.

Conceptually, this research contributes to transition studies by highlighting the importance of a configurational understanding of the factors influencing the success or failure of sustainability experiments. Our findings show that no single factor is sufficient; rather, the interplay of social, organizational, and behavioral dimensions determine outcomes of community waste management. Key implications for policymakers in community waste management include emphasizing participants long term engagement, leveraging local government and community support, and strengthening grassroots leadership. Policymakers may promote a configurational understanding of factors influencing experiments outcomes, encouraging holistic approaches rather than single-factor solutions. It would be also beneficial for local governments to develop a comprehensive framework delineating stakeholders’ responsibility, identifying interdependencies, and enhancing interactions within the community.

Nonetheless, the findings should be interpreted with caution. The fsQCA is based on a relatively small sample of 26 experiments within a single city, which, while appropriate for exploring causal complexity, limits the statistical generalizability of the results. However, the selected cases are broadly representative of the diversity of community waste management experimentation in Shenzhen. While it was not feasible to expand the sample further within the city, we acknowledge that representativeness may be more limited when applying these findings to other urban contexts. While Shenzhen’s context, marked by openness to innovation, a strong volunteer culture, and proactive civil society actors, offers valuable lessons for sustainability experimentation, it also introduces certain limitations regarding generalizability. The specific institutional environment of Shenzhen may not be fully representative of other Chinese cities or regions, especially those with weaker NGO ecosystems or more hierarchical governance structures. This limits the direct transferability of certain approaches and outcomes. However, the principle of equifinality suggests that similar outcomes can be achieved through different pathways. Other cities with active environmental NGOs and supportive governments, e.g., Shanghai and Chengdu could implement the third pathway. In contrast, cities like Tianjin and Hangzhou or international counterpart such as Singapore, with robust government structures but less active NGO participation, might find the first or second pathways more applicable. Additionally, the choice of pathway should consider specific local contexts, such as schools, residential communities, factories, and restaurants. For example, factories may benefit from the first pathway, emphasizing strong community governance to engage participants, while restaurants, often lacking consistent regulation, may need strong government intervention and support from environmental NGOs.

Moreover, the analysis is based on short-term outcomes and does not assess the durability or long-term impact of these experiments. Some unobserved or unmeasured contextual conditions, such as shifts in local leadership or socio-economic changes, may also affect

experiment outcomes. Future research should focus on large-scale and longitudinal studies to track the evolution of waste management experiments over time, enabling a deeper understanding of the factors that influence long-term sustainable waste management.

Furthermore, the 26 experiments analyzed in this study represent a wide range of contexts including neighborhoods, schools, urban villages, factories, parks, and restaurants. These settings involved different actor profiles, activities, logistical conditions, and organizational needs. This research may be limited by the absence of a sub type analysis of these settings. Future studies would benefit from comparing subsets of similar cases to explore whether particular causal combinations work better in specific types of experimental environments. Additionally, while several factors from the literature, such as legislative environment, financial resources, and performance management were consistent across our cases and thus excluded from fsQCA, their importance remains acknowledged. Their uniform presence may indicate they are necessary for experimentation to occur. Future studies could further explore the foundational role these conditions play in enabling sustainability experiments across diverse contexts.

Our findings do not yet allow for the prediction of outcomes across all waste management experiments, as regional development levels and individual behaviors vary significantly. There are additional factors, often described as context specific conditions, that were not measured or observed in this study but may also influence the results. Therefore, a universal solution is unlikely to be effective and strategies must be adapted to fit specific local contexts.

### CRedit authorship contribution statement

**Shengnan Wang:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **Bernhard Truffer:** Writing – review & editing, Validation, Supervision, Methodology, Conceptualization. **Xuemei Bai:** Writing – review & editing, Validation, Supervision, Conceptualization.

### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Co-author Bernhard Truffer is the Editor-in-Chief of the journal of Environmental Innovation and Societal Transitions that we are submitting our manuscript. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgement

This work is supported by the Australian National University Research Scholarship (International) Full-Time (595/2017). We acknowledge the Australian Centre on China in the World (CIW) for supporting the data collection costs. We also acknowledge Dr. George Kiambuthi Wainaina for his time and insightful discussion on the method of QCA. We also acknowledge Kainan Xu, Xiaoqing You and Zhen Yang for their time and efforts in connecting us with participants.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.eist.2025.101032](https://doi.org/10.1016/j.eist.2025.101032).

### Data availability

Data will be made available on request.

### References

- Arantes, V., Zou, C., Che, Y., 2020. Coping with waste: a government-NGO collaborative governance approach in Shanghai. *J. Env. Manage.* 259, 109653.
- Bai, X., McPhearson, T., Cleugh, H., Nagendra, H., Tong, X., Zhu, T., Zhu, Y.-G., 2017. Linking urbanization and the environment: conceptual and empirical advances. *Annu. Rev. Env. Resour.* 42 (1), 215–240.
- Bai, X., Roberts, B., Chen, J., 2010. Urban sustainability experiments in Asia: patterns and pathways. *Env. Sci. Policy* 13 (4), 312–325.
- Berkhout, F., Verbong, G., Wiczorek, A.J., Raven, R., Lebel, L., Bai, X., 2010. Sustainability experiments in Asia: innovations shaping alternative development pathways? *Env. Sci. Policy* 13 (4), 261–271.
- Brangwyn, B., Hopkins, R., 2008. Transition Initiatives Primer. TransitionNetwork. org.
- Breaugh, J., McBride, K., Kleinaltenkamp, M., Hammerschmid, G., 2021. Beyond diffusion: a systematic literature review of innovation scaling. *Sustainability* 13 (24), 13528.
- Chan, L., Bishop, B., 2013. A moral basis for recycling: extending the theory of planned behaviour. *J. Env. Psychol.* 36, 96–102.
- Corbin, J., Strauss, A., 2014. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*. Sage publications.
- Cui, N., Li, J.X., Tu, J., Zhou, M.C., 2022. Evolutionary game analysis of non-governmental organizations participating in garbage management under the background of internet of things. *Sustainability* 14 (20).
- De Feo, G., Ferrara, C., Iannone, V., Parente, P., 2019. Improving the efficacy of municipal solid waste collection with a communicative approach based on easily understandable indicators. *Sci. Total Environ.* 651, 2380–2390.

- Devine-Wright, P., Wiersma, B., 2013. Opening up the “local” to analysis: exploring the spatiality of UK urban decentralised energy initiatives. *Local Env.* 18 (10), 1099–1116.
- Duygan, M., Stauffacher, M., Meylan, G., 2018. Discourse coalitions in Swiss waste management: gridlock or winds of change? *Waste Manag.* 72, 25–44.
- Elzen, B., Geels, F.W., Green, K., 2004. *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*. Edward Elgar Publishing.
- Fagan, G.H., 2003. Sociological reflections on governing waste. *Ir. J. Sociol.* 12 (1), 67–84.
- Feola, G., Nunes, R., 2014. Success and failure of grassroots innovations for addressing climate change: the case of the transition movement. *Glob. Environ. Change* 24, 232–250.
- Fiss, P.C., 2011. Building better causal theories: a fuzzy set approach to typologies in organization research. *Acad. Manag. J.* 54 (2), 393–420.
- Forrest, N., Wiek, A., 2014. Learning from success—Toward evidence-informed sustainability transitions in communities. *Environ. Innov. Soc. Transit.* 12, 66–88.
- Forrest, N., Wiek, A., 2015. Success factors and strategies for sustainability transitions of small-scale communities—evidence from a cross-case analysis. *Environ. Innov. Soc. Transit.* 17, 22–40.
- García-Castro, R., Aguilera, R.V., Ariño, M.A., 2013. Bundles of firm corporate governance practices: a fuzzy set analysis. *Corp. Gov.* 21 (4), 390–407.
- Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Res. Policy* 31 (8–9), 1257–1274.
- Geels, F.W., 2004. From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. *Res. Policy* 33 (6–7), 897–920.
- Greckhamer, T., 2016. CEO compensation in relation to worker compensation across countries: the configurational impact of country-level institutions. *Strateg. Manag. J.* 37 (4), 793–815.
- Greckhamer, T., Furnari, S., Fiss, P.C., Aguilera, R.V., 2018. Studying configurations with qualitative comparative analysis: best practices in strategy and organization research. *Strateg. Organ.* 16 (4), 482–495.
- Greckhamer, T., Misangyi, V.F., Fiss, P.C., 2013. Chapter 3 The two QCAs: From a small-N to a large-N set theoretic approach, Configurational theory and methods in organizational research. Emerald Group Publishing Limited, pp. 49–75.
- Hoffman, S.M., High-Pippert, A., 2010. From private lives to collective action: recruitment and participation incentives for a community energy program. *Energy Policy* 38 (12), 7567–7574.
- Hoogma, R., Kemp, R., Schot, J., Truffer, B., 2002. *Experimenting for Sustainable Transport*. Taylor & Francis.
- Hoornweg, D., Bhada-Tata, P., 2012. What a waste: a global review of solid waste management.**
- Hossain, M., 2018. Grassroots innovation: the state of the art and future perspectives. *Technol. Soc.* 55, 63–69.
- Hou, D., Al-Tabbaa, A., Guthrie, P., Watanabe, K., 2012. *Sustainable Waste and Materials Management: National Policy and Global Perspective*. ACS Publications.
- Huang, M., Law, K.M., Geng, S., Niu, B., Kettunen, P., 2022. Predictors of waste sorting and recycling behavioural intention among youths: evidence from Shenzhen, China and Turku, Finland. *Waste Manag. Res.* 40 (6), 721–735.
- Irvine, S., Bai, X., 2019. Positive inertia and proactive influencing towards sustainability: Systems analysis of a frontrunner city. *Urban Transform.* 1 (1), 1–27.
- Kemp, R., Schot, J., Hoogma, R., 1998. Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management. *Technol. Anal. Strateg. Manag.* 10 (2), 175–198.
- Kivimaa, P., Boon, W., Hyysalo, S., Klerkx, L., 2019a. Towards a typology of intermediaries in sustainability transitions: a systematic review and a research agenda. *Res. Policy* 48 (4), 1062–1075.
- Kivimaa, P., Hyysalo, S., Boon, W., Klerkx, L., Martiskainen, M., Schot, J., 2019b. Passing the baton: how intermediaries advance sustainability transitions in different phases. *Environ. Innov. Soc. Transit.* 31, 110–125.
- Klöckner, C.A., Matthies, E., 2004. How habits interfere with norm-directed behaviour: a normative decision-making model for travel mode choice. *J. Env. Psychol.* 24 (3), 319–327.
- Köhler, J., Geels, F.W., Kern, F., Markard, J., Onsongo, E., Wieczorek, A., Alkemade, F., Avelino, F., Bergeck, A., Boons, F., 2019. An agenda for sustainability transitions research: state of the art and future directions. *Environ. Innov. Soc. Transit.* 31, 1–32.
- Lishan, X., Sha, H., Zhilong, Y., Ouwen, Z., Tao, L., 2021. Identifying multiple stakeholders’ roles and network in urban waste separation management—a case study in Xiamen, China. *J. Clean. Prod.* 278, 123569.
- Macklin, J., Curtis, J., Smith, L., 2023. Interdisciplinary, systematic review found influences on household recycling behaviour are many and multifaceted, requiring a multi-level approach. *Resour. Conserv. Recycl. Adv.* 18, 200152.
- Markard, J., Raven, R., Truffer, B., 2012. Sustainability transitions: an emerging field of research and its prospects. *Res. Policy* 41 (6), 955–967.
- Middlemiss, L., Parrish, B.D., 2010. Building capacity for low-carbon communities: the role of grassroots initiatives. *Energy Policy* 38 (12), 7559–7566.
- Ornetzeder, M., Rohrer, H., 2013. Of solar collectors, wind power, and car sharing: comparing and understanding successful cases of grassroots innovations. *Glob. Environ. Change* 23 (5), 856–867.
- Pappas, I.O., Woodside, A.G., 2021. Fuzzy-set qualitative comparative analysis (fsQCA): guidelines for research practice in Information systems and marketing. *Int. J. Inf. Manage.* 58, 102310.
- Pennings, P., 2009. Fuzzy-sets and QCA—The methodology of the fuzzy-set logic and its application. *Methoden Vgl. Polit.-Sozialwiss.* 347–363.
- Qiao, H., Tong, X., Han, L., Wang, S., 2024. Incorporating decentralized facilities into the food waste treatment infrastructure in Megacity: a locational optimization in Beijing. *Resour. Conserv. Recycl. Adv.*, 200221.
- Qin, X., Owen, C., 2021. Social forces and street-level governance in Shanghai: from compliance to participation in recycling regulations. *China Q.* 248 (1), 1081–1102.
- Ragin, C., 2008. *Redesigning Social Sciences. Fuzzy Sets and Beyond*. University of Chicago Press, Chicago.
- Ragin, C.C., 2000. *Fuzzy-Set Social Science*. University of Chicago Press.
- Ragin, C.C., Strand, S.I., Rubinson, C., 2008. User’s guide to fuzzy-set/qualitative comparative analysis. *Univ. Ariz.* 87, 1–87.
- Ramayah, T., Lee, J.W.C., Lim, S., 2012. Sustaining the environment through recycling: an empirical study. *J. Env. Manage.* 102, 141–147.
- Rasoolimanesh, S.M., Valaei, N., Rezaei, S., 2023. Guideline for Application of Fuzzy-Set Qualitative Comparative Analysis (fsQCA) in Tourism and Hospitality Studies, Cutting Edge Research Methods in Hospitality and Tourism. Emerald Publishing Limited, pp. 137–156.
- Read, B.L., 2003. *State, Social Networks, and Citizens in China’s Urban Neighborhoods*. Harvard University.
- Schneider, C.Q., Wagemann, C., 2012. *Set-Theoretic Methods for the Social Sciences: A Guide to Qualitative Comparative Analysis*. Cambridge University Press.
- Sengers, F., Turnheim, B., Berkhout, F., 2021. Beyond experiments: embedding outcomes in climate governance. *Environ. Plan. C* 39 (6), 1148–1171.
- Seyfang, G., Smith, A., 2007. Grassroots innovations for sustainable development: towards a new research and policy agenda. *Env. Polit.* 16 (4), 584–603.
- Stoeva, K., Alriksson, S., 2017. Influence of recycling programmes on waste separation behaviour. *Waste Manag.* 68, 732–741.
- Timlett, R.E., Williams, I.D., 2008. Public participation and recycling performance in England: a comparison of tools for behaviour change. *Resour. Conserv. Recycl.* 52 (4), 622–634.
- Tonglet, M., Phillips, P.S., Read, A.D., 2004. Using the theory of planned behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. *Resour. Conserv. Recycl.* 41 (3), 191–214.
- Truffer, B., Murphy, J.T., Raven, R., 2015. *The Geography of Sustainability Transitions: Contours of an Emerging Theme*. Elsevier, pp. 63–72.
- van den Heiligenberg, H.A., Heimeriks, G.J., Hekkert, M.P., van Oort, F.G., 2017. A habitat for sustainability experiments: success factors for innovations in their local and regional contexts. *J. Clean. Prod.* 169, 204–215.
- Van der Heijden, J., 2015. The role of government in voluntary environmental programmes: a fuzzy set qualitative comparative analysis. *Public Adm.* 93 (3), 576–592.
- van der Heijden, J., 2019. **Using qualitative comparative analysis (QCA) logic and tools for theory testing and development in a medium-n urban climate governance research.**
- Vergara, S.E., Tchobanoglous, G., 2012. Municipal solid waste and the environment: a global perspective. *Annu. Rev. Env. Resour.* 37, 277–309.

- Wainaina, G.K., Truffer, B., 2024. The missing link for effective informal settlement upgrading: appropriation shaping the outcome of new infrastructure. *Urban Stud.* 00420980241236077.
- Wainaina, G.K., Truffer, B., Lüthi, C., 2022. The role of institutional logics during participation in urban processes and projects: insights from a comparative analysis of upgrading fifteen informal settlements in Kenya. *Cities* 128, 103799.
- Wang, S., Bai, X., Jeroen, V.D.H., Tong, X., 2024. The evolving roles of actors in sustainability experiments: evidence from community waste management in a Chinese city. *Technol. Forecast. Soc. Change.* 205 (123469).
- Wang, S., Bai, X., van der Heijden, J., Tong, X., 2025. Catalyzing changes on the ground and up: evidence from 106 ENGOs in community waste management in China. *npj Urban Sustain.* 5 (1), 5.
- Wang, Y., Hao, F., 2020. Public perception matters: individual waste sorting in Chinese communities. *Resour. Conserv. Recycl.* 159, 104860.
- Wilson, D.C., Rodic, L., Modak, P., Soos, R., Carpintero, A., Velis, K., Iyer, M., Simonett, O., 2015. *Global Waste Management Outlook*. UNEP.
- Zhang, B., Lai, K.-H., Wang, B., Wang, Z., 2019. From intention to action: how do personal attitudes, facilities accessibility, and government stimulus matter for household waste sorting? *J. Env. Manage.* 233, 447–458.