

Research Paper

Co-creating eco-cities

Increasing residents' willingness to take action to enhance biodiversity in their neighbourhood

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Abstract

This study investigates strategies to enhance resident engagement in increasing neighbourhood biodiversity in Rotterdam, aligning with municipal biodiversity agendas. Despite competing priorities, residents' proactive involvement is crucial. Insights from expert interviews and behavioural models inform recommendations for effectively motivating residents and addressing urban biodiversity challenges.

Keywords

Participatory city making, Citizen engagement, Urban Living Lab, Nature-inclusive cities, Behaviour change, Urban Biodiversity

1. Introduction

Biodiversity and the quality of nature worldwide is rapidly declining (IPBES, 2022). This is also the case in the Netherlands. Not only in the countryside but also in cities. Meanwhile, many municipalities have adopted biodiversity implementation agendas. However, the agenda of the city of Rotterdam published in 2023 indicates that achieving systemic change also requires the engagement of the city's residents (Gemeente Rotterdam, 2020). Residents' understanding and willingness to take action and engage with nature can contribute to increasing biodiversity in both (semi-)private areas and public spaces.

This paper examines how the COM-B behavioural model and related Behaviour Change Wheel (BCW) framework (Michie et al., 2011) can be valuable within the context of participatory design research. On the base of expert interviews, this study aims to nuance the BCW framework and formulate recommendations for engaging and motivating residents to take action in order to increase the amount of green space and biodiversity in their neighbourhood. The contribution of this study lies not only in identifying what topics might be relevant in this context, but also in offering practical guidelines on how to translate these to working practices.

The findings describe opportunities and challenges for involving and engaging residents and nature in enhancing neighbourhood-level biodiversity. Thus, the research also provides valuable insights into translating biodiversity policy into practical implementation.

2. Context

In January 2024, the four-year research project "Neighbourhood as Biotope" (Dutch WAB) was launched, investigating how networks of people, nature, and technology can collaborate to enhance biodiversity at the neighbourhood level (Hogeschool Rotterdam, 2022). In partnership with a quadruple helix consortium of multidisciplinary partners, Rotterdam University of Applied Sciences will conduct practice-oriented participative design research in two districts in the province of South Holland. This research will use the Urban Living Lab methodology, where solutions to increase biodiversity at the neighbourhood level will be co-created with local residents (De Lille and Overdiek, 2021; Slingerland, G., & Overdiek, A., 2023).

Oud-Mathenesse is one of the neighbourhoods involved, where many residents face socio-economic and other challenges which are quite possibly experienced as more pressing than increasing biodiversity or greening their environment (Gemeente Rotterdam, 2024a). This neighbourhood is characterised by a relatively young population, low incomes and a predominantly pre-war housing stock with significant maintenance backlogs. Additionally, the neighbourhood has a highly diverse population of which 75% has a migrant background and a relatively low number of residents feels a sense of connection to the neighbourhood (Gemeente Rotterdam, 2024a, 2024b). The neighbourhood profile of Oud-Mathenesse and Witte Dorp shows that the objective figures regarding safety (above average relative to all districts of Rotterdam) and physical aspects (equal to the average) perform well compared to the average score for Rotterdam. However, the objective figures of the social index present a less positive picture. What is particularly striking is that the subjective figures, reflecting residents' perceptions, reveal a very negative outlook (Gemeente Rotterdam, 2024b). Consequently, a key question that emerged in the context of the WAB research is how to increase residents' willingness to take action to enhance biodiversity in this neighbourhood?

At present, the willingness of residents in the Oud-Mathenesse district to engage in greening the neighbourhood and enhancing biodiversity is low (Slingerland, G. and Overdiek, A., 2023). In general, biodiversity is perceived as an abstract concept by many individuals (Christmas et al., 2013). To encourage residents to take action, it is essential to explore how pro-environmental behaviour can be influenced.

3. Literature

The Municipality of Rotterdam has commissioned research on this topic (Christiaanse et al., 2022) and it is also widely studied in previous academic literature (Michie et al., 2011). Scientific literature identifies citizen science as a method to engage citizens in biodiversity efforts. In citizen science, citizens assist scientists with their research (Newman et al., 2012). However, it is often observed that only a small group of citizens with an interest in science and climate participate in such initiatives. Furthermore, while citizen science raises awareness, it does not necessarily change attitudes or behaviours (Peter et al., 2021). Therefore, alternative interventions are required to motivate residents to act.

Knowledge transfer is another approach to activate people, but it is a limited intervention when considering the full range of possible interventions (Cipriani et al., 2024). A review of the literature on "co-creation", "urban biodiversity", "urban living lab", and "biodiversity" provides general, practical guidelines for shaping such co-creation interventions (Mohr-Stockinger et al., 2023; Wilk et al., 2020) but does not offer specific direction for activities focused on promoting biodiversity action. In most cases, the emphasis in the literature on similar frameworks is placed on the role of government, specifically in the design of governance structures (Hölscher et al., 2024). Moreover, existing knowledge regarding the engagement of hard-to-reach actors remains limited (Hölscher et al., 2024). Nielsen et al. argue that the lack of

scientifically grounded policies and interventions for behavioural change may be a key reason for the failure to effectively address the biodiversity crisis (K. Nielsen et al., 2021; K. S. Nielsen et al., 2021).

4. The Behavioural change wheel and the COM-B model

The Behavioural change wheel (BCW) is an evidence based framework underpinned by nineteen previous behavioural change frameworks. At the core of this framework lies the COM-B behaviour model. "In this 'behaviour system,' capability, opportunity, and motivation interact to produce behaviour, which in turn influences these components" (Michie et al., 2011) as illustrated in Figure 1. Although primarily a behavioural model, COM-B also serves as a foundation for designing interventions aimed at behaviour change. By incorporating intervention functions and policy categories, the Behaviour Change Wheel (BCW) is formed, enabling the COM-B model to be linked to potential behaviour-influencing interventions. Any intervention may modify one or more elements within the behaviour system. The causal relationships within the system can either mitigate or amplify the effects of interventions by triggering changes in other areas. In the BCW framework, the three components that generate behaviour are further subdivided based on key distinctions noted in the research literature. See Figure 2 for the BCW. This serves as the foundation for a systematic analysis to guide the selection of interventions and policies.

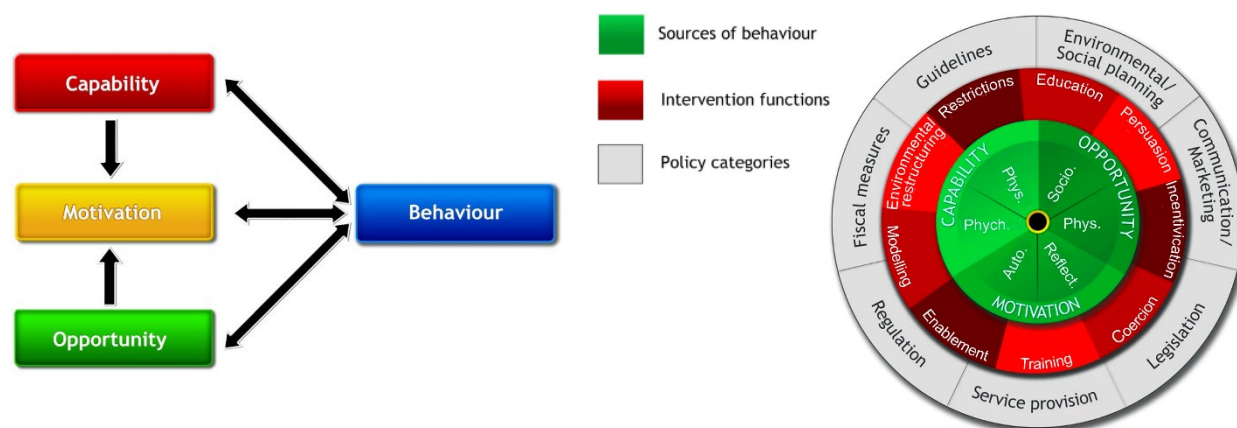


Figure 1. The COM-B system - a framework for understanding behaviour (Michie, van Stralen and West, 2011).

Figure 2. The Behaviour Change Wheel (Michie, van Stralen and West, 2011), adaptation of text size and addition of abbreviations of sub-determinants by J. Spoelman, 2025. For full description of sub-determinants see figure 3.

Marselle and Golding (Marselle, Melissa R. and Golding, Sarah E., 2023) describe how the BCW and the associated COM-B model can provide a scientific basis for designing and selecting the type and desired function of an intervention aimed at mitigating the biodiversity crisis. Their work explores the BCW by plotting possible biodiversity enhancing interventions on the intervention functions of the framework (figure 2). They highlight one of the key strengths of the BCW framework: its applicability across various contexts. However, the work of Marselle and Golding does not detail how possible interventions should be specifically designed, nor how they contribute to the three behaviour-influencing components of the COM-B model, thus providing an incomplete response to the preciously stated key question in the WAB research. Therefore the research question for this paper became:

How can the core determinants of the COM-B model (capability, motivation and opportunity) be nuanced by contextual knowledge?

In the following sections, the methods used will first be explained and substantiated in the Methods chapter. The “Results and Findings” chapter will then present the findings in the form of identified topics and practices, which are discussed according to each determinant of the COM-B model. These findings will be elaborated with brief descriptions and illustrated using one or more quotes. Finally, the Discussion chapter will explore the relevance of these findings for both practice and theory, including an analysis of how some results relate to the practical challenges in Oud-Mathenesse. The paper will conclude with a summary and recommendations for further research.

5. Methods

The aim of this research is to identify topics and practices that can serve as input for an Urban Living Lab to be organised in the Oud-Mathenesse neighbourhood in Rotterdam, as part of the participatory design research project Wijk als Biotoop (WAB). As outlined in the literature review, no single theory fully addresses this question. Therefore, this paper explores the application of behaviour change theory to substantiate the choice of specific interventions in participatory design research.

During this study, semi-structured and in-depth interviews were conducted with experts working within the Dutch context to gather practical knowledge. The transcribed interviews were thematically coded, with motivation emerging as the most prominent concept. This led to the decision to compare the findings with the evidence-based behaviour model, COM-B, developed by Michie, van Stralen and West (2011), which places motivation at the centre of influencing and changing behaviour. For this investigation, the most recent version of the COM-B model was used, including the subdivision of the primary determinants of behaviour. See Figure 3.

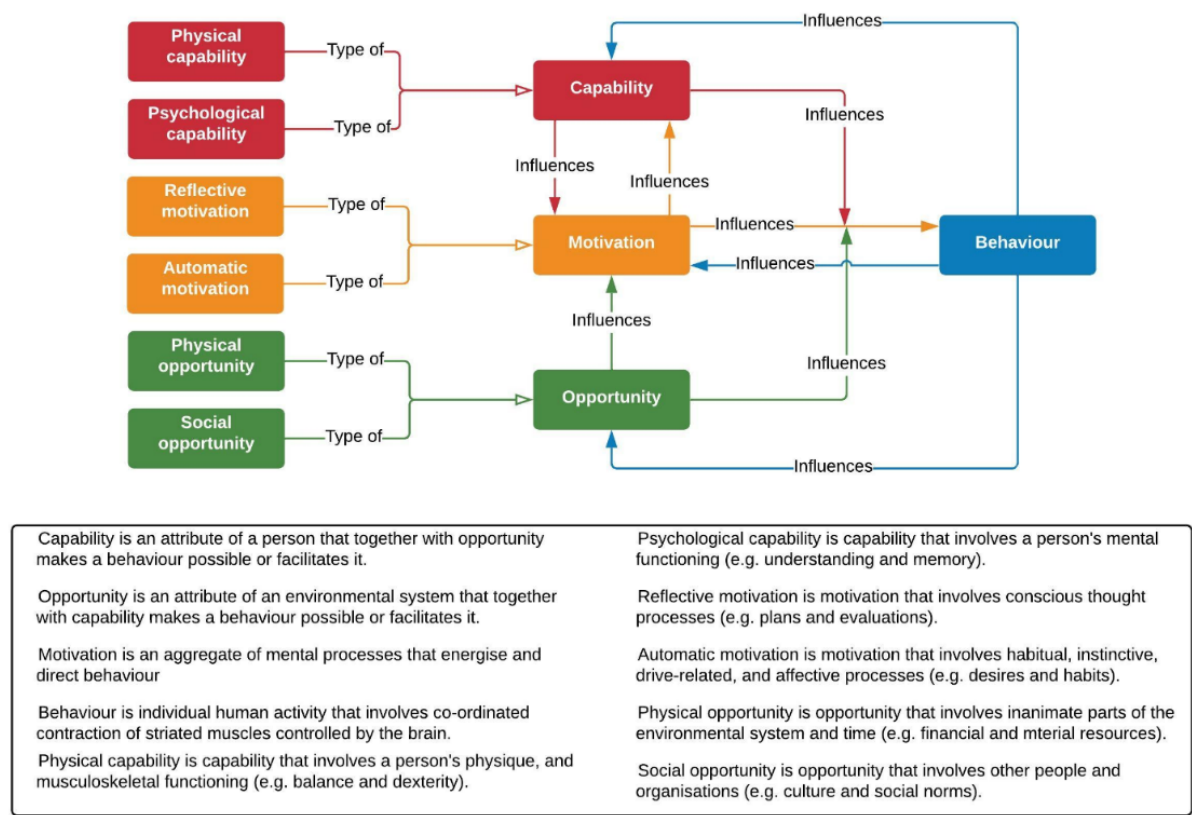


Figure 3. The COM-B model behaviour change with sub-division of the main determinants for behaviour (West and Michie, 2020).

The Oud-Mathenesse neighbourhood, the research area for the first Urban Living Lab in the WAB project, was then used as a case study to assess the applicability of the results and to help formulate practical recommendations.

In total, fourteen experts were interviewed using an open, thematic interview style. Whenever possible, the interviews were conducted face-to-face and voice recorded. Eleven of the experts were from the WAB research consortium, with three additional external experts recruited through snowball sampling. All participants provided consent for their data to be used in this paper. The experts represented a range of expertise areas, working either at a national level or within the regional context of the WAB project. Collectively, their knowledge and experience provided a broad range of insights into the relevant aspects of increasing residents' willingness to act on biodiversity at the neighbourhood level. For an overview of the interviewees' expertise and roles within the WAB project, see Table 1.

ID	Internal /external (of consortium)	Organisation	Expertise	Role in research consortium
R1	Internal	Regional government	ecology, biodiversity	LL2
R2	Internal	Knowledge institution	citizen participation	LL1 en 2
R3	Internal	Civil organisation	local context, citizen participation	LL2
R4	Internal	NGO	biodiversity monitoring	LL1
R5	Internal	Regional government	ecology, biodiversity	LL1
R6	Internal	Knowledge institution	citizen participation	LL1 en 2
R7	Internal	Civil organisation	local context	LL1
R8	External, local expertise	NGO	biodiversity, citizen participation	external
R9	Internal (joined after interview)	NGO	biodiversity, citizen participation, citizen science	advisory board
R10	Internal	Company	developer built environment en biodiversity	advisory board
R11	External, local expertise	Company	greening the city, urban ecology	external
R12	Internal	Knowledge institution	biology, biodiversity	advisory board
R13	Internal	Regional government	innovative collaboration	LL1
R14	External, citizen sciences expertise	Company	citizen science, biodiversity monitoring	external
O1	Internal	Knowledge institution	urban and regional development	researcher
O2	Internal	Knowledge institution	citizen participation, Urban Living Lab	researcher, main responsible

Table 1. This table shows an anonymised overview of all respondents, detailing whether they are part of the research consortium (internal) or not (external), the type of organisation they represent and their expertise relevant to the research (by J. Spoelman, 2024).

Based on the main research questions and the knowledge and experience of the second author (interviewed in her role of lead researcher with expertise in urban and regional development, as O1) the interview was structured around five key themes:

1. Introduction: to gain a general understanding of the respondent. While not all information gathered in this section was directly relevant to the main research question, it contributed to the broader context of the RAAK-pro research proposal.
2. Experience with biodiversity: what experience does the respondent have in working on biodiversity with citizens?
3. Engaging citizens: what knowledge or experience does the respondent have regarding involving citizens in projects aimed at enhancing biodiversity?
4. Role of government: how does the respondent perceive the role of government in such initiatives?
5. Conclusion: questions regarding collaboration with other parties and technologies, and suggestions for additional respondents

For each theme, related questions were developed, but depending on the respondent's expertise and answers, deviations were made; questions were either skipped or explored in greater depth. On average, the interviews lasted 60 minutes, with some extending up to 150 minutes. After 14 interviews, data saturation was observed.

The interviews were transcribed using the online transcription program Sonix and then thematically coded in Atlas.ti. Documents with numbers five and six are from respondent five and documents with number fifteen and sixteen are from respondent fourteen as they both were interviewed on two different days. Open coding was employed without any predetermined theoretical framework. Based on recurring themes, thematic groups were created in Atlas.ti, and the frequency of codes in each group was analysed. The codes were mapped onto the COM-B model in Atlas.ti by assigning them to one of the three behavioural determinants: capability, motivation, and opportunity. Additionally, all codes were examined to determine whether they answered the two sub questions:

RQ1a: What can be done to enhance each main determinant of the COM-B model in order to increase residents' willingness to act?

RQ1b: How can these three determinants be increased in order to increase residents' willingness to act?

In this research, the “what” refers to a description of an action or intervention (in this paper later referred to as topics), while the “how” refers to the manner in which such actions or interventions can or should be implemented (later referred to as practices). The codes for each determinant were then categorised into two groups, distinguishing between those that describe the 'what' and those that describe the 'how'. To ensure the reliability of the research, inter-coder calibration was conducted. The created codes were reviewed by the second author who is an expert in co-creation within Living Labs. Since all interviews were conducted in Dutch, the codes and quotes were translated into English by the two authors with the help of Chat GPT-4. Chat GPT-4 was also used for translation of original (Dutch) text passages throughout this paper. All translated text passages generated by Chat GPT-4 were reviewed by the authors before inclusion in this paper.

In a series of three collaborative sessions, both authors analysed the codes, identifying the key topics and practices that emerged. Through thorough discussion and mutual deliberation, they jointly formulated topics for the 'what' category and practices for the 'how' category. A detailed overview of these can be found in the section "Results and Findings".

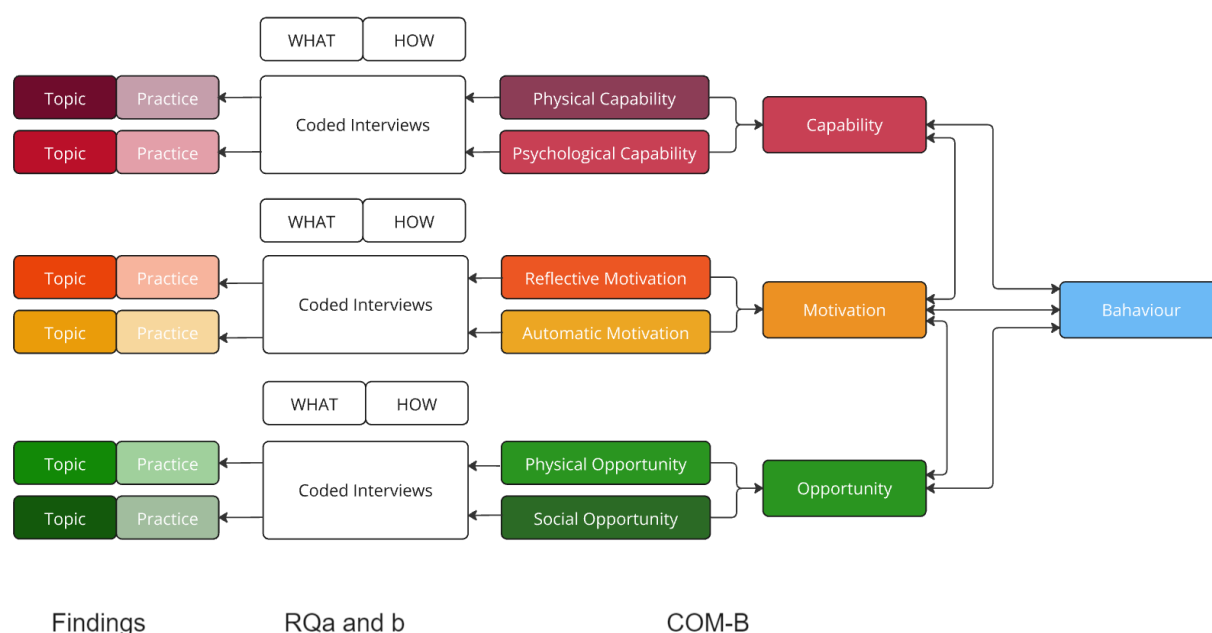


Figure 4. Visualization of relation between theory, methods, research questions and findings (by J. Spoelman, 2024).

Zotero was used as a citation manager to add in-text citations and to generate the accompanying reference list.

In the Discussion paragraph we describe how the Oud-Mathenesse neighbourhood was used as a testcase for the applicability of the results.

6. Results and findings

The results and findings included below will together contribute to answering the research question: How can the core determinants of the COM-B model (capability, motivation and opportunity) be nuanced by contextual knowledge?

The results describe opportunities and challenges for involving and engaging residents and nature in enhancing neighbourhood-level biodiversity. The table below provides an overview of the formulated topics and practices for each determinant.

Element COM-B	Topics	Practices
Capability	C-T1 Knowledge acquisition (through cs)	C-P1 Collective learning (about biodiversity)
	C-T2 Nature conscious	C-P2 Sharing/ communicating knowledge
	C-T3 Care for nature	C-P3 Mode of communication
	C-T4 Diversity (in capabilities)	
Motivation	M-T1 Positive urgency	M-P1 Communicate with visuals and stories
	M-T2 Eco-system services	M-P2 Trigger curiosity and playfulness
	M-T3 Empathy with nature	M-P3 Trigger reflection on different ideals of nature
	M-T4 Social values of green	M-P4 Connect with values and needs of residents
		M-P5 Provide feedback on impact of interventions
Opportunity	O-T1 Economic aspects	O-P1 Aligning different interests
	O-T2 Social cohesion (in the neighbourhood)	O-P2 Connect networks and initiatives
	O-T3 Rol of the municipality	O-P3 Multifunctional use in public space
	O-T4- Synergy	O-P4 Regenerative approach

Table 2. Overview of found topics and practices per determinant (by J. Spoelman, 2024).

These new, original topics and practices have been derived from the interview data. A more detailed overview of all these topics and practices can be found in table 5, 6 and 7 in the Appendix. In these three tables the topics and practices have been structured per main determinant (see table 5 for capability, table 6 for motivation and table 7 for opportunity). Each topic and practice is accompanied by an interpretation and illustrated with one or more quotes from the interviews.

7. Discussion

The previous paragraph outlined how the core determinants of the COM-B model (capability, motivation, and opportunity) could be nuanced by contextual knowledge. The topics and practices formulated based on the data can be applied in participatory design research projects aimed at enhancing biodiversity. This paragraph discusses the relevance of the research for both theory and practice.

7.1. Relevance for theory

During the process of mapping the data onto the COM-B model, several observations were made.

Nuancing the Core Determinants of the COM-B Model. Mapping the data onto the COM-B model has yielded not only topics relevant to co-creation processes for enhancing biodiversity but also practices that outline specific methods for strengthening each determinant. Through this process, the research has contributed to a more nuanced understanding of the COM-B model. In addition to mapping the data onto the COM-B model, the topics and practices were assigned to the sub-determinants (Figure 3).

This assignment was successful for three-quarters of the topics and practices. The remaining six could be aligned with a primary determinant but not with a specific sub-determinant (see Table 3). These six related topics and practices could be described as general (or cross-over) sub-determinants and provide new knowledge for the intentional design of interventions.

Element COM-B	General determinant or Sub-determinant	Topics	Practices
Capability	Physical capability	C-T3 Care for nature	
	Psychological capability	C-T1 Knowledge acquisition (through cs)	C-P2 Sharing/ communicating knowledge
		C-T2 Nature conscious	
	General (both physical and psychological)	C-T4 Diversity (in capabilities)	C-P1 Collective learning (about biodiversity) C-P3 Mode of communication
Motivation	Reflective motivation	M-T2 Eco-system services	M-P3 Trigger reflection on different ideals of nature
		M-T4 Social values of green	M-P5 Provide feedback on impact of interventions
	Automatic motivation	M-T3 Empathy with nature	M-P1 Communicate with visuals and stories
			M-P2 Trigger curiosity and playfulness
Opportunity	General (both reflective and automatic)	M-T1 Positive urgency	M-P4 Connect with values and needs of residents
	Physical opportunity	O-T1 Economic aspects	O-P3 Multifunctional use in public space
	Social opportunity	O-T2 Social cohesion (in the neighbourhood)	O-P1 Aligning different interests
		O-T3 Rol of the municipality	O-P4 Regenerative approach
		O-T4- Synergy	
	General (both physical and social)		O-P2 Connect networks and initiatives

Table 3. Overview of alignment topics and practices with sub-determinants of COM-B model, with new sub-determinants in white rows (by J. Spoelman, 2024).

The topics and practices that could only be assigned to a primary determinant are as follows:

- **C-T4 Diversity (in capabilities):**
Diversity in capabilities may relate to knowledge or skills, both of which are relevant within a community group. For instance, while some individuals have extensive knowledge of certain plants, others may be particularly skilled in applying for grants.
- **C-P3 Mode of communication:**
The mode of communication is relevant to all topics and practices, particularly for sharing both knowledge and skills.
- **C-P1 Collective learning (about biodiversity):**
Collective learning encompasses both skills and knowledge.

- **M-T1 Positive urgency:**
Creating a sense of positive urgency can impact both conscious and unconscious motivation.
- **M-P4 Connect with values and needs of residents:**
People may consciously or unconsciously embody certain values and pursue specific needs.
- **O-P2 Connect networks and initiatives:**
Connecting networks and initiatives can influence both organisational and social aspects, as well as mobilising material resources.

Not Only *What* but Also *How*. The model is applicable not only to interventions that describe *what* can be done, but it also provides guidance in strategically determining *how* a particular intervention can best be designed. The *how* is equally important in shaping co-creation interventions. This addition provides a valuable nuance to the COM-B model

Not all data can be easily mapped onto one of the three primary determinants of the COM-B model. Respondents placed significant emphasis on methods of collaboration and communication. While this is partially reflected within capability and opportunity, it is also broadly applicable to the overall co-creation process. Consequently, it cannot be mapped onto the model, as it pertains to all determinants.

Distinction between Physical and Mental Capability: Noticeable absence of data on individuals with physical (or mental) limitations. It is notable that none of the respondents mentioned physical factors—such as individuals' physical characteristics that influence their capability to participate in a co-creation project. This could include auditory, visual, or other physical impairments that might limit participants in performing specific actions. Respondents did, however, describe how sharing knowledge and experience can help increase both the mental (knowledge, memory, understanding) and physical capacity (dexterity, skills) of participants. It was also emphasised that involving participants in co-creation should be done in an inclusive manner. The primary emphasis in capability-building, however, remains on learning and knowledge-sharing. Further research into the topic should be formulated more inclusively.

7.2. Relevance for practice

Applicable to other transition issues vs Biodiversity specific. Several identified themes are not necessarily unique to behaviour change related to willingness to act for biodiversity. They are also applicable to engaging residents in other major transition issues that require transformative change, such as the energy and climate transitions.

However, the research design did yield five biodiversity-specific topics: “Nature Consciousness” and “Care for Nature” for enhancing capability, and “Ecosystem Services,” “Empathy with Nature,” and “Social Values of Green” for strengthening motivation. Additionally, a practice specific to motivation was identified: “Trigger Reflection on Different Ideals of Nature” (see Table 4).

COM-B determinant	Broader applicable themes	Biodiversity specific themes
Capability	C-T1 Knowledge acquisition (through citizen science)	C-T2 Nature conscious
	C-T4 Diversity (in capabilities)	C-T3 Care for nature
	C-P1 Collective learning (about biodiversity)	
	C-P2 Sharing/ communicating knowledge	
	C-P3 Mode of communication	
Motivation	M-T1 Positive urgency	M-T2 Eco-system services
	M-P1 Communicate with visuals and stories	M-T3 Empathy with nature
	M-P2 Trigger curiosity and playfulness	M-T4 Social values of green
	M-P4 Connect with values and needs of residents	M-P3 Trigger reflection on different ideals of nature
	M-P5 Provide feedback on impact of interventions	
Opportunity	O-T1 Economic aspects	
	O-T2 Social cohesion (in the neighbourhood)	
	O-T3 Rol of the municipality	
	O-T4 Synergy	
	O-P1 Aligning different interests	
	O-P2 Connect networks and initiatives	
	O-P3 Multifunctional use in public space	
	O-P4 Regenerative approach	

Table 4. Overview of topics and practices that are more broadly applicable versus those that are biodiversity specific (by J. Spoelman, 2024).

Participatory Design Research Meets Behavioural Change Research. This study integrates and focused specifically on identifying tools for an Urban Living Lab project. Our analysis shows how the COM-B model can aid in designing more targeted interventions for co-creation in ULL settings. However, focusing solely on one component of the COM-B model does not always lead to behavioural change in practice. For example, simply providing information on a municipal website (C) is often insufficient; this approach only benefits those who are already motivated (M) and capable of creating their own opportunities, such as by applying for a grant from the municipality (O).

Finally, the limitations of this research need to be clarified.

- Specifically relevant to participatory design research within the Urban Living Lab (ULL) setting.
- Outcomes gathered within a Dutch context; for example, engagement with residents has been a long-established practice in the Netherlands, and participation is now incorporated into the Environmental Planning Act.
- Practices and topics: the distinction between practices and topics is not always clearly defined. A topic can often also be translated into a practice.

By identifying the specific needs of a target group or neighbourhood, interventions can be more strategically and substantively tailored using the COM-B framework. The formulated topics and practices provide additional guidance for the development of effective interventions. The below test case illustrates how a practice can be applied during the research process.

Test Case: Oud-Mathenesse

To assess the applicability of our findings, one of the practices was translated into the context of the WAB Urban Living Lab (ULL1) in Oud-Mathenesse.

The motivation-enhancing practice, M-P3 “Trigger Reflection on Different Ideals of Nature,” was implemented during the first workshop of the project in Oud-Mathenesse on 22 and 24 October, 2024.

During the workshop, participants were invited to share a cherished childhood memory of nature and were subsequently asked to create a collage representing their ideal vision of nature (Figure 4 and 5). Extensive reflection on these memories and perceptions of nature took place during and after the activity. The childhood memory exercise facilitated rich and meaningful conversations, where participants, many of whom were previously unacquainted, shared recollections of the places where they grew up. This was further explored during a communal meal, fostering deeper discussions.

Participants indicated that memories which had not surfaced in their daily lives were revived. This led to profound and insightful contributions for the collage depicting their ideal vision of nature. Through these two exercises, participants were able to transcend the challenges of the present moment and engage in profound discussions about nature and biodiversity.

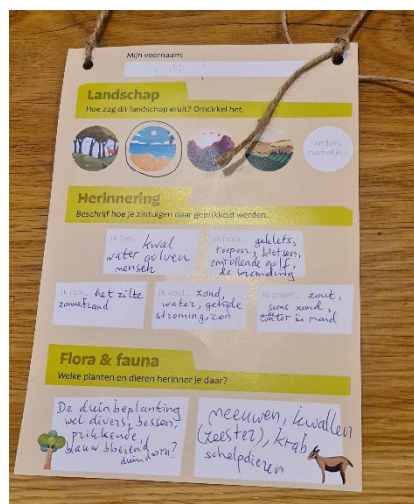


Figure 5. Memory of nature card (Photograph by C. Duijsens, 2024).



Figure 6. Making a collage of one's ideal vision of nature (Photograph by C. Duijsens, 2024).

This case shows how differences in perceptions of nature can be significantly influenced by factors such as age, cultural background, and the place where an individual grew up. Memories from childhood can profoundly impact our functioning later in life.

8. Conclusion and recommendations

This study has demonstrated the value of applying the COM-B model in participatory design research. The model could be nuanced by primary determinants into topics and practices that can be implemented in practice. The majority of these are broadly applicable and can assist in shaping interventions, also for other transition contexts. Four topics and one practice are specifically aimed at engaging residents in enhancing biodiversity.

The research adds value to existing studies, which are predominantly written from the perspective of governmental roles. The findings of this study emerged from the experiences of practitioners who indicated

how to activate residents and what residents need. Our results provides tools focused on involving residents in participatory design research to enhance biodiversity at the neighbourhood level. These tools are intended not only for municipalities but also for other stakeholders involved in participation projects.

The formulated topics and practices will be further tested in practice during Urban Living Lab workshops, organized in four iterative rounds from October 2024 to December 2025 in more urban districts . In these workshops, residents will collaborate with partners, including the different municipalities, to increase biodiversity at neighbourhood level. Ultimately, the findings will contribute to the development of a scalable model for neighbourhood-focused action to enhance biodiversity. The findings will also contribute to theory development by making the COM-B model applicable to required transitions regarding biodiversity loss in cities.

Recommendations for future research:

- Inventory the extent to which the found topics and practices (table 2) are reflected in municipal biodiversity policies.
- Investigate how the topics and practices can be linked to intervention functions as described by Michie et al. (2011) and connected to successful existing interventions.
- Pay attention to inclusiveness (people with mental or physical disabilities).
- Explore further how modes of collaboration and communication relate to the COM-B model.

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9. Appendix

Table 5. Topics and practices about increasing capability illustrated by quotes from respondents (by J. Spoelman, 2024).

Capability			
Topic	Description	Quote(s)	Rx
C-T1 Knowledge acquisition (through citizen science)	Biodiversity is an abstract concept for many individuals, and knowledge about biodiversity and ecosystems is complex. It concerns systems in which various elements interact and influence one another. Respondents indicate that this knowledge is often lacking among many residents. Additionally, maintaining greenery within a community requires knowledge (and perseverance). Citizen science offers a means for residents to actively acquire knowledge on biodiversity and the impact of specific actions over time through measurement and monitoring.	1 "There's very little knowledge about nature and plants, and about what is or isn't possible. Let alone what is or isn't allowed. So, knowledge is really important."	R4
		2 "And then there are also people who may be true experts, for example, in a specific group of birds. But that doesn't necessarily mean they have a full understanding of the broader concept of biodiversity, or how a bird relates to that."	R5
		3 "So, you can actually consider what you could try to investigate. What would a green element, that's more or less the same, do in an urban environment? What kind of services does it provide—such as cooling or supporting biodiversity, those kinds of things. Of course, there are always physical differences, like different soil types where such a forest is located. Or whether it's more on the outskirts of a city, in a green park, or even on a parking lot, and so on."	R14
		4 "...that is citizen science from the perspective of wanting to increase the number of data observations. But you also have citizen science aimed at contributing to engagement and awareness around a topic, like, for example, the air quality lab around Tata Steel. By actively getting involved themselves, people became much more aware of the issue. I think it would be wonderful if something like that could also be meaningful for biodiversity. If you encourage people, for instance, to map urban nature—because, as the saying goes, you can't care for what you don't know."	R5
C-T2 Nature awareness	It is noted that people are often no longer fully aware of the natural environment around them; they do not truly see it. While common species may be visible and perhaps even recognizable, there are numerous other organisms of which we are largely unaware. These organisms, however, are crucial to us—we are part of their ecosystem and even dependent on them. Respondents indicate that this awareness is often lacking.	1 "If I hear a woodpecker a kilometre and a half away, I think, "Ah, a Great Spotted Woodpecker." That's something you can pick out from all the other sounds. It gives you an awareness of nature and a connection to it, and that's something we need to teach people. Because what is it, really? What are you seeing? What are you hearing? There's a whole story behind it that makes you feel like a part of nature. And it also gives you a sense of responsibility—that, the city is also for these creatures. And they are so fortunate. Literally. Because if the weather is bad, they can just fly somewhere else, where the sun is shining."	R12
C-T3 Care for nature	In addition to knowledge of nature and biodiversity, it is equally important to understand how to care for the natural environment. This requires not only knowing what actions can be taken but also understanding how to effectively carry	1 "It is very easy to create a green design, and the implementation is relatively straightforward. Designing is also quite simple; however, ensuring that the greenery is maintained over time is considerably more complex."	R11

	them out. Such efforts require specific skills. By actively engaging with and maintaining nature, individuals become more familiar with it and are likely to develop a greater sense of care and responsibility toward it.		
C-T4 Diversity (in capabilities)	Respondents describe a significant disparity in capability, both among individuals and across different neighbourhoods. While some individuals navigate funding opportunities with ease, others struggle to do so. Similarly, gaining knowledge and skills requires access to experts or a digital platform where such information is available. Respondents emphasise the importance of experiencing success occasionally, as this fosters a sense of competence and accomplishment. Therefore, it can be beneficial to keep projects manageable in scope and grounded in local settings.	1 "Some people know how to navigate the council exceptionally well, while others do not at all. Each neighbourhood is also quite different. For instance, if we had conducted this project in neighbourhood X instead of neighbourhood Y, there would likely have been a waiting list for that community garden. It can be quite challenging to explain that I have to attend meetings there to encourage people to get involved in the garden, especially when I had to lobby internally for that budget myself."	R5
Practice	Description	Quote(s)	Rx
C-P1 Collective learning (about biodiversity)	Residents possess substantial experience and knowledge about their neighbourhood. They understand local dynamics, what is effective, and what is not. Often, there is also a rich diversity of knowledge present; for instance, one resident may have extensive understanding of biodiversity and plants, while another may be experienced in securing grants. By sharing knowledge and experiences, community members can support one another. Such exchanges and collaborative learning can also reveal gaps in knowledge and identify ways to collectively address them. A greening initiative or a citizen science project focused on biodiversity monitoring can further enhance this shared learning process.	1 "For example, I adopted a few tree pits with my fellow residents. And, in conversations with the neighbours, you notice things like, "No, you shouldn't prune the ivy just yet, because it's blooming now, and in early spring or late winter, it produces berries, which are good for this and that." You can see that, even on that level, it's already making a difference."	R12
C-P2 Sharing/communicating knowledge	Knowledge is not always easily accessible, and determining which sources are reliable can be challenging. Clear sharing and communication of information are therefore essential. Consolidating and presenting various types of knowledge on a (digital) platform—through stories, practical examples of plants, or useful tips and tricks—can help individuals more readily locate the information they need.	1 "How can you best reach people...? Well, I think ultimately by simply involving them. That's what they do at 'Duurzaam Den Haag' by just telling the story: why is it important? 2 "You can explain that every bit of nature supports every other bit of nature. And by doing so, you maintain that larger complex of what nature is—which you can call an ecosystem, or whatever—keeping it intact. This ensures that ecosystems remain healthy and continue to provide the services you need to survive, both now and in the future."	R1 R12

	Additionally, a “green coach” within the community or distributing maintenance tips via flyers are highlighted as effective methods to facilitate learning about green spaces and biodiversity.	
C-P3 Mode of communication	Biodiversity is a complex concept, yet it is important to clearly explain why it matters. The same applies to ecosystems. Simplifying explanations and making these concepts visible can help engage people more effectively. Additionally, introducing the concept gradually can be beneficial: starting with “green” initiatives, then moving on to biodiversity. For example, beginning with a community greening project in the neighbourhood can provide a foundation upon which the importance of biodiversity can later be introduced and explained.	1 “by giving examples. That could be something digital, like a website where you see a sort of virtual garden and how it works. But it can also be done, for instance, by simply showing people—like when I was on that rooftop in Rotterdam, where they showed those small plots and explained which plants were grouped together and how that works. Just giving a real-life example of how it looks and functions. And what is native and what isn’t? I think that’s a good way to convey the message.” 2 “And I think it’s much better to actually approach it through green spaces. Then, gradually, through the activities you do together, you arrive at questions like, “What do we do with the soil? How do we manage the water? Which plants go well together? Which plants support each other?”

Table 6. Topics and practices about increasing motivation illustrated by quotes from respondents (by J. Spoelman, 2024).

Motivation			
Topic	Description	Quote(s)	Rx
T1 Positive urgency	Respondents emphasise the importance of framing the issue of greening and enhancing biodiversity as urgent, given that residents often prioritise other concerns. It is essential to create a sense of urgency, but in a positive and constructive manner.	1 "...people here are focused on survival. Or... or they only see green spaces as, well, just somewhere to walk the dog, so to speak, or it has to be functional, or it just needs to look neat." 2 "...you do come across people who are constantly telling everyone that you must consider every single species. Well, that's not going to work. It doesn't resonate with anyone."	R1 R9
T2 Eco-system services	A greener environment provides several ecosystem services, such as food production, water retention, cooling, and air purification. Explicitly highlighting and emphasising these services can help residents recognise the broader benefits of greening initiatives.	1 ...But that you want an environment where you can also see a tree and have the sense that there is fresh air. 2 There are people who think, "Yes, the hedgehog is nice and all, but my health is what matters to me." For that reason, they are motivated to support the preservation of certain ecosystems.	R2 R13
T3 Empathy with nature	People do not always feel connected to nature. Out of sight, out of mind. By making nature once again tangible and visible, we can cultivate empathy for the natural world. A positive relationship with nature also contributes to an improved sense of well-being.	1 " ...a filmmaker has created some truly fantastic documentaries. He approaches the subject very locally and even watches a roof across the street with someone at home, observing oystercatchers. That can really resonate with a person, can't it? I find it very appealing that he seeks to make it very close and personal."	R12

T4 Social values of green	A green environment can encourage social gatherings, recreation in public spaces like sports, walking, or simply sitting. Moreover, greening initiatives can help foster community engagement by bringing residents together through collective action within the neighbourhood. This can serve as a motivation for residents to participate in greening initiatives.	1 "Social factors can also serve as motivation. For instance, engaging in biodiversity initiatives, such as collaboratively creating a facade garden with the appropriate plants, can be beneficial. This could involve working together to establish a garden or maintaining a specific garden in the neighbourhood." 2 "Whether you are practically or theoretically educated, or wherever you come from and whatever your background may be, nature holds a certain importance across all cultures, and that is something that connects us all, so to speak. Yes, engaging with the environment. Literally."	R6 R5
Practice	Description	Quote(s)	Rx
P1 Communicate with visuals and stories	Utilising visualisation techniques can make it easier to inform and engage residents. Spatially representing data can, for instance, provide insights into the current situation or demonstrate the impact of activities they have been involved in. Visualisation can also help to sharpen the focus of discussions during co-creation processes. Storytelling enhances engagement by making it easier for people to empathise with others—whether human or animal. Additionally, it aids in perceiving the broader system and the interconnections within it, rather than focusing solely on individual elements.	1 We had a table with a map of the neighbourhood, and we highlighted opportunity areas by enlarging them and marking them with a pin connected by a string. The residents could then look at these opportunity areas. "Why is this an opportunity spot?" On the back of the photo of each opportunity area, they could read the reasons why it was considered one. 2 You may enjoy watching that little bird, but you forget that there's an entire system behind it. However, when you share the story behind the bird, that's when it becomes clear.	R2 R4
P2 Trigger curiosity and playfulness	You can enhance people's engagement by stimulating their curiosity. Additionally, incorporating elements of play can be effective in involving individuals with a topic in a more light-hearted manner.	1 "I believe it should always be enjoyable, in the sense that it should spark their curiosity. For example, with (that research project in which we used) that pop-up tea stall. That was really successful because we were able to engage with a wide variety of residents." 2 "Go and see what you can discover in the summer with a magnifying glass or something like that. It's about introducing knowledge in a more playful way, rather than discussing it in abstract terms... because that makes it too difficult to grasp. Yes, too complex concepts."	R2 R3
P3 Trigger reflection on different ideals of nature	We are not always aware that we do not all share the same perception or ideal image of nature. Differences in this perception can be influenced by factors such as age, culture, or the place where one was raised. By reflecting on each individual's view of nature, these potential differences can be made explicit, while also creating opportunities for open discussion.	1 "Rewilding is such a beautiful concept—it's about letting nature take its course, like in Chernobyl, which has beautifully regained balance. That's one vision. But you can also take a more active role, ensuring people find it enjoyable, and not just leaving everything to nature's power, which indeed often starts with pioneer species. So, these are different perspectives." 2 "Someone else's idea of nature might be that cow in the meadow. And that's not necessarily wrong, but it is different. So if your image of nature is a manicured lawn with neatly raked parks, you'll never see the value of the jungle on Earth, because that's frightening, dangerous, and somewhere you shouldn't go."	R4 R1
P4 Connect with values and	When working with residents to green their environment and enhance biodiversity, it is essential to listen to their concerns and	1 "I will listen to their needs or the issues in the neighbourhood, and then explore how nature and biodiversity can be part of the solution."	R10

needs of residents	align projects with these local issues. Seek solutions that both address their needs and values, while also contributing to the greening of the area and the promotion of biodiversity.	2 "... connecting with people's experiences, focusing on what they find interesting and important, and in that way also teaching them about biodiversity."	R5
P5 Provide feedback on impact of interventions	Biodiversity, like climate change, is a crisis that can seem abstract to individuals; they may question the value of their contribution. By providing feedback on the impact of actions they have participated in, their personal contribution to the desired change is made more tangible.	1 I think it really comes down to the idea of, "OK, if I do something now, does it actually make a difference?" That's very important if you want to encourage people to take action. So, you need some kind of feedback or examples of others taking action. That really plays a significant role.	R6

Table 7. Topics and practices about increasing opportunity illustrated by quotes from respondents (by J. Spoelman, 2024).

Opportunity			
Topic	Description	Quote(s)	Rx
O-T1 Economic aspects	Financial aspects have a significant impact on the extent to which residents can take action to enhance biodiversity at the neighbourhood level. Budgets from local councils for increasing biodiversity are often tight, requiring creative solutions to source funds, such as those allocated for climate adaptation. However, residents need to be able to locate these funding sources, which not everyone manages to do. When they do succeed, residents may find the financial administration of greening initiatives a heavy responsibility to bear. Many people are already busy with work and making ends meet, so increasing biodiversity may not be their top priority. Financial incentives for biodiversity-enhancing activities could provide additional motivation for residents to contribute.	1 "How can we, linked to their regular tasks, embed this theme there? What about the sewage system? Are renovation works going to take place, or will the street need to be opened up? Seize that opportunity. And then it turns out that, without specifically allocating a budget for biodiversity, if someone were to simply create an overview of everything that's going to happen in that neighbourhood over the next two or three years... Well, I think you'd end up with a really great layering of activities."	R10
		2 "You can also pay people if they contribute to biodiversity, water management, education, and so on."	R11
		3 "It's also difficult, of course, even for us, to apply for projects or get subsidies or funding. Yes, because you can't precisely say what the impact will be."	R14
		4 "Because a lot of people who live in those concrete urban neighbourhoods don't want the responsibility of spending, say, €1,000, or even €20,000 for bulbs. They simply don't want that responsibility."	R14
		5 "But subsidies aren't really that accessible to everyone. They often require you, firstly, to be able to find the subsidy. Secondly, to understand the rules of the subsidy. And thirdly, to be able to fill out the form properly. Those are quite specific skills that not every resident in Rotterdam has."	R6
O-T2 Social cohesion (in the neighbourhood)	Working to increase biodiversity can help strengthen social cohesion within a neighbourhood. Green spaces are generally viewed positively by many, making it a unifying topic. Working together in the local area can help bring people into contact who might not	1 "At the same time, there are plenty of people who, for example, go green simply because they see it as a social thing. If you can then say, for instance, well, there's a community initiative and we provide the plants, it doesn't really matter that they don't know the plants are organic and good for butterflies and bees, as long as you tap into that effectively. You see, you may not really raise their awareness, but you do get them to take action."	R5

	otherwise meet or engage in conversation with one another.	2 "Everyone is welcome, and maintaining contact with one another is, of course, highly useful for connecting with like-minded individuals."	R11
O-T3 Role of the municipality	The local council plays an essential role in increasing biodiversity at the neighbourhood level. It sets policies, provides grants, and carries out (green) maintenance in public spaces. Additionally, the council is key in sharing knowledge and facilitating resident-led initiatives. A collaborative, supportive council is seen as crucial in working effectively with residents. At the same time, "the council" is not a single entity. Within the council, there are various departments, roles, areas of expertise, and people, who may not always speak the same language. For residents, it's not always clear how decisions are made or who has the mandate to make decisions on matters such as carrying out a greening initiative or adjusting mowing policies.	1 "And we approach this in a much more facilitative way. So, we have various subsidies, "Opzoomer mee" budgets, community initiatives. And since this year, people can receive a contribution for greening their private spaces."	R5
		2 "That leads to a lot of good cross-pollination, and that's how we learn to speak each other's language. Sometimes you do have to take a step back, and then I see, for example, that an ecologist looks at trees in a functional way, thinking about which insects will be attracted to them. A landscape architect, on the other hand, looks at a tree and wonders if it fits the aesthetic and if it's functional in the sense that people can relax under it. Then a maintenance manager thinks, "Is it functional? How often will I need to prune it?" So, we're all talking about the function of that tree, but we're talking about completely different things. And the urban planner is thinking, "There's going to be a building development here, and I need a sightline," so to them, the tree isn't functional. All about the same tree!"	R4
		3 "You can also start from the idea of temporariness, recognising that you're actually a guest in a context where people have been around much longer than you. And how do you then behave as a good guest? Often, we as the council take on more of a host role, even though we're only temporarily active in a neighbourhood."	R13
O-T4 Synergy	At the neighbourhood level, many individuals and organisations are active. This may involve greening efforts but also, for example, work in the fields of well-being and care. By linking the activities and interests of different parties, greater effectiveness can be achieved, and knowledge-sharing is encouraged. In this way, the combined impact can be greater than the sum of each part individually.	1 "Usually, there's already some kind of action group or something like that within the neighbourhood—people who feel something needs to be done or who are already working on greening a school playground or something similar. You try to build on and strengthen that. Because we, as an external organisation, especially X with its international reputation, can seem a bit like an outsider at the local level. So, you want to activate and support such local groups. And that works best because they have a strong connection with the residents." 2 "That really is a responsibility of the government—working with green initiatives in neighbourhoods because that's where the actual work is being done. And, of course, the policy is made at the council level. So, if you can build that fruitful bridge, I'd say, both parties can really benefit from it. ... On the one hand, you're taking action, but at the same time, the question is: what do you need from the officials or those involved? And what can you do? Could we, for instance, speak at a council meeting? Would that create momentum? So, how can we complement each other in a way that works for both sides, so to speak."	R14 R3

Practice	Description	Quote(s)	Rx
O-P1 Aligning different interests	Parties involved in co-creation processes often have different interests. For an initiative to succeed, it is essential to continually seek the common interest. This can be between the council and residents, but also among various resident initiatives or between residents themselves. It can be helpful to articulate these differing interests, making them open for discussion.	1 "When I listen to their needs or the problems in the neighbourhood, I then look at how nature and biodiversity can be part of the solution. So, you're not saying, "I want to sell this," but rather, "I'll listen to their issues and see how what I'm offering can be part of the solution."	R10
O-P2 Connect diverse networks and initiatives with one another	By connecting active parties, networks, and existing initiatives, benefits can be generated for all involved. Linking different interests and initiatives creates greater support and effectiveness, and can sometimes attract additional external opportunities, such as funding.	1 "Additionally, it's important to involve as many people and organisations in the neighbourhood as possible, especially those who will still be there after the project ends. That's why we're working with the two foundations that are based in the neighbourhood and will remain there." 2 "I would really look at what is already there and tap into that. Yes, I think that's quite important. And the initiatives that exist—some are very open to getting involved, while others feel like they're already so busy. So, don't be put off by that."	R2 R11
O-P3 Strive for multiple functional uses in spatial initiatives	By designing spatial projects for multiple functions, they can serve various interests and target groups. In this way, an initiative becomes appealing to multiple parties, as it addresses several goals simultaneously.	1 "With the garden, what else can you do? I think it's important that we focus more on its functional use and improve that. Perhaps we could also link it to food?" 2 "I've noticed that they are more easily motivated when we link biodiversity to various functions, such as recreation and relaxation. So, it's important to connect functions to greenery—such as spaces for staying, recreational areas, and places for sports."	R10 R5
O-P4 Regenerative approach	Ensure that a co-creation initiative genuinely originates from the neighbourhood. Only when residents feel truly involved in the project and endorse its importance will it yield sustainable results. Therefore, focus on the ambitions of residents rather than what must be done in co-creation projects. As an organisation supporting the co-creation process, come in as a guest. Adopt that mindset. You are only there for a short time. Instead of telling residents what to do, inspire them and encourage them to come up with their own ideas.	1 "And that does mean you have to be willing to relinquish some control. For a council, this is particularly challenging because they are used to having total control over their projects. However, we're seeing in our projects that when you let go, something beautiful can happen. You also can't control participation; I can't just tell someone, "Now you have to participate." I need to persuade them to take part." 2 "Additionally, it's important to involve as many people and organisations in the neighbourhood as possible, especially those who will still be there after the project ends."	R14 R2