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MATERIAL INNOVATION AS A CULTURAL MATERIAL PRACTICE: COCONUT BASED PRODUCT DESIGN FOR REGENERATIVE FUTURES

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ABSTRACT

The growing recognition that sustainability alone may be insufficient to address contemporary ecological and social crises has led to increased attention toward regeneration as an expanded design paradigm. While sustainable design has focused largely on efficiency and harm reduction, regenerative approaches seek to restore, renew, and strengthen the living systems upon which the built environment depends. However, translating regenerative principles to the level of materials and products remains underdeveloped, particularly within design education. This paper examines how regeneration can be cultivated through a practice based and participatory material exploration process. Using Culture Code 2025, a design led educational initiative centred on coconut-based product innovation in Sri Lanka, the study investigates how regeneration can emerge through observation, experimentation, prototyping, and collaboration with craftspeople. Based on the ecological and cultural context of the coconut palm (Cocos nucifera), the project engages students in hands on exploration that emphasises material intelligence, circularity, and cultural continuity. The findings suggest that practice led material innovation offers a viable pathway for approaching regeneration in the built environment, demonstrating how educational settings can nurture regenerative thinking and action at the scale of everyday products. The findings further suggest that this approach offers a replicable educational model for embedding regenerative thinking within design curricula. By demonstrating how locally rooted, practice-based engagement with natural materials can generate regenerative outcomes, the study contributes to the growing body of knowledge on sustainable built environment practice at the intersection of material culture, design education and ecological stewardship.

Keywords: *Coconut Based Materials; Design Education; Material Innovation; Practice-led Design; Regenerative Practice.*

1. INTRODUCTION

Sustainability has shaped built environment conversations for decades, guiding efforts to reduce environmental impact, conserve resources, and improve efficiency. Yet despite significant progress in standards, certifications, and technological optimisation, global ecological degradation and interconnected social crises continue to intensify. Increasingly, scholars argue that harm reduction alone cannot address systemic breakdowns in ecological and social systems (Buckton et al., 2023). In this context,

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regeneration has emerged as a complementary and expanded paradigm; one that seeks not merely to sustain current conditions, yet to restore vitality and support the long-term nurturing of living systems.

Regenerative development extends sustainability by shifting emphasis from minimising negative impact to fostering co-evolution between human and natural systems (Buckton et al., 2023). Rather than focusing solely on efficiency or compliance, regeneration is grounded in an ecological worldview that values mutualism, reflexivity, diversity, and long-term systemic health (Yunibandhu & Hallinger, 2025). Within design discourse, regenerative approaches are increasingly recognised as capable of generating positive environmental and social contributions within the built environment (Kumar et al., 2025). However, while regenerative concepts have matured within architecture and large-scale planning, there remains a recognised methodological gap at the product and material level (Sörensen et al., 2024). Designers lack clear frameworks for translating regenerative thinking into tangible material practices.

Material innovation within the built environment offers a particularly powerful entry point for addressing this gap. Everyday products such as tools, domestic objects, packaging systems etc. mediate human interaction with space and shape patterns of use, care, and disposal. Approaching material innovation through practice-based approaches allows regeneration to move from theory into embodied experience. Making through observation, cutting, joining, testing, refining, creates direct engagement with material behaviour and lifecycle considerations. When such practice is based on local ecological and cultural contexts, it becomes participatory, drawing upon community knowledge and craft traditions.

In Sri Lanka, the coconut palm represents a deeply integrated ecological and cultural material system. Historically regarded as Kapruka, the "tree of life," the coconut has long supported domestic tools, vernacular artefacts, and livelihoods. Its renewable and biodegradable properties also position it as a viable bio-based material resource within contemporary sustainable built environments.

The aim of this research is to examine how a practice-based and participatory design approach can cultivate regeneration within material innovation for sustainable built environments. Using Culture Code 2025 (a design led educational initiative at the Department of Integrated Design, University of Moratuwa, Sri Lanka, centred this year on coconut-based product innovation), this paper investigates how regeneration can emerge through phases of observation, experimentation, prototyping, and collaboration with craftspeople. Rather than treating regeneration as a fixed metric or certification target, the study explores how regenerative capacity can be developed gradually through material literacy, ethical making, and sustained engagement with local ecological systems.

2. LITERATURE REVIEW

2.1 COCONUT TREE AS A MATERIAL SYSTEM

Natural materials derived from agricultural ecosystems have increasingly gained attention within discussions of sustainable and regenerative design. Among these, the coconut palm occupies a particularly important position in tropical regions due to its ecological abundance and cultural integration into everyday life. Historically described as a "tree of

life," the coconut palm has supported a wide range of domestic, agricultural, and material uses, with nearly every part of the plant serving a functional purpose.

The coconut tree provides multiple material resources that can be utilised for product development. The coconut shell, a dense lignocellulosic material, has traditionally been used for utensils, bowls, decorative artefacts, and charcoal production. The coconut husk contains coir fibre, which is widely used in ropes, brushes, mats, and biodegradable composites (Nissar et al., 2025). Coconut wood, obtained from mature palms, has been used in furniture and structural components, while coconut leaves and midribs have historically supported woven products such as baskets, roofing materials, and domestic tools. These materials are renewable, biodegradable, and often derived as by-products of agricultural processes (Kumar et al., 2024) (refer Figure 1).

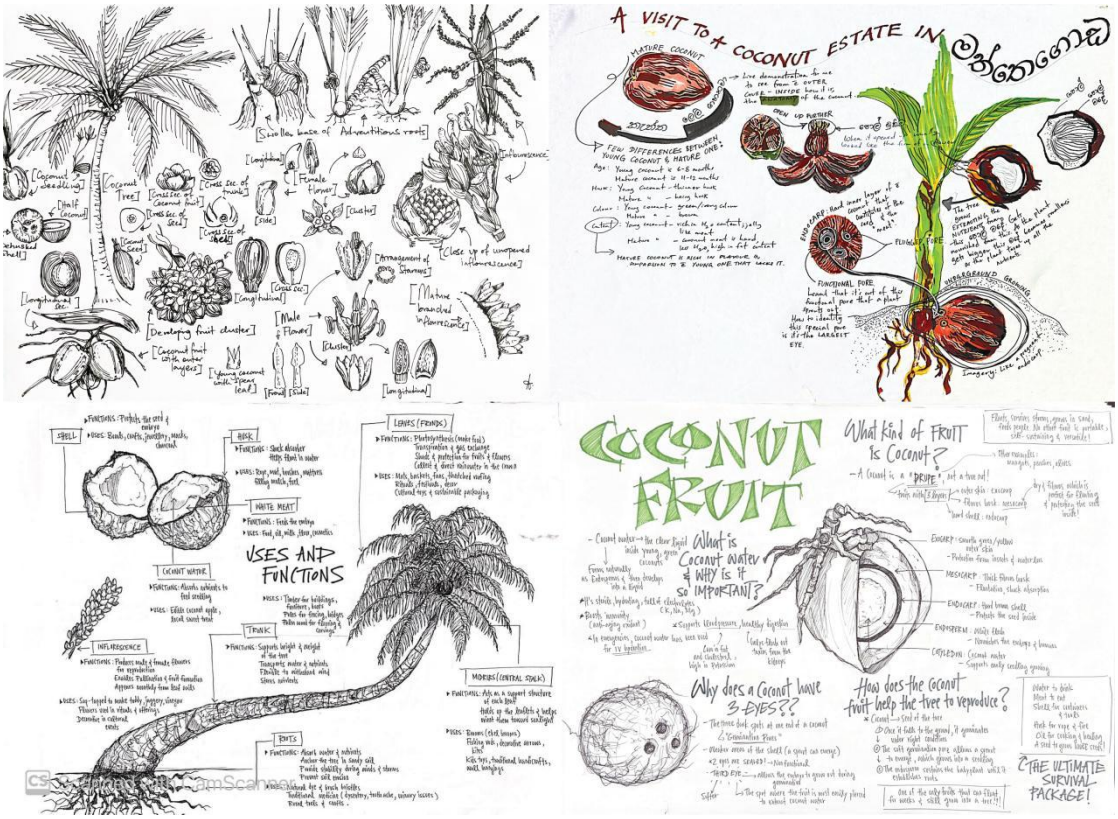

Figure 1: Studies on coconut tree material system

Recent discussions on regenerative materials highlight the importance of using bio-based resources and agricultural residues that do not compete with food production and that can circulate within ecological systems (Sörensen et al., 2024). Agricultural by-products such as coconut shell, fibre, and biomass therefore present opportunities for material innovation that aligns with regenerative principles. Rather than relying on resource intensive synthetic materials, locally available plant-based resources can enable design systems that are renewable, repairable, and biodegradable (Yang et al., 2024).

In many parts of South and Southeast Asia, coconut-based craft traditions have demonstrated such material intelligence. Local craft communities have historically developed techniques that utilise the material properties of coconut components efficiently, often producing objects that are durable, multifunctional, and culturally embedded. These traditions illustrate how material use can be closely tied to ecological

cycles and everyday life, suggesting that coconut-derived materials may serve as a valuable foundation for contemporary product innovation within regenerative design contexts.

2.2 REGENERATIVE PRACTICES

While sustainability initiatives have focused largely on reducing environmental damage, regenerative approaches seek to actively restore ecological and social systems. Regeneration moves beyond strategies of efficiency or harm reduction and instead aims to renew the vitality of ecosystems and communities through mutually beneficial relationships between human and natural systems (King, 2022).

Regenerative design therefore shifts attention from minimising negative impact to generating positive ecological contributions. Within the built environment, regenerative design frameworks emphasise holistic thinking, systems awareness, and the integration of human activity within ecological processes (Kumar et al., 2025). This perspective views buildings, materials, and products not as isolated technical artefacts yet as components within broader socio ecological systems.

Regenerative material practices often draw upon renewable biological resources, waste streams, and locally available feedstocks. In particular, bio-based materials derived from agricultural residues have been identified as promising resources within regenerative material systems because they can participate in circular biological cycles (Sörensen et al., 2024). When materials are biodegradable, compostable, or capable of re-entering ecological processes at the end of their lifecycle, they can contribute to regenerative systems that restore soil health, reduce waste, and support biodiversity.

Beyond material selection, regenerative practice also involves a shift in worldview that recognises human societies as embedded within living ecosystems (Or, 2021). As a result, regenerative approaches emphasise learning from ecological systems, strengthening local knowledge, and designing in ways that enhance the vitality of both natural and social environments.

2.3 PARTICIPATION AND REGENERATIVE PRACTICE

Regenerative approaches are understood not only as technological or environmental interventions but also as social and relational practices. Central to regenerative thinking is the recognition that ecological transformation requires changes in the ways people relate to each other and to the natural world.

Regenerative practice frameworks emphasise reconnection and relationality as essential components of eco-social transformation. Regeneration is therefore seen as a process that involves rebuilding relationships between humans, communities, and more-than-human nature (Or, 2021). Rather than promoting predetermined solutions, regenerative practice frameworks aim to create conditions that allow collective learning and transformation to emerge.

Participation plays a key role in this process. Community participation allows diverse knowledge systems including craft knowledge, indigenous practices, and local ecological understanding to enrich design processes. Participatory approaches therefore help bridge the gap between contemporary design practices and longstanding cultural relationships with materials and landscapes.

Within regenerative practice frameworks, participation can also enable collective action and shared responsibility for environmental change. Instead of waiting for institutional or policy driven solutions, regenerative initiatives often emerge through collaborative local action and experimentation (Or, 2021). Through participatory engagement, communities contribute their knowledge, skills, and lived experiences, enabling design solutions that are contextually relevant and socially meaningful.

In the context of material innovation, participatory approaches allow designers to engage directly with craft communities, material practitioners, and local users. Such collaboration can facilitate knowledge exchange, expand design possibilities, and ensure that material experimentation remains connected to real ecological and social contexts.

Despite the growing recognition of participation within regenerative practice frameworks, existing research has largely engaged community participation at architectural or systems scales. There remains limited scholarly attention to participatory design as a means of cultivating regenerative thinking specifically at the product and material level, and particularly within design education contexts. This study addresses that gap by examining how a participatory, practice-based material exploration process centered on a locally significant biological resource can explore regenerative design outcomes within an educational setting.

The literature highlights three key insights. First, the coconut palm provides a diverse range of renewable material resources that have historically supported craft practices and everyday product systems. Second, regenerative design approaches emphasise the importance of restoring ecological and social relationships through material systems that operate within circular and living processes. Third, participatory approaches play a crucial role in enabling regenerative practices by reconnecting design processes with local knowledge, communities, and ecological contexts.

Despite these insights, there remains limited research exploring how product design using materials derived from the coconut tree (or similar such materials) can contribute to regenerative practices through participatory design processes, particularly within design education.

Therefore, this research investigates how products developed from various components of the coconut tree can contribute to regenerative practices when explored through a participatory and practice-based design approach. Using the Culture Code 2025 project as a case study, the study examines how collaborative material experimentation, craft engagement, and design education can support regenerative thinking and practice within sustainable built environments.

3. METHODOLOGY

This research adopts a practice based participatory design methodology to examine how coconut-based material exploration can contribute to regenerative practices within product innovation. The study is based on Culture Code 2025, a design led educational initiative conducted at the Department of Integrated Design, University of Moratuwa.

Culture Code forms part of a long running design research project originally established in 2012 under the name “Adjoining Traditional Crafting”, which aimed to explore sustainable product development through organic materials and local craft traditions.

Over time the initiative evolved into a platform for investigating the relationship between material culture, ecological responsibility, and design practice.

Renamed "Culture Code" in 2017, the initiative expanded its scope to examine a variety of organic materials including cane, talipot, banana fibre, bamboo, cinnamon, and leather. Across these iterations this initiative has operated not merely as a design project but as a reflective system of material exploration, where experimentation, cultural learning, and ethical design thinking are prioritised over rapid solution driven outcomes.

The 2025 edition of the project, titled "RE:NIU – The Coconut in Full Circle," focuses on the coconut palm as a regenerative material system embedded within Sri Lanka's ecological and cultural landscape. The coconut tree has historically supported a wide range of craft traditions and domestic objects, with its shell, husk, fibre, trunk, and fronds contributing to tools, vessels, woven products, and household artefacts.

By revisiting this material system through contemporary design practice, the project seeks to investigate how product innovation using coconut derived materials can contribute to regenerative practices within everyday environments.

3.1 REGENERATIVE DESIGN APPROACH

Beyond functioning as a design education project, Culture Code 2025 was structured to explore regenerative thinking through practice-based material engagement. Regenerative approaches within the built environment emphasise restoring relationships between human activity, ecological systems, and cultural knowledge rather than merely reducing environmental harm (Buckton et al., 2023; Kumar et al., 2025). Within this study, regeneration is therefore understood not as a fixed technological outcome but as a design capacity that develops through iterative engagement with materials, communities, and ecological contexts.

The project adopts a regenerative approach in three keyways. First, the use of coconut-derived materials situates design exploration within an existing biological resource system that is renewable, biodegradable, and deeply embedded in local ecological cycles. Second, the project reconnects contemporary design practice with traditional craft knowledge by involving artisans who possess tacit expertise in working with coconut-based materials. Such knowledge exchange supports the continuity of cultural practices while promoting sustainable material innovation (Dhar et al., 2025).

Third, the methodology emphasises participatory learning through observation, experimentation, reflection, and collaboration. Rather than promoting predetermined design outcomes, students were encouraged to develop material understanding through direct interaction with the coconut tree and its various components. This practice led approach reflects regenerative practice frameworks that prioritise relational learning, local knowledge systems, and collective experimentation as pathways toward ecological and social renewal (Or, 2021; King, 2022).

By structuring the design process around these principles, the Culture Code 2025 framework positions material exploration as a means of cultivating regenerative thinking within design education. The following phases describe how this approach was implemented through observation, material experimentation, product development, and craft collaboration.

3.2 PARTICIPANTS AND RESEARCH SCOPE

The study involved 84 undergraduate students from the Department of Integrated Design. Participants worked individually or in small collaborative groups within a structured research environment.

This research was conducted taking into consideration the ethical guidelines of University of Moratuwa. All participants including students and artisan collaborators provided consent and were made aware that their work, processes and collaborative activities maybe documented and included in research outputs.

At the start of the project, students were introduced to the central research objective: to explore how products developed from different parts of the coconut tree could contribute to regenerative ecosystems through material innovation and participatory design practice. Participants were expected to:

- Investigate the material properties of coconut derived resources
- Experiment with new product concepts using natural materials
- Consider cultural relevance and everyday usability
- Develop solutions that support sustainable and regenerative ecosystems

Rather than focusing solely on final product outcomes, the research emphasised learning through making, allowing regenerative thinking to emerge through direct engagement with materials, craft practices, and ecological systems.

3.3 RESEARCH PHASES

The methodology was structured around three interrelated phases, followed by a stage of prototyping and craft collaboration. These phases formed an iterative learning environment where observation, experimentation, reflection, and collaboration continuously informed the design process.

3.3.1 Phase 1: Observation, Immersion, and Cultural Learning

The first phase centred on material observation and cultural research. Students engaged with the coconut palm as a living ecological presence rather than simply as a design resource.

Participants explored different parts of the tree including husk, shell, fibre, fronds, trunk, and pith; documenting their observations through material journals, visual mappings, and sensory narratives. These exercises examined textures, traditional uses, cultural associations, and everyday interactions with the material.

This phase revealed how the coconut palm has historically supported domestic environments, craft traditions, and informal built spaces across Sri Lanka. Known locally as Kapruka, the “tree of life,” the coconut palm represents a system where material use is closely connected to ecological cycles and community knowledge (refer figures 2 and 3).

Figure 2: Coconut material exploration as student studies

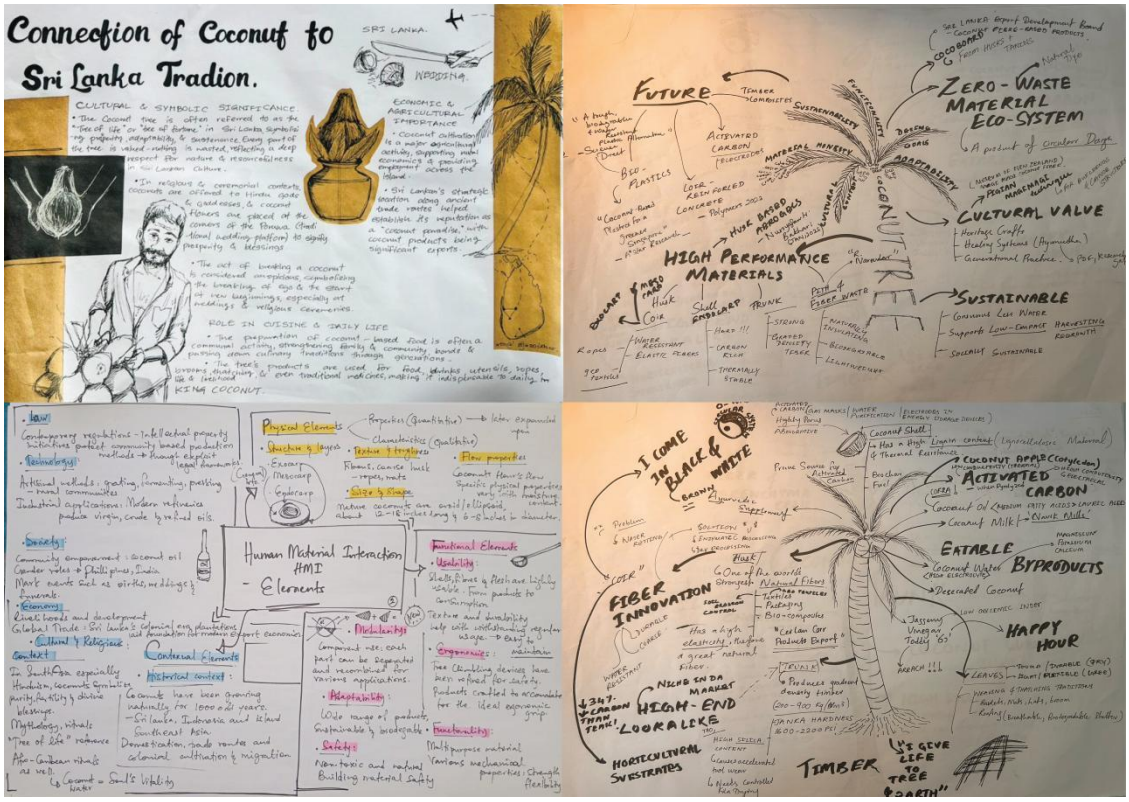

Figure 3: Student material research journals with focus on cultural associations

3.3.2 Phase 2: Material Exploration as Discovery

The second phase focused on hands on material experimentation, positioning making as the central research activity.

Students worked directly with coconut materials by cutting, charring, grinding, boiling, compressing, sanding, and binding different components of the tree. Through this process they explored properties such as strength, flexibility, acoustic behaviour, texture, and ageing. Material inconsistencies and failures were treated as opportunities for discovery. Repeated experimentation enabled participants to develop knowledge of material

behaviour, allowing design ideas to emerge organically from the material itself systems (refer figures 4 and 5).

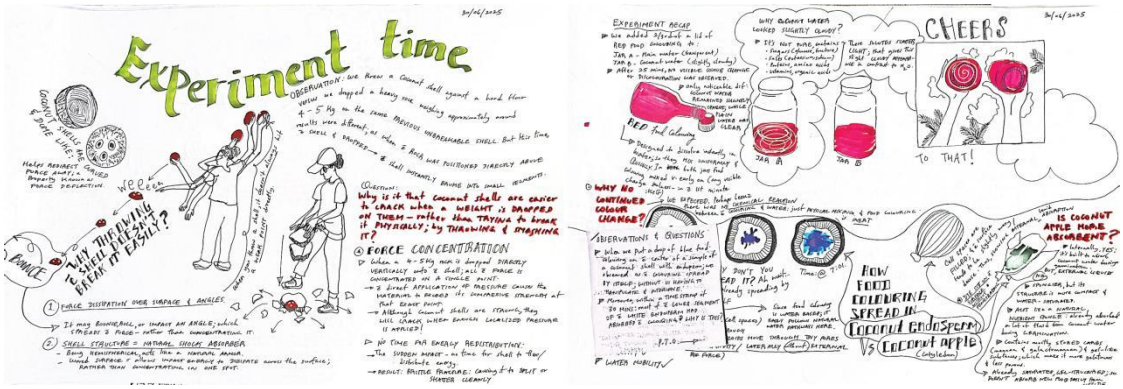

Figure 4: Material experimentation process

Figure 5: Material testing outcomes

One outcome of this phase was the exploration of experimental composites such as CocoBoard, a cork-like material created using coconut pith and natural starch binders. These explorations contributed to the broader understanding of coconut-based materials and their potential application within sustainable product.

3.3.3 Phase 3: Form, Meaning, and Contextual Translation

In the third phase students began translating their material discoveries into product concepts. Design development was guided by a balance between material behaviour, cultural meaning, and user experience. Rather than imposing predetermined aesthetics, students allowed the characteristics of coconut materials to guide form generation (refer Figure 6).

Figure 6: Product concept developments, initial prototypes and market studies

Concepts were evaluated based on usability, cultural relevance, and their potential to support everyday sustainable practices. To contextualise these ideas, students conducted market observations and research, visiting retail spaces and exhibitions while analysing contemporary product narratives and consumer behaviours.

3.3.4 Prototyping, Refinement, and Craft Collaboration

The final stage focused on prototyping and refinement, where concepts were translated into tangible designs. Students refined proportions, tested joinery techniques, and experimented with finishes to align design intentions with material behaviour. This process emphasised iterative learning and continuous improvement.

A key aspect of this stage was collaboration with local craftspeople who possess specialised knowledge of coconut-based materials. Students worked with artisans to translate design concepts into practical production techniques, gaining insight into the tacit knowledge embedded in traditional craft practices (refer figures 7 and 8).

Figure 7: Final product prototypes

Figure 8: Artisan collaboration process

Through this collaboration the project reinforced the participatory nature of regenerative design, demonstrating how knowledge exchange between designers and craft communities can contribute to sustainable material innovation.

4. RESULTS AND DISCUSSION

The outcomes of the Culture Code 2025 project demonstrate how practice-based design exploration can generate diverse product concepts rooted in regenerative material thinking. Through the participation of 84 students, a wide range of coconut-based products were developed. These products were organised into six thematic categories, each representing different ways in which coconut derived materials could interact with everyday environments. The findings presented in this section illustrate how coconut-based material systems can support regenerative design practices within the built environment in a holistic manner.

4.1 RE:CARRY – PORTABLE PRODUCT SYSTEMS

Eleven student projects focused on portable objects designed for everyday mobility and convenience.

These included wearable accessories, earphone cases, portable stands, and small personal objects developed using coconut shell and fibre components. The designs explored lightweight material use while maintaining durability and tactile quality. From a regenerative perspective, these products emphasise material longevity and user attachment, encouraging long term use rather than disposable consumption.

4.2 RE:LIVE – DOMESTIC PRODUCT SYSTEMS

18 student projects explored domestic objects that integrate natural materials into interior environments. These included lighting devices, planters, decorative elements, and small

household accessories that incorporate coconut shell and fibre structures. Such objects reintroduce natural materiality into everyday domestic spaces, strengthening sensory connections between people and natural materials.

4.3 RE:HEAL – WELLNESS AND CARE OBJECTS

Eleven student projects were developed around products that support physical and emotional wellbeing. Examples include massage tools, baby care products, aroma diffusers, and relaxation devices designed using coconut wood and shell elements. These designs emphasise ergonomics, tactility, and sensory engagement. These objects highlight how regenerative thinking can support human wellbeing while relying on biodegradable natural materials.

4.4 RE:NOURISH – FOOD AND KITCHEN PRODUCTS

24 student projects focused on culinary tools and food-related objects. These included spice infusers, juicers, serving utensils, and teapots developed using coconut shell and wood components. The designs encourage mindful cooking and shared food experiences while promoting the use of renewable materials.

4.5 RE:PLAY – LEARNING AND INTERACTION

Eight student projects explored playful and educational product systems. These designs include games and interactive objects that use sound, texture, and movement to encourage creative engagement. Coconut shell and fibre elements were used to create tactile and acoustic experiences. Such designs demonstrate how natural materials can support educational and cognitive engagement.

4.6 RE:WRAP – SUSTAINABLE PACKAGING SYSTEMS

Twelve student projects investigated sustainable packaging solutions. These projects reimagined packaging for products such as Ceylon arrack, Cinnamon, and Kithul based goods, using coconut-based materials to create biodegradable and culturally meaningful packaging alternatives. These packaging systems illustrate how regenerative design can extend beyond product objects to influence broader material cycles within production and consumption systems.

Taken collectively, the outcomes of the Culture Code 2025 project illustrate how participatory design education can contribute to regenerative material practices. The involvement of 84 student designers created a collaborative research environment where diverse ideas, experiments, and material interpretations emerged simultaneously. Through observation, making, and collaboration with craftspeople, participants developed an expanded understanding of how natural materials can operate within sustainable product systems.

The resulting product concepts demonstrate several regenerative qualities:

- Utilisation of renewable coconut-based materials
- Potential for biodegradable and circular material cycles
- Integration of traditional craft knowledge
- Development of products that encourage long term everyday use

These outcomes suggest that regenerative thinking can emerge not only through technological innovation but also through practice-based exploration and participatory learning environments. By examining the products developed through this process, the study demonstrates that coconut-based material systems can support regenerative design practices within the built environment, offering a culturally rooted pathway for sustainable product innovation.

5. CONCLUSIONS

This study set out to examine how regenerative thinking can be approached through material innovation and participatory design practice within the built environment. While sustainability initiatives have traditionally focused on reducing environmental impact, emerging regenerative perspectives emphasise restoring relationships between human activity, ecological systems, and cultural practices. The aim of this research was, therefore, to explore how a practice-based design approach, centred on coconut derived materials and collaborative experimentation, could contribute to regenerative practices.

Using the Culture Code 2025 project as a case study, the research engaged 84 design students in a participatory process of observation, material experimentation, product development, and collaboration with craftspeople. By revisiting the coconut palm as a holistic material system, the project enabled students to investigate the potential of its various components including leaves, shell, husk, fibre, and wood for contemporary product design.

The outcomes of the project demonstrate that coconut-based materials can support diverse product systems across domestic, portable, wellness, educational, and packaging contexts. More importantly, the process itself revealed how regenerative thinking can emerge through practice-based engagement with materials, communities, and ecological systems. Through experimentation, collaboration, and reflection, students developed products that emphasise renewable resources, cultural continuity, material longevity, and everyday usability.

Taken collectively, the findings suggest that regeneration is not solely a technological challenge but also a practice based and relational process. By engaging natural materials through participatory design processes, designers can develop products that contribute to sustainable material cycles while strengthening connections between people, materials, and local ecosystems.

This research is based on a single institutional context and focuses on one material system, which limits the generalisability of findings. Future research should extend this participatory, practice-based approach to other significant material systems and cultural contexts. Further work on how coconut-based product innovations might scale within the built environment industry, bridging the gap between educational prototypes and commercial applications would significantly advance the area of this study.

This research, therefore, demonstrates that product innovation using coconut derived materials, explored through participatory and practice led design education, can contribute to regenerative approaches within the built environment. Such initiatives highlight the importance of design education as a pathway for cultivating regenerative thinking and experimentation. Rather than presenting a universal model, the Culture Code framework illustrates how locally rooted material systems when explored collaboratively can provide meaningful pathways toward regenerative futures.

6. ACKNOWLEDGEMENTS

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