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Co-Creating an Urban Circularity Questionnaire: A Workshop Approach With Experts

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ABSTRACT

As cities strive for sustainable development, the concept of urban circularity is gaining increasing recognition as a framework for systemic transformation. Yet, tools used to assess circularity, such as questionnaires, are often limited to traditional measurement functions. This paper argues that adopting new methods for developing questionnaires can serve as both a mechanism for creating a circularity measurement tool and for initiating conversations with stakeholders. It details a co-creation process involving international stakeholders (architects, urban planners, local government representatives, and social scientists) in the development of a circularity questionnaire and argues that these should be context-driven, methodologically sound, and, more importantly, socially accountable tools that include all stakeholders. This paper emphasizes ensuring effective measurements of urban circularity through the participation of all perspectives, improving the development process and the quality of surveys, and increasing stakeholder participation and dialog to effect change and increase insights into circularity practices.

1 | Introduction

Urban circularity, often considered as an element of the circular economy, aims to reframe urban systems as more resource-efficient, regenerative, and resilient (Vanhuyse 2024). Its goals are to achieve climate change mitigation, resource management, and societal welfare (Petit-Boix and Leipold 2018; Vanhuyse 2024; Vanhuyse et al. 2021). The transition to urban circularity takes place due to necessities rooted in issues like resource depletion, waste creation, and environmental degradation triggered by rapid urbanization. One of the main definitions of urban circularity revolves around the idea of closed-loop systems where product, material, and resource life cycles are maximized while limiting the use of raw materials and excessive waste creation (Geissdoerfer et al. 2017).

Even though this concept is based on circular economy principles, it mainly focuses on the urban context and its complex infrastructures (such as transportation, housing, energy, and waste) (Fratini et al. 2019). Pomponi and Moncaster (Pomponi and Moncaster 2016) describe urban circularity as the intersection of environmental and social aspects; addressing social equity and quality of life is essential to the circularity of any strategy. Challenging to account for, the complexities of urban systems and numerous stakeholders lead to a broader inability to operate circularly in coordination with other urban systems. In urban studies, various approaches have been explored to measure urban circularity. For example, the Circular City Index (CCI) (Muscillo et al. 2021) and the Circular City Indicators (CityLoops, n.d.) have been developed to evaluate the performance of cities in achieving circularity. CCI identifies municipality-level key performance

indicators to measure circularity and to support the green transition. The latter provides an assessment framework comprising 86 indicators. Of these, 72 are quantitative, measured using values such as percentages or absolute units (for instance, tonnes). Additionally, 12 indicators are qualitative, based on descriptive data that capture context-specific insights. The remaining two indicators are semi-quantitative and are evaluated using a scoring system ranging from 1 to 5. These frameworks incorporate indicators about material and energy flows, waste generation and management, reuse and recycling practices, emissions, human well-being, and stakeholder involvement. However, they tend to center on environmental issues while neglecting a critical part of implementing circularity: the social, technical, and economic aspects (Vanhuyse et al. 2021).

Environmental indicators measure the footprint of the activities, emissions, resource consumption, energy usage, ecosystems, and biodiversity (Li et al. 2025). Social indicators highlight the broader societal impacts of circularity, including social inclusion, health and well-being, housing demand, and preservation of cultural heritage. Design principles, innovative solutions, and construction management and quality assurance are some of the technical indicators. Economic indicators indicate the circular economy's (CE) influence on sustainable economic growth via circular investment, productivity, return on investment, and labor impacts (Li et al. 2025). Overall, these indicators provide an integrated framework to measure and promote the application of circularity principles across regions and sectors, but not all indicators are studied equally and may be insufficient to determine the performance of circularity in the built environment and the CE policies. Circularity is a global theme, standing high on the political agendas (European Commission 2020). Therefore, instruments (for instance, validated questionnaires) should be developed in such a way that an international and human-centric perspective together with the coverage of all the indicators is included. For this reason, an international project aims to foster a shared understanding of circularity in urban renewal through the implementation of co-creative urban living labs (ULLs) across diverse geographic and cultural contexts have been initiated. By definition, ULLs are umbrella platforms for experimental tools on governance, whereby urban stakeholders develop and test new technologies, products, services and ways of living to produce innovative solutions to the challenges of climate change, resilience and urban sustainability (Voytenko et al. 2016). In mentioned project, it focuses on environmental and socio-economic indicators of circular urban regeneration and seeks innovative solutions to support informed decision-making by local authorities. As urban circularity is based on resource efficiency, waste reduction, and regenerative urban systems that aim to close material loops and alleviate environmental pressure, assessing the progress of circular approaches requires examining social, technical, and economic aspects. To this end, circularity needs robust and pluralistic evaluation instruments to inform policy and support evidence-based decisions. At present, such instruments are often developed ad hoc within individual studies by the researchers themselves, leading to self-constructed instruments aimed solely at answering a specific research question. As a result, validation is frequently omitted, raising concerns about the validity, reliability, responsiveness, and interpretability of the findings presented (Rosenfeld et al. 2016). However, to draw scientifically sound conclusions, the development process must be rigorous, ensuring that the instruments used are valid and reliable. In this end, the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) initiative offers valuable guidance (COSMIN 2025; Mokkink et al. 2010). As the acronym suggests, the COSMIN group promotes consensus-based standards for the selection of measurement instruments, with a strong focus on aspects such as reliability, validity, and usability. Applying such standards is crucial to ensure that instruments used in circularity research are trustworthy, reproducible, and useful across different contexts (such as cultures, countries, and languages). As recommended by COSMIN, the first essential step in the development of a new instrument is to establish detailed agreement on the construct to be measured (i.e., the domain or outcome of interest) and the characteristics of the target population. The co-creation and validation of evaluation instruments, grounded in international collaboration and methodological rigor, is a fundamental step forward toward advancing urban circularity in a way that is credible, inclusive, and actionable. Only after rigorous development and testing of reliability and (cross-cultural) validity can such instruments be applied across countries, as circularity is a global challenge.

In this paper, we therefore describe both the process and outcome of this initial, COSMIN-recommended step: reaching agreement among international stakeholders on the construct and the population to be addressed, using participatory methodologies that bring together diverse perspectives from an international transdisciplinary group of experts working together on urban circularity.

1.1 | Participatory Methodologies in Urban Circularity Research

Participatory methodologies, especially multi-stakeholder co-creation approaches, are considered methods where stakeholders have the chance to actively participate in the decision-making process focused on a specific issue (Kazadi et al. 2016). Co-creation processes are considered an integrative research method for urban circularity (Huang et al. 2021). In general, co-creation workshops aim to identify a problem solution that is relevant to the context and based on local activities by bringing together various participants such as city officials, community members, urban planners, architects, and business representatives (Helbing et al. 2024). These workshops aim to ensure that the results reflect the needs, priorities, concerns, and perspectives of various urban stakeholders and to ensure the legitimacy and relevance of the strategies that emerge from them. According to (Vaidya and Mayer 2014), co-creation workshops can also promote the creation of more inclusive and transparent policy frameworks. They indicate that while participatory methods improve the effectiveness of circularity strategies and actions, they can also cultivate a sense of ownership and collective responsibility among participants (Kayaçetin et al. 2022).

Regarding urban circularity, participatory methodologies are especially critical for ensuring that urban policies are consistent with priorities in local contexts. The study conducted by (Paoli

et al. 2024) examined the Circular City (CC) paradigm being implemented in Genoa, Italy, by mapping sustainability and circularity practices. The study, which uses Geographic Information System (GIS) based participatory mapping, identified good practices and pointed out convergence between top-down and bottom-up approaches in facilitating circularity in urban planning toward the Sustainable Development Goals (SDGs). (Van De Ven et al. 2016) argued that co-creation workshops provide purposeful opportunities for collaboration between participants for important functions in urban environments, such as identifying circularity indicators and developing methodologies for monitoring urban transitions. Additionally, participatory methodologies are increasingly being recognized as a way to enhance the design of questionnaires. Engaging stakeholders in the development process ensures that the questions are relevant to the local context and reflective of the diverse concerns of urban populations (COSMIN 2025). (Videira et al. 2017) emphasize that participatory design processes help to ensure that questionnaires are not only scientifically rigorous but also socially inclusive, providing a more accurate picture of the challenges and opportunities related to urban circularity. However, one of the limitations of the above-mentioned study is that it does not address psychometric validation or provide evidence of content- and construct validity nor the reliability of the developed instruments. Lack of psychometric power compromises the potential applicability and robustness of the findings, especially when seeking comparability across contexts.

1.2 | Developing a Construct for Measuring Urban Circularity

In urban studies, questionnaires are a common methodology to assess perceptions, behaviors, and institutional capacities. However, developing a validated questionnaire means attending to both theoretical frameworks and practical use. Input from practitioners is key to ensuring the questionnaire aligns with practice issues, research, and policy requirements. Although significant progress has been made in creating frameworks to assess urban circularity, more participatory and inclusive approaches are still needed in the design of circularity measurement instruments. Measures often exclude the social, technical, and economic dimensions of urban circularity and focus primarily on environmental outcomes. Moreover, instruments are often solely used to measure specific constructs, being used for research purposes; however, it is more effective when they are also used to steer discussions among stakeholders based on the outcomes in practice, for example when building a Sustainable Innovation Ecosystems. Such an ecosystem refers to a collaborative network of actors, such as policymakers, researchers, industry practitioners, communities, and innovators, who interact to co-create, test, and scale sustainable solutions. This dual function enables instruments not only to assess but also to deepen understanding of the construct being measured, such as circularity, while simultaneously fostering reflection on participants' thoughts, knowledge, and feelings. For example, engaging with a questionnaire on circularity can serve as a starting point for dialog, potentially shifting perspectives and behaviors through discussion and shared interpretation of results. While participative methods such as co-creation workshops have been observed to improve the relevance and effectiveness of sustainability programs, the use of co-creation methods in questionnaire design for the study of urban circularity is still rare. Therefore, co-creation, the strategy of actively involving stakeholders in developing an instrument, is valuable in developing context-oriented, methodologically sound, and inclusive instruments. Involving interdisciplinary experts, such as architects, urban planners, environmental scientists, and social scientists, in the co-creation process allows the questionnaire development process to bring together different but compatible perspectives.

Geissdoerfer et al. 2017 assert that circularity research inherently measures multiple interrelated factors, as it is generally considered to include environmental impact, social equity, and economic feasibility. This nature of measuring multiple interrelated factors complicates the design of questionnaires, as many existing questionnaires simplify measures or target a narrow set of indicators, such as waste management, extraction of materials, or energy consumption. Several authors have suggested mixed-methods approaches to questionnaires, such as incorporating closed-ended quantitative questions with open-ended qualitative questions, allowing researchers to measure data together with contextual data (Martinho 2021). However, recent research suggests that flexibility and adaptability are additional important inputs into designing questionnaires, while establishing methods and indicators that are appropriate for various urban contexts and actors (Antwi-Afari et al. 2022). This is particularly a consideration for urban circularity as cities will inherently have different infrastructures, resources, and cultural thinking, which uses more dynamic and specific urban approaches and is less likely to apply a unified cross-cultural validation. Concerning urban circularity, questionnaires can provide insights into different perception levels of the public connected to sustainability efforts, attitudes to circularity, and resource consumption behaviors (Martinho 2021). The challenge for constructing effective and appropriate questionnaires that measure urban circularity and capture the knowledge, attitudes, and behaviors of users/people interacting with circular buildings/solutions is to properly consider the multidimensional nature of urban circularity. Therefore, our social approach used in this study goes beyond determining a structure using only technical indicators and adopts a broader perspective that encompasses the social, behavioral, and experiential dimensions of urban circularity.

This paper addresses these gaps by presenting the methodology from a participatory co-creation workshop realized by a mixed group of experts to construct an urban circularity questionnaire for future studies. It describes the co-creation workshop approach as being both a rigorous and contextualized methodology to highlight the complexities of urban circularity, the key decisions taken in the development of future planning, and the indicators highlighted within a survey framework. It also explores the advantages and disadvantages of expert instrument development. The results of this workshop offer meaningful potential for future questionnaires to measure urban circularity. By reporting on the methodology, this paper aims to add to the growing literature on participatory sustainability research approaches and also addresses future empirical research around urban circularity.

2 | Methodology

To develop a measurable construct of circularity suitable for future questionnaires, a co-creation workshop was held with 20 experts in the field of urban circularity (architects, urban planners, local government representatives, and social scientists) during the international project's kick-off meeting in Ankara (Türkiye) in March 2025. Experts are from various universities, institutions, businesses, and municipalities from Belgium, Italy, Poland, Romania, the Netherlands, and Türkiye. Participants were divided into four groups, ensuring a balanced distribution of expertise and representation of their sector: academia versus municipalities within each group (Figure 1).

2.1 | Expert Participation

Interdisciplinary collaboration provided a holistic approach to urban circularity. While architects and urban planners provided technical and spatial knowledge, social scientists ensured that social aspects such as social inclusion and equity, health and well-being, social innovation, and preservation of cultural heritage and value creation were well covered. Local government representatives provided practical knowledge about policy implementation and municipal constraints, making the questionnaire more applicable to real-world governance. Contextual relevance was also a significant benefit of the multicultural team. Experts from different countries provided a variety of regional perspectives on urban circularity. These policy, regulatory, and socio-economic differences helped the questionnaire to be adaptable enough to respond to different urban realities rather than being biased toward a single national or regional model. Bringing together university academics, institutional members, business experts, and city government officials provided a balance between theoretical knowledge and real-world applications. Scientists provided concepts based on the existing body of research, while practitioners contributed real case studies and feasibility tests for the proposed indicators. This resulted in the initiation of the development of an evidence-based and actionable questionnaire. Cultural and industry diversity, as well as the economic, innovation, and regulation level differences of countries, added richness to the process by preventing blind spots in the questionnaire design. Different

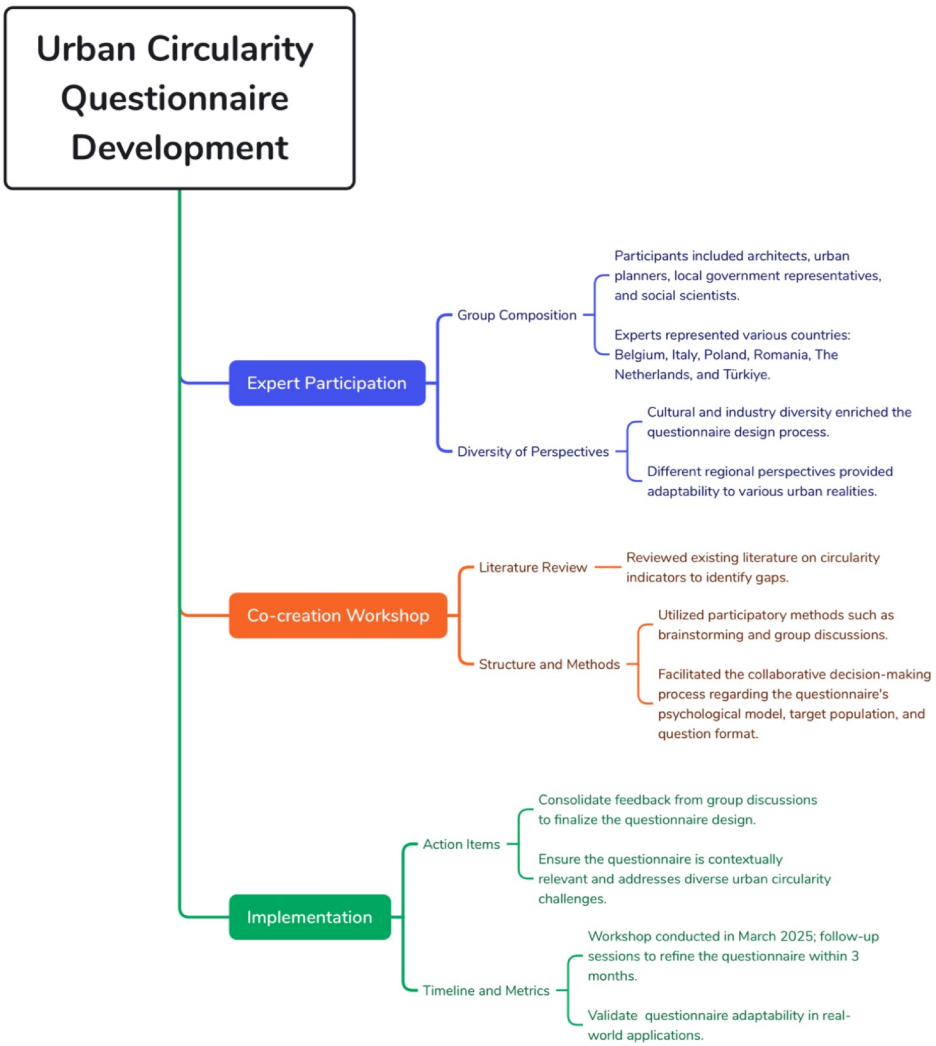

FIGURE 1 | Tree chart showing the sequence of the co-creation workshop.

perspectives helped clarify language, ensure understanding, and avoid biases that could make the measurable construct of circularity suitable for future questionnaires less useful in certain settings.

2.2 | Co-Creation Workshop

The co-creation workshop was initiated by reviewing existing literature on circularity indicators to ensure the questionnaire was filling a gap in existing frameworks based on the work of (Li et al. 2025), which highlights the complexity of assessing circularity in the built environment. This complexity arises from the absence of standardized circularity assessment indicators, which has led to the development of a wide range of context-specific indicators and frameworks. As a result, diverse evaluation approaches, including quantitative, qualitative, and semi-quantitative, are used inconsistently across different studies. Additional challenges include a lack of transparency in some methodologies (for instance, unclear criteria for developing scoring systems in semi-quantitative indicators) and limited guidance on how to select suitable indicators or indicator sets for particular applications. During the workshop, the experts decided together on several psychological models of the questionnaire, its target population, and the form of the questions. Insights about the target population directly influenced the choice of psychological models, and vice versa, dynamically and reciprocally. All of the phases, led by the researcher and supported by visual props and prompts prepared in advance, created space for critical reflection and exchange of ideas from different sectors. In addition, mapping exercises were used to spatially ground concepts and ensure they were connected to actual urban places.

2.2.1 | Phase 1

When developing questionnaires, particularly in complex domains such as urban circularity, it is essential to ground the instrument in established psychological models. Introducing psychological constructs early in the development process ensures that the questionnaire captures clearly defined, theoretically meaningful aspects of behavior, improving its validity, interpretability, and relevance for intervention planning (Hawkins and McMahon 2020). In this workshop, three psychological models were purposefully introduced to guide construct discussion and, in a later phase, item development: the Knowledge-Attitude-Behavior (KAB) model, the Theory of Planned Behavior (TPB), and the Dual Process Model (DPM). The KAB model (Rogers and Cartano 1962) was chosen for its ability to conceptualize how knowledge acquisition influences attitude change and subsequent behavioral shifts, providing a strong framework for educational and awareness-based interventions. The TPB was incorporated because it explains how behavior is directly predicted by intention, which itself is shaped by attitudes, subjective norms, and perceived behavioral control, offering a valuable model for designing strategies aimed at behavior change (Ajzen 1991). The DPM (Carlston 2013) added depth by emphasizing that decision-making results from both rational (systematic) and emotional (heuristic) processes, enabling the questionnaire to explore both deliberate planning and intuitive, habit-driven behaviors related to circularity practices. By applying these models, the questionnaire is positioned to capture the multifaceted psychological drivers of sustainable behavior, enhancing its robustness and applicability across different urban contexts. Additionally, during this phase, the key target groups for the questionnaire were also discussed.

2.2.2 | Phase 2

Once the constructs were defined (both the content domains based on the work of (Li et al. 2025) and the psychological constructs guided by established models), participants moved into the next phase: practicing item generation. It was emphasized that each psychological construct requires a specific style of item formulation, and that understanding these requirements beforehand is crucial for building a methodologically sound questionnaire. For instance, items assessing absolute knowledge were aligned with the principles of Item Response Theory (IRT). IRT focuses on modeling the relationship between an individual's latent trait (such as, level of knowledge) and their probability of correctly answering an item, enabling precise measurement and differentiation across the spectrum of ability (Furr and Bacharach 2014; Hambleton and Jones 1993). In this approach, items are typically formulated with objectively correct response options, such as the dichotomous true or fFalse, or multiple-choice (A/B/C/D), so that item difficulty and discrimination parameters can later be evaluated. Selecting appropriate formats at the outset is essential because IRT-based analysis relies on distinguishing respondents based on these objective, latent traits.

Conversely, items targeting attitudes, behaviors, opinions, or intentions were developed following the principles of Classical Test Theory (CTT). Under CTT, the focus is on creating a set of standardized items whose scores are summed or averaged to yield an overall score for each psychological construct (Kyriazos and Stalikas 2018; Spector 1992). Typically, these items are formulated using Likert-type scales or similar graded response formats, capturing subjective perceptions where no objectively correct answer exists (Likert 1932). Reliability and validity under CTT are assessed at the scale level rather than at the individual item level, assuming that all items contribute equally to the measurement of the underlying construct.

Recognizing and applying these distinctions at an early stage is critical, as it directly influences how questions were phrased, how response options were structured, and how the questionnaire would eventually be analyzed. For example, knowledge questions required categorical answer formats with clear correct/incorrect options, whereas behavioral or opinion-related items needed scales reflecting frequency, agreement, or intention.

During the workshop, these methodological foundations were explained, discussed and illustrated through practical examples, highlighting the inherent challenges of item generation across different psychological constructs. This session was deliberately designed to foster a shared understanding among participants of the complexity involved when developing a questionnaire and to set clear expectations for the next phases.

Following these discussions, the workshop transitioned into an iterative feedback phase. Experts collaboratively assessed and refined the appropriateness of the planned questionnaire's scope, structure, and item types. This iterative engagement ensured that item generation started on a strong conceptual and methodological foundation, aligning the questionnaire development process with best practices in psychometrics.

3 | Results

The current paper's results illustrate the outcomes of the three-hour co-creation workshop of urban circularity experts to design the construct to be measured in a questionnaire to assess urban circularity and practicing with item generation.

3.1 | Phase 1

In the first phase of the co-creation workshop, three main target populations were defined for the questionnaire: (1) the general public, including everyday building users; (2) professionals such as architects, engineers, planners, and others who work in the built environment; and (3) experts who have in-depth, specialized knowledge in circularity and circular economy practices. In order to gain a complete and comprehensive representation of circularity from many points of view, those separate target populations were selected for this research. The first group is made up of general users and inhabitants of a building to ascertain their baseline knowledge, views, and behaviors connected to circularity from the perspective of those who do not have a professional interest in, or have any knowledge about, CE practices in the built environment. The second group consists of the professionals involved in the design, development, and utilization of buildings, that is, architects, planners, engineers, and others within the built environment profession, to learn from them about the industry's capacity to adopt circular approaches with respect to practical challenges, as well as the various realities being faced within the industry by professionals seeking to adopt circular approaches. Lastly, the third group comprises specialists who have specific advanced knowledge of circularity and CE practices in the construction industry, to gain insights into their advanced theoretical methodology and strategic considerations, and thereby ensure that the questionnaire captures the most recent developments in CE-related research and policy. When taken together, these three groups offer a comprehensive range of perspectives and contribute to both the relevance and accuracy of this study. In other words, these groups served as hypothetical profiles, based on assumed levels of knowledge, attitude, and affinity with circularity, intended to guide discussion and development rather than represent fixed or rigid categories (Figure 2). This decision for these groups reflects the reality that circularity is not the domain of a single group or discipline; on the contrary, it is a shared societal challenge involving a wide variety of actors. Policymakers, urban planners, architects, engineers, residents, future residents, researchers, and private investors, and so on, all play a role in shaping circular urban development. In such a complex landscape, where "everybody is at the table," it becomes essential to understand the diverse perspectives, knowledge levels, and attitudes that each individual brings into the discussion. Circularity cannot advance through technical solutions alone, it requires mutual understanding, shared language, and the ability to engage with different starting points. For example, what a professional assumes to be common knowledge might be completely unfamiliar to members of the general public, and what an expert considers a priority might not align with what matters most to those who live in or use the buildings being developed. Therefore, it was discussed that the questionnaire should capture insights across these three populations to support dialog, alignment, and ultimately, more inclusive and actionable strategies for circular development. In this way, the instrument serves not only as a measurement tool, but could also serve as a bridge between stakeholders.

While these three groups offer a useful conceptual structure, they are not homogenous in practice. Within each group, individuals may vary widely in their levels of knowledge, affinity, and attitude toward circularity. For instance, members of the general public might include both highly engaged citizens with strong environmental values and others with little awareness or

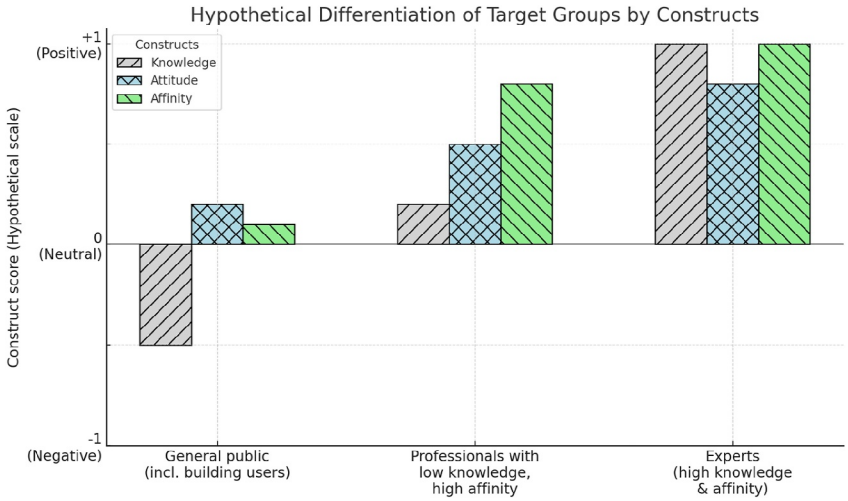

FIGURE 2 | The graph showing the hypothetical differentiation of target groups by construct.

interest in the topic. Similarly, experts may possess deep technical knowledge but hold critical views on current circularity practices or policies. Recognizing this internal variation is essential when designing an instrument for making the interpretability of its results meaningful and with nuance (Figure 3).

Then the discussion continued and it was decided that the questionnaire should be able to distinguish knowledge levels (low–medium–high) and affinity (low–medium–high) (Figure 2). The TPB and the KAB model were both seen to be a good fit for this audience segment as they allow sense-making of how knowledge, perceived norms, and attitudes shape intentions. When thinking about generating questionnaire items for the general public, the focus should be on simplifying, ensuring ease of comprehension, and being structured around basic knowledge, awareness, perceived control, and intention. Professionals with an affinity but low knowledge presented a unique opportunity. Their base-level interest indicates there may be an openness to interventions, despite their knowledge. The DPM was proposed here as a model to account for both the intuitive and reflective decision-making processes. Developing reflective knowledge and training professionals so they can move from a base-level motivational disposition toward more informed behavior could be valuable for this group. Experts were categorized as high in both knowledge and affinity. For this audience, the framing of communications in the questionnaire would shift away from general awareness toward more specific implementation issues, policy implications, and system-level changes. This segment's contribution to the evidence may also be useful in developing evidence-based strategies and institutional frameworks.

The experts discussed some key issues, such as how awareness and circularity actions correlate across different sectors, and how behavioral readiness could be mobilized with relevant interventions. Some of the visual materials from the workshop show clear attention to connecting user profiles to psychological constructs, demonstrating the importance of designing engagement strategies based on stakeholders' roles and capacities (Table 1). This participatory and theory-informed work will allow the instrument to be flexible and context-specific, while also producing insights that are more nuanced and able to serve multiple purposes to inform policy, educational outreach, or support circularity planning and transfer in urban transformation contexts. After the discussion, it was decided that the instrument should be able to distinguish people in groups, hypothesizing that the general public demonstrates low affinity and low knowledge of circular principles, professionals might have lower knowledge levels, but higher affinity levels, and experts demonstrate high levels of both knowledge and affinity.

3.2 | Phase 2

The second phase built on the questionnaire development process by more fully elaborating the types of questions and constructs that can operationalize awareness, knowledge, and behaviors concerning circularity. This set of materials was focused specifically on three important domains of circularity: energy, water, and material efficiency. Based on these selected domains, experts started to develop the items and discussed their formats (Table 2). For example, in the energy domain, simple knowledge-check questions such as "*Do you know that cooling uses more energy than heating?*" were articulating baseline awareness and planning for follow-up on behavior willingness. As was studied in the broader conceptual model sketched out by participants, action is understood as a function of interconnected components of knowledge and belief, benefit, willingness, and context, such as culture and health. Similarly, in water, the questions were framed from awareness ("*I am aware that if you use less water in the kitchen, you help protect the environment*") to behavioral intention ("*If you try to use the washing machine less, you protect the environment*"). These were framed with pairs of Likert-scale statements to facilitate quantification of the degree to which individuals adopt environmental attitudes in practice with different water-saving behaviors. These questions also reflect constructs within both the KAB model and the TPB, particularly in how beliefs about environmental outcomes may influence individual decision-making. In terms of material efficiency, discussion among the participants covered the acceptability and practicality of acquiring second-hand or reused materials at home. Questions like "*Would you be willing to incorporate reused materials in your home?*" and "*Do you think second-hand*

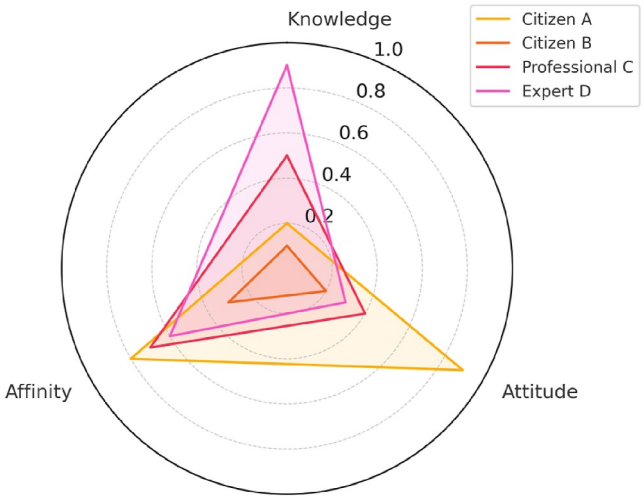

FIGURE 3 | Hypothetical example of differentiation on individual variation on circularity constructs.

TABLE 1 | Stakeholder groups and example user profiles identified by the four expert groups in phase 1, highlighting their roles and capacities in relation to circularity (for visuals see appendix A).

Expert group	Stakeholder/user profiles identified	Illustrative roles and capacities in circularity transitions
1	Building users; real-estate developers; general public in public spaces (e.g. parks and facilities); designers (architects and engineers).	Everyday use and maintenance of buildings and public spaces; making investment and construction decisions; designing and planning the built environment; providing technical expertise and solutions.
2	Young generation; owners (households); educators; NGOs; communities; bodies/administrators; city councils; public bodies; professional chambers.	Raising awareness and educating others; taking household-level decisions on consumption and renovation; representing communities and professional interests; designing and implementing local policies and programs; coordinating collective initiatives.
3	Local residents; policy makers (local, regional, national); SMEs; corporates; community organizations; third-sector organizations (including NGOs); academic institutions/ universities; asset managers and real-estate developers.	Shaping everyday practices in neighborhoods; formulating and enforcing regulations; developing and marketing circular products and services; organizing community action; generating and translating scientific knowledge; managing and retrofitting building stocks and assets.
4	Local government and regulators; students/learners; citizens; industry (contractors, distributors, producers); water and wastewater service companies; experts (academia, policymakers).	Implementing and monitoring circularity policies; building future professional capacity; engaging citizens in behavior change; providing technical infrastructure and services; offering expert knowledge to support decision-making and scenario development.

TABLE 2 | Domains, example items, and psychological constructs elaborated by experts in phase 2 to operationalize awareness, knowledge, and behavior regarding circularity (for visuals see appendix B).

Domain	Intended respondents/sample	Psychological construct	Example items
Energy	General public, with possible adaptation for specific user groups (e.g. household decision-makers, building users).	Awareness and basic knowledge of energy use; perceived benefits of saving energy; willingness/intent to change; contextual factors (e.g. culture, health, comfort).	Simple knowledge-check and awareness questions such as: "Do you know that cooling uses more energy than heating? (Y/N)" and comparisons between processes/ services that consume more or less energy. Follow-up items on willingness to change behavior.
Water	General public and households, adaptable to different demographic or professional groups involved in water use.	Awareness of water use; pro-environmental attitudes; intention to adopt water-saving behaviors; perceived impact of own actions (KAB, TPB).	Awareness and intention statements, often in Likert-scale pairs, for example: "I am aware that if you use less water in the kitchen, you help protect the environment" and "if you try to use the washing machine less, you protect the environment."
Material efficiency	General public, with relevance for professional groups involved in material choices (e.g. homeowners, designers, contractors).	Knowledge and beliefs about reused/ second-hand materials; social acceptability and norms; perceived behavioral control; value orientations (health, comfort) and key motivational drivers (TPB, DPM).	Questions on the acceptability and practicality of reused or second-hand materials at home, e.g.: "Would you be willing to incorporate reused materials in your home?", "would you place a reused material at home?", "do you think second-hand materials are a viable option?".

materials are a viable option?" were aimed at exploring knowledge and how socially acceptable these options were, critical elements in efforts toward transforming consumer behavior in the built environment. These elements were mapped to the public audience respondents, but acknowledged as relevant targeting various professional and demographic sample groups. Along with this, the discussion also referred to the psychological factors of perceived control, value orientation (for instance, health and comfort), and social norms (primary constructs within TPB and DPM) that promote or deter sustainable action.

Overall, these workshop outcomes demonstrated the value in constructing questionnaire items that hold psychological meaning while remaining user-friendly and relevant to the context. By developing and refining more specific questions to the circularity domains, the expert group felt confident that developing not only measurable outcomes but also potentially, practical insight about behavioral intensive policy and design interventions intended to support circular behaviors at various social levels. In group discussions, each indicator was examined by experts on its relevance, wording, and potential impact. This revealed gaps and ensured that the most critical dimensions of urban circularity were comprehensively addressed.

4 | Discussion

The current work presents the procedure for developing a questionnaire aimed at assessing urban circularity at the city and neighborhood levels, involving a group of international experts from six countries through a co-creation approach (Appendix C). Different phases of the process are described here: (1) defining the target population, and to whom the questionnaire is to be addressed; (2) operationalization of the concept of "urban circularity" and suggesting items for each of the dimensions of this concept are part of a process that could be further replicated thus contributing to the creation of new measurements in the circularity domain. This work has discussed the challenges of the implementation phase of the co-creating workshop and how these challenges have been addressed to use the group resources and generate the first draft of items for the questionnaire.

First, the group composition of experts was a challenge as they had different backgrounds and levels of understanding of urban circularity. Some experts with a background in social sciences had a human-centered perspective, whereas others, from the urban planning, engineering, architecture, and design domain, have a better experience of circularity as a process and the urban infrastructure associated with such a process. As a result, communicating each other's perspectives and expectations toward the workshop's outputs was key in the first phase of the process. Using visual materials, as the ones illustrated in the current manuscript, facilitated the communication between experts with various backgrounds. In addition, experts from municipalities and different city associations had a more pragmatic perspective on the whole process and the feasibility of different indicators.

Second, when co-creating an instrument that will be further used to measure some people's attitudes, behavior, and beliefs about circularity in their cities/neighborhoods, having a group of experts from different countries is both a resource and a serious challenge. Such instruments need to be culturally sensitive, especially if they will be used in transnational research. The variety of cultural contexts that experts come from could contribute to the culture-sensitive measurement, provided that they can harmonize their views and expectations during such workshops. To achieve that, we have created sub-groups to work on various tasks during the workshop, while including people from each of the six countries in each sub-group and defining a way of communicating the views not only verbally, but also visually.

Third, when the experts mentioned possible items to be included in the questionnaire, we used brainstorming techniques aimed at increasing the number of ideas (production gains, which refers to situations where working in a group leads to more ideas, better ideas, or more diverse ideas than individuals would produce alone) and reducing the inhibitory factors discussed above (production losses). Individual brainstorming and group brainstorming alternated during the workshop, and there were three facilitators with a key role in organizing the tasks and stimulating the production of ideas. Facilitators have the role of making all group members valuable resources during the process and stimulating the debate with no judgment over each other's perspectives. The results show that experts could transcend their field of expertise if they are properly stimulated, and the workshop creates a secure environment for their views that would not be judged but understood by others.

Nevertheless, this co-creation process, with the phases described here, could be further used in research on urban circularity in a transnational frame and a bottom-up approach. Also, other initiatives to measure policies and strategies in the area of urban sustainability could benefit from the same research procedure when creating different standardized measurements.

4.1 | Further Development

Following the results of the co-creation process and the initial pilot test conducted in October 2025, an important direction for future work is to evaluate the questionnaire's applicability to other urban sustainability activities, particularly through the development and refinement of circularity assessment tools. As data collection continues, subsequent steps involve adapting and validating the questionnaire across different languages and cultural contexts to ensure its broader relevance. This cross-cultural validation involves iterative testing phases that incorporate localized feedback from diverse participant groups, ensuring both conceptual consistency and cultural appropriateness. The full validation process includes both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) to assess the questionnaire's structure, reliability, and construct validity. Such efforts enhance the tool's utility not only for academic researchers but also for policymakers, city planners, municipal departments, and educators seeking to understand and promote circularity-related awareness, attitudes, and behaviors across various urban settings. The co-creation workshop

approach used in this study is planned to be tested and used in future ULLs in Belgium, Italy and Türkiye. These ULLs are diverse in geographic and socio-economic contexts and will provide test beds for connecting each co-created set of indicators to local decision-making. Given the context specificity of ULLs, it is reasonable to expect an emphasis on developing multiple, context-specific and time-dependent layered sets of indicators at the outset, and recombining them over time into a common, flexible, core set that can be leveraged across contexts.

5 | Conclusion

Developing a set of circularity indicators is a complex process, involving technical, ecological, environmental, and social aspects. This work has shown that a collaborative and co-creative approach can overcome this complexity. Hence, a co-creation session with multiple stakeholders was conducted, which guaranteed the relevance, comprehensiveness, and clarity of the instrument that has been developed. Concurrently, this study addresses the important gap by engaging stakeholders at a sufficiently early point to help determine the construct and target population. While participatory approaches are important for initial questionnaire development, advancing the field requires moving beyond early tools to fully validated scales and instruments that can measure core constructs in a valid and repeatable manner across contexts.

Through collaboration across a diverse group of disciplinary backgrounds and perspectives, a richer and more inclusive framework for addressing circularity becomes possible. Rather than pursuing a single solution across disciplinary divides, the collaborative approach we explore here recognizes the potential value of dialogic process, iteration, and situational awareness for developing meaningful and actionable circular urban sustainability indicators.

Author Contributions

Rengin Aslanoğlu: conceptualization, data curation, formal analysis, methodology development, visualization, writing – original draft preparation. **Loredana Ivan:** conceptualization, data curation, formal analysis, methodology development, visualization, writing – original draft preparation. **Cihan Kayaçetin:** conceptualization, data curation, formal analysis, methodology development, visualization, funding, writing – original draft preparation. **Qiuxian Li:** conceptualization, data curation, formal analysis, methodology development, visualization, writing – original draft preparation. **Joost van Hoof:** conceptualization, data curation, formal analysis, methodology development, visualization, writing – original draft preparation. **Jeroen Dikken:** conceptualization, data curation, formal analysis, methodology development, visualization, writing – original draft preparation.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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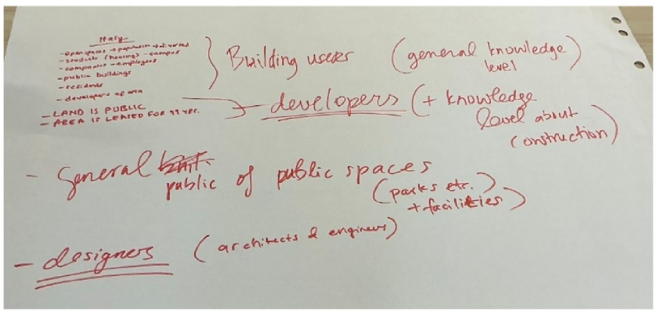
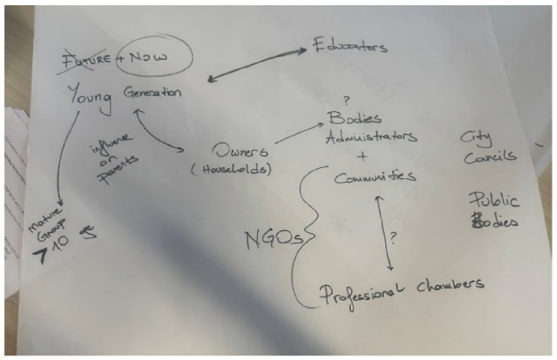
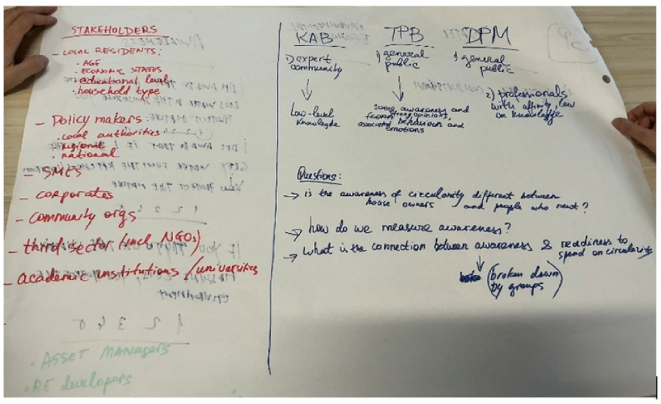
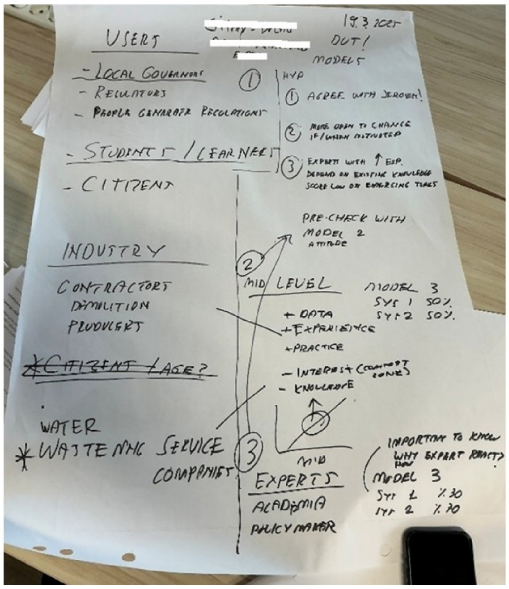
Appendix A

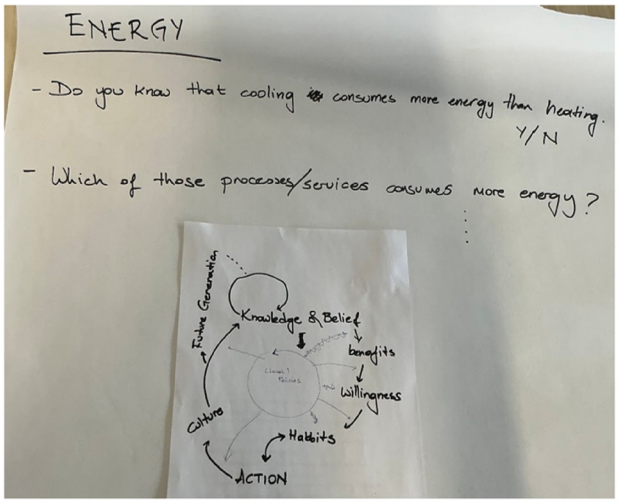


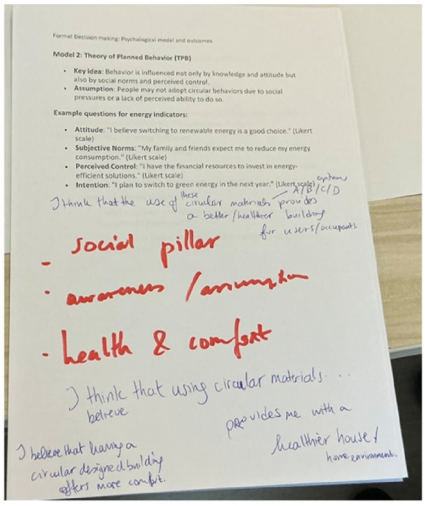


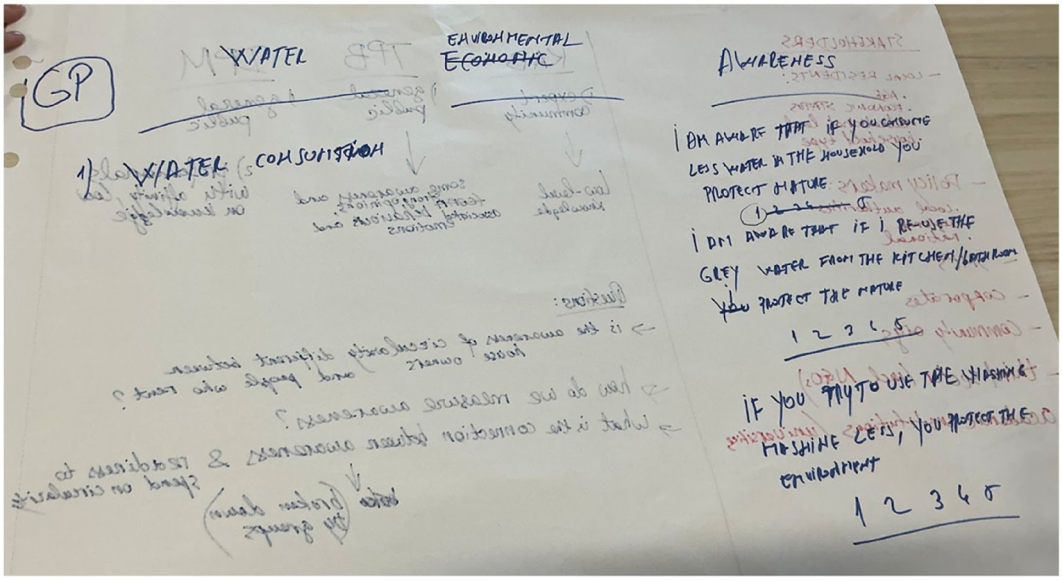


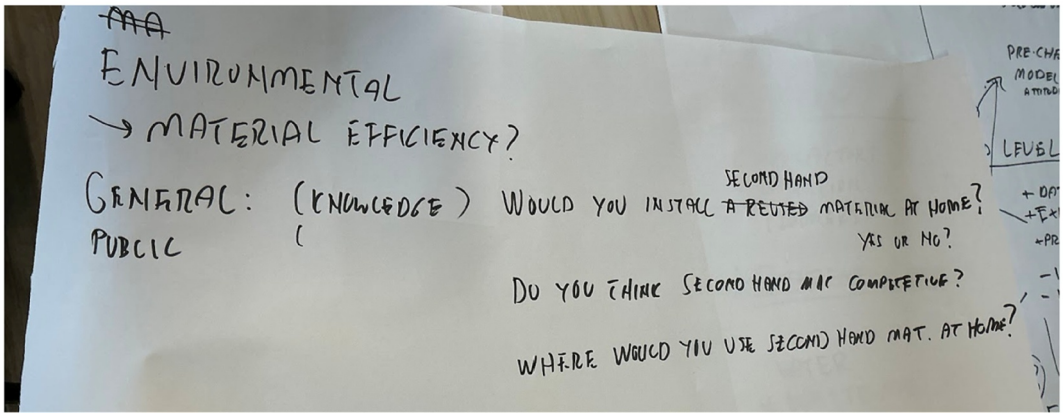


Appendix B









Appendix C

Some examples from the attitudes toward circularity questionnaire (ATCQ)			Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Questions	1	I actively try to decrease my daily waste (by waste categorization, composting).					
	6	I actively seek out buildings with natural materials when I look for a place to rent/buy.					
	7	I actively try to decrease my energy use on the workfloor.					
	8	I actively try to decrease my use of materials on the workfloor.					
	9	I actively use renewable energy sources (such as installing solar panels, green electricity)					
	10	I support practices that promote material efficiency through buying second-hand, using sharing platforms.					
	11	I support practices that promote material efficiency through choosing minimal packaging.					
	13	I have experience working with reused or recycled construction materials on-site.					
	14	I opt for energy providers that generate most of their electricity from renewable sources.					
	15	I actively choose products or services that help reduce negative impacts on the climate and waste generation.					
	51	I am committed to sorting waste even if it requires time.					
	52	I intend to participate in energy sharing or community energy programs (e.g., peer-to-peer electricity trading, local energy cooperatives) in the future.					
	55	I would pay/contribute more to live in a neighborhood with zero emissions!					
	56	I am ready to change my current daily behaviors toward a smaller environmental impact, even if this means accepting lower comfort.					
	57	I intend to support community-based circular initiatives in parks, such as composting programs or materials recycling.					
	59	In my designs, I try to use circular materials as often as I can.					
	60	I would rather not rent out property that is not sustainable in terms of energy and material use.					
	63	I'd like to have a compost bin for my food waste in the kitchen.					
	65	I am motivated to reduce environmental impact through circular solutions.					
	66	I intend to prioritize repairing broken household items rather than replacing them with new ones.					
	71	I plan to share my experiences with circular solutions with friends, neighbors, or online communities.					
	72	I aim to support actions that involve community-based sharing, repairing, or reuse models.					
	76	I intend to track my consumption habits to reduce unnecessary purchases and waste.					