

RESEARCH ARTICLE

The Carbon Commons: Carbon sequestration for a post-growth society

Riel Bessai ^{a,*}, Roy Bendor ^a, Ruud Balkenende ^a

^a Delft University of Technology, Delft, Netherlands

* Corresponding author. Email address: r.bessai@tudelft.nl

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Abstract

This article introduces the *Carbon Commons* as a theoretical and practical framework for reimagining carbon sequestration within a post-growth context. Although carbon sequestration is central to most climate mitigation pathways, it has received little attention in post-growth discourse, where it is often overshadowed by critiques of green-growth strategies and their limited capacity to challenge the social and economic forms driving emissions. Instead, we argue that organising sequestration as a commons can address these limitations by rooting climate mitigation in community-defined values, needs, and aspirations rather than the profit-oriented logics of the market. We then present findings from a living lab in Amsterdam—an experimental carbon-sequestering public garden co-created with a community centre—which demonstrates how sequestration can become meaningful when woven into everyday practices that meet immediate social needs. Across provisioning, social life, and governance, sequestered carbon operated as a shared material, a social mediator, and a political catalyst. While modest in scale, the living lab revealed how community-embedded sequestration can cultivate belonging, agency, and stewardship. We conclude that carbon commoning offers a post-growth pathway in which ecological benefits emerge through the collective shaping of place and the strengthening of communal life.

1. Introduction

Carbon sequestration, also referred to as carbon dioxide (CO₂) removal or negative emissions, is a climate mitigation strategy that aims to remove CO₂ from the atmosphere and store it in long-term sinks (IPCC, 2023; Minx et al., 2018). Approaches to carbon sequestration include industrial technologies that capture and inject carbon underground (Fuss et al., 2018), nature-based solutions that enhance storage in soils, forests, and oceans (IPCC, 2023; Kabisch et al., 2017), and construction practices that embed carbon in biobased materials (Arehart et al.,

2021; Churkina et al., 2020; Kinnunen et al., 2022). In theory, the logic is appealing: if CO₂ emissions drive global warming, removing CO₂ should help reverse it. Yet scholars have pointed out that these techniques differ widely in capacity, environmental impacts, and social implications, raising doubts about their viability as a central pillar of climate policy (Carton et al., 2021; Gunderson et al., 2020; Malm & Carton, 2024; Palazzo Corner et al., 2023).

Despite repeated warnings from the Intergovernmental Panel on Climate Change that achieving the Paris Agreement goals requires a rapid phase-out of fossil fuels (IPCC, 2023), global emissions continue to rise (IEA, 2025). In this context, carbon removal has become an increasingly attractive policy tool, promising to reconcile continued economic growth with climate stabilisation (Malm & Carton, 2021). This paper critically questions that promise and asks: how might carbon sequestration be organised beyond market logics and techno-optimism to align with ecological integrity, social justice, and democratic governance?

The growing reliance on carbon removal reflects what Malm and Carton (2024) term "Overshoot Ideology," the belief that societies can exceed safe emission limits now and depend on future technologies to clean up later. This ideology allows policymakers and industries to defer systemic change while sustaining the illusion of progress. In practice, carbon sequestration often serves as a form of status quo maintenance (Gunderson et al., 2020), reconciling fossil-fuel expansion with the rhetoric of sustainability. Under the banner of 'net zero,' governments and corporations pledge future removals to offset present emissions, postponing decarbonisation.

To move beyond these contradictions, post-growth scholarship offers a significantly different starting point. Post-growth thinkers argue that perpetual economic expansion is fundamentally incompatible with planetary boundaries, and that climate stabilisation depends on reducing energy and material throughput rather than relying on speculative green-growth techno-fixes (Hickel, 2021; Jackson, 2011; Parrique, 2019). From this perspective, large-scale carbon removal appears less as a solution than as a continuation of the growth logic that underpins the climate crisis.

Yet even within post-growth frameworks, societies must still address historical and residual emissions. Recent modelling shows that some level of sequestration will remain necessary to avoid dangerous warming scenarios (Hickel et al., 2021; Kikstra et al., 2024; Moyer, 2023; Slameršak et al., 2024). The challenge, then, is not whether to pursue sequestration, but how to organise and design it in ways that reflect post-growth values—emphasising ecological integrity, democratic participation in the economy, just distribution of resources, and social wellbeing over accumulation and profit (Jackson, 2011; Pouw, 2020; Raworth, 2017). Addressing this challenge is this paper's overarching aim.

To explore how we might organise carbon sequestration for a post-growth society, we turn to the commons as a potential socio-economic model. The commons refer to collectively managed resources and the social commoning practices through which communities govern and share them in accordance with collectively defined needs and values (Euler, 2019; Jakob & Edenhofer, 2014; Perkins, 2019; Schmelzer et al., 2022; Singh, 2019; Wittel & Korczynski, 2023). Rather than relying on markets or centralised control, commons-based systems emphasise reciprocity, cooperation, and care. From community-managed forests to open-source knowledge platforms, such arrangements demonstrate that resources can be governed effectively outside profit-driven frameworks (Bollier, 2014; Le Crosnier, 2012; Ostrom, 1990). Commoning also embodies a relational ethos that contrasts with the competitive individualism of capitalist markets, emphasising interdependence and abundant access to resources rather than artificial scarcity and exchange (Euler, 2019; Stavrides, 2016). As Bollier (2024, p. 293) notes, commoning marks a shift "from a world defined by individualism, calculative rationality, and material self-interest in markets, to one that is richly relational in all directions." These principles suggest a powerful lens for reimagining carbon sequestration not as a tradable asset, but as a shared ecological responsibility embedded in collective life.

Building on this perspective, we propose the Carbon Commons as both a theoretical and practical framework for reimagining carbon sequestration within a post-growth context. The Carbon Commons envisions sequestration as a communal, participatory practice through which carbon is treated as a shared resource rather than a commodity. Technical design strategies—such as restoring ecosystems to enhance carbon sequestration or constructing

shared infrastructure from carbon-storing materials—can be organised and maintained collectively to meet local needs and aspirations. Beyond carbon as a shared resource, carbon commoning can cultivate what Bollier (2024) calls an "onto-shift," changing how we perceive reality and relationships in favour of a worldview grounded in reciprocity, collective responsibility, and care. The Carbon Commons, therefore, invites a shift from technocratic, efficiency-driven models of carbon management to ones that recognise sequestration as a social and cultural process, designed and embedded in place. Through this reframing, sequestration becomes not a distant technological fix but a lived practice of ecological and social stewardship.

To enact and study these ideas in context, we established a living lab in collaboration with a community centre in Amsterdam (see more in Section 4). The living lab served as a participatory environment for experimenting with the Carbon Commons concept through the co-production of a public garden that functioned as a shared carbon sink. Within this setting, community members collectively designed, fabricated, and maintained carbon-sequestering elements in materials, soils, and plants, transforming the technical process of sequestration into a social practice. The living lab thus operated as the methodological site through which we explored how carbon sequestration might be designed and organised in line with post-growth and commons-based principles. Given that the research was conducted by an external team of design experts, we pay particular attention throughout to the role of designers as situated actors, examining how specialist knowledge and positional privilege shape the commoning process, and what this implies for design practice in post-growth climate futures.

The paper proceeds as follows. Section 2 examines the political economy of carbon sequestration, critically analysing dominant industrial approaches and identifying nature-based alternatives more aligned with post-growth values. Section 3 develops the theoretical framework of the Carbon Commons, drawing on commons scholarship to propose commoning as an organising principle for sequestration while acknowledging the challenges and contradictions of commons-based governance in practice. Section 4 introduces the living lab methodology and the Amsterdam community centre context in which the Carbon Commons was enacted and studied. Section 5 presents and analyses the findings through Bollier and Helfrich's Triad of Commoning—provisioning, social life, and governance—and

reflects on the role of designers across each dimension. Section 6 concludes by drawing out the theoretical contributions of the Carbon Commons framework and the practical lessons it offers for designers, community practitioners, and policymakers working toward post-growth climate futures.

2. The political economy of carbon sequestration

The dominant "green growth" strategy for addressing climate change assumes that technological innovation can decouple economic expansion from carbon emissions, allowing societies to grow while reducing environmental impact (OECD, 2011; Shieh et al., 2025). Yet, there is little empirical evidence for such absolute decoupling at the global scale (Parrique, 2019). While efficiency improvements can lower the carbon intensity of production in specific sectors, they rarely reduce overall emissions, an effect known as the Jevons' Paradox. More broadly, rather than reducing environmental pressures, efficiency often accelerates economic growth and, consequently, total emissions (Hickel & Kallis, 2020). The limits of technological solutionism point to a deeper issue: the structural features of capitalism that make continuous economic expansion appear both necessary and desirable. The problem, in other words, is not merely a technical one but a social and systemic one.

Within a political economy of green growth, carbon becomes deeply commodified. Private actors invest in carbon-offset schemes and speculative credit markets, while corporate net-zero pledges promise climate responsibility without requiring fundamental economic transformation. As Palm (2024, p. 1) observes, this framing reduces the climate crisis to a problem of carbon management rather than one of political-economic choices and ecological limits. The result is a depoliticised vision of climate action that privileges measurement, accounting, and techno-solutions over systemic change. In this way, carbon removal becomes a tool for business-as-usual, legitimising continued fossil-fuel dependency under the guise of innovation and corporate sustainability.

These contradictions become especially clear when we examine the technologies underpinning the "circular carbon economy" (Palm, 2024, p. 1). Within the dominant climate policy frameworks, including the majority of IPCC's 1.5°C or 2°C emission pathway scenarios,

two large-scale carbon removal methods are most prominent: bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC) (Fuss et al., 2018; IPCC, 2018, 2022; Minx et al., 2018). Both rely on industrial processes to capture CO₂ and store it underground—the former by burning biomass for energy and capturing the emissions, the latter by filtering air for chemical capture. While these technologies are often presented as neutral tools for climate mitigation, a closer look reveals that they reinforce the very political-economic structures driving the crisis. First, they enable the privatisation of public investment in climate action. Oil and gas companies have positioned themselves as essential partners in developing these technologies, lobbying for carbon tax revenues and for public funds to be directed toward capture and storage infrastructure that they alone can build (Occidental Petroleum, 2024). Despite decades of research and billions of dollars in investment, carbon capture and storage delivers negligible net atmospheric removal, accounting for less than 0.1% of annual CO₂ emissions (Rasool & Moiz Hashmi, 2025; Wang et al., 2021). Second, these technologies serve to prolong the fossil fuel economy. Occidental Petroleum, a major oil and gas producer, exemplifies this trend. In 2023, Occidental announced it would acquire Carbon Engineering, a leading DAC firm, with plans to use captured CO₂ for enhanced oil recovery. This process injects captured CO₂ into depleted wells to increase crude oil recovery. The company's stated aim is to produce "net-zero oil" and thereby secure a long-term role for fossil fuels in the global energy mix, explicitly in service of shareholder value (Occidental Petroleum, 2023). Finally, large-scale deployment of BECCS or DAC would entail severe social and ecological trade-offs. Modelling suggests that achieving the necessary sequestration volumes through BECCS could require converting an area comparable to 6–45% of global cropland into bioenergy plantations (Braun et al., 2025). This would intensify pressures on food systems, biodiversity, and land rights, particularly in the Global South. In effect, both BECCS and DAC displace the burdens of decarbonisation onto ecosystems and communities while preserving existing power structures. In this light, capitalist forms of carbon sequestration demonstrate a new variation of the Jevons' Paradox: technologies intended to mitigate emissions become instruments for reproducing the growth imperative, deepening dependence on fossil fuels and extractive logics. The result is not a break from the fossil economy but its technocratic rebranding under the banner of sustainability.

If industrial carbon capture reproduces the very dynamics it claims to counter, an alternative approach must look different. Many nature-based strategies offer more promising directions for addressing both social and environmental needs. Regenerative agriculture, for instance, can increase soil and biomass carbon while improving biodiversity, food security, and farmer livelihoods (Niether et al., 2020). Similarly, adding biochar to soils enhances nutrient and water retention, improving plant growth (which sequesters additional carbon), while storing carbon in the soil for millennia (Wang et al., 2016). In urban contexts, green spaces like parks, community gardens, and green roofs can strengthen social ties, provide leisure and food, and improve local climate resilience while acting as carbon sinks (Kinnunen et al., 2022; Quaranta et al., 2021; Rogge & Theesfeld, 2018; Sharifi, 2021).

Construction-stored carbon seeks to transform the built environment from a carbon source to a carbon sink by using bio-based materials such as mass-timber, straw, or hempcrete, which capture carbon during plant growth and lock it into buildings for decades or centuries (Bjånesøy et al., 2023; Churkina et al., 2020; Pittau et al., 2019). The potential scale of urban carbon storage is significant, possibly exceeding that of forests per unit area (Talvitie et al., 2022). Importantly, such approaches can also deliver social co-benefits. For example, public housing projects designed and built with mass timber could provide affordable homes, embedding carbon in the urban fabric while simultaneously generating social solidarity (Bianchi & Costa, 2024; Hafner et al., 2020; Pittau et al., 2019).

These strategies share key features: they are nature-based, socially embedded, and multifunctional. They generate ecological and social value simultaneously rather than subordinating one to the other. As such, they suggest a fundamentally different orientation to carbon sequestration, grounded in collective benefit rather than accumulation and profit. Building on this, the next section explores the potential for carbon sequestration to be designed and organised as a commons.

3. Commoning carbon: reclaiming sequestration as a social-ecological practice

As the previous section showed, many nature-based carbon sequestration strategies hold the potential to deliver climate mitigation while generating significant social benefits. The question, then, is what prevents these strategies from being more widely implemented. When economic life is organised around profit, environmental stewardship is structurally cast as a cost. As the system stands, it is always less profitable to farm regeneratively, to preserve urban land for green space instead of commercial development, or to build with bio-based materials. A different approach to climate mitigation, therefore, requires a different economic logic—one capable of integrating unquantified social and ecological values into decisions about which kinds of carbon-related infrastructures to invest in, design, build, and sustain.

The commons provides such a framework by grounding the organisation of resources and infrastructure in shared needs and values rather than profitability (Bollier, 2014; Bollier & Helfrich, 2019; D'Alisa et al., 2015). In commons scholarship, the "commons" refers both to systems of shared resources and to the social practices—commoning—through which communities collectively govern, use, care for, and reproduce those resources (Bollier, 2014; Bollier & Helfrich, 2019; D'Alisa et al., 2015). Commons systems tend to prioritise need-satisfaction by enabling open participation in governance and collective decision-making about what gets produced and for whom (Moreira & Fuster Morell, 2020).

When applied to carbon sequestration, a commons approach could reorient efforts away from extractive optimisation (maximising biomass yield at the expense of communities or biodiversity, for instance) and toward what communities deem essential. The Carbon Commons thus extends Jakob and Edenhofer's (2014) argument for organising key social resources—public housing, parks, schools, water, and public transport—as commons capable of sustaining social welfare in an age of climate uncertainty. Importantly, commons governance is not limited to natural resources; it can also sustain complex socio-technical systems, as demonstrated by large-scale peer-produced knowledge infrastructures such as

Wikipedia, which show how collective stewardship can scale while remaining open, participatory, and non-commodified.

When framed through the commons, carbon becomes embedded in a wider constellation of values understood qualitatively and relationally rather than financially. Communities engaged in stewarding soils, forests, or materials for their carbon-cycling capacities can connect this work to broader concerns: healthy environments, shared spaces, opportunities for creativity and learning, and the ability to meet basic needs without relying on extractive market systems. Carbon sequestration thus becomes inseparable from the flourishing of the ecosystems and social relations that sustain it. This inevitably makes governance more complex and negotiated than a singular metric of cost per tonne of CO₂. Yet it is precisely this complexity that enables commons systems to account for the full spectrum of what is required for a good life.

A commons lens therefore reframes carbon sequestration from a costly, end-of-pipe climate solution into a shared resource and a collective project of ecological and social reproduction. Rather than concentrating responsibility in industrial actors, commoning invites communities to co-produce, steward, and democratically govern the flows of carbon that sustain life. This perspective aligns with post-growth insights that mitigating climate change requires transforming not only infrastructures but also the social relations and value systems that underpin them (Euler, 2019; Hickel, 2021). As Varvarousis and Kallis (2017, p. 128) argue, commons-based practices can prefigure economies built around "new forms of 'common-wealth' – wealth that no longer relies on more and more money." The Carbon Commons thus reimagines prosperity as the joint restoration of ecological integrity and social well-being, positioning carbon sequestration not as an economic burden but as a shared pathway toward a post-growth future.

Realising this vision, however, is far from straightforward. Scholarship on actually existing commons reveals persistent challenges around power dynamics, hybridity, and fragility. Commons governance frequently operates in entanglement with state regulation and institutional compromise rather than as a clean alternative: governmental actors participating in collaborative governance often revert to centralised, managerial logics that impede the

deliberative and consensus-oriented processes on which commoning depends (Meerkerk, 2024). Hybrid arrangements between commons and market or state institutions carry their own risks, and a politics of hybridity, while sometimes necessary, requires embedded transformative strategies that resist co-optation by more powerful actors (Schmid, 2021). Moreover, the autonomy that commons-based practices seek to cultivate is not an end-state but a condition requiring constant renewal; it emerges within existing socio-economic institutions while simultaneously depending on new ones to be sustained (Savini, 2022). Acknowledging these tensions is essential for a realistic account of the Carbon Commons, and it is precisely these dynamics that surface in our empirical findings in Section 5.

4. A carbon commons living lab

We now turn to what the carbon commons may look like in practice by reflecting on the results of a living lab established in collaboration with a community centre in Amsterdam. During the "Carbon Commons Living Lab," we tested how sequestration practices could be integrated into neighbourhood life while simultaneously contributing to shared social and ecological values. Rather than introducing a predefined technical intervention, we sought to design carbon sequestration within a process of commoning.

4.1. Living labs as methodological ground

We conducted our research in the context of a living lab, an experimental real-world environment that integrates research, innovation, and everyday life while engaging citizens as co-creators rather than research subjects (Evans & Karvonen, 2014; Rizzo et al., 2021). Central to our methodological grounding was the role of design—and, relatedly, of designers as situated actors. The research team consisted of design and engineering researchers based at a Dutch university, more highly educated than most participants in the community centre, and not from the Netherlands. As external experts, we brought disciplinary knowledge and institutional resources that community members did not have equal access to, an asymmetry that inevitably shaped the dynamics of co-creation and that we reflect on explicitly across Section 5.

Working through a research-through-design process (Stappers & Giaccardi, 2017), the living lab became not only a site for observing situated practices but a means of materially exploring alternative socio-technical arrangements. Prior scholarship has shown that design is fundamental to generating new imaginaries and configurations for sustainable socio-technical systems (Pineda et al., 2024). Within sustainability-oriented living labs, design has also been used to bridge technical and social innovation by experimenting with both how technologies are shaped and the social relations into which they are embedded, enabled, produced, and used (Belfield & Petrescu, 2024).

Building on this foundation, we reframed the living lab itself as a commoning process. Rather than positioning participants as users or stakeholders of a predefined intervention, we approached all those involved as commoners who collectively shaped both the material intervention and its modes of governance. This reframing allowed us to focus on carbon sequestration not merely as a technical challenge but as a shared social and ecological process, enacted and negotiated through collaborative design within the living lab.

4.2. Context and setup

The community centre that hosted the living lab is a lively social hub in a dense, multicultural neighbourhood characterised by residential tower blocks and limited green space. When we first arrived, the atmosphere was vibrant and chaotic: the sound of children's kickboxing lessons mingled with gentle chatter over tea, and the smell of lunch from the community kitchen lingered in the hall. Posters advertising concerts, workshops, and youth programmes covered the entrance walls. Our entry into the community centre was facilitated by an existing contact—a university acquaintance of the lead author—who works as a community programmer. This relationship provided an initial layer of trust and understanding, important for negotiating our presence as external design researchers.

We began by introducing the idea of carbon sequestration to the community programmers. The concept was initially unfamiliar, but it sparked curiosity once the abstract explanations of CO₂ shifted to a conversation about designing and building something useful and lasting for the community. To expand the community centre's presence and visibility within the wider neighbourhood, the programmers expressed a desire to create a garden and usable public

space on the sidewalk between the parking lot and the building (Figure 1–3). The co-production of this garden became the focal point of the living lab.

Through a series of preliminary meetings, we established a core team comprising the three community programmers and an external architect versed in participatory design, who was invited to join the project. Together, we decided to embed our project within an existing initiative called Technical Lab, a month-long programme offering technical education to local youth. This alignment was both strategic and symbiotic: it provided access to funding, offered a ready-made structure for workshops, and allowed us to link the (still) abstract concept of carbon sequestration to tangible, hands-on activities. During early meetings with the centre's Board, reactions varied: one advisor with a scientific background was particularly drawn to the environmental focus, while others connected more with the vision of a garden that would draw people in from the street and provide space for gatherings. This difference in resonance became a productive tension throughout the project, shaping how sequestration was translated into shared language and practice.

As we came to know the centre better, we realised that the commons already existed informally. Some people were employed by the centre; others volunteered in exchange for food, coffee, or access to space for their own activities. Children drifted in and out freely after school, and the building functioned as a safe social space that blurred the line between public and private. Our project, therefore, would not create a commons but amplify and materialise its existing practices through the lens of carbon sequestration.

4.3. Data collection and analysis

Over the design, construction, and a six-month period of community use, we observed the project's evolution through our own observations and informal conversations with commoners. These were recorded through daily journalling following site visits, yielding a total of 18 entries. In addition, we conducted four semi-structured interviews with core team members following the construction phase. All semi-structured interviews followed the same format: interviewees were asked to reflect on which community values and needs were evident across the project; how important the carbon sequestration aspect of the project was, and which sequestration techniques were most beneficial for what the community deemed

important; and how well the project was able to foster "commoning practices," or social relations based on reciprocity, participation, and collective action. In addition, interviewees were asked to reflect on the hurdles encountered, including community buy-in, permitting challenges, and the team's facilitation role. Interviews were transcribed and analysed alongside the journal observations using thematic analysis (Braun & Clarke, 2006). Coding considered technical aspects, social aspects, stakeholder roles and responsibilities, and challenges. The analysis was then used to synthesise the insights we discuss next.

5. The Carbon Commons

5.1. The Living Lab in practice

5.1.1. *Co-design: making space together*

The co-design of the garden unfolded as an iterative process between the authors, the architect, the community programmers, the broader community, and external municipal stakeholders. Our first step was to map existing desires and needs through a simple public survey. The survey listed possible outdoor features—planter beds, picnic tables, jeux-de-boules, and an activity board—but also invited open suggestions. Responses emphasised greenery, comfort, and conviviality: "a place for outdoor meals," "planters," and "space for children to play."

We translated these responses into an initial design, which was prototyped in 1:1 spatial layouts using tape on the pavement, and invited spontaneous feedback from passersby. Some people paused to give comments; others walked through the taped outlines, informally testing the proposed circulation. For many, it was the first tangible sign that something might change. Through these everyday exchanges, the design gradually took shape.

The concept of carbon sequestration remained in the background during this phase. We found that direct discussions of sequestration often alienated participants as they appeared too technical or too abstract. Instead, we worked through material metaphors: soil health, greenery, reused wood. This subtle translation allowed us to embed sequestration materially—through biochar-enriched soil and carbon-storing wood—without imposing scientific language that was inaccessible to the community.

Through this iterative process, we developed a technical design in collaboration with the architect. The final proposal featured three large planters, several benches, and an activity board for public announcements (Figure 1–3). The design was also influenced by locally available materials from bio-waste streams (Figure 4–9, Table 1), which could be salvaged to store carbon and avoid incineration (CE Delft, 2022): from an urban sawmill we salvaged large timber beams cut from felled municipal trees (e.g., due to safety or wind-blow); from a pile of construction waste we gathered useful posts; we also made use of donated bio-composite panels and large CLT timber blocks. Softwood components were treated for weather resistance. In addition, we produced biochar from the wood offcuts from our project, in collaboration with a local NGO specialising in this process, to be added back to the gardens' soil.

Some of our initial technical design ambitions had to be adjusted. We had hoped to experiment with hempcrete to demonstrate carbon-negative construction, but its permanence conflicted with the site's temporary lease and the Board's practical concerns. Instead, the focus shifted toward flexibility and maintenance. At one point, we debated whether to prioritise fast-growing biomass crops for carbon drawdown (e.g., bamboo) or to plant edible species preferred by residents. The latter won. Participants wanted food and flowers, not only climate utility. This moment highlighted a recurring point: a group's social drives may not always align with the most technically efficient approach. The co-design phase thus became not only about shaping a physical garden but also about negotiating meaning and ownership. Decisions were made collectively, though often informally, around coffee tables, during workshops, or while watching kids play.

5.1.2. Co-building: learning and doing

Embedded in the Technical Lab, the co-building phase became the most dynamic moment of the project (Figure 10–14). Over three weekends in late summer, around 20 local youth (aged 8–22) participated in workshops to build the garden. The atmosphere was energetic. On the first day, children eagerly began prying up the concrete tiles to make space for soil. Shouting and laughing could be heard from a distance, as young children competed to lift the heavy tiles and wheelbarrows of soil.

The workshops were designed to engage younger participants through accessible activities such as painting or planting. Between workshops, we completed the more complex carpentry tasks, often drawing in curious bystanders who stopped to help. This led to many organic learning moments, for instance, showing a teenager how to use a drill. We had several long chats with the municipal gardeners, who were curious about our project and the sustainability gains, or with a group of teachers who had come to view the community centre and learn about what was going on there. In one memorable moment, a group of teenage girls scolded an older man for throwing trash into the new planters they had just finished working on—a small but telling sign of emerging stewardship. Through such moments, the act of making together became an education in both material and social care.

Decision-making was equally improvisational during construction. When benches seemed too close to the entrance, we consulted a few parents leaving the centre at sunset, and their suggestions directly informed the final layout. These spontaneous interactions were part and parcel of the process, where shared responsibility unfolded through conversation and action rather than formal meetings.

One significant challenge with such an approach emerged during the building phase: an unexpected permitting complication with the municipality. While we had understood that the municipality had already granted all necessary approvals for the garden, midway through construction, a different municipal department visited the site and informed us that additional permissions were required. Over the following months, we entered a process of negotiation, redesign, and compliance, working with municipal staff to adjust several elements to meet safety and accessibility standards. Ultimately, this cooperation led to a two-year permit that enabled the garden to remain in place. This was a win for the community centre but a hindrance to the project's carbon sequestration goals, which would require a much longer lifespan. While the situation was at times demanding, it proved instructive, revealing how grassroots experimentation and municipal governance operate with different logics, and how creating space for commoning within public systems requires sustained dialogue, translation, and mutual adjustment. The persistence of all involved demonstrated that such processes, though laborious, can build new forms of partnership.

5.1.3. Co-use: living with the garden

After securing the permits and implementing the necessary changes, the garden was inaugurated with a spring celebration, and the community planted two symbolic olive trees and a variety of vegetable seeds. The once-empty strip of pavement became a hinge between the building and the neighbourhood (Figure 16–18). Cars no longer parked there; instead, people gathered on benches, children played on the edges of the planters, and evening events spilled outdoors. During summer, community dinners and performances were occasionally held in the new space, while in quieter months, a few dedicated neighbours tended the plants. Over time, the garden's appearance evolved. In the beds, vegetables emerged alongside some less desirable nettles and weeds. Maintenance fluctuated with the seasons and people's availability. On hot days, some planters dried out; trash occasionally blew in. Yet, despite its imperfections, as of writing, the garden persists as a living commons: as an ordinary, working landscape shaped by care and neglect alike. As one community member remarked, "It's better like this than empty."

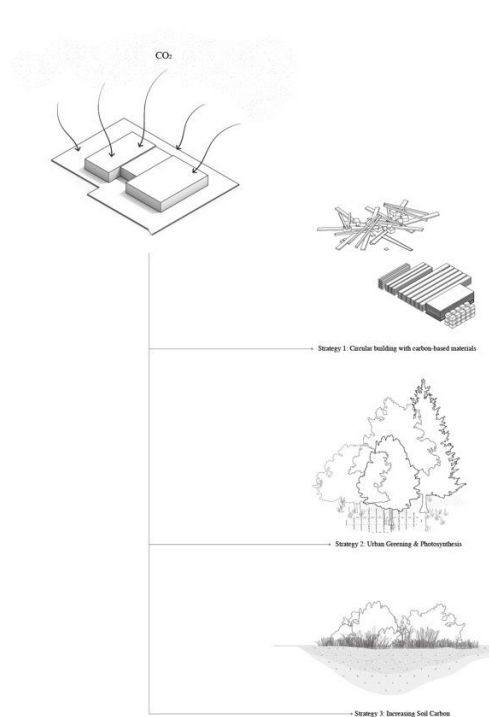


Figure 1: Bio-based carbon sequestration strategies used in the Living Lab

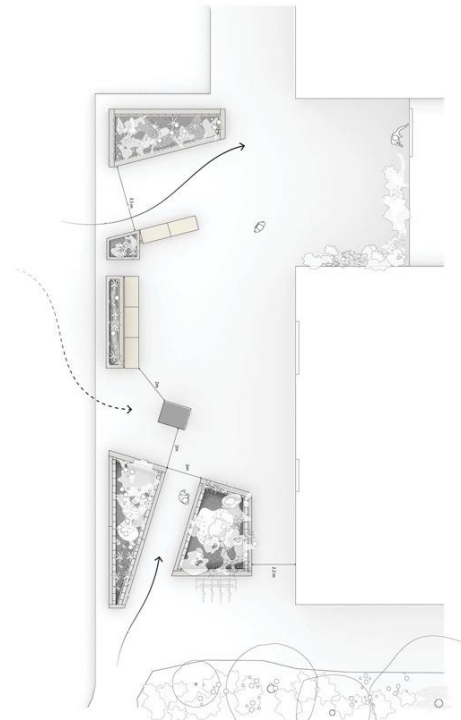


Figure 2: Plan of the garden design

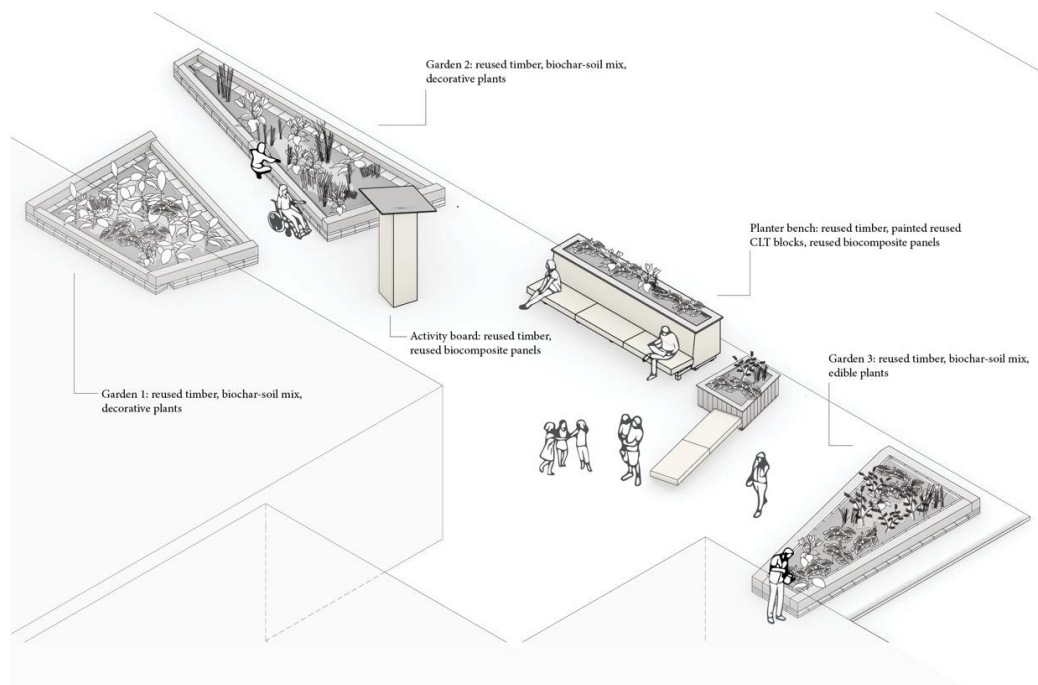


Figure 3: Axonometric drawing of the garden



Figure 4: Reused elm timber beams and urban wood at the circular sawmill



Figure 5: Reused elm timber beams and CLT blocks on site



Figure 6: Reused construction timber waste wood for the garden



Figure 7: Preparing CLT blocks for painting



Figure 8: Plants for the garden sourced from a local garden shop



Figure 9: Producing biochar from construction off-cuts



Figure 10: Technical Lab Workshop 1: Children preparing the site



Figure 11: Technical Lab Workshop 1: Shovelling soil into a garden bed



Figure 12: Technical Lab Workshop 2: Collective painting of the CLT benches



Figure 13: Technical Lab Workshop 3: Planting the gardens



Figure 14: Explaining the project to municipal gardening crews



Figure 15: Community event inside the community centre



Figure 16: The Carbon Commons Living Lab Garden in July

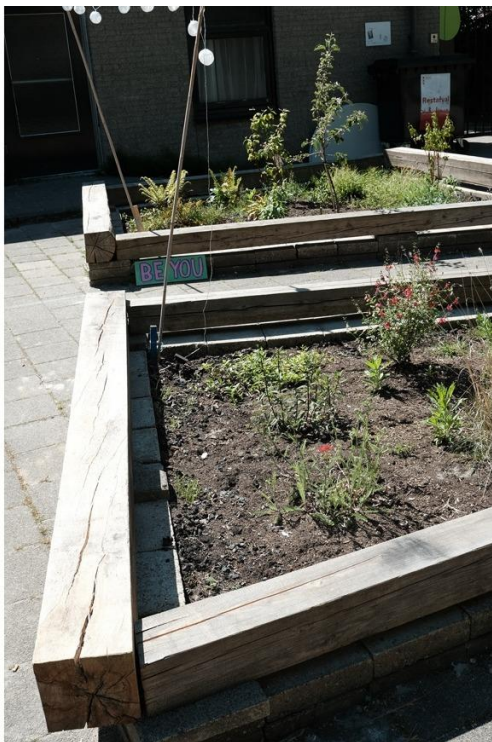


Figure 17: Detail of the garden showing elm timber beam borders and benches



Figure 18: The planter bench

Table 1: Materials and Estimated Carbon Sequestration Potential of the Garden

Material	Volume (m ³)	Density (kg/m ³)	Mass (kg)	Carbon content (%)	Carbon sequestered (kg-C)	CO ₂ -eq sequestered (kg-CO ₂)	Lifespan (years)
Elm 'city-wood'	1.4	560	784	0.5	392	1,437.3	10
Larix 'city-wood'	0.42	560	235.2	0.5	117.6	431.2	10
Third-life reused hardwood from dock piles	0.09	850	76.5	0.5	38.25	140.3	20
Reused CLT blocks (originally trade samples)	0.5	430	215	0.5	107.5	394.2	20
Reused plywood panels	0.05	430	21.5	0.5	10.75	39.4	2
Donated bio-composite panels	0.16	850	136	0.2	27.2	99.7	50
Soil	5	1,400	7,000	0.01	70	256.7	5
Biochar produced from construction off-cuts	0.125	100	100	1	100	366.7	>1,000
Total	—	—	—	—	863.3	3,165.4	—

Note. Estimated values for the bio-based materials used in the garden. CLT = cross-laminated timber; C = carbon; CO₂-eq = carbon dioxide equivalent. Dashes indicate that a value is not applicable. The Total row sums the Carbon sequestered and CO₂-eq sequestered columns. Values are reproduced from the source manuscript.

Next, we reflect on the carbon commons living lab using Bollier and Helfrich's (2019) "Triad of Commoning." The Triad identifies three central components of commoning—provisioning, social life, and peer governance—and highlights the interdependence of the material, relational, and institutional dimensions that together sustain the commons. The triad is "based on the premise that commoning is primarily about maintaining relationships – among people in small and big communities and networks, between humans and the non-human world, and between us and past and future generations" (Bollier & Helfrich, 2019, p. 93). Each dimension of the triad was variably enacted in the living lab, revealing both the potential and the limitations of carbon commoning as a post-growth practice. Furthermore, for each dimension, we reflect on our own positionality as design-researchers and generalise this to prospective roles for design in facilitating the Carbon Commons.

5.2. Provisioning with carbon

Provisioning, in Bollier and Helfrich's triad, refers to the collaborative production and upkeep of shared resources. Rather than treating goods or infrastructure as commodities, commons-based provisioning emphasises making and maintaining "useful, durable things that have ongoing social importance" (2019, p. 165). When applied to carbon sequestration, this means co-creating and caring for things made from sequestered carbon. Instead of outsourcing sequestration to industrial systems, communities directly engage with the material processes that hold carbon in soils, vegetation, and built structures, turning climate action into a shared, regenerative practice.

In the living lab, provisioning appeared through experimentation with three sequestration strategies: adding biochar to the soil, storing carbon in timber-based constructions, and replacing concrete with permeable, planted surfaces. Each method offered not only a pathway to store carbon but also to produce new forms of shared value. The clearest expression of "useful and durable things" was the garden itself. What had been a derelict strip of pavement became an extension of the community centre. It became a place where children could play, where neighbours could gather, and where food and plants could grow. It hosted dinners, workshops, and informal encounters. It became a recognisable symbol of the community's presence—materialised, for example, in the olive trees planted as a symbol of diversity and resilience.

Provisioning also unfolded through the project's alignment with the community centre's existing Technical Lab. Because the Lab already provided youth with practical skills and creative outlets, our role as designers involved extending these motivations toward ecological and material practices. Workshops on working with reclaimed timber, for instance, supported self-provisioning that could empower future projects well beyond the garden. In this way, the living lab produced not only physical objects but also capacities, skills, and confidence—resources equally essential to commons-based provisioning.

A critical lesson, however, was that participants almost never understood provisioning as carbon sequestration. Our early emphasis on CO₂ removal felt abstract and disconnected from the community centre's lived experience. When framed scientifically or quantitatively,

sequestration appeared "too academic" or even a "luxury" in a context shaped by immediate concerns such as social isolation or lack of youth spaces (Hutak, 2020). While climate change was acknowledged as important, it was often perceived as distant from daily life. The use of biochar made this gap visible: although it is an effective long-term carbon sink, the material carried little meaning for participants because it was introduced outside a hands-on, relational context. Had biochar been integrated into a participatory workshop, it might have become a sensory, shared practice. Instead, its technical benefits remained abstract, whereas the garden—something participants could see, touch, and shape—generated an immediate sense of ownership.

This gap points to a broader insight: what makes carbon sequestration meaningful within a commons is not simply its climate efficacy but its relational embeddedness in community life. Relational embedding differs from technical embedding (e.g., underground storage) by strengthening connections among people, materials, and place. Bio-based materials in buildings or landscapes can store carbon while physically reshaping shared environments (Churkina et al., 2020); nature-based approaches can create green, biodiverse, socially vibrant public spaces (Kabisch et al., 2017; Raymond et al., 2017). These interventions do more than capture carbon—they create opportunities for communities to remake their surroundings in ways that deepen belonging and resilience.

Seen this way, it becomes clearer why industrial negative-emissions technologies often fail to produce meaningful social or ecological outcomes: oriented toward efficiency and profit, they remain detached from the relational contexts that give sequestration its capacity to sustain life. By contrast, embedding carbon into shared practices—in gardens, buildings, infrastructure, or skills—offers a different paradigm in which carbon becomes a medium through which communities cultivate ties to one another and their environments.

5.2.1. Designers as embedded technical mediators

As designers, we played a mediating role in this provisioning process. Our responsibility was not merely to supply technical expertise but to translate sequestration techniques into accessible community practices. Following Schranz (2023), design here functioned as an embedded mediator between technical and social domains: a relational practice of inhabiting,

explaining, and co-working alongside participants. Working in public view, discussing design decisions on site, and demonstrating material processes turned technical knowledge into shared know-how. This embeddedness blurred conventional boundaries between expert and layperson. Such interactions transformed specialised design knowledge into a common resource, strengthening local capacity for maintenance and future adaptation. Provisioning thus extended beyond immediate construction to include the exchange of skills and knowledge.

5.3. Socialising through carbon

Within Bollier and Helfrich's triad, the social life of the commons refers to the relational and cultural practices that sustain a commons. Commoning is not only a mode of resource management but a shared way of being together (Stavrides, 2016). Patterns such as "cultivating shared purpose and values," "ritualizing togetherness," and "deepening communion with nature" (Bollier & Helfrich, 2019) describe how purpose, cooperation, recognition, and everyday interaction with place reproduce the commons as a social world. For carbon sequestration, this dimension is essential: technical efficiency alone cannot ensure that carbon stays stored in soils, vegetation, or materials. Long-term stewardship depends on communities that identify with and care for the ecologies that hold carbon. Co-design processes can nurture these relationships by cultivating social bonds around shared work (Bassetti et al., 2018), turning environmental maintenance into a collective practice of mutual care rather than a technical obligation.

In the living lab, the social life of the commons emerged most vividly through the embodied practices of co-design, co-production, and co-use. Workshops brought together diverse participants to dig, plant, paint, cook, eat, and improvise solutions side by side, cultivating a shared purpose: to create a space the group could use, inhabit, and genuinely call its own. These activities ritualised togetherness—whether through meeting regularly to work, celebrating milestones such as the garden's opening, or gathering around symbolic elements like the planting of the olive tree. Carbon therefore functioned less as a technical target than as a pretext for assembling, learning from one another, and collectively shaping the environment. For many, participation also offered a chance to contribute creatively and

meaningfully: to beautify the neighbourhood, to steward the local ecosystem, and to act on desires for self-actualisation often excluded from routine urban life.

In doing so, the project began to suggest the contours of what Illich (1973) describes as a more convivial mode of production: social, engaged, participatory, and oriented toward human autonomy. As Illich argues, modern societies often rely on tools and systems that, while indispensable, diminish people's capacity to shape their own material worlds. Conventional, expert-driven models of carbon sequestration reflect this pattern, reproducing technical lifeworlds in which most people are positioned as passive consumers rather than co-producers. By contrast, the garden offered moments of conviviality that resisted what Euler (2019) calls the enclosure of social life within the commodity form.

The sociality of the carbon commons did not end with construction. Everyday acts of maintenance—watering plants, sweeping leaves, repairing benches—continued to sustain the garden as a site of relationality. These mundane routines translated carbon from an atmospheric abstraction into a lived practice of care, reinforcing what Weber (2019) identifies as a latent ecological bond linking people with the more-than-human world. In this sense, carbon commoning supported forms of social production oriented toward participation, creativity, and self-actualisation. The technical work of sequestration became inseparable from the work of building community.

Looking beyond this case, these dynamics highlight a broader lesson: for carbon sequestration to function as a commons, it must become socially meaningful. Whether through a community-managed forest, collective repairs of bio-based buildings, or neighbourhood stewardship of green infrastructure, sequestration becomes durable when woven into everyday rituals, relationships, and shared identities and purpose. This relational embedding allows carbon to act not only as a climate instrument but as a medium for cultivating collective life. As provisioning already suggested, the social life of the commons is not an addition to carbon sequestration—it is one of the primary conditions through which a Carbon Commons can take root and expand.

5.3.1. The designer as facilitator of commoning rituals

Our role as designers here was to facilitate and ritualise by creating conditions for participation, learning, and coming together around the materiality of carbon. By organising workshops, structuring accessible building tasks, and making design decisions transparent, we supported the emergence of informal social structures around the project. For many participants, the process opened new avenues for social recognition. Youth who attended the workshops gained visible ownership over the space, while the community centre's programmers integrated the garden into their regular activities. The material presence of the carbon-storing garden thus anchored social life, serving as a backdrop for events, teaching, and everyday encounters.

5.4. Governing Carbon into the Future.

In Bollier and Helfrich's terms, governance is "a reliable means by which commoners can build authentic, living relationships among themselves, and in so doing, develop a coherent, stable commons" (2019, p. 127). Governance is therefore less an institutional blueprint than a regenerative social process that continually rearticulates roles, norms, and shared expectations. Within carbon sequestration, this dimension becomes particularly challenging. The atmosphere and biosphere already form a planetary carbon commons historically enclosed and exploited (Bellamy Foster, 2022; Weber, 2019). Local initiatives such as community forests, cooperative green spaces, or neighbourhood gardens represent situated expressions of this commons, requiring forms of governance that accommodate both everyday stewardship and broader climate responsibilities. Peer governance thus becomes the connective tissue that enables commoning practices to be reproduced and "scaled out" (Dengler & Lang, 2021), shaping how credibility, responsibility, and benefits are collectively negotiated. Yet it is also the most fragile dimension, as practices of commoning must navigate established institutional and technical regimes.

In the living lab, provisioning and social life were readily enacted, but peer governance emerged only partially and with difficulty. Because the project was situated on municipal land, relied on external funding, and operated within safety and accessibility guidelines, governance quickly became a shared concern across community members, designers, and municipal actors. These interdependencies were workable during implementation, yet they

complicated the question of long-term responsibility: who ultimately governs the Carbon Commons once initial facilitators withdraw? How can governance ensure the long-term sustainability of bio-based or green infrastructure mandated by the technical necessity of carbon sequestration, which may outlast the original designers or users? While residents could maintain the garden informally, issues of liability, ownership, and ongoing accountability remained unresolved. The project thus exposed a structural tension within carbon commoning: sequestration requires monitoring, upkeep, and material longevity, while the social practices that give sequestration meaning are fluid, adaptive, and relational. Peer governance must bridge these temporalities by aligning the quantitative rhythms of carbon accounting with the lived time of commoning.

The challenges encountered with the municipality highlighted one potential future direction for governance: the possibility of public–commons partnerships that can stabilise such initiatives without subsuming them (Bollier & Helfrich, 2019). Rather than governing through command or incentives, governments can play an enabling role by providing infrastructure, equipment, expertise, and funding that allow communities to assume shared responsibility for local carbon stewardship. As Bollier and Helfrich (2019) note, public institutions possess unique capacities to establish "macroplatforms" which can facilitate or hinder climate accountability within the commons. For example, safety standards for public spaces that can be achieved by communities themselves, interoperable tools for measuring carbon sequestration, or financing mechanisms that are accessible at the local level but geared toward long-term ecological and social value. These forms of support do not replace peer governance but make it viable, helping align community initiative with broader climate mandates over the long run. Governing carbon into the future thus requires a layered model in which community self-organisation, municipal recognition, and state-enabled infrastructures work in concert. With such arrangements, carbon commoning could move beyond isolated experiments and evolve into a durable institutional form capable of contributing to post-growth climate futures.

5.4.1. Designers as translators

As designers, we occupied a mediating role in this governance gap. Acting as intermediaries between the community and external authorities, or between social needs and technical

climate-mitigation concerns, we translated the immediate, lived language of commoning into bureaucratic formats for permit applications, safety reports, technical designs, and funding proposals. As Parker and Schmidt (2017) observe, such mediation is essential for negotiating between public-sector gatekeepers and collective rights to use space.

Rather than treating technical oversight and bureaucratic compliance as external burdens, design may be particularly suited to reimagine these as elements of a collectively negotiated peer governance. Facilitated by designers, communities could, for instance, develop open-source carbon logs, shared maintenance calendars, or distributed knowledge-sharing for monitoring and design. Seen this way, the work of design is not to bridge two worlds but to help cultivate new ones: governance infrastructures that grow out of everyday practices, reflect local values, and remain open to more durable, long-term alliances.

6. Conclusions

Across Bollier and Helfrich's (2019) Commoning Triad—provisioning, social life, and governance—the Carbon Commons Living Lab reveals how carbon sequestration can be reframed as a relational, community-driven practice. Provisioning transformed carbon into shared material and spatial infrastructure; social life animated that infrastructure through ongoing collective action; and governance exposed the institutional tensions that determine the Carbon Commons' capacity to endure across timescales necessitated by carbon sequestration.

Theoretically, the Carbon Commons makes a distinct contribution to both post-growth and commons scholarship. While post-growth literature has extensively critiqued market-based carbon removal, it has paid comparatively little attention to how sequestration might be organised outside those logics. The Carbon Commons fills this gap by proposing commoning as a concrete socio-economic framework for sequestration that treats carbon not as a tradable asset or technocratic target but as a shared material embedded in collective life. In doing so, it extends commons theory into a domain where it has rarely been applied, and offers a conceptual bridge between post-growth economics and the practical design of carbon-storing infrastructures and landscapes.

For technical designers concerned with carbon sequestration or climate mitigation more generally, these dynamics redefine professional roles. The designer becomes an infrastructural mediator who embeds technical expertise within communities, facilitates social processes, and helps to navigate interfaces with and across governance systems. This triadic role aligns design with Bollier and Helfrich's understanding of commoning as a living, evolving practice rather than a fixed model. For practitioners more broadly, including community organisers and local policymakers, the living lab offers several concrete lessons. Carbon sequestration becomes meaningful to communities not through scientific framing but through material and social embeddedness: gardens, buildings, and shared infrastructures that people can shape, use, and identify with. The role of expert designers in such processes is necessarily relational and political, requiring active attention to power asymmetries and a commitment to redistributing knowledge and agency rather than delivering solutions. And durable carbon commons depend on enabling institutional arrangements, such as flexible municipal governance, accessible funding mechanisms, and long-term stewardship structures that can outlast any single project or team.

Ultimately, the Carbon Commons points toward a different approach to organising technology for a post-growth future grounded in collective needs and values rather than the logic of profit maximisation. Carbon, in this view, is not merely a pollutant to be managed cost-effectively, but a medium through which new techno-social relations can be formed. By provisioning together, sustaining social life, and negotiating governance, communities can transform sequestration into a practice of shared ecological responsibility that sequesters not only carbon but also value, meaning, and collective agency.

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Use of artificial intelligence

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The authors

Riel Bessai is a PhD candidate at the faculty of Industrial Design Engineering, within the Design for Sustainability department. His doctoral research investigates design practices for post-growth, with a particular focus on climate change as a crisis of carbon and the potential of carbon regeneration through design.

Roy Bendor is Associate Professor of Critical Design in the Department of Human-Centered Design at Delft University of Technology, the Netherlands, where he also directs the Design for Interaction (Dfi) Master's program. His research explores the capacity of design to disclose alternative social, political and environmental futures. Roy is also Fellow of the Urban Futures Studio at Utrecht University, former editor of the sustainability forum in the ACM's magazine Interactions, and author of *Interactive Media for Sustainability* (Palgrave, 2018).

Ruud Balkenende is professor of Circular Product Design at the faculty of Industrial Design Engineering at TU Delft. He received his PhD on a doctoral thesis about the use of copper as an automotive exhaust catalyst material. In 1990 he joined Philips Research, where he has been active at the interface of technological innovation and business applications. Since 2009 he has been mainly involved in research and development related to materials scarcity and product recyclability. Linking product architecture and materials science to resource efficiency was the main driver. Since 2013 his activities extended from recyclability to circular economy, i.e. reusing products or parts at a functional level instead of recovering materials.