R&D Management Conference – Innovation & Biodiversity- Pisa 2025

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TRACK 1.5 : Aligning Business and Biodiversity Imperatives Through Innovation

Designing for regeneration: A framework to support socio-ecological value creation through industrial innovation processes

Abstract

Facing the insufficiency of sustainable development in addressing ecological crises, this paper explores how regenerative design (RD) can support manufacturing industries in creating socio-ecological value. Through a literature review and six expert interviews, we identify and validate a conceptual framework of 14 regenerative design principles structured around four relational dimensions: complexity, the living world, time, and the human role. Although RD is well developed in architecture and urban planning, its application to industry remains nascent. The findings confirm the framework's theoretical primarily robustness while highlighting practical barriers, including limited tools, ecosystem knowledge, and structural constraints. This first phase of an action-research initiative opens the path for testing the framework with industrial teams to assess its relevance and operationality. The study opens on the overlooked role of contractual models in enabling regenerative design adoption, arguing that value creation must be embedded in reimagined incentive structures to achieve net-positive impacts.

Context

Sustainable development is no longer sufficient to address today's ecological and social challenges, as evidenced by the transgression of six out of nine planetary boundaries (Rockström et al., 2023). Industrial organizations, both contributors to and victims of these imbalances, face increasing risks linked to environmental disruptions, resource depletion, and market volatility. Current engineering practices, rooted in reductionist thinking, emphasize efficiency and product optimization while overlooking ecological and systemic impacts. This legacy sustains the illusion of a separation between humanity and nature, rendering ecosystems and non-human stakeholders invisible. Design practices remain extractive, linear, and standardized, focusing on object delivery over fulfilling human and ecological fundamental needs (Max-Neef, 1991). Even sustainability metrics often fall short, neglecting systemic interdependencies and thermodynamic realities. As Pavez et al. (2024, p.6) note, such metrics must evolve toward integrative, holistic, and non-linear approaches.

A shift toward strong sustainability (Vivien, 2009; Upward & Jones, 2016) is needed to avoid problem displacement and foster positive impact (Dyllick & Muff, 2015). Faced with these challenges, companies are exploring alternative models that support socio-ecological regeneration. Regenerative business models (Hahn & Tampe, 2020; Konietzko et al., 2023; Das & Bocken, 2024) offer a promising pathway.

Business models, commonly understood as frameworks for value creation and capture (Casadesus-Masanell & Ricart, 2010; Osterwalder & Pigneur, 2010; Teece, 2010), must be reexamined in this context. Traditional models prioritize financial returns, but the regenerative

paradigm broadens this to include socio-ecological value across the entire value chain and product life cycle. Financial performance becomes a means, not an end, in fostering enterprise resilience and planetary wellbeing (Konietzko et al., 2023, p.382; Das & Bocken, 2024, p.539&542).

This paper focuses on value creation, specifically through design in manufacturing companies—a key determinant of a product's life cycle impacts. Regenerative design (RD) , as defined by Mang and Reed (2012a), aims to enhance socio-ecological vitality. While it has largely been applied in urban planning, this study shifts attention to industrial organizations, where RD remains underexplored and represents real opportunity to support regenerative value creation. Therefore, we will propose regenerative design principles modelization and start exploring its transposability to industrial contexts, answering the question : What conceptual framework can support industrial teams in exploring and creating regenerative value for both social and natural ecosystems during the solution design process?

Literature review

A literature review of regenerative design (RD) in the building sector—where RD is most advanced—enabled the extraction and modelization of core design principles as a framework meant to support industrial designers in generating regenerative value. A review of four foundational articles on RD identified 20 core principles (Appendix 1), also revealed very frequently through reviewing six additional articles and books. Four new ones were uncovered there but withdrawn or merged with others (Appendix 2). This abductive process (figure 1) led to consolidating the findings into fourteen design principles that consistently appear in the analyzed RD literature, particularly within the building context.

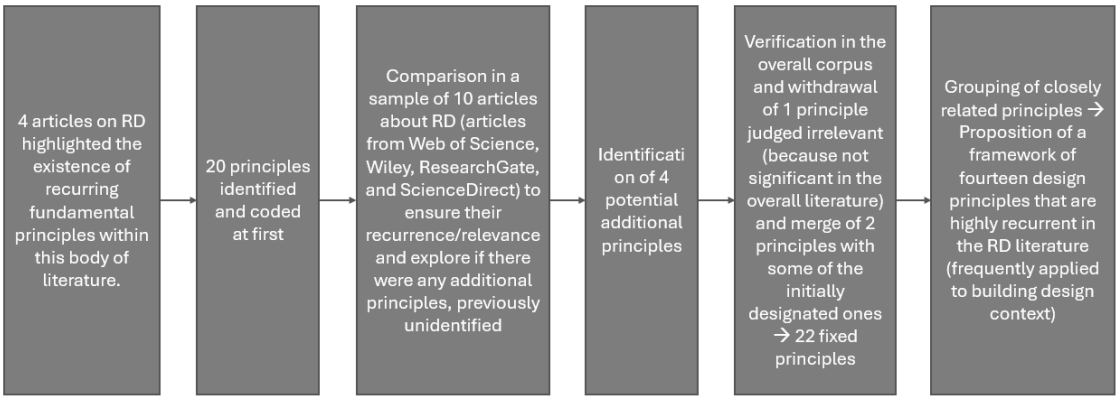

Figure 1 : Process of identification of RD principes

Following the presented approach above, we proposed to represent our framework by ranking those principles into four types of relations to characterize the way regenerative designers could be engaged with the world through their practice : the relation to complexity, to the living world, to time and to the role of humans within the living world (Figure 2).

Relationship to complexity :

1. **Holistic design** : Far from fragmenting reductionist vision, regenerative thinking invites us to see systems as interconnected wholes, requiring designers to engage with

all ecological, social, and temporal layers simultaneously, at the different levels of a system, rather than a sum of subsystems or entities.

2. **Designing within interdependencies respecting the system's nestedness and patterns** : Design is based on understanding patterns and relationships within complex living systems, focusing on relationships between the constituents of a system..
3. **Teleological design** : Teleological design begins with a shared, deeper purpose—seeking to align form and function with the values, aspirations, and meaningful goals of communities. It ensures that every decision and action is guided by a regenerative intention. In this approach, technical development is not an end in itself but a means to serve both humanity and the living world.

Relationship to the living world :

4. **Ecocentered design** : Design grounded in an ecocentric worldview positions humans not as separate from, but as integral components of the biosphere (Pavez et al., 2024, p.4), embedded within a dynamic web of living relationships (Mang & Reed, 2012a, p.8). This perspective calls for deep ecological literacy—defined as "*the ability to understand the natural systems that make life on Earth possible*" (Mang & Reed, 2012a, p.1)—as a foundation for restoring our relationship with the living world.
5. **Place-based design** : Regenerative design emphasizes the ecological and cultural identity of place, fostering solutions that are deeply embedded within local contexts, relationships and ecosystems. Blanco et al. (2021, p.4) describe ecosystems as biological organizational units comprising all organisms in a given area that interact with the physical environment and abiotic elements, generating flows of energy and material cycles.
6. **Essence-centered design** : Every social and ecological system possesses a distinct identity, and design should emerge from this inherent essence through a process of co-discovery honoring the diversity, and making the resulting project a true expression of its context.
7. **Potential-oriented design** : Rather than focusing on problem-solving, regenerative design seeks to reveal and activate the latent potential of places, people, and systems.

Relationship to the role of human beings :

8. **Circular design** : Inspired by nature, circularity means designing systems to mimic the zero-waste cycles of ecosystems—maximizing reuse and bio assimilation, minimizing resource use, and cutting waste across the entire life cycle of a product or built environment.
9. **Participative design** : People support what they create (Hoxie et al., 2012, p.70). Though, it is important to design solutions through long-term, participatory processes in which a diverse array of stakeholders—designers, ecologists, artists, policymakers, and community members (Pavez et al., 2024, p.5)—are involved from the outset and remain engaged well beyond project delivery. Such processes are not meant to be one-off consultations, but rather deep, reflexive, and iterative engagements (Foissac et al., 2022, p.95; Pavez et al., 2024, p.1; Hoxie et al., 2012, p.66–67). Through dialogue, trust-building, and collective learning, stakeholders co-create a shared vision rooted in the place's unique ecological, social, and cultural systems (Reed, 2007, p.678; Mang & Reed, 2012a, p.22).
10. **Mutually beneficial design aiming positive impacts (net as much as possible)**: Design should strive to follow a trajectory that generates net-positive

outcomes—enhancing both ecological integrity and human well-being through reciprocal relationships across systems.

11. **Design to support life** : To ensure Earth's habitability again, RD aims at creating the conditions that allow life to flourish by supporting ecosystems and their essential functions and services—such as water cycling, soil formation and retention, fertility, habitat and material provision, and climate regulation—through alignment with natural processes and the systemic health of living systems.

Relationship to time :

12. **Resilience and robustness oriented design** : Design processes should aim to generate solutions that uphold ecological integrity by incorporating key functional criteria—such as entropy production, nutrient cycling, energy efficiency, spatial heterogeneity, and, most notably, biodiversity—which collectively enhance a system's capacity to absorb disturbances and recover from disruptions (Blanco et al., 2021, p.4).
13. **Developmental design for harmonious coevolution** : Design must enable systems to evolve in symbiosis with their changing environments seeking dynamic balance. This co-evolutionary intention manifests both physically—through modular, flexible infrastructures capable of adapting to environmental shifts and supporting ecosystem functions (Attia, 2018; Mang & Reed, 2012a)—and relationally, by fostering continuous learning and participatory engagement during and after implementation (Mang & Reed, 2012a; Pavez et al., 2024; Du Plessis & Brandon, 2015).
14. **Empowering design** : Regenerative systems are designed to spontaneously self-sustain and self-regenerate with minimal external input, enhancing autonomy across ecological and cultural dimensions. This principle is a true enabler — prerequisite even — for implementing co-evolutionary design. Empowering stakeholders allows the solution to continue serving the eco-socio system it is embedded in. The regenerative paradigm calls for humility: far from an interventionist approach, it urges us to create the conditions for both the system and the solution to self-organize.

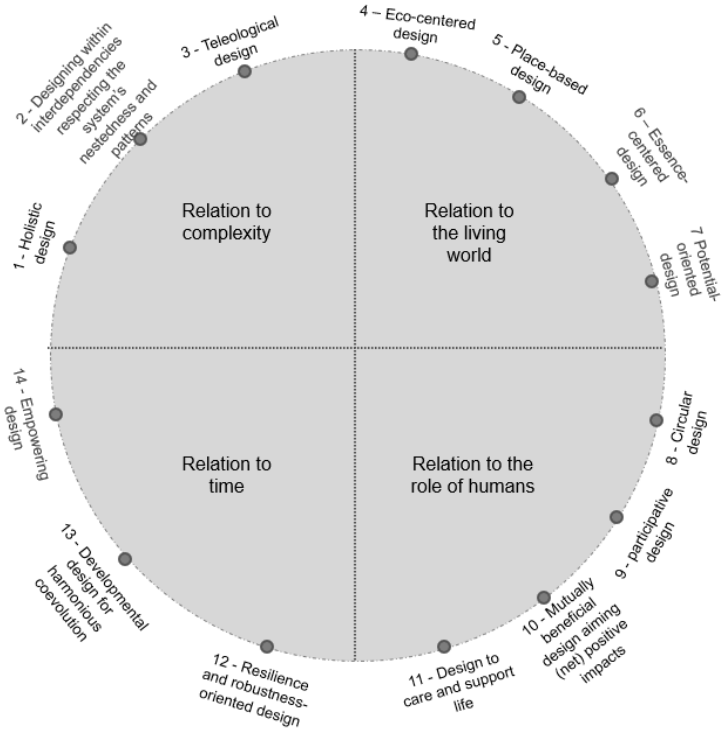

Figure 2 : A wheel to summarize the conceptual framework : Fourteen key design principles of RD literature to guide design decisions towards socio-ecological regenerative ambitions

Qualitative methodology

This paper —adopting a constructivist and transformative stance— presents the first phase of an action-research initiative using an exploratory qualitative approach to investigate strategic diversification pathways in manufacturing industry, with companies willing to prototype regenerative "by-design" solutions at the level of innovation projects. The term "solution" is used deliberately to encompass products, services, and broader value propositions. Here, the solution design process involves exploring regeneration-oriented diversification, identifying human and more-than-human stakeholder needs, and specifying requirements and preliminary design choices to prototype solutions aimed at regenerative outcomes.

The proposed exploratory framework was examined through one-hour semi-structured interviews with six R&D experts and practitioners, followed by a qualitative analysis. In this deductive approach, the interviews were coded through the 14 principles, analyzed and treated to test, refine and confirm relevance of our RD principles framework, and to make preliminary assessment of the interviewees' perception of its transposability to manufacturing contexts. To avoid inductive bias, the framework was not presented. Instead, interviewees were invited to reflect on regenerative principles and their perception of their industrial applicability (Appendix 4). Although regenerative expertise remains rare in industrial contexts, the selected profiles possess solid experience in regenerative approaches across various disciplines such as architecture, urban planning, and innovation (Appendix 3). Half are authors of key articles reviewed, allowing direct validation of our interpretation of their work and extraction of RD principles. The remaining practitioners provided complementary perspectives grounded in systems thinking and holistic worldviews, often linked to academic or public policy work. Their contributions draw on real-world projects, adding practical depth, and they are recognized for shaping regenerative practices. Their diverse cultural backgrounds (France, Brazil, United States) bring a plurality of perspectives on the empiric world.

Results

The coding and analysis of the interviews resulted in confirming the preliminar robustness of the framework: no principles were removed or added, but all were enriched by confirmations and complementary insights.

Relationship to complexity :

1. **Holistic design** : The interviewees strongly validated this principle, advocating for integrative thinking and design that considers nested, interrelated systems. Interviewee 1 stated, "*We have to stop fragmenting the world. Our practice is about working with wholes.*" Interviewee 5 added, "*You can't portion out pieces and fix things*." Two interviewees also advocate for a broader, more systemic outlook beyond the product itself, considering the entire business model, added value, relationships, value chain, and living systems they are rooted in (Interviewee 2 and 3)
2. **Designing within interdependencies** : The principle that design should embrace complexity by being grounded in the interdependencies and nested structures of living

systems—including their components and patterns—is strongly supported by all experts. They emphasized its critical role in ensuring coherence between a designed solution and the larger systems it inhabits, particularly in light of multiscale dynamics and the cascading effects of systemic crises.

3. **Teleological design** : The need for a clear regenerative intention emerged as fundamental. Interviewee 5 noted, "*None of [the RD principles] work if we can't generate the spirit and will in people—and in organizations.*" Interviewee 4 distinguishes designs with either primary intention or secondary regenerative functions, reinforcing the importance of an operational and situated intentionality. "*We either make objects whose primary function is to revitalize ecosystems,[...] or we embed regenerative capacity into objects whose primary function lies elsewhere, like via the materials they are made of.*" (Interviewee 4). Interviewee 1 even emphasized that a design process should inherently ask what is to care about and should come "*from the heart, [...] from the energy of love*".

Relationship to the living world :

4. **Eco-centered design** : the interviews show a strong convergence around the necessity of systemic understanding of ecosystems (ecoliteracy) and that design must adopt an ecocentric worldview, where humans are interconnected with all living systems. Interviewee 1 stated, *"It can't just be anthropocentric. [...] You have to serve the soil, the trees, the birds, the animals, and your human customers*. [...] *Regeneration should not start from the product, but from life in a given place [...]and emerge from an understanding of the living systems present there.*" Interviewee 6 highlights that while biosourcing is a promising approach, "*a real challenge lies in reconnecting manufacturing industries to the living world through means other than just material choice.*"
5. **Place-based design** : Territorial anchoring was seen as foundational by all professionals. Only living systems possess the intrinsic capacity for regeneration, and as Interviewee 1 asserted, "*Place is how we actually interact with life*". Design must therefore be *"based on real facts and data that express the reality of these sites"* (Interviewee 2). If place-based design may seem counterintuitive in a manufacturing context —where products are often mobile and globally distributed — Interviewee 6 argued that even industrial companies could reconnect with territory across the value chain —through traceability when possible, or probabilistic and stochastic data when not. "*Indeed, any manufactured product involves the use of materials and energy originating from specific territories—whether during the phase of sourcing, processing, or usage. This makes it possible [...] to initiate regenerative dynamics in the relevant areas*." (Interviewee 6). Interviewees 2, 3, and 4 emphasize the importance of context-sensitive, place-based design. Such a situated approach is seen as crucial to prevent interventions that are ecologically misaligned or culturally disconnected.
6. **Essence-centered design** : Five of the six interviewees emphasized that design should stem from the unique essence of a system. As Interviewee 6 highlighted the importance of local conditions in the expression of this essence. Interviewees 1 and 3 advocated for decentralizing industrial practices to better reflect local needs and essence of places. This principle could also extend to the core attribute of materials for example. As Interviewee 5 explained : The design process should shift the relationship to material from "*being something that's used for a short period of time and then*

tossed to fill up landfills" to a wonder about where we need material with such attributes.

7. **Potential-oriented design** : Closely tied to essence, this principle calls for revealing latent capacities. "*[In RD], what we work in is not problems, we work with potential*." Interviewee 1 said. This was supported by interviewees 3, 5 and 6. With respect to materials, Interviewee 3 suggested that a step towards potential oriented design could be favoring elements that are abundant in the biosphere (e.g., CHONPS).

Relationship to the role of human beings :

8. **Circular design** : While regenerative design should not be conflated with circular design, experts viewed circularity as a means of mitigating environmental impacts and as a stepping stone toward regeneration "*for the benefit of all living beings as well as society"* (Interviewee 4.). Interviewee 3 stated, "*We will need the toolbox of the circular economy [...] radically applied [...]such as cradle-to-cradle.*" Some interviewees likened RD to an enriched form of industrial ecology, based on reversible, repairable, modular, interoperable and adaptable design, with bottom-up assembly —such as 3D printing— and traceable, biosourced and biocompatible materials.
9. **Participative design** : Participative process is seen as essential for sustaining regenerative projects, but was explicitly addressed in only three of the six conducted interviews. Interviewee 1 and 2 argued that stakeholders must be included and cared for, and have a voice represented in the design process, as a prerequisite for term local dynamics in the project. Interviewee 3 would extend the representation to non-human stakeholders. This relative silence may be attributed either to a tacit integration of the principle into everyday practice, or to a lack of structured tools and frameworks enabling it to be articulated as a clearly operational approach. Although only half of the interviewees mentioned this principle, the insights collected point to a shared understanding of the importance of place-based anchoring through stakeholder participation.
10. **Mutually beneficial design for (net) positive impacts** : The principle of reciprocity and going further than stopping degradation and reaching aggradation of living systems —equitably shared between nature and society— is broadly validated by all professionals. Yet, diverging views seem to emerge regarding the reference point used to define what constitutes a "positive" impact. Interviewees 1, 2, and 6 stress that regenerating ecosystems to an idyllic pristine state is unrealistic. For them, RD should enhance the adaptive and recovering capacities of systems to evolve within a larger, often unstable context, rather than attempting to reestablish historical baselines. In contrast, Interviewee 4 describes projects aimed at revitalizing living systems to their pre-degradation state. While he emphasizes the need to foster co-evolution between the solution and its environment, his phrasing indicates that he views the ecosystem's condition before human impact as the primary reference point : *"We are building underwater structures aimed at revitalizing marine habitats [...] to recreate life zones as they were before human activities."* Further he says *"So we're going to make objects [...] to help recreate life zones as they were before.".*
11. **Design for life** : This principle of supporting ecosystems and their services is broadly validated by the professionals interviewed - though not often operationally linked to industrial contexts. Participants emphasize the need to "*add value to life*" (Interviewee 1) and "*revitalize the environments in which [a solution] evolves*." (Interviewee 4 and

6) by *"improving the health condition for all—living beings, water, soil, air, and society*" (Interviewee 2) and "*sustaining biodiversity*" (Interviewee 6). Concrete applications are cited in agroecology and architecture. Nonetheless, several remarks reflect a pragmatic lucidity to industrial transposition. Interviewee 3 acknowledges: "*More often [in industrial context], we'll be contributive rather than regenerative*." Interviewee 4, involved in a project on regenerative mobility, reports that no credible environmentally beneficial proposals emerged, given the technical and systemic complexity.

Relationship to time :

12. **Resilience and robustness oriented design:** Interviewee #6 clearly articulates this by stating: *"Regeneration is the capacity for resilience [...] and panarchy [...]. Real regeneration is about minimal interventions for maximal effect.*" The principle of designing for system resilience and robustness is supported by some experts (mainly 3, 5 and 6) and can be considered validated as it provides a relevant lens to support the subsequent principle of design for co-evolution.
13. **Developmental design for harmonious coevolution** : This principle was strongly validated by all the interviewees, who consistently described lasting co-evolution between humans, socio-technical systems, and ecosystems as a core aim of RD. As Interviewee 1 puts it, "*our whole purpose is to develop a co-evolutionary relationship with all life* [...] *building the capacity and capability for people to co-evolve with each other and with the living systems that support them.*" Interviewee 4 offers a situated, practical illustration of co-evolution through a new professional figure able to read environmental health and translate feedback signals into actionable insights for inhabitants and designers, enabling them to continuously adjust how they inhabit a place. Developmental process is fundamental so that once designers and project leaders withdraw, the project can persist within a local governance dynamic (Interviewee 2 and 5).
14. **Empowering design** : Five professionals emphasized the importance of a design approach that gives autonomy to the system in which the solution is embedded, enabling it to self-organize, self-regenerate, and pursue its evolutionary trajectory with minimal external intervention. Interviewee 3 recalls the principles of *autopoiesis* and *self-regulation* in planetary living systems, which should inspire us to envision decentralized interdependencies. Interviewees 2 and 5 add that consciousness should be reinforced "*to enable an entity to evolve, originating in its essence [...] to start a next level of process of evolution*" (Interviewee 5).

Taken together, these insights demonstrate strong convergence between the proposed theoretical framing of this principle and its practical relevance across multiple contexts and actors.

Discussion and Conclusion

The proposed conceptual framework was preliminarily tested through interviews with regenerative design (RD) experts. Aiming to guide design decisions aligned with socio-ecological goals, it should help industrial teams create regenerative value for both social and natural ecosystems. This marks a first step toward validating the fourteen identified principles. However, the current empirical base—six interviews, including two from the same

institute—remains too limited and potentially biased. Expanding the literature review and conducting further expert interviews is necessary.

Moreover, confronting the RD principles from the literature with practitioners' experience and industrial specificities revealed several barriers to implementation, such as:

- **Lack of ecosystem knowledge and inadequate measurement and cooperation tools:** Designing regeneratively requires an in-depth environmental assessment. Yet, as several interviewees noted, most assessment tools are ill-suited to support regenerative approaches, making it hard to evaluate effectiveness.
- **Persistent anthropocentric mindset:** A dominant tendency persists to see the living world as a resource for human benefit, rather than recognizing its intrinsic value. Social representations still influence design choices, as "big" and "massive" remain reassuring to customers (Interviewee 3).
- **Dissonance with the dominant industrial system:** Industrial design often follows linear trajectories with fixed or deterministic visions, poorly suited to systemic, uncertain, and dynamic contexts. Moreover, the prevailing model favors mass production, centralized ownership, and quick returns, while regenerative projects require shared long-term vision and upfront investment, with benefits that are often delayed, diffuse, or non-monetary.

Interviewees acknowledged the framework's relevance but also their limited experience applying regenerative thinking in industrial settings. To enhance transposability, the principles should be compared to existing industrial frameworks and tools—both conceptually, possibly under different terms, and practically. The next step is to engage industrial professionals directly to assess the framework's relevance, applicability, and usability in manufacturing. Further empirical testing will help refine the framework to support regenerative value creation in industrial design.

While this paper focuses on the value proposition dimension of business models, achieving net-positive impacts also requires rethinking contractual models. Regardless of design intent, positive outcomes cannot emerge if solutions remain embedded in volume-based contractual logics, and if manufacturers lack incentives. As contracts formalize the terms of exchange —monetary and otherwise—they shape industrial incentives by defining performance metrics and strategic behaviors. They are thus key levers for aligning industrial practices with regenerative goals. Yet, their role remains underexplored in the regenerative business model literature. Future work must address not only what to incentivize—regenerative value creation—but also how to embed it into the structures guiding industrial dynamics and decision-making.

References

Attia, S. (2018). Regenerative and Positive Impact Architecture: Learning from Case Studies. Springer Briefs in Energy; Springer International Publishing AG: Cham, Switzerland. 10.1007/978-3-319-66718-8

Blanco, E., Pedersen Zari, M., Raskin, K., & Clergeau, P. (2021). Urban Ecosystem-Level Biomimicry and Regenerative Design: Linking Ecosystem Functioning and Urban Built Environments. *Sustainability, 13*(404).

Casadesus-Masanell, R., & Ricart, J. E. (2010). From Strategy to Business Models and onto Tactics. *Long Range Planning, 43*(2), 195-215.

Clergeau, P., Blanco, B. (2022). Projets urbains régénératifs : de l'idée à la méthode. *Métropolitiques*, Id: hal-03767218

Das, A., & Bocken, N. (2024). Regenerative business strategies. *Sustainable Production and Consumption, 49*, 529-544.

Du Plessis, C., Brandon, P., (2015). An ecological worldview as basis for a regenerative sustainability paradigm for the built environment. *Journal of Cleaner Production*. *109*, 53–61.

Dyllick, T., & Muff, K. (2016). Clarifying the Meaning of Sustainable Business: Introducing a Typology From Business-as-Usual to True Business Sustainability. *Organization & Environment, 29*(2), 156-174.

Foissac, M., Jouault, C., Dumasny, R., Foissac, G. (2022). Du design bio-inspiré au design systémique : la régénération à l'épreuve des pratiques de design. *Sciences du Design*, *16*, 86-101

Hahn, T., & Tampe, M. (2020). Strategies for regenerative business. *Strategic Organization, 19*(3), 456-477.

Hoxie, C.; Berkebile, R.; Anntodd, J. (2012). Stimulating regenerative development through community dialogue: Regenerative design and development. *Building Research & Information*, *40*(1), 65-80

Konietzko, J., Das, A., Bocken, N. (2023). "Towards regenerative business models - A necessary shift? *Sustainable Production and Consumption, 38*, 372–388

Mang, P., et Reed, B. (2012a). Regenerative Development and Design, *Encyclopedia Sustainability Science & Technology, Regenesis Group and Story of Place Institut*e, 2112(303)

Max-Neef, M. (1991). Human Scale Development: Conception, Application and Further Reflections. With contributions from Antonio Elizalde and Martin Hopenhayn. *The Apex Press New York and London*. ISBN 0-945257-35-X

Osterwalder, A., & Pigneur, Y. (2010). Business model generation: A handbook for visionaries, game changers, and challengers. John Wiley & Sons.

Pavez, F.; Maxwell, D.; Bunster, V. (2024). Towards a Regenerative Design Project Delivery Workflow: A Critical Review. *Sustainability Review, 16*(13), 5377, 1-10

Reed, B. (2007). Shifting from ‘sustainability’ to regeneration, *Building Research & Information, 35*(6), 674-680.

Rockström, J., Gupta, J., Qin, D.,, Lade, S., Abrams, J., Andersen, L., McKay D.A., ,Bai, X., Bala G., Bunn, S., Ciobanu, D., DeClerck, F., Ebi, K., Gifford, L., Gordon, C., Hasan, S., Kanie, N., Lenton, T., Loriani, S., Liverman, D., Mohamed, A., Nakicenovic, N., Obura, D., Ospina, D., Prodani, K., Rammelt, C., Sakschewski, B., Scholtens, J., Stewart-Koster, B., Tharammal, T., van Vuuren, D., Verburg, P., Winkelmann, R., Zimm, C.,Bennett, E.,

Teece, D.J. (2010). Business Models, Business Strategy and Innovation. *Long Range Planning 43*(2010). 172-194

Toner, J.; Desha, C.; Reis, K.; Hes, D.; Hayes, S. (2023). Integrating Ecological Knowledge into Regenerative Design: A Rapid Practice Review. *Sustainability*, *15*(13271). 1-29

Upward, A., & Jones, P. (2016). An Ontology for Strongly Sustainable Business Models. *Organization & Environment, 29*(1), 97-123.

Vivien, F.-D. (2009). Les modèles économiques de soutenabilité et le changement climatique. *Regards croisés sur l’économie, 6*(2), 75-83.

Authors' Note

This work was carried out with the assistance of three generative AIs for the following tasks:

- Transcription of semi-structured interview recordings (via Zoom’s AI Companion)
- Editing and formatting of transcripts, including correction of AI Companion’s errors and removal of timestamps (via OpenAI’s ChatGPT)
- Support in synthesizing ideas, refining syntax, and rephrasing certain passages for improved readability (via OpenAI’s ChatGPT)
- Translation from French to English (via OpenAI’s ChatGPT)
- Identification of relevant complementary papers and articles for the literature review (via Consensus App)

Appendices

Appendix 1 : Twenty two first principles initially coded during literature review.

	Principes / Articles	Code	Blanco et al (2021)	Clergeau et Blanco (2022)	Mang & Reed (2012a)	Pavez et al. (2024)	Reed (2007)	Foissac et al. (2022)	Du Plessis & Brandon (2015)	Hoxie et al. (2012)	Attia (2018)	Toner et al. (2023)
1	Ecocentred design	#CodeRDprincip_écocentrisme	x	x	x	x	x	x	x	x	x	x
2	Place-based design	#CodeRDprincip_ancrage	x		x	x	x	x	x	x	x	x
3	Designing with and from unique essence	#CodeRDprincip_unicité	x	x	x	x	x	x	x	x	x	x
4	Designing with and from diversity	#CodeRDprincip_diversité										
5	Potential oriented design (rather than problem)	#CodeRDprincip_potentiel			x	x	x	x	x	x		x
6	Applying systems and interdependencies thinking	#CodeRDprincip_systémic	x	x	x	x	x	x	x	x	x	x
7	Holistic design	#CodeRDprincip_holisme	x	x	x	x	x	x	x	x	x	x
8	Respectfully integrating the system's motif-patterns	#CodeRDpricinp_motif-pattern	x	x	x	x	x	x	x	x		x
9	Teleological/intentional design	#CodeRDprincip_téléologie			x	x	x	x	x	x		x
10	Circular design	#CodeRDprincip_Circularité	x		x	x					x	x
11	(net)Positive impact design	#CodeRDprincip_positiv	x		x	x	x	x	x	x	x	x
12	Design for reciprocity	#CodeRDprincip_réciprocité	x	x	x	x	x	x	x		x	x
13	Design to support ecosystem services	#CodeRDprincip_soutienSE	x	x	x	x		x		x	x	x
14	Dynamic design to integrate a dynamic environment	#CodeRDprincip_dynamic	x	x	x	x	x	x	x		x	x
15	Design for the resilience and robustness of the system	#CodeRDprincip_robust-résil	x	x	x	x	x	x	x	x	x	x
16	For coevolution and long terme adaptability	#CodeRDprincip_coévolution	x	x	x	x	x	x	x	x	x	x
17	Design to empower/ give autonomy to the system	#CodeRDprincip_autonomie	x	x	x	x	x	x	x		x	x
18	Participative design	#CodeRDprincip_particip		x	x	x	x	x	x	x	x	x
19	Efficient use of local and/or carbon incorporated	#CodeRDprincip_matériaux	x	x	x	x		x	x		x	x
20	Pratiques de processus dévelopemental	#CodeRDpractices_developmental			x	x	x	x				
21	Principe d'harmonie	#CodeRDprincip_harmony	x	x	x	x	x	x	x	x	x	

Appendix 2 : Fourteen structuring principles selected for addressing RD to build the conceptual framework

		Principes / Articles	Blanco et al (2021)	Clergeau et Blanco (2022)	Mang & Reed (2012a)	Pavez et al. (2024)	Reed (2007)	Foissac et al. (2022)	Du Plessis & Brandon (2015)	Hoxie et al. (2012)	Attia (2018)	Toner et al. (2023)
Relation to the living world	1	Ecocentred design	x	x	x	x	x	x	x	x	x	x
	2	Place-based design	x		x	x	x	x	x	x	x	x
	3	Designing with and from unique essence	x	x	x	x	x	x	x	x	x	x
	4	Potential oriented design (rather than problem)			x	x	x	x	x	x		x
Relation to complexity	5	Holistic design	x	x	x	x	x	x	x	x	x	x
	6	Reading the system's patterns to design within interdependencies	x	x	x	x	x	x	x	x		x
	7	Teleological design			x	x	x	x	x	x		x
Relation to the role of human beings	8	Circular design	x	x	x	x		x	x		x	x
	9	Cooperative design		x	x	x	x	x	x	x	x	x
	10	Positive impact and mutually beneficial design	x	x	x	x	x	x	x	x	x	x
	11	Design to support ecosystem services	x	x	x	x		x		x	x	x
Relation to time	12	Design for the resilience and robustness of the	x	x	x	x	x	x	x	x	x	x
	13	Developmental design for lasting harmonious coevolution seeking dynamic balance	x	x	x	x	x	x	x	x	x	x
	14	Design to empower autonomy and spontaneous self organization of the system	x	x	x	x	x	x	x		x	x

Appendix 3 : List of interviewees and profiles

Interviewee	Profile	Experience
Interviewee n°1	practitioner, lecturer, and author	50 years of leadership in ecological and regenerative practice of which 29 years experience exploring regenerative development and design. Interviewee n°1 is an internationally recognized architect, planning consultant, facilitator, lecturer, and author in sustainability and regenerative development. Interviwee n°1 has a strong pedagogical and advisory presence internationally (Harvard, MIT, UPenn, etc.) He is a principal at a leading regenerative design and education organization, and a partner in organization, which invests in regenerative ESG real estate. A pioneer in the green building movement, Interviewee n°1 co-founded the U.S. Green Building Council and the LEED rating system. He has served on numerous national committees and co-authored the influential book The Integrative Design Guide to Green Building. Over his career, he has consulted on more than 200 green and regenerative projects across buildings, city master plans, and industry sectors worldwide. Interviewee n°1's work focuses on developing living system design processes that go beyond sustainability—supporting people and organizations in co-evolving with the places they inhabit. His approach centers on unlocking the unique potential of individuals, communities, and ecosystems by working with nested wholes and living systems.
Interviewee n°2	chercheur	Interviewee n°2 is an environmental engineer, urban planner, and PhD holder in regenerative design. He has extensive international experience (Brazil, France, UN) in ecological transition, sustainable urban planning, active mobility strategies, and water management. His doctoral research focused on applying biomimicry and regenerative principles to urbanism and architecture, conducted in partnership with CEEBIOS. He is currently a project coordinator in a European network representing over 1,000 municipalities, where he leads EU-funded initiatives on ecological and energy transition. Interviewee n°2's scientific and operational expertise a rare profile combining academic depth (PhD) with hands-on work in cities and policy-driven projects; with ecosystem-centered approach focused on delivering positive impacts for both nature and society, grounded in local realities makes a strong voice on regenerative design. Systemic thinking bringing together governance, value chains, and co-creation as core levers for regeneration; along with interviewee n°2's real-world experimentation with municipalities, industry, and innovation labs to test and apply regenerative approaches in practice are real plus for the interviews.
Interviewee n°3	practitioner	Interviewee n°3 is one of the pioneers of the regenerative paradigm in France. As a consultant, author, and speaker, he brings a unique perspective at the intersection of biomimicry, biodiversity expertise, ecosystem services, and socio-ecological regeneration. For over 20 years, he has explored the links between economics, biodiversity, and systemic innovation, supporting businesses, territories, and institutions in their transition toward more resilient, fulfilling, and regenerative models of organization. Author of several books on the relationship between economics and ecology, Interviewee n°3 has been commissioned by the French government for missions related to biodiversity-based employment. His approach stands out through a rare combination of economic expertise and deep knowledge of biomimicry, which he uses to help reconnect human systems with the living world and build a regenerative economy. Interviewee n°3's work is reinforced by multiple institutional roles — President of INTER-MADE, Secretary General of the French Committee of IUCN, Member of the CEEBIOS Ethics Committee, Member of the INDDIGO Mission Committee, and Founder of the INSPIRE Institute — as well as entrepreneurial initiatives, including co-founding the consultancy company and co-authoring the Regenerative Economy Fresk.
Interviewee n°4	chercheur & practitioner	Interviewee n°4 is a designer, researcher, and founder of an innovation agency, pioneer of biomimicry applied to design in France, he has spent over fifteen years exploring the living world as a source of inspiration to create sustainable solutions. His hybrid approach—at the intersection of science and design—has led him to collaborate with numerous research centers and major industrial groups such as L'Oréal, Saint-Gobain, Renault, and Volvo on topics ranging from mobility and energy to food systems, housing, space, and beauty. He leads the "Nature-Inspired Design" master's program at ENSCI – Les Ateliers, trains future designers of the living at the Nantes School of Design, and also teaches at Sciences Po. He has led over forty interdisciplinary projects, given more than three hundred lectures worldwide, participated in over thirty international exhibitions, contributed to specialized books and journals, and appeared in a wide range of documentaries and broadcasts. Recognized for his systemic and critical perspective on design, he develops objects, materials, and systems intended to revitalize the environments they inhabit, with a strong emphasis on socio-ecological regeneration. Advocating for innovation grounded in ecosystem understanding, de-anthropocentrized design practices, and ethics of the living world, he stands out as a leading voice in regenerative design both in France and internationally.
Interviewee n°5	chercheur & practitioner	Interviewee n°5 is a pioneer in regenerative development and a co-founder of both the Regenesis Group and the Regenesis Institute for Regenerative Practice. For over four decades, she has been transforming how we approach planning, design, and development by integrating living systems thinking and a deep understanding of place-based identity. Her work focuses on guiding complex projects—from land use to strategic planning—by helping teams build their capacity for critical thinking and holistic design, rooted in the unique ecological and cultural dynamics of each context. She has been a lead instructor of The Regenerative Practitioner series since its launch in 2013, training professionals around the world in place-sourced regenerative practice. Interviewee n°5 is also the co-author of a foundational book about Regenerative Development and Design, which offers a clear framework for embedding regenerative principles into real-world practice, illustrated with concrete examples. Based in Santa Fe, New Mexico, Interviewee n°5 continues to play a central role in advancing the field of regenerative design—emphasizing the co-evolution of human and natural systems, and championing inner transformation as a critical lever for lasting, systemic change.
Interviewee n°6	practitioner	Interviewee n°6 is an ecological engineer, biologist, co-author and one of the pioneers of biomimicry in France. A specialist in integrated management of natural environments, he led the "Science and Environment" department of the Cousteau Team for thirteen years, where he conducted scientific expeditions and conservation projects in fragile marine ecosystems such as the Red Sea and the polar regions. He is currently Director of the Biomimicry Program and an associate expert in two firms, where he develops training and strategy programs to embed living systems principles into innovation and ecological transition processes. A founding member of the French committee of Biomimicry Europa and of the European Center of Excellence in Biomimicry (CEEBIOS), Interviewee n°6 has spent over two decades advancing biomimicry as a tool for systemic transformation. Interviewee n°6's approach goes beyond reducing negative impact; it seeks to build a regenerative economy by drawing inspiration from the intelligence of natural ecosystems such as forests and coral reefs. As one of the leading figures in nature-inspired design for regenerating ecosystems, Interviewee n°6 is part of the pioneering collective of French experts in socio-ecological regeneration. He brings a deeply systemic, operational, and field-based perspective, grounded in an intimate understanding of living systems and their transformative potential.

Appendix 4 : Questions asked during interviews

Question number	Approximative timing	Topic	Question
Introduction	5 to 6 minutes each	Introduction	Self presentation
Question 1	about 10 min	Principles and Practices of Regenerative Design	In your opinion, what are the fundamental principles and practices of regenerative design?
Question 2	about 10 min	Transposing RD Principles into Industry	If you were to apply the principles and practices we've just discussed to the manufacturing sector, how would you go about it? Have you come across any attempts to do so in that context?
Question 3	about 10 min	Potentials and Barriers to RD in Industry	What specific opportunities and regenerative potentials do you see in manufacturing industries? On the other hand, what structural barriers or constraints do you perceive in industrial environments?
Question 4	about 10 min	Identifying Regenerative Potentials for Strategic Diversification	In my fieldwork, I've encountered manufacturers whose current activities are quite distant from the living world, but who are willing to explore regenerative strategic diversification through innovation units. If you were to support such companies in identifying their regenerative potentials to develop a "Regen by Design" solution, how would you proceed? What would your approach look like, and how would it translate concretely?
Conclusion	about 3 minutes	Conclusion	