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REVITALISING BUILDING PRODUCTION THROUGH REGENERATION: A POSITIONAL PAPER

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This paper explores regenerative building production as an approach that goes beyond minimising environmental harm to actively generating net-positive socio-ecological impacts. Grounding the discussion in sustainability transitions theory, we highlight how construction significantly contributes to global carbon emissions and waste. Using the phenomena construction methodology, a conceptual framework is proposed to integrate regenerative design principles with sociotechnical perspectives, framing the shift to regeneration as a transitional phenomenon and revealing how multilevel interactions among stakeholders, policies, and niche innovations can drive adoption. Practical steps for clients, designers, contractors, policymakers, and communities include revised procurement models, ecological design solutions, and policy incentives that support deeper collaboration and accountability. The paper underscores that achieving a regenerative transition requires shifting incentives, fostering collaboration, and effecting systemic change across the sector.

Keywords: regeneration; building production; construction management; net positive impact; planetary boundaries

INTRODUCTION

The mainstream construction industry accounts for around 40% of global CO_2 emissions (Burns *et al.,* 2024) and 40% of EU waste (Eurostat, 2024). A significant portion of this impact arises from building production—that is, on-site processes, supply chains, and management practices. Although measures such as emission-free sites, recycling, and lifecycle analyses have been introduced, entrenched norms still prioritise short-term cost reduction over long-term resource efficiency (Oyefusi *et al.,* 2024). Regeneration offers a pathway beyond sustainability and circularity by focusing on repairing damage, improving well-being, reversing environmental degradation, and restoring ecosystems for a net positive impact; it involves humans as key ecosystem contributors engaging and collaborating holistically (Mang *et al.,* 2016). However, regenerative measures, strategies and business models have not been widely adopted in building production. To examine how that can become

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regenerative, this paper employs a systematic literature review and the phenomena construction methodology (Alvesson and Sandberg, 2024), framed by sustainability transitions theory (Köhler *et al.,* 2019). We propose an early conceptual framework that positions regenerative building production within the sociotechnical system of construction and outlines practical steps for stakeholders to move from niche experiments to broader implementation.

Sustainability transitions theory aims at conceptualising how sociotechnical systems can be radically changed to address challenges incurred by unsustainable consumption and production - as it is considered that incremental improvements and technological fixes ultimately fail to address those (Köhler *et al.,* 2019). This theory is primarily grounded in the interplay of the sociotechnical concepts of the multilevel perspective (MLP), technological innovation systems (TIS), and strategic niche management (SNM) (Bergek *et al.,* 2008; Schot and Geels, 2008; Köhler *et al.,* 2019). Those concepts and their interaction are elaborated below and will later frame the integration of regeneration into building production as a systemic transition rather than a standalone technical fix.

MLP explains transitions as non-linear processes unfolding across three nested structuration levels: niches, socio-technical regimes, and the landscape (Köhler *et al.,* 2019). Niches are protected "incubation rooms" for radical innovations, where novelties can develop shielded from market selection (e.g., pilot projects for reuse). Regimes represent the dominant technologies, infrastructures, business models and institutions that are stabilised by incumbent actors and routines, leading to path-dependence and incremental change (Köhler *et al.,* 2019). The landscape denotes broader exogenous trends (e.g., climate targets, economic conditions, cultural values) pressuring the regime; transitions occur when niche innovations mature and align with landscape pressures to sufficiently destabilise existing regimes, thus becoming the new regimes (Köhler *et al.,* 2019). In MLP, stability and change interact; regimes are typically change-resistant, so niche breakthroughs often require both internal momentum and external landscape pressure (Geels and Schot, 2007).

Apart from MLP, the TIS framework focuses on the development of innovation systems around a specific technology or solution, and consists of actor networks (e.g., firms, users, policymakers), institutions (regulations, norms), and technological artifacts related to innovations (Bergek *et al.,* 2008). Rather than multilevel structures, TIS evaluates seven systemic functions - i.e., key processes that must be fulfilled to successfully develop and diffuse a novel technology: (1) knowledge development and diffusion; (2) entrepreneurial experimentation; (3) directionality of innovation efforts; (4) market formation; (5) sociopolitical acceptance and legitimation; (6) resource mobilisation; and (7) positive externalities (spillovers reinforcing the system) (Köhler *et al.,* 2019). By assessing functional strengths and weaknesses, systemic barriers hindering innovation can be pinpointed - e.g., a stagnation in thinking beyond sustainability and towards regeneration might reveal a lack of relevant business models, or insufficient legitimation (scepticism about quality or building code compliance). TIS is especially useful for understanding early-phase innovation dynamics and identifying policy or network interventions to strengthen the innovation system (Bergek *et al.,* 2008). It emphasizes the emergence and diffusion of novel innovations more than the active destabilisation of incumbent systems - which is MLP's focus (Köhler *et al.,* 2019).

Furthermore, SNM examines how to deliberately nurture niche innovations so they can grow and challenge the regime (Schot and Geels, 2008). It posits that radical innovations typically start in protective niches - e.g., subsidised demonstration projects, living labs, or specialised markets - where they are shielded from mainstream selection pressures (Köhler *et al.,* 2019). There, dedicated actors (e.g., ConTech startups or clients practicing social procurement for community buildings) invest in developing the innovation. SNM emphasizes three key processes for niche development: (1) first- and second-order learning about technical issues and broader societal impacts; (2) network building by forming broad stakeholder alliances to support the innovation; and (3) articulating compelling narratives to attract attention and resources (Köhler *et al.,* 2019). Through iterative cycles of experimentation and feedback, a niche innovation can improve on technical performance, reduce uncertainties, and build up a supportive coalition (Köhler *et al.,* 2019). Successful niches may then scale up and enter mainstream markets. SNM can thus guide experimental projects and strategically position innovations - which is highly relevant for adopting regeneration in building production.

In practice, MLP, TIS, and SNM are often seen as complementary; niche experiments can function as seeds for broader transition dynamics (Markard *et al.,* 2012). However, while all three concepts adopt a systemic perspective to capture the complexity of sociotechnical change (Köhler *et al.,* 2019), they differ in focal scale and analytical lens. MLP provides a broad structural overview of transition dynamics across levels, highlighting how landscape pressures and niche-regime interactions drive systemic change. TIS functionally analyses the innovation process for a given technology, identifying which system functions are blocking or enabling progress. SNM gives a process view for cultivating practical innovations through experiments and learning-by-doing. In short, MLP is useful for understanding the macro-context and timing of transitions, TIS for diagnosing innovation system weaknesses and crafting policy support for meso-level system building, and SNM for informing on-the-ground experimentation and micro-level innovation and stakeholder management. As such, to implement all three concepts in tandem, a positional framework needs to account for this variation in application levels, as well as their vertical interaction.

METHOD

We first conducted a systematic literature review (SLR) (Bell *et al.,* 2022) to explore the general application of regeneration in the built environment. We focused on 2016-2025 to capture the recent emergence of, primarily, regenerative design as a distinct paradigm (Cândido *et al.,* 2023). This is justified on the basis that the field is relatively nascent and rapidly evolving, with key definitions, frameworks, and examples solidifying only in recent years. We targeted peer-reviewed academic sources across Scopus and Web of Science, using keywords like "regenerative design", "regenerative urban development", "built environment", and "circularity". We prioritised literature from the Global North, given that much of the relevant discourse originates there, while also incorporating studies from the Global South when available to provide broader context. We applied standard systematic screening (Bell *et al.,* 2022), first by filtering by title/abstract relevance and followed with full-text review to identify sources that substantively discuss regeneration in the built environment. Grey literature (e.g., industry reports, guidelines) was consulted sparingly to illustrate practical applications (e.g., specific regenerative building projects) but did not dominate our source base. The SLR was conducted in iterations, at first broadly netting 1,800 hits; subsequently, after five systematic screening loops and gradually more specific keywords (e.g., "regenerative construction cases"), we ended up with 20-25 references in the paper. Following the SLR, we synthesized our findings into the previously unutilised context of building production, by employing the phenomena construction methodology (Alvesson and Sandberg, 2024), which encourages researchers to actively construct the phenomenon of interest rather than simply accept established definitions. In our case, "regeneration in building production" is not an existing well-defined concept, so we iteratively built it by integrating insights from regenerative built environment literature framed within the previously expounded sociotechnical concepts of sustainability transition theory; reviewing the literature helped identify key attributes of regenerative practice, which we then re-conceptualised for building production to address our research question (Alvesson and Sandberg, 2024). We thus combined, e.g., regenerative design principles and sociotechnical transition factors, to establish regenerative building production as a new phenomenon.

Literature Review and Findings

Regeneration in the built environment has emerged as a paradigm that goes beyond traditional sustainability. While conventional "green" design aims to reduce harm (e.g., lower energy use), regenerative approaches strive for net-positive outcomes actively restoring and improving socio-ecological systems (De Wolf and Bocken, 2024). This marks a conceptual departure from more reductionist, mechanistic views on sustainability (Camrass, 2022). Regeneration embraces the interconnectedness of socioecological systems, viewing human development as part of nature (Mang *et al.,* 2016; Camrass, 2022), promoting co-evolution and mutual thriving through deeper integration and interdependence (Jones *et al.,* 2023).

In the built environment, regeneration contrasts the ecosystem degradation often associated with urban development, with regenerative practices seeking to renew soils, boost biodiversity, enhance community well-being, and restore the human-nature relationship (Toner *et al.,* 2023). It spans frameworks such as regenerative design, urban planning, and architecture by grounding them in the shared principles of systems thinking (situating projects within broader socioecological systems), place-based design (responding to local culture and ecology), co-evolution (adapting with natural systems), and net positivity (e.g., buildings enhancing ecosystem health and social footprint) (Camrass, 2022; Jones *et al.,* 2023). A regenerative building might generate renewable energy, clean more water than it consumes, increase biodiversity, and foster community ties. This approach redefines success, measuring outcomes like ecosystem services, community well-being, and cultural value in addition to resource efficiency (Sadat *et al.,* 2024; Oyefusi *et al.,* 2024). Recent research highlights both growing interest in putting regenerative ideals into practice and the challenges of doing so. While ambitions like net-positive energy, biodiversity, and social equity are well articulated, definitional and paradigmatic inconsistencies persist (Camrass, 2022). Still, moving "beyond sustainability" while rooted emerges as a shared emphasis (De Wolf and Bocken, 2024). This reflects a shift, where embracing complexity, long-term vision, and an ethic of care for living systems, is pronounced.

Regenerative principles can be applied across levels (Oyefusi *et al.,* 2024). Nonetheless, neighbourhood and district levels are often highlighted as ideal for intervention, based on balancing building integration, green infrastructure, community systems, and strong stakeholder engagement (Camrass, 2022). Precinct-scale projects (e.g., eco-districts) enable synergies like shared energy, water recycling, and community gardens, fostering circular, closed-loop systems (Camrass, 2022). Moreover, place-based design and community involvement are repeatedly cited as keys to success (Toner *et al.,* 2023). Other examples occur at the master-planning scale (e.g., ecovillages, campuses) where architecture, landscape, and community can be integrated holistically (Toner *et al.,* 2023). Building-scale examples also exist, notably through the Living Building Challenge (LBC), with net-positive cases like the Bullitt Centre and the Phipps Centre (Cole, 2023). However, by early 2025, fewer than 25 projects worldwide had achieved full LBC certification, underscoring the gap between regenerative ideals and mainstream practice (Green Building Alliance, 2025).

While regenerative visions are often conceptually ambitious, translating them into building production practice remains challenging and underexplored (Camrass, 2022). There is limited guidance on how planning-stage ideals can be realised through conventional construction, supply chains, and contractor practices (Sadat *et al.,* 2024). Barriers include inadequate stakeholder engagement, entrenched industry norms, and lack of supportive incentives; for example, market valuations rarely reflect socio-ecological benefits, making regenerative investments hard to justify (Camrass, 2022; Cole, 2023). Moreover, regenerative building requires systems thinking, ecological literacy, and community facilitation - areas where many professionals lack training and skills (Toner *et al.,* 2023). A few pilots have attempted to foster such training; e.g., LENSES (Living Environments in Natural, Social and Economic Systems), a tool developed to help project teams conceptualise and implement regenerative design, was applied in an Australian development (Plaut *et al.,* 2016); and regenerative development was attempted in Chile and Mexico, through co-designing with local communities, restoring brownfield and degraded sites into healthy ecosystems, and creating local economic value (Gibbons *et al.,* 2018). Nonetheless, these sparse examples exemplify the gap in mainstream practice even more and highlight the need for capacity-building and education.

In summary, regeneration in the built environment is framed as a systems-based paradigm aiming at net positivity. Over the past decade, its principles and frameworks have been tested in selected projects, but mainstream adoption remains limited due to definitional ambiguities, unsupportive policies, entrenched industry norms, and coordination challenges across disciplines and scales (Cole, 2023). A key gap lies in integrating regeneration into building production, which largely depends on how its principles are implemented in material sourcing, construction methods, supply chains, and on-site management.

Positional Framework: Regenerative Building Production

Informed by the phenomena construction methodology, our proposed framework places our literature insights (i.e., principles, challenges, multiscale considerations) within building production using the previously expounded concepts of MLP, TIS, and SNM. Thus, it positions regenerative building production as an innovation to be nurtured and scaled within the sociotechnical system of construction. Specifically, our framework is delineated into: (a) a multilevel perspective on integrating regeneration into building production, and (b) proposals for practical implementation steps for key stakeholders aligned with this perspective.

MLP, TIS, and SNM on Regenerative Building Production

MLP can help identify landscape, regime, and niche factors shaping a regenerative transition in building production. At the landscape level, pressures such as the climate crisis, biodiversity loss, international policy shifts, and changing market expectations can create momentum for a regime change (from "doing less harm" to "doing more good"). However, the current building regime is resistant: contractors prioritise cost and speed, regulations focus on minimum compliance, supply chains depend on high-carbon materials, and a risk-averse culture limits experimentation (Cole, 2023).

To drive regenerative building production, TIS points to niche innovations nurtured and connected to regime actors. Small-scale projects testing regenerative methods (e.g., biodegradable materials, zero-waste sites, habitat restoration, and community co-building) can act as "learning laboratories" for new practices. Finally, SNM incentives are essential, offering support through research funding, green procurement, and clients prioritising regenerative goals. As successful experiments accumulate, networks can then form to share knowledge and build momentum (Cândido *et al.,* 2023), like how LEED scaled sustainable practices. A feedback loop can emerge, where landscape pressures (e.g., climate targets) increase regime openness, enabling niche innovations to influence mainstream practice. As projects prove viable (e.g., restoring ecosystems within budget) larger actors can begin to adapt in the new regime; over time, building codes, standards, and financing tools can evolve to support regeneration, marking a sociotechnical transition from niche to norm.

In this process, intermediaries and coalitions are key - e.g., an alliance of architects, contractors, and environmental NGOs can develop guidelines for regeneration, acting as a bridge between niches and regime. This multilevel view informs our suggested practical steps (see below) by highlighting that change must happen at different levels: bottom-up innovation, top-down pressure, and lateral spread through networks.

Stakeholder Implementation Steps

Achieving regeneration during building production requires coordinated action from all relevant key stakeholders. Based on our multilevel perspective, we outline practical steps for each stakeholder category to advance regenerative building production.

Project developers/clients/owners: Setting ambitious goals and demanding innovation
Clients play a pivotal role in embedding regeneration by defining ambitious targets. Specifying goals such as zero waste, net-positive energy, or biodiversity gains in project briefs can provide mandates for design and construction teams (Cole, 2023). Adopting collaborative procurement models (e.g., integrated project delivery (IPD)) can further align stakeholders around regenerative outcomes. Clients must also invest with a long-term perspective, as regenerative features may not yield immediate profit but build resilient, future-proof assets. Incentives, pilot programs, and public-private partnerships can help offset initial costs. Ultimately, clients can drive change by championing the vision, committing resources, and creating demand that pulls niche innovations into mainstream practice.

Design professionals (architects, engineers, consultants): Translating regenerative principles into buildable solutions and guiding the team
Designers can translate regenerative principles into actionable plans - like specifying materials and methods that support regeneration (e.g., carbon-storing or pollution-absorbing materials) and designing for deconstruction and circularity (Remat, 2025). Engineers can then ensure the safety and feasibility of regenerative systems (e.g., rainwater harvesting). A practical tool is a Regenerative Construction Plan, outlining how site work will avoid harm and create positive impacts (e.g., reusing topsoil, preserving native vegetation). Workshops and value-engineering sessions can then

align design intent with construction methods and educate builders on regenerative goals. As "niche intermediaries," designers mediate between radical ideas and practical delivery, bridging vision and execution (Cole, 2023).

Construction managers and contractors: Implementing regenerative practices
Building production is where plans materialise, so it must evolve to meet regenerative goals. Contractors can consult the previously conceived Regenerative Construction Plan and adopt a "construction ecology" approach, treating the site as an ecosystem to be improved. This includes rigorous waste management (aiming for zero landfill), using low-emission or renewable-powered equipment, and protecting or enhancing habitats during construction (e.g., timing work to avoid disturbing wildlife, creating wetlands to treat runoff). Training site workers in regenerative practices (in continuation to the workshops) and appointing an ecological supervisor can reinforce these efforts. Contractors can also innovate through modular or prefabricated methods to reduce waste, prioritise early installation of green infrastructure, and try emerging materials like algal concrete or mushroom-based insulation (Remat, 2025). Participating in pilot programs and industry networks can also support knowledge exchange. From a sustainability transitions lens, contractors can scale niche innovations; once a method proves viable, they can refine, standardise, and replicate it. Sharing project data (e.g., on carbon sequestration, biodiversity gains, etc.) can then help build the business case and an industry-wide technical foundation.

Policy makers and regulators: Enabling and incentivising regenerative practices
Local and national governments can play a key role in advancing regenerative building production by shaping the regulatory regime. The first step is integrating regenerative criteria into building codes and approvals (e.g., requiring large projects to demonstrate net-positive environmental impact or contribute to urban ecological networks). While traditional codes focus on health, safety, and minimum standards, new performance-based criteria could reward outcomes like habitat restoration or surplus clean energy. Policymakers must also ensure regulations do not stifle innovation; overly prescriptive rules risk creating a compliance mentality that discourages experimentation (Cole, 2023). Innovation zones or pilot exemptions can provide flexibility for testing regenerative approaches. Financial tools, such as fast-track permitting, grants, and tax incentives, can offset upfront costs and de-risk pioneering projects. Public procurement can lead by example, setting regenerative requirements for government projects and creating market demand. Additionally, policy should build industry capacity through funding training, research, and knowledge-sharing (Cole, 2023). Incentivising niche innovation would mean moving from enforcing minimum standards to enabling transformation and gradually redefining standard practice.

Community and end-users: Participating in the building production processes for local value
Often overlooked in production, local communities and end-users can be key in regenerative outcomes. Participatory practices (e.g., involving residents tree planting or placemaking) can minimise disruptions and enhance local value. Community input, including indigenous ecological knowledge, can also improve project alignment with local ecosystems (Cole, 2023). Maintaining transparent dialogue throughout construction, e.g., by sharing updates on progress towards regenerative goals, can build trust and public support. Treating the site as part of the community can foster education through tours or workshops. Engaging future users during construction can

also improve the long-term success of regenerative goals, as those involved are more likely to sustain and advocate for them.

These proposed actions show that all stakeholders in building production can have a role in driving systemic change. Our positional framework places regenerative building production at the nexus of multilevel transformation and multi-actor participation: clients set the vision and fund it; designers translate it into plans; contractors deliver with suitable methods; policymakers enable the shift; and communities co-create and benefit. These roles align with sustainability transitions theory, where regime elements must align to enable a new configuration (Cole, 2023; Cândido *et al.,* 2023). The framework also emphasizes feedback loops, where early project outcomes should inform evolving policies and practices. The aim is to institutionalise regenerative approaches by moving from isolated experiments to mainstream norms. Building production can thereby scale from niche innovation to a catalyst for socioecological transformation in the built environment.

DISCUSSION

The proposed framework shows how insights from regenerative built environment literature can be practically applied to the construction phase through a sociotechnical sustainability transition lens. A key implication is that regenerative building production requires technical solutions, process innovation, and cultural change. Framing regeneration within a multilevel perspective reveals that green construction techniques, however advanced, will not drive systemic transition without aligned support from clients, supply chains, and regulations.

The framework's multi-stakeholder approach initiates the addressing of a key gap: how to operationalise regeneration in building production. It offers a proposal for a structured roadmap to translate high-level principles into construction practices. A key takeaway for practitioners is the need for early collaboration; regenerative outcomes like zero waste or habitat preservation depend on design-stage decisions being carried through to execution. Strategies such as IPD and early contractor involvement are therefore crucial. Similarly, policymakers can use the framework to identify leverage points (e.g., reforming procurement policies and introducing innovation-friendly codes).

A key consideration is the feasibility and pace of transition. Despite recent momentum (particularly through digital tools like BIM) and the specific attributes of different national contexts, the construction industry as such largely remains risk-averse and slow to change. Regenerative practices today are at a stage comparable to early green building efforts; emerging but lacking widespread institutional support. With only a few realised projects, regeneration remains a niche. Therefore, deep-seated regime inertias, like entrenched business models, education gaps, and short-term cost thinking, must be addressed. Our stakeholder recommendations target these barriers: realigning incentives to reward long-term regenerative value, recognising ecosystem services, and advancing professional education and knowledge exchange. Still, the transition will likely be gradual. Early successes should be celebrated but scaled thoughtfully to preserve quality and credibility.

Developing measurable indicators is also essential. While net-positive goals are conceptually clear, assessing biodiversity gains or social well-being is complex. Without clear metrics, it is difficult for industry and regulators to set targets or verify outcomes. Tools like the LBC certification have begun defining such metrics (e.g., net-positive energy, and habitat impact), but further refinement is needed. We can thus highlight the development of indicators like a construction biodiversity index, well-being metrics, or circularity scores to track progress and ground regenerative goals in practice, as a key area of future research. As another future direction, digital technologies could support this effort: AI-enabled digital twins might enable real-time monitoring of environmental performance, while blockchain could support transparent, collaborative tracking of regenerative criteria across stakeholders.

CONCLUSIONS

Integrating regeneration in building production represents a frontier for sustainable development that requires reimagining roles, retooling practices, and realigning incentives. While the vision of regenerative built environments is increasingly well-articulated, the implementation details, especially during building production, remain a challenge. We therefore propose a structured positional framework that can act as a conceptual bridge between theory and practice. In the long term, a transition to regenerative building production could significantly amplify the sector's contribution to moving from mitigating harm to actively healing and improving our ecosystems and societies. Such a shift would represent a profound sociotechnical transition where the construction industry could lead in demonstrating how human enterprise not only coexists with nature but helps it thrive.

Our positional framework is limited in that it is conceptual; however, it does carry practical significance, so we encourage stakeholders in research and practice to refine, test, and implement it. For industry actors, it provides a vision of a collaborative, multilevel effort for shifting building production towards regeneration. For academics, it demonstrates the combination of the sociotechnical aspects of sustainability transitions theory with regeneration concepts in the built environment to structure a complex problem. In that sense, we effectively constructed a new phenomenon: regenerative building production. We thus aspire to influence how future studies evaluate construction projects, i.e., looking at them in terms of regenerative contributions, or how construction-phase innovations diffuse.

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