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Regenerative Design And Open Systems: Material, Social, And Economic Reactivation In Post-Disaster Emergency Scenarios

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Abstract:
Background: *Extreme weather events and socio-environmental disasters have exposed the limitations of conventional reconstruction models. Standardised solutions ignore local productive capacity, creating a paradox of critical scarcity in the face of idle resources. In the field of design, especially in the development of emergency furniture, more ethical responses that integrate environmental, productive and social criteria are needed. Based on the theoretical intersection between regenerative design, circular economy and distributed economy, this research proposes an innovative approach to guide solutions in post-disaster contexts, with an emphasis on materiality and local production systems and open systems, among other strategies.*
Materials and Methods: *This is a qualitative and exploratory research, structured by theoretical foundations, a critical analysis of the ReMakeRS Challenge (2024) case study, and the systematisation of design guidelines. The analysis focused on the selection of materials, construction systems, and production strategies applicable to post-disaster reconstruction.*
Results: *The results indicate that the adoption of renewable, recycled or low environmental impact materials, associated with circularity and simple and modular construction systems, favours local production viability, the reduction of environmental impacts and the replicability of solutions. The guidelines were summarised in a table organised by environmental, social, productive, logistical and systemic dimensions.*
Conclusion: *It is concluded that the intersection between the concepts forms a consistent basis for the development of furniture in post-disaster contexts, but goes beyond the object,*
contributing to more environmentally appropriate, productively viable, and territorially articulated solutions, in addition to broadening perspectives for research in sustainable design. The research points to the need for future studies that validate the technical and economic viability of the model and investigate public policy instruments for its expansion. It is concluded that the approach transcends the provision of objects, positioning design as a facilitator of resilient infrastructures, capable of transforming crises into opportunities for endogenous and fair territorial regeneration.

Keywords: *Regenerative Design; Circular and Distributed Economy; Post-Disaster Furniture; Open Systems.*

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I. Introduction

The Anthropocene has been marked by the intensification of intertwined socio-environmental crises, where extreme weather events and forced displacements are not exceptions, but characteristics of a new global normality. In Brazil, this reality is manifesting itself with increasing drama. In February 2023, extreme rainfall on the northern coast of São Paulo triggered a series of landslides that resulted in 64 deaths, left 2,800 people homeless and 1,300 displaced, and blocked or destroyed around 790 buildings [16] Just one year later, in 2024, Rio Grande do Sul was hit by the worst climate disaster in its history. The floods affected 2.3 million people in 478 municipalities, causing 175 deaths, 806 injuries and leaving 85 missing. The economic impact was devastating, with approximately 100,000 commercial establishments severely affected.[15]

These events are not isolated phenomena, but symptoms of a global climate crisis that is causing mass displacement. In 2022, climate-related disasters caused 32.6 million new internal displacements worldwide, with floods accounting for more than half of this total. [18]

At the same time, conflicts and persecution raised the total number of forcibly displaced people to 110 million in 2023, including 36.4 million refugees, according to reports by the United Nations Refugee Agency UNHCR.[18]

This dual scenario—of severe climate disasters and forced displacement—exposes the profound limitations of conventional emergency response models.

The conventional model, characterised by the distribution of standardised temporary shelters and industrialised furniture from distant sources — often manufactured with reconstituted panels that use formaldehyde-based resins, a recognised carcinogen[17] — reveals a double structural gap. First, it systematically disregards local productive capital — carpentry shops, workshops, and small businesses that, even when affected by the crisis, retain idle capacity and valuable know-how. Second, it perpetuates a vicious cycle of dependence and extraction, in which financial resources are channelled into external supply chains, while local economies, already weakened, remain inactive. Such an approach is not only inefficient in the long term, but also wastes a historic opportunity to convert reconstruction into an active process of economic and social regeneration, [25]

It is in this context of insufficiency that this research fits in, proposing a regenerative model for post-crisis reconstruction. The proposal is structured around three interconnected pillars, designed to transform the immediate need for shelter and furniture into a vector for systemic recovery:

1. **Open and modular systems:** development of an accessible project library under open licences (e.g., *Creative Commons*), containing digital files for both traditional and digital manufacturing (laser cutting, CNC), ensuring replicability, adaptability, and local reparability; [8;]
2. **Regenerative and non-toxic materials:** selection of materials from renewable sources that are intrinsically resilient, non-toxic and reusable, suitable for both emergency contexts and permanent resettlement, prioritising human health and circularity; [7; 17]
3. **Distributed economy and productive inclusion:** Activation of small entrepreneurs, artisans, and local workshops as central agents in the production chain, fostering the regeneration of the economic fabric from within and promoting economic justice. [25; 32]

Anchored in the fundamentals of regenerative design [30;37] this approach transcends the logic of merely providing products or mitigating damage. Its goal is to create systems that restore and amplify the socio-ecological capacity of the territory, converting the response to disaster into a catalyst for the development of more resilient, diverse, and autonomous local ecosystems. By integrating material innovation, technological democratisation, and productive inclusion, the research argues that it is possible to address climate and humanitarian crisis not through welfare, but through a process of regenerative co-creation, [33] which dignifies affected populations and promotes sustainable and distributed futures.

II. Material And Method

This research is characterised as a qualitative, exploratory and applied study, situated in the field of design research, in which knowledge generation occurs through the articulation between theoretical foundations and project development. [10; 5] Regenerative design constitutes the central theoretical-methodological framework, positioning design activity as a catalyst for integrated transformation in the social, environmental and economic dimensions. [22;23;30;36]

From a methodological point of view, we opted for the case study strategy, considering its relevance for investigating contemporary phenomena in real and complex contexts, where the boundaries between the object of study and its surroundings are fluid. [39] The methodological approach was structured in four interdependent and iterative stages:

1. **Narrative-analytical literature review:** a critical survey and analysis of the literature on regenerative design, social and humanitarian design, distributed economy, and modular construction systems was conducted to establish the conceptual framework of the research;
2. **Definition of regenerative design criteria:** based on the theoretical foundation, guiding criteria were established for the development of the project, prioritising attributes such as modularity, reduction of components, ease of assembly without specialised tools, feasibility of local production, and promotion of environmental health;
3. **Development of the case study via *Research Through Design*:** the design stage was operationalised using the *research through design* approach. [13;10] The ReMakeRS Challenge (2024) was selected as the main empirical case study. This initiative, on post-disaster emergency furniture solutions, served as the applied context for exploring, testing, and reflecting on the materialisation of theoretical principles, using the research design and prototyping process. [30]
4. **Critical analysis and synthesis of guidelines:** finally, a qualitative and interpretative analysis of the results and learnings derived from the case study was carried out, comparing them with the theoretical framework, with the aim of synthesising a set of design guidelines that articulate theory and practice in the field of regenerative reconstruction.

Regenerative Design: beyond sustainability

Regenerative design represents a paradigmatic evolution from conventional approaches to sustainability. While the latter focus on mitigating negative impacts, regenerative design proposes an ambitious advance: designing systems that actively restore, revitalise and enhance the capacity of socio-ecological ecosystems (Wahl, 2020). This perspective radically redefines design practice, transforming the designer from a solver of specific problems into a catalyst for systemic processes of healing and evolution.

The theoretical foundations of this approach emerge from the convergence of interdisciplinary currents of thought. Lyle's seminal work (1994), in establishing that human systems should operate as living ecosystems — where the waste from one process becomes a resource for another — shifted the goal of design from mere efficiency to active restoration. This vision was expanded by Mang and Reed (2012), who articulates regenerative design as a practice aimed at developing the evolutionary capacity of living systems. In this conceptual framework, the focus shifts from the creation of objects to the cultivation of processes and relationships that continuously increase the vitality of places, seeking evolution towards states of greater health, resilience, and life-support capacity. [6]

Its operating principles—systems thinking, co-evolution, and increased vitality—are particularly relevant in post-disaster contexts. In these scenarios of disruption, the regenerative approach offers a framework for transcending reactive reconstruction, promoting a positive multidimensional transformation:

1. **Economic regeneration:** reactivation of local economic cycles through decentralised production and income generation, building systems that are less dependent on vulnerable global chains. [24] This dimension aligns with the precepts of the circular economy, which advocates keeping resources in use for as long as possible; [12]
2. **Social regeneration:** strengthening community ties and rebuilding social capital through collective work and co-creation. [33; 17] It is recognised that communities with strong networks and collective purposes are intrinsically more resilient;
3. **Ecological regeneration:** prioritising renewable, non-toxic materials and low-impact production processes, designed to be reused, repaired or reinserted into biological or technical cycles, embodying the principles of circularity.

In the specific context of climate disasters and forced displacements, regenerative design therefore offers an integrated response that recognises the interdependence between ecological health, social well-being and economic vitality. As Birkeland (2008) points out, such approaches convert contextual limitations into opportunities for systemic innovation, generating solutions that are both locally adapted and globally relevant.

Distributed economy and productive inclusion

The concept of distributed economy, articulated by Ezio Manzini (2016) in the context of design for social innovation, is an alternative socioeconomic model to centralised and globalised production paradigms. It is based on the organisation of production systems based on local, collaborative and small-scale networks that are highly connected and adapted to the territorial context. This is not mere decentralisation, but a profound reconfiguration of the relationships between production, consumption and community, in which value creation is intrinsically linked to the strengthening of social ties and the regeneration of local ecosystems.[24]

This model dialogues with theoretical currents that value local autonomy and shared governance. It is similar, for example, to Elinor Ostrom's (1990) theory of *the commons* and polycentric governance, which highlighted the capacity of communities to manage collective resources sustainably through constructed social arrangements. It also resonates with the principles of Murray Bookchin's (1982) social ecology, which advocated for self-managed societal units at the municipal level ( ). In the field of design, this vision is materialised in the creation of "social infrastructures" — platforms and networks that enable people to meet collective needs in a collaborative and localised manner.[24]

In post-disaster contexts, such as those resulting from floods or forced displacement, the distributed economy proves to be strategic and transformative, offering structural responses to key challenges:

1. **Strengthening territorial economic sovereignty:** by reducing dependence on long and vulnerable global logistics chains, local production networks increase community resilience. Local production of essential goods allows financial resources to circulate and multiply within the affected territory itself, activating a local economic multiplier and initiating a virtuous cycle of recovery, in line with endogenous development visions; [32]
2. **Agility and adaptability in response:** the flexible and less hierarchical nature of distributed networks allows specific and changing needs to be identified and responded to more quickly than centralised systems. This location-sensitive responsiveness is crucial in the immediate post-disaster phases;
3. **Productive inclusion and reconstruction of the social fabric:** perhaps the most regenerative aspect of this model is its ability to convert passive victims into active agents of reconstruction. By integrating small entrepreneurs, artisans, and local workers—many of whom have also been affected—into a productive network, it promotes not only income generation but also the restoration of social capital and a sense of collective agency,

which are fundamental elements for psychosocial recovery. [2] It is, therefore, a practice of design for dignity, replacing the logic of welfare with self-determination.

In this way, the distributed economy provides the operational socioeconomic structure necessary to materialise the principles of regenerative design and open modularity. It constitutes the implementation system that transforms local inputs and knowledge into concrete material solutions, simultaneously generating shelter, work, and a sense of collective reconstruction. The response to disaster thus transcends the emergency, becoming a political and economic project of regenerative and emancipatory reconstruction.

Project Design: furniture modularity, its systemic evolution and the legacy of Michel Arnoult

Modularity in furniture transcends its status as a mere production strategy, becoming a fundamental design premise for flexibility and resource optimisation in the built environment. Historically, its concept emerged concurrently with the transition from artisanal manufacturing to mass production, finding in Michael Thonet and his revolutionary wood bending technique one of the first examples of interchangeable components and optimised logistics. [34]

However, it was within the Modernist Movement that modularity became established as a coordinated system. Le Corbusier's seminal contribution, with the development of *the Modulor* (1943), institutionalised dimensional standardisation based on harmonic proportions — founded on the Golden Ratio and the Fibonacci sequence — and anthropometric scale. More than a table of measurements, the *Modulor* proposed a universal visual grammar, ensuring coherence and ergonomics in the relationship between furniture and architectural space (Corbusier, 2000). Its relevance lies precisely in giving industrial production a human scale, defining parameters for work surfaces, seats and other elements, ensuring integration and comfort.

After the Second World War, material shortages and the urgent need for mass housing catapulted modularity to *the status* of domestic infrastructure. Designers such as George Nelson, with his *Storage Wall* concept (1945), and Dieter Rams, with the *606 Universal Shelving System* (1960), promoted the dematerialisation of objects in favour of modular systems. These proposals transferred the capacity for spatial and functional reconfiguration to the user, anticipating, through modular coordination, the contemporary principles of *Design for Disassembly* (DfD) and circular economy. [11;29]

In the Brazilian context, this line of thinking found paradigmatic expression in the work of French-Brazilian designer Michel Arnoult. In the 1960s, his Peg-Lev line was a seminal milestone, anticipating with remarkable vision central principles of contemporary sustainability and resilience. Developed in a scenario of intense industrialisation and urban expansion, the Peg-Lev system responded to the demand for affordable, functional and adaptable furniture. Based on extreme modularity, complete disassembly, optimised logistics and autonomy of assembly by the end user, it not only revolutionised the market by popularising the concept of *flat-pack*, but also demonstrated the feasibility of reconciling scale production, economic accessibility and user empowerment. [34;21]

Arnoult's contribution is part of a broader design lineage that values the rationalisation and democratisation of the object. His work dialogues directly with the precepts of social and critical design of Victor Papanek (2017), who advocated for the ethical responsibility of the designer and the creation of solutions appropriate to real human needs, especially in contexts of scarcity. Peg-Lev materialised this vision by offering not a product, but a system of several products where the components are common, they are modules for building other pieces that, when recomposed, formed other pieces of furniture to serve different functions and spaces.

Digital Manufacturing and Open Systems: Productive Autonomy and Resilience

Arnoult's strategic legacy finds direct resonance in contemporary open design movements and maker culture. Initiatives such as WikiHouse and OpenDesk [8;26] operate under a similar logic of dematerialisation and distribution: instead of marketing end products, they provide digital files (blueprints) that enable local, on-demand manufacturing, usually through computerised numerical control (CNC) technologies.

Such platforms radicalise the concept of autonomy proposed by Arnoult, transferring not only assembly but also manufacturing itself to local and community spheres. They are based on the do-it-yourself (DIY) philosophy and the culture of participation[19] in which users take on the role of active co-creators. Licensing under Creative Commons Attribution-ShareAlike (CC BY-SA) is central to this ecosystem. This licence, analogous to *copyleft* in free software, allows the use, remixing, adaptation and even commercial exploitation of projects, provided that credits are attributed to the original authors and that derivative works are shared under the same terms. This legal mechanism ensures the perpetuation of openness and stimulates a continuous cycle of collaborative innovation and contextual adaptation.

The connection between Arnoult's legacy and these current movements is therefore deeply philosophical. Both share the premise that modularity is a superior strategy for resilience. In dynamic and uncertain contexts, such as post-disaster scenarios, the ability to adapt, repair, and reconfigure artefacts becomes critical. A modular system enables:

1. **Spot Repair:** The specific replacement of damaged components, rather than the entire object, dramatically extends its useful life and reduces waste.
2. **Functional Reconfiguration:** The same set of parts can meet different needs over time (e.g., a bookcase that converts into a partition or temporary shelter furniture).
3. **Efficient Logistics:** *Flat-pack* transport and storage reduce costs and operational complexity, a decisive factor in emergency situations with compromised infrastructure.

This approach is fully aligned with the principles of the circular economy and *Design for Disassembly* (DfD) [17] which aim to ensure the recovery and recyclability of materials at the end of a product's life cycle. In this way, modularity transcends practical convenience to become an instrument of material regeneration, facilitating maintenance, updating, and the responsible closure of resource cycles.

In summary, analysis of the trajectory from *Peg-Lev* to contemporary open digital systems reveals a continuous evolution of the concept of decentralised productive autonomy. What Arnoult inaugurated as an industrial response to the needs of a developing society finds its most radical unfolding in digital networks that empower communities to design, manufacture, and adapt their own material solutions. This lineage provides the essential historical-conceptual substrate for this research proposal: a post-disaster regenerative system that combines the modular intelligence of modernism with the open, distributed, and collaborative tools of the digital contemporary world.

Case Study: Remakers Challenge As An Empirical Reference

The practical application of the revised theoretical foundations finds empirical resonance in the ReMakeRS Challenge (2024), a paradigmatic case study in the field of design applied to emergency contexts. This initiative, coordinated by a network of universities, digital fabrication laboratories (*FabLabs*) and professional designers, was conceived as a rapid response to the urgent material demands generated by the catastrophic floods in Rio Grande do Sul in 2024. Its central objective was to promote the development of low-cost furniture that was easy to manufacture and assemble, aimed at restoring the habitability of affected homes.

Structurally, ReMakeRS positions itself at the intersection between material reconstruction and social recovery, proposing to reestablish the domestic environment through essential furniture that meets fundamental daily activities. It therefore adopts a design approach guided by functionality, economic accessibility, and immediate production feasibility. [31]

An analysis of its call for proposals identifies criteria that directly dialogue with the specialised literature on design for emergencies:

1. **Systematisation of supply:** development of furniture families (limited to four pieces), promoting functional coherence and overcoming isolated solutions;
2. **Focus on domestic activities:** focus on the primary needs of food, hygiene, rest, and organisation;
3. **Emphasis on resilient strategies:** prioritisation of modular solutions that are easy to replicate and assemble autonomously;
4. **Openness and democratisation:** making projects available in open digital files, facilitating reproduction, adaptation and distributed manufacturing.

These aspects establish ReMakeRS as an interesting empirical reference for investigating the role of design in post-disaster reconstruction processes. Its logic of modularity, constructive simplification, and open licensing establishes explicit conceptual interfaces with the principles of social design, distributed economy, and open innovation.

However, a critical analysis reveals a substantive contradiction: although the structure of the challenge incorporates relevant advances in organisation, modularity, and dissemination, the materiality of the proposals tends to resort to conventional industrialised sheets. Such materials, although easily accessible and reasonably priced, remain associated with significant environmental impacts and potential health risks due to the use of synthetic resins, representing a departure from regenerative principles.

Thus, ReMakeRS is adopted in this research not as a conclusive model, but as an exemplary and analytical case. It serves to simultaneously elucidate the potentialities of a systemic and open design response, and the gaps and tensions still present, especially with regard to material choice, environmental regeneration, and integration with local production chains. Confronting this case with the regenerative design *framework* thus allows us to map points of convergence and dissonance, contributing to critical reflection on the evolution of design practices in crisis scenarios.

III. Results

After theoretical consolidation and critical analysis of the case study, this research systematises a set of regenerative design guidelines. These guidelines constitute strategic orientations, translating the theoretical references of regenerative design, circular economy, and distributed economy into principles applicable to furniture design for post-disaster reconstruction contexts and socio-environmental vulnerability. They aim to

guide both design practice and future research, functioning as a framework for the conception of interventions that are materially, socially, and economically regenerative.

The first and fundamental guideline establishes the conscious selection of materials as a structuring and ethical act of the project, with direct implications for public health, ecological cycles, local economic viability, and the potential for systemic regeneration. [7]

In post-disaster scenarios, the recurrent use of standard industrialised materials, such as fibreboard panels with formaldehyde-based resins — classified as carcinogenic to humans [17] — poses a double risk. From a health perspective, emissions of Volatile Organic Compounds (VOCs) can persist in confined environments, such as temporary shelters, exacerbating respiratory and allergic problems. [38]. Environmentally, the disposal of these materials generates a contaminating liability, polluting already fragile soils and water resources.

It is therefore proposed to replace them with regenerative materials, selected using a multi-criteria matrix that assesses:

1. **impact on health and ecology**, prioritising non-toxic, low-emission materials from renewable sources with low embodied energy;
2. circularity and performance, favouring durable, repairable, dismantlable, recyclable or compostable materials with adequate technical performance (e.g. mechanical resistance and hydrophobicity for humid environments);
3. **economic and territorial feasibility**, considering cost, regional availability, and potential for boosting local production chains (such as natural fibres and recycled polymers of regional origin).

This replacement of conventional materials should be explored using natural and renewable resources — such as wood from planted forests or certified sustainable management, bamboo, vegetable fibres and recycled polymer composites, for example, recycled matrix *Wood Plastic Composite* (WPC), and panels with bio-based resins, known as "green resins". These alternatives are based on a new generation of regenerative and resilient materials ( ), aligned with a reconstruction guided by health and environmental ethics, with the aim of transcending damage mitigation and generating positive impacts throughout the life cycle of the artefacts.

The selection is part of the same multi-criteria matrix — which measured ecological potential, health impact, circularity, technical performance, and regional economic viability — applied systematically according to the methodology proposed by Ashby (2016), resulting in the recommendation of bio-based compounds and closed-loop technical systems. The operationalisation of the regenerative material selection guideline requires concrete mechanisms for action. It is imperative to establish more ethical technical specifications in tender notices and project manuals, requiring certifications of low emissions of volatile organic compounds (VOCs) — such as the CARB (California Air Resources Board) standard — and prioritising materials with post-consumer recycled content or certified renewable origin. At the same time, mapping local production chains is essential to identify and qualify regional suppliers of alternative materials, such as composite panels with natural resins and local fibres, strategically integrating them into the reconstruction flow. To scientifically validate choices and ensure process accountability, the implementation of post-occupancy evaluation procedures that monitor the health and safety of shelters and rebuilt homes is essential, generating data on the benefits achieved. [3] Therefore, the conscious selection of materials forms the indispensable material basis for an authentic reconstruction system, realising the ethical commitments of the project and building healthier, more resilient and circular foundations. This material foundation is a precondition for the subsequent guidelines on modularity, open systems and distributed economy to reach their full regenerative potential.

The integrated implementation of this set of guidelines aims to catalyse a systemic transformation, generating positive and synergistic impacts in four interconnected dimensions.

In the economic dimension, the model acts as a territorial activator, promoting immediate income generation with a multiplier effect, the systemic reactivation of local production chains, and the creation of a new market paradigm centred on resilient and healthy furniture.

In the social dimension, it promotes psychosocial recovery through the empowerment and restoration of dignity of those affected, transforming them from assisted victims into active protagonists. The process strengthens social capital through co-creation and community management and ensures greater sociocultural and affective adequacy of solutions, which come to reflect local habits and needs.[33]

And in the environmental dimension, the approach ensures a positive legacy by eliminating toxicological risks through the replacement of formaldehyde-emitting materials, contributing decisively to public health. [17;38] The materialisation of the principles of the circular economy is made possible by *design* for disassembly and modularity, which radically extends the useful life of products and minimises waste.[17] In addition, the model can foster a regional bioeconomy by encouraging the local cultivation and processing of natural fibres.

Finally, in the cultural dimension, there is a profound appreciation of local know-how, recognising and projecting technical and ancestral knowledge against the tide of cultural homogenisation, while the narrative of self-managed reconstruction consolidates collective psychosocial resilience. [14;35]

In summary, the convergence between regenerative design, distributed economy, and open systems constitutes an operational prototype of socioeconomic infrastructure. This model of guidelines can act as a lever

for the integral healing of the territory, demonstrating that disaster response can and should be reconceived as a political project of multidimensional regeneration. As a summary of the proposals presented, Table 1 consolidates the fundamental design guidelines and their expected impacts.

Table 1: Design Guidelines and Expected Impacts for the Development of Regenerative Furniture in Post-Disaster Contexts

Dimension	Central Design Guideline	Expected Impacts	Theoretical Basis/Objective
Economic	Activation of local production networks (distributed economy).	1. Income generation with a local multiplier effect. 2. Systemic reactivation of regional production chains. 3. Creation of a market niche for resilient and healthy furniture.	Manzini (2016); Sachs (1986). **Objective:** Transform reconstruction into a vector for endogenous development.
Social	Co-creation and community empowerment in the production process.	1. Empowerment and restoration of dignity for those affected. 2. Strengthening social capital and community governance. 3. Sociocultural, ergonomic, and affective adequacy of solutions.	Sanders & Stappers (2012); Freire (2021). **Objective:** To rebuild the social fabric and promote collective agency.
Environmental	Selection of materials from renewable, non-toxic, and/or recyclable sources that are durable and designed for circularity.	1. Materials and manufacturing processes with less impact and health risks. 2. Extension of the life cycle through reuse, repair, and reconfiguration. 3. Promotion of regional bioeconomies and ecosystem services.	Braungart & McDonough (2002); IARC (2018); Ellen MacArthur Foundation (2013). **Objective:** To ensure health and generate a positive environmental legacy.
Cultural	Valorisation and integration of local know-how into the open system.	1. Documentation and transmission of knowledge. 2. Strengthening regional identity and community pride. 3. Psychosocial resilience based on self-determination.	Santos (2000); Almeida (2021). **Objective:** To counteract cultural homogenisation and reinforce local identity.
Productive/Technical	Development of modular, collapsible and easy-to-assemble systems with open digital files.	1. Ease of transport, storage and autonomous assembly. 2. Adaptability and repairability *on site*, ensuring longevity. 3. Democratisation of manufacturing and contextualised replication.	DfD - Crowther (2005); *Open Design* - Bristow (2017). **Objective:** To ensure material resilience, technical accessibility and replicability.

IV. Discussion

This discussion is based on the theoretical framework developed throughout this research on regenerative design, the circular and distributed economy, and analytical lenses for evaluating design strategies in post-disaster contexts. From this perspective, design is understood not only as a mediator of the form and function of artefacts, but as a structuring agent of socio-economic systems, capable of influencing productive flows, territorial relations and long-term environmental impacts. *36;23;25*

The analysis focuses on a systemic and integrated reading of the materiality, modes of production, economic arrangements, and social dynamics involved in reconstruction, shifting the focus from immediate efficiency to processes oriented towards the regeneration of human and natural ecosystems.

In this context, the *Desafio ReMakeRS* (2024) case study offers fertile ground for a consistent empirical framework to discuss the evolution and persistent challenges of design in emergency situations. The initiative represents a significant advance in the adoption of a systemic and open logic, overcoming fragmented and strictly welfare-based responses. By structuring itself around families of furniture geared towards essential domestic activities, the challenge recognises the domestic environment as the nucleus for the restoration of dignity and normality after trauma. The choice of open digital files (*open design*) and modular systems that can be dismantled

embodies important principles of social design and distributed innovation, providing agility, scalability, and potential for local appropriation—critical attributes in disaster scenarios. [33;8]

However, when confronted with the regenerative design framework, the initiative reveals a fundamental gap that could compromise its long-term legacy: materiality. The prevalence of conventional industrial sheets, based on formaldehyde resins, contradicts the regenerative principle of generating positive impacts on health and the ecosystem. [7; 17] This choice, although pragmatically guided by wide availability, perpetuates a linear model, transfers toxicological risks to vulnerable populations in shelters, and ignores the opportunity to foster healthy and circular material chains. Materiality, therefore, cannot be a mere technical detail; it is an ethical and political design act that structures the entire system. [4]

At the same time, there is a mismatch between the potential for distributed manufacturing, enabled by open archives, and the absence of an explicit distributed economy strategy. The dependence on industrialised materials from long global chains, without a counterpart in local productive activation, undermines the model's transformative potential. The financial capital mobilised for reconstruction tends not to be applied in the affected territory, instead of circulating and multiplying locally in the local economy, as recommended by Manzini (2016) and Sachs (1986). This limitation exposes the need to think about the product system, the production system and the economic system in an integrated way.

It is at this point that the analysis converges on the central diagnosis discussed in this research: the paradox of idle capacity amid critical scarcity. The tragedy in Rio Grande do Sul (2024) brought this paradox into sharp relief: massive demand for furniture coexisted with the paralysis of the local furniture production sector, consisting of carpentry shops, metalworking shops, and workshops. [15] The conventional response, importing standardised solutions, not only disregarded this productive and cognitive capital, but also deepened territorial economic dependence and fragility.

The proposal presented is a direct response to the identified paradox, arguing that overcoming it requires a systemic reconfiguration for which only a regenerative approach offers the appropriate structure. The tripartite model — which interdependently articulates non-toxic and circular materials, open and modular systems, and distributed economy networks — is a roadmap for such a reconfiguration.

Materiality acts as the ethical and ecological foundation of the system. Replacing toxic materials with alternatives selected based on criteria of health, circularity, and local origin reverses the logic of harm, creating the material conditions for healthy indoor environments and long, closed life cycles. This first step aligns the immediate emergency response with the community's long-term goals.

Open systems function as a tool for technological empowerment. Digital file libraries, inherited from the logic of *open design*, transcend the function of mere rapid dissemination to become instruments of empowerment and productive sovereignty. They transfer the power to manufacture, adapt, and repair to the territory, making decentralised production technically feasible.

Finally, the distributed economy establishes the structure for social implementation and regeneration. This pillar converts technical potential into tangible socioeconomic reality. By mapping, accrediting, and integrating local entrepreneurs and artisans into a formal productive network, the model transforms the demand for shelter into demand for local labour. This dynamic interrupts the external drain of resources, activates the local economic multiplier and, more profoundly, restores dignity and social capital, effecting the transition from victims to agents of their own recovery. [34; 14]

In summary, the discussion shows that initiatives such as ReMakeRS, 2024 represent a necessary advance in project organisation for emergencies, but remain incomplete. True regeneration requires transcending logistical efficiency and digital openness, demanding an unyielding commitment to material health, economic justice, and the activation of local knowledge. The paradox of idle capacity is not inevitable, but a symptom of a flawed response model. The regenerative approach outlined here is therefore presented as a political and practical project for its resolution, proposing that reconstruction itself should constitute the process of building a more resilient, healthy, and autonomous territory. The guidelines systematised in Table 1 summarise this vision, offering a concrete path for its implementation.

V. Conclusion

The climate crises and forced displacements of the 21st century demand responses that radically transcend conventional models of emergency assistance. This research began with the identification of an acute socioeconomic paradox characteristic of post-disaster scenarios: the coexistence of a critical shortage of essential goods with the idle capacity of local productive assets — workshops, carpentry shops, and valuable traditional know-how. This "paradox of idle capacity amid critical scarcity" summarises the failure of linear and centralised approaches, which, by ignoring endogenous potential, perpetuate cycles of external dependence and erosion of local socioeconomic capital.

To overcome this contradiction, an operational model of regenerative infrastructure has been proposed, based on the synergistic convergence of three interconnected pillars: i) Regenerative Design, which provides an

ethical and systemic vision, reorienting the response to the emergency from a logic of mere provision to an intentional process of healing and increasing socio-ecological vitality; [36; 23;]; ii) Distributed Economy and Productive Inclusion, which offer the operational model, positioning local and collaborative networks as the core of reconstruction, transforming potential victims into protagonists and activating virtuous cycles of capital generation and retention in the territory[25] Open Systems and Modularity, which provide the technical tools, where the legacy of systems such as Michel Arnoult's *Peg-Lev*, updated by the logic of *open design*, enables decentralised production through digital files and demountable *designs*, prioritising health, material resilience and local technological appropriation.

The application of this *framework*, integrated with the case study of Rio Grande do Sul post-2024, demonstrates that the proposed flow — from territorial diagnosis to networked production — is much more than a method of furniture manufacturing. It presents itself as a procedure to activate local regeneration ecosystems, whose expected impacts go beyond the restoration of the economic and social fabric, the construction of a positive environmental legacy, and cultural reaffirmation.

Therefore, the main contribution of this work is to articulate a concrete path to dissolve the post-disaster productive paradox. The research demonstrates that it is feasible and strategic to convert the urgent need for shelter into a lever for regenerative development. From this perspective, design transcends its traditional function as a supplier of objects to take on the critical role of designer of resilient socio-economic infrastructures, empowering communities to overcome crises and build fairer, healthier, and more autonomous futures.

As necessary steps to move from theoretical proposition to effective practice, this research outlines horizons for future investigation. It is urgent to technically and economically validate the regenerative materials chain through prototypes and life cycle analyses that define cost, performance, and logistics parameters for regional production. At the same time, it is crucial to develop methodologies to measure the long-term systemic impacts of pilot interventions, assessing results in economic, social, and environmental dimensions.

A complementary development is the design of an adaptive hybrid management platform that efficiently connects local demand to distributed production capacity. In post-disaster contexts, where digital infrastructure may be severely compromised, such a system would operate flexibly: on the one hand, using pre-existing community networks — such as neighbourhood associations, committees of affected people, etc. — as points for collecting demands and distribution; on the other hand, integrating, where connectivity is feasible, a minimalist digital interface (*web-based* or messaging app) for direct registration of needs, transparent production management, and delivery tracking. This hybrid model avoids excessive complexity, maintains shared governance, and strengthens community control over the process. [25;20]

Finally, it is essential to investigate and propose public policy and financing models—such as contracting instruments, public notices, and regulatory frameworks—capable of scaling up and institutionalising this distributed and regenerative economy approach in national and local disaster response and territorial development plans. In a world marked by overlapping crises, the proposal outlined here offers more than a design solution; it proposes a principle of active hope and a strategy for action: that the most powerful resources for dignified and resilient reconstruction already reside in the territory itself, waiting to be recognised, valued, and mobilised by ethical and truly regenerative design processes.

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