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DEVELOPING A SUSTAINABILITY ASSESSMENT INDICATOR FRAMEWORK FOR TEMPORARY USES BASED ON THE CASE OF THE FLOATING LAB

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ABSTRACT
In the surge of urbanization, cities face growing challenges in achieving resilience, equity, and sustainability. The temporary use of leftover spaces offers a potential solution, presenting new opportunities for sustainable development. However, the absence of comprehensive, measurable sustainability assessment (SA) tools for temporary use limits the optimization of these strategies. This paper addresses this gap by developing SA indicators tailored to the "Stand-in" strategy, a specific type of temporary use defined by the Urban Catalyst research group, within the Chinese context. Using the 2023 "Floating Lab" case in Shanghai's Knowledge and Innovation Community as a basis for scope definition and discussion, this research develops an SA tool for these temporary use cases.
The study is structured into three parts. In the first part, the initial framework is introduced, with indicators pre-selected from literature reviews. Feedback from 16 expert groups across four disciplines—academia, government and developers, content providers, and construction engineers—is synthesized to guide framework revisions. In the second part, key insights from these interviews are presented, followed by the detailed introduction of the revised framework, which incorporates a three-tier structure of 23 indicators across four sustainability categories. At the end of this paper, two potential application scenarios are proposed. This study provides a reference for developing generalizable SA tools for temporary use and offers an applicable tool for assessing the sustainable impact of similar temporary use cases.

Keywords: Temporary Use, Sustainable Assessment (SA) Indicator Framework, Urban Sustainable development, Expert Interview.

1 INTRODUCTION

In rapidly evolving world, the need for resilient, equitable, and sustainable urban development is increasingly urgent. Many developing countries are undergoing rapid urbanization, with spatial constraints in central areas presenting significant challenges in meeting the diverse societal and developmental needs of cities [6]. Despite this growth, many "leftover space" remain across cities globally. These spaces are often overlooked by large-scale developers due to their fragmented nature, short-term availability, and unclear boundaries, leading to wasted resources and reduced urban vitality [10]. This usustainability also results in economic and cultural losses. For instance, low-vitality spaces might lead to illegal activities, increase social security risks, and raise management costs. Thus, innovative solutions are vital for sustainably repurpose leftover spaces and enhance urban futures.
Temporary use strategies offer a promising approach to revitalizing leftover spaces. Unlike traditional developments, temporary use maximizes the utility of built-up spaces for a limited period without aiming for permanent occupation [8]. Temporary use provides flexibility in activating these spaces and is increasingly being applied worldwide. For example, the first Chinese leftover space planning guideline highlights "short-term mobility" as a key intervention [17].
However, despite its potential, there is a lack of integrated and measurable tools for assessing the sustainability impacts of temporary use. Triple Bottom Line (TBL) theory advocates for a comprehensive assessment of sustainability, covering environmental, social, and economic aspects [1]. In the context of temporary use, however, the absence of measurable environmental and social indicators has prevented decision-makers from taking a holistic approach to sustainability [18]. Tools like CASBEE-TC, developed for short-term buildings, focus primarily on “environmental quality and load

reduction" [11]. Similarly, Chinese national standard for Sustainability Evaluation Guidelines for Large Events (GB/T 44160) target temporary facilities but remain a traditional construction perspective[13]. Thus, sustainability assessment (SA) of temporary use remains a challenge.

In contrast, SA tools for traditional permanent development are well-established and widely applied. For instance, BREEAM and LEED are recognized and applied globally[9][15]. In China, the National Standard for Assessing the Sustainability Potential of Cities and Communities (GB/T 40757) also provides a SA tool for traditional space uses [12]. However, the differing goals and value between temporary and permanent uses make these tools unsuitable for evaluating temporary use. The lack of integrated and measurable SA tools hinders the optimization of temporary use strategies. In response, this study aims to develop a comprehensive, measurable SA framework for temporary use.

However, temporary use covers a wide spectrum. The European research group, Urban Catalyst identifies 8 models of temporary use, each with distinct goals, time constraints, and interactions with urban activities [16] [19]. Regarding the diversity, applying a universal SA framework to all temporary use models is impractical. Therefore, this paper does not seek to create a general SA tool. Instead, it focuses on the "Stand-in" strategy, one of the eight models, to develop a tailored framework and offer expert insights into the relevant indicators. While this paper provides an applicable SA tool for similar cases, it also aims to inspire further research on general SA tools for temporary use.

2 METHODS

This study employs a case study approach to define the scope and provide a practical context for expert discussion. The Floating Lab serves as a typical "Stand-in" in the Chinese context [16]. Conducted by the research team in 2023 in Knowledge and Innovation Community (KIC), Shanghai, the Floating Lab occupies a temporarily vacant street-side store. This vacancy arises from a 30-day gap between tenants. During this period, the Floating Lab hosted exhibitions and workshops, attracting 2,052 visitors. This effort revitalized the space that would otherwise left vacant, activating it before returning to its original state. Meanwhile, KIC, is known for its active temporary uses, e.g. weekend pedestrian streets, providing a rich context for SA tool development.

Table 1. Expert List

Area	Code	Position	Area	Code	Position
Academia	A1	PhD researcher in the field of social innovation design	Content Providers（e.g. start-ups, artists and NGO)	C1	Start-up founder
	A2	Associate Professor (Italian) in the field of temporary use		C2	Grassroots organizer team
	A3	Associate Professor (Chinese) in the field of sustainable design		C3	Grassroots organizer
	A4	Dean of research institution in the field of sustainable design and social innovation design		C4	NGO social worker and local resident
Government & Developers	B1	Real Estate Developer from State-Owned company	Construction Engineers	D1	Architect
	B2	Real Estate Developer from State-Owned company		D2	Design Consultant
	B3	Real Estate Developer from foreign-funded company		D3	Architect
	B4	Dean of Homeowners' Association		D4	Architect team

With the scope defined, the study employs a two-phase process to develop this SA framework. Firstly, potential indicators are identified through literature and producing a preliminary framework. The research team refines this list by removing redundancies, resulting in an initial framework. Afterwards, invitations are sent to over 30 individuals and working groups, yielding 16 valid interviews. These experts are drawn from 4 sectors: academia, government and developers, content providers, and construction engineers (Table 1). Noticeably, half of these experts (A4, B4, C2, C3, C4, D1, D2, and D3) are local participants currently or have participated in temporary use activities in KIC. Their interviews are recorded, transcribed, and coded, with the feedback synthesized. Based on their feedback,

the initial framework is revised and sent back for confirmation, leading to the final SA indicator framework presented in this paper.

3 PRELIMINARY FRAMEWORK

The preliminary framework is developed through literature reviews, drawing from 3 primary sources: (1) existing SA tools, (2) research on the sustainability of temporary use, and (3) Chinese national standard and regulations. This process initially produces 63 indicators, which are subsequently refined to 20 for the initial framework (Figure 1). This initial framework was sent to experts before the interviews, and during the discussions, the focus is on refining the framework.

This framework employs a multidimensional, mixed-methods approach to assess the sustainability of temporary use, incorporating "narrative evaluation approaches for cases" [18]. A three-tiered SA framework was constructed to meet sustainability impact assessment goals, consisting of the criteria level, sub-criteria level, and indicator level. The next section summarizes key insights from the interviews, while Section 5 presents the revised framework in detail, with the expert comments.

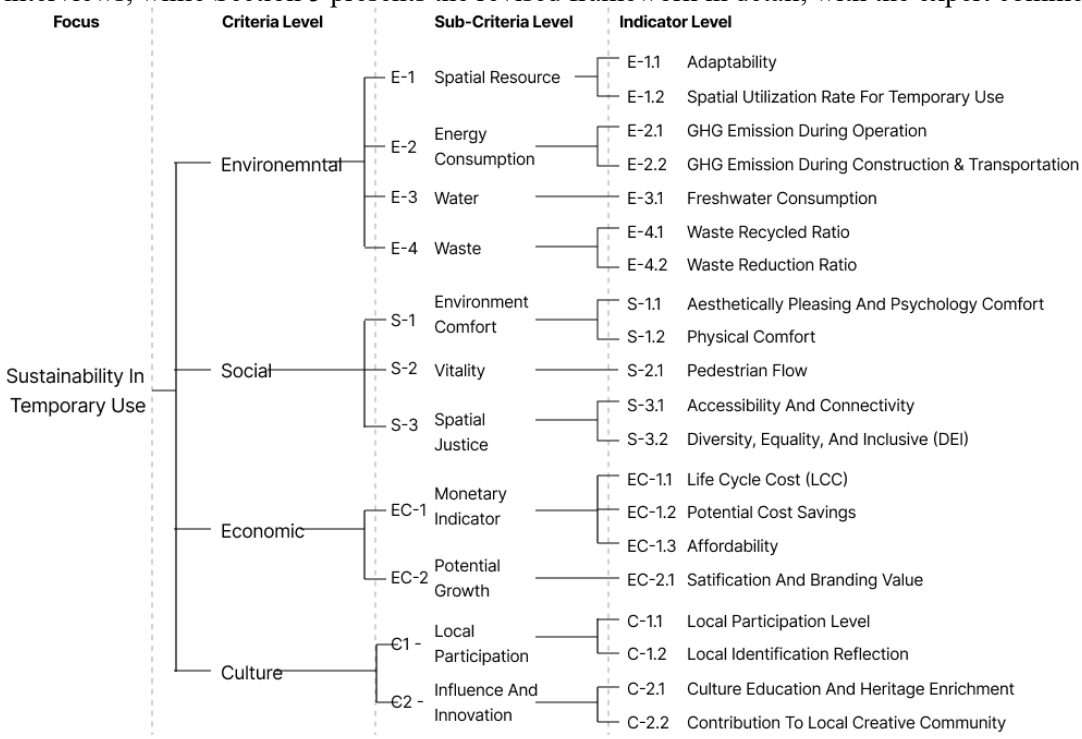

Figure 1. Preliminary SA Indicator Framework

4 EXPERT INSIGHTS

This four-criteria framework is developed based on TBL theory. While the traditional TBL model has limitations, recent research increasingly emphasizes the inclusion of cultural sustainability as a fourth dimension, recognizing its importance in sustainable development [7]. In temporary use projects, cultural sustainability also plays a significant role, especially for engaging local communities and marginalized groups [18][19]. Accordingly, this framework incorporates cultural sustainability as addition, with a focus on locality.

From the interviews, experts reached consensus on environmental and economic indicators, while the discussion focused on social and cultural sustainability. The insights are synthesized as follows.

- **Framework Comparisons:**Three experts compare the proposed framework with other SA frameworks. Expert B3 notes, "The cultural criteria remind me of the governance indicators in the ESG (Environmental, Social, Governance) framework." Similarly, Expert D1 suggests aligning this framework with the United Nations Sustainable Development Goals (SDGs).
- **Overlap Between Cultural and Social Sustainability vs. Emphasis on Locality.** Six experts perceive overlap between cultural and social sustainability. Expert A4 states, "Culture is the bond of society... local participation, for example, is a typical social sustainable indicator." However, most experts emphasize the importance of local culture in SA. Five experts strongly support

focusing on locality as a means to prevent the instrumentalization of temporary use for gentrification. Expert D1 concludes that while cultural criteria remains, all indicators should prioritize local identity and cultural capacity building.

- **Lack of Partnership-Related Indicators in Social Sustainability Criteria.** Two experts identified a absence of indicators for strengthening and renewing “partnerships” in the preliminary SA framework. D1 highlighted the importance of such indicators by referencing the Floating Lab project, where the temporary users collaborated with various stakeholders, including artists and community gardening groups, to co-create value.

Suggestions primarily focus on refining indicator names for clarity and avoiding redundancy, rather than changing the content. Moreover, Since there is no existing SA framework for temporary use to refer to, some experts express concerns about collecting quantitative data:

- **"Invisible Value Creation" as an essential Economic Indicator.** The sub-criterion of "potential growth" attracts considerable attention. The keywords of "barter trade among partners," the "ripple effect of Points of Interest (POI)," "branding value," and the "invisible economic value of charity" are frequently mentioned. Expert B3 cites the Floating Lab as an example: "The Floating Lab attracts 2,000 people, some of whom might dine nearby, boosting the local economy. However, quantifying that impact is challenging." Expert A2 suggests renaming the categories to "monetary flow" and "value flow" to better capture this indicator.
- **"Local Social Learning and Cultural Capacity" for Chinese-Speaking Contexts.** In the initial framework, the indicator “Culture Education And Heritage Enrichment” is developed from the international tool, BREEAM. However, during the interview, five experts raise concerns about the term "education," finding it too broad, and "heritage" as too closely tied to material or traditional aspects in Chinese contexts. Thus, Expert D4 proposes "community culture capacity" as a more suitable term, referencing the anime culture in the KIC neighbourhood also is an example of cultural capacity.
- **Challenges in Collecting Participant Data. S**ignificantly, all expert groups highlight challenges in gathering participant data for temporary use projects. Relevant data includes age, gender, occupation, intent, length of stay, visit frequency, satisfaction, and place of residence. Expert C2 notes, "Visitors may just want to explore and enjoy themselves, and might reject to provide personal information." Expert B3 proposes sampling research as a solution, while C2 suggests using co-creation whiteboards to encourage participants to record data collaboratively.

5 REVISED FRAMEWORK

Based on expert feedback, the initial framework is revised (Figure 2). The following sections dive into each sub-criterion and indicator,providing clarification on content and the measurement factors:

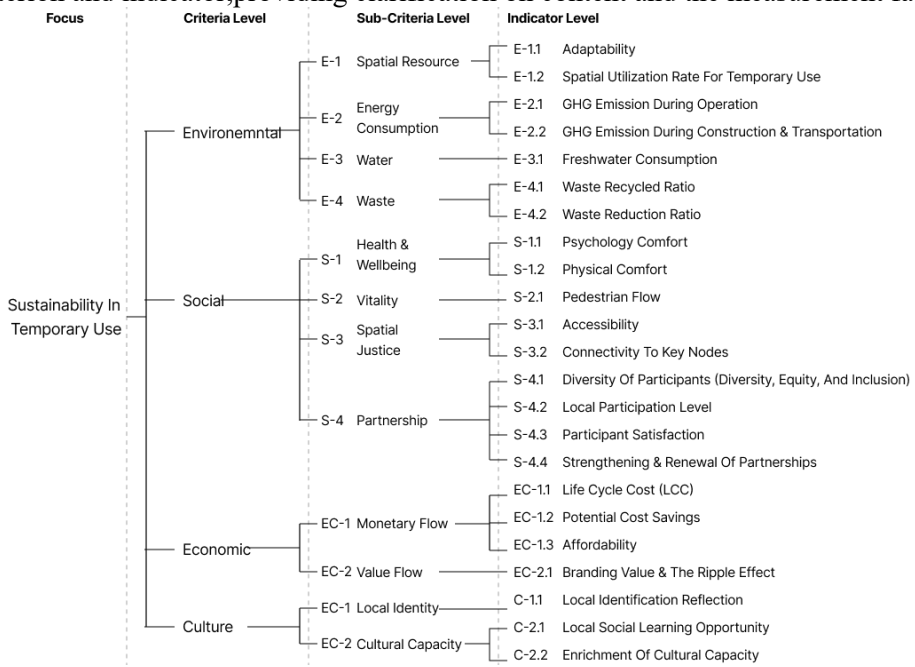

Figure 2. Revised SA Indicator Framework

5.1 Sub-criteria and Indicators for Environmental Sustainability

While the unsustainable impact of vacant leftover space has been noted, activating these spaces inevitably involves the consumption of environmental resources. This framework evaluates how efficiently and responsibly these resources are used, regarding the short life cycle of the "stand-in" strategy. The environmental criterion is subdivided into four categories: E-1 Spatial Resource, E-2 Energy, E-3 Water Resources, and E-4 Waste.

E-1 Spatial Resource

This sub-criterion assesses the efficiency and quality of temporary use in utilizing urban spatial resources across both temporal and spatial dimensions. Rating systems like LEED emphasize the importance of smart space selection and community planning to promote sustainable urban development [15]. The sub-criterion includes two indicators:

- **E-1.1 Adaptability:** This indicator evaluates how effectively temporary uses repurpose and adapt leftover spaces in a temporal perspective. As Expert A2 noted, "whether you can play with what you have", maximizing the use of existing infrastructure, is critical. Factors such as the condition of the leftover space and the ease of negotiations with property owners also affect this indicator.
- **E-1.2 Spatial Utilization Rate for Temporary Use:**This indicator measures the efficiency of temporary use by calculating the ratio of leftover space activated to the total leftover space available in the neighborhood. It draws from the "percentage of renovated buildings" in research by Rall and Haase [5] and space utilization metrics from GB/T 44160 [13].

E-2 Energy

In temporary use projects, energy consumption is significant, particularly during construction and transportation, which often exceed operational energy consumption [2]. Referring to LEED and the GB/T 40757 standard, greenhouse gas (GHG) emissions are a core indicator [12][15]. This framework divides energy consumption into two quantitative indicators:

- **E-2.1 GHG Emission During Operation** and **E-2.2 GHG Emission During Construction & Transportation.** Both indicators are measured in tCO2 eq/㎡/day, providing a precise reflection of environmental impact. All 16 expert groups agreed with this division, with some even noting the differing weightings of these two indicators in terms of overall sustainability impact.

E-3 Water

The Stand-in strategy commonly leverages the existing infrastructure of leftover spaces through short-term reoccupation. Thus, water consumption depends largely on the original design and facilities.

- **E-3.1 Freshwater Consumption:** Following the GB/T 40757, this indicator evaluates water efficiency [12]. It is assessed by comparing actual freshwater consumption with the theoretical consumption for the same space when vacant, measured in m^3/㎡/day.

E-4 Waste

The short life cycle of temporary use, particularly Stand-In types, poses challenges for waste management. Drawing from the GB/T 40757 standard and relevant studies [3][4][12], this criteria are divided into 2 quantitative indicators:

- **E-4.1 Waste Recycled Ratio:** This indicator measures the proportion of reusable, recyclable, and energy-recoverable materials to the total construction material used. This indicator emphasis what happen before and after the temporary use, e.g. the recycling pathways.
- **E-4.2 Waste Reduction Ratio:** This indicator assesses the reduction in waste relative to the total construction materials used, focusing on minimizing waste from the design stage, such as repurposing existing facilities in leftover spaces.

5.2 Sub-criteria and Indicators for Social Sustainability

By utilizing leftover space, temporary use strategies address diverse social needs and contribute to social sustainability. This framework structures the social criterion into three sub-criteria:

S-1 Health and Well-being

Although the stand-in strategy involves temporary use of leftover spaces, it still significantly affects the health and well-being of users. The Chengdu Guideline stresses the importance of comfortable furnishings, etc., to meet health needs [17]. This sub-criterion is further divided into 2 indicators:

- **S-1.1 Physical Comfort:**This indicator is standard across SA tools for traditional developments, e.g. China's Green Building Evaluation Standard (GB/T 50378) and LEED [14]. It uses systemic and quantitative metrics to evaluate air quality, thermal comfort, lighting, acoustics, and humidity throughout the temporary use life cycle.
- **S-1.2 Psychology Comfort:** This indicator addresses the mental health of users, incorporating elements like color psychology, spatial perception, connection to nature and aesthetic appeal.

S-2 Vitality

Temporary use strategies activate otherwise vacant spaces, introducing events, creating POIs, and enhancing neighborhood vibrancy,while reducing social risks. **S-2.1 Pedestrian Flow** is a common indicator in both research and existing SA tools. This indicator measures the vitality of spaces by comparing the average daily number of visitors during temporary use with that of the vacant period.

S-3 Spatial Justice

Temporary use strategies offer unique opportunities to promote spatial justice, particularly benefiting marginalized groups by creating accessible "incubators" for all community members [19]. The revised framework reflects significant changes compared to the initial version:

- **S-3.1 Accessibility:** This indicator assesses whether temporary uses are accessible to all social groups through both quantitative and qualitative measurements. Factors such as proximity to road systems, preferred neighborhood pathways, and transportation nodes are nominated in interviews.
- **S-3.2 Connectivity to Key Nodes:** This indicator evaluates whether temporary use establishes meaningful links with other spatial nodes in the surroundings. It assesses both strategic intentions and practical performance. As Expert C4, who is also a local resident, noted, “I like the idea of connection, but in practice, the community garden (one node the Floating Lab aimed to connect with) was too far, requiring a 10-minute walk... To achieving the intended connection, on-site staff need to persuade visitors to go there."

S-4 Partnership

This sub-criterion was not included in the initial framework but was proposed by experts during the review process. It builds on the Partnerships goal from the UN SDGs, which cross-sector collaboration can help achieve sustainability. This sub-criterion comprises four qualitative indicators::

- **S-4.1 Diversity of Participants (Diversity, Equity, and Inclusion, DEI):** This indicator evaluates the inclusiveness of the temporary use by considering the diversity of participants in terms of gender, age, disability, occupation, etc.
- **S-4.2 Local Participation Level:** This indicator measures the level of participation and the number of local community members, particularly marginalized groups, involved in the temporary use. As Expert B1 noted, “In KIC, local merchants and residents often have conflicting interests, with merchants usually having a louder voice. I hope that events like the Floating Lab can facilitate more seamless collaboration between these two groups.”
- **S-4.3 Participant Satisfaction:** Drawing from BREEAM and CASBEE, this indicator evaluates participant satisfaction based on factors such as length of stay and frequency of revisit. Sampling and questionnaires are employed to gather data from participants [9][11].
- **S-4.4 Strengthening & Renewal of Partnerships:** The keyword “ecosphere of participants” emerged during the interviews. This indicator evaluates whether original partnerships can be strengthened and new ones established by temporary use. Expert C2 stated, “The lack of information flow between partnerships is the biggest obstacle preventing cases like Floating Lab from occurring. For example, start-ups want to participate but do not know who to talk.”

5.3 Sub-criteria and Indicators for Economic Sustainability

Economic indicators are critical for evaluating the sustainability of temporary use strategies, particularly concerning financial returns and economic impact, which are top priorities for space users [18]. Based on expert feedback, the original two sub-criteria is renamed for clarity:

EC-1 Monetary Flow

This sub-criterion covers tangible, quantitative indicators derived from precise financial data, attracting the greatest interest among experts, with some claiming they are the most weighted factors:

- **ECO-1.1 Life Cycle Cost:** This indicator assesses the total cost of a project over its life cycle, including materials, labor, transportation, and related expenses. Based on research by Janjua et al., it involves a threshold comparison of the average daily cost per square meter for temporary use projects with similar developments in the same city [3].
- **ECO-1.2 Potential Cost Savings:** This indicator evaluates potential cost savings through temporary use, such as bargaining with landowner or adopting barter trade. As Expert B3 noted, "Through strategic negotiation with partners, Floating Lab saved cost significantly on rent and maintenance, which are considerable expenses in a costly city like Shanghai."
- **ECO-1.3 Affordability:** As discussed, **t**emporary use aim to be accessible for low-incomers for experimental social innovation [19]. Drawing from Janjua et al., this indicator assesses the economic impact on users by comparing event costs to average local incomes [3].

EC-2 Value Flow

This sub-criterion addresses the potential economic value created by temporary use, a topic that initially sparked divergent opinions among experts. However, consensus was reached in the revised framework. **ECO-2.1 Branding Value & the Ripple Effect** evaluates the indirect economic growth resulting from temporary use, including the ripple effect and neighborhood brand enhancement.

5.4 Sub-criteria and Indicators for Culture Sustainability

Although some experts noted an overlap between cultural and social criteria, the final framework retains a distinct cultural category with a stronger focus on locality. Many existing tools emphasize the significance of locality in SA process, as CASBEE includes "Continuation of unique local character" [11], while BREEAM prioritizes local identity [9]. The final framework includes three indicators:

C-1 Local Identity

This sub-criterion emphasizes the significance of fostering a sense of identity and belonging within local communities, particularly among marginalized groups, in the context of temporary use. **C-1.1 Local Identity Reflection** evaluates the extent to which temporary use can express the uniqueness of local culture. As Expert D2 noted, "When a sense of belonging is established, marginalized groups are likely not driven away, and the unsustainable effects of gentrification can be somehow reduced."

C-2 Cultural Capacity

This sub-criterion is emphasized in many existing SA tools. For instance, CASBEE encourages the enhancement of cultural activities in the community by providing spaces and facilities [11]. However, the use of term "cultural heritage," which carries different implications in Chinese-speaking contexts. Therefore, suggested by experts, these indicators have been renamed:

- **C-2.1 Local Social Learning Opportunity:** This indicator assesses the ability of temporary use to support local cultural capacity by providing learning opportunities and enhancing knowledge transfer. Expert A2 highlighted that, "The Floating Lab offers four artist workshops where local families can engage in activities like painting and jewelry making while learning about sustainability. It's a form of social learning to me, or you can say public education."
- **C-2.2 Other Enrichment of Cultural Capacity:** This indicator evaluates the indirect enrichment of local culture generated by temporary use. As Expert D4 noted, "The influence of the community management team and the Floating Lab has led to an increase in temporary uses within the KIC, creating a vibrant atmosphere and contributing to new community capacity."

6 CONCLUSION AND DISCUSSION

This study addresses the lack of a sustainability assessment (SA) tool for temporary urban use by developing an indicator-based framework, centered around a case study of the Floating Lab in China. The framework is initially structured from a set of indicators identified in the literature and refined through 16 expert interviews. At the end of this paper, resulting framework is presented, aiming to assess the sustainability impacts of future temporary uses.

Throughout the expert interviews, potential applications of this tool are widely discussed, leading to two primary application scenarios: (1) as a negotiation tool for initiators of temporary use projects and (2) as a project review tool for stakeholders.

In the first application scenario, this framework can systematically predict the potential sustainability impacts and value of upcoming temporary use events. Temporary use initiators, such as property owners of vacant leftover spaces or local residents aiming to activate such spaces, can leverage these evidences provided by the framework to persuade or coordinate with other stakeholders concerned with urban sustainability. Experts reveal the absence and importance of this tool when it comes to negotiation of temporary uses. In the second scenario, the framework serves as a feedback tool, allowing stakeholders of temporary use, especially investors and designers, to evaluate the sustainability performance and impacts of completed temporary use. This feedback loop not only informs more sustainable investment choices but also guides designers in refining strategies to enhance sustainability in future projects. Both are beneficial for the urban sustainable development.

To realize these scenarios, several study limitations should be addressed in future research. First, despite the refinement process of this framework, some ambiguity remains within certain indicators. For instance, indirect causal relationships among indicators may affect performance assessments, potentially amplifying or diminishing particular outcomes. However, these interactions may also reveal strategies that improve multiple indicators simultaneously, highlighting their unique sustainability value. Second, for efficiency, we reduced the granularity of certain well-established indicators in the expert interviews. For instance, we discussed physical comfort as a single concept (S-1.1 Physical Comfort) rather than dissecting it into specific aspects like acoustic and thermal comfort, which are already well-covered in other tools. While this approach streamlined discussions, future framework iterations should further detail each indicator to enhance practical value.

This study also uncovers research opportunities for future research. During the interviews, experts expressed varying degrees of importance and practical feasibility for each indicator, generating valuable raw data that can inform weighting and threshold calculations in future framework revisions. Methods like the AHP method and Delphi technique could refine this framework further, expanding its applicability across the cityscape and enhancing its contributions to sustainable development.

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