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Regenerative Design in the Circular Economy: an oxymoron?

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ABSTRACT |
The Circular Economy (CE) model considers the life cycle of material goods and examines its journey from cradle to cradle, which tries to put human beings in the same species picture as other living things and focuses on design of materials and systems. The Ellen MacArthur Foundation (EMAF) argues for an industrial economy that is restorative or regenerative by design and aims. Regenerative design requires a multi-disciplinary approach which transcends the disciplines of design only. Despite the use of the terms restoration and regeneration, these have not been readily defined in the context of a circular economy. In this paper we critique the term 'regenerative' from different interdisciplinary perspectives. Interdisciplinarity analyses, synthesizes and harmonizes links between disciplines into a coordinated and coherent whole. Regenerative design has found different meanings and outcomes in different disciplines. Regenerative design is a key component of heterodox economic models such as the circular economy and doughnut economics which contend that the current orthodox economic model of indefinite linear growth is not compatible with 21st century needs. Regenerative design is proposed as a key tool in meeting the needs of the heterodox economic models. In this paper use cases illustrate the different understandings of regenerative design from different disciplinary backgrounds and proposes a unifying definition. This paper argues that regenerative design in context of the Circular Economy is misunderstood and needs clearer definitions that support a genuinely restorative economy but conversely will need a new politics, fit for the conditions of the Anthropocene.

KEYWORDS | ONE, TWO, THREE, FOUR, FIVE

Regenerative design, interdisciplinarity, doughnut economics, Anthropocene, ontopolitics

1. Introduction

We examine the role of design in shaping governance, business, and innovation by exploring the emergence of designing for alternative economic frameworks through the lens of regenerative design as a design process that aims to repair, recreate, or restore the ecosystems in which it operates and on which it relies. It has been applied mostly in the built environment. The fields of Design and Architecture, conscious of their roles in the creation of demand for and consumption of natural and synthetic resources, have been at the forefront of the call to re-imagine how we design our society and how economic systems may be optimised to respond to the climate crisis. In this paper we incorporate understandings of 'regenerative' from other disciplinary perspectives, such as marine science and computer science. We contend that regenerative design in context of the Circular Economy is misunderstood and needs clearer definitions and policies that support a genuinely regenerative economy.

Scientific consensus has, unusually, unanimously concluded that the climate is changing and that this is 'unequivocal' due to human activities affecting every part of the globe at an unprecedented scale (IPCC 2021). The Anthropocene, a concept from the Earth Sciences (Crutzen and Stoermer 2000a, 2000b), posits that the impact of human activity on the Earth's systems can be clearly observed and measured in climatic changes, geological findings such as sediments and ice, and a steep decline in biodiversity (58%) in the last four decades which has lead scientists to call it the Sixth Extinction (Kolbert, 2014). The Anthropocene has arguably heralded the end of Modernity and its associated focus on progress. The pursuit of scientific knowledge driven by the Enlightenment values of the seventeenth- and eighteenth centuries and attendant 'improvement' of the social and natural world gave birth to the Industrial Revolution and the emergence of design as instrument of industry and commerce. Whilst Modernity led to a general improvement of (some) human ecosystems, this came at the cost of systematic destruction of human and non-human habitats, decimation of many other species, and decline in the quality of the Earth's ecosystems. The Anthropocene thus provides a shorthand to describe the planetwide condition of anthropogenic environmental degradation and climate change but also of the human capacity to effect change.

The earth's climate is at a critical juncture, with urgent action needed to avert catastrophe on a planetary scale. Yet, commitment to the necessary actions remains elusive, and a clear gap remains between the stated intentions of governments, and the actions that are required to achieve this target. A lack of concrete outcomes from the latest COP 28 meeting of the UNFCC is only the most recent of successive missed opportunities (House of Commons Library, 2024). The ambition of Net Zero targets by many governments, including in the UK (2021), is undoubtedly welcome, but academics, practitioners, and activists concerned with climate change have increasingly concluded that, given the already-degraded state of the environment, sustaining Net Zero is not enough. Instead, we must adopt a regenerative mindset that rethinks how systems, products and services are designed to service and operate a circular economy that not only sustains but replenishes the ecosystems on which it depends: through a regenerative doughnut economics (Raworth, 2017).

Regenerative design, then, critiques the concept of Net Zero in so far as it does not include an ambition to positively contribute to the environment's restoration. Regenerative thinking can avoid some of the risks associated with the rush to embrace Net Zero, including that centuries of ecological thought, particularly that of indigenous peoples, are disregarded, and that environmentalism is framed simply and exclusively as the technological optimisation of lower carbon manufacturing, distribution, and servitisation.

Our arguments have been informed by a workshop held in June 2023 (see acknowledgments) that examined the term 'regenerative' in context of regenerative tourism, drawing from different interdisciplinary perspectives spanning ecology, biology, design, literature, craft, computing, business studies and tourism. In the rest of this paper, we begin by presenting an overview of the framings which intersect with regenerative design: design theory, critical studies, heterodox economics, and ecology. We critique the circular economy through the examination of the term 'regenerative', expanding on its interdisciplinary meanings beyond a design lens only, and go on to describe our proposals for the benefits of regenerative design. These will be descriptions of regenerative design in other disciplinary contexts such as marine ecology and computing. Finally, we end with a provocation that perhaps regenerative design is ultimately an oxymoron as it might not be possible to design in a truly regenerative way, certainly not within the constraints of the current economic system.

2. Introduction and Background

What then, is design? If design is the process of applying creativity to solve problems (Design Council, n.d.) then "everything not made by nature, has been designed" (Design Council, n.d.). The expansive notion of design as 'design thinking', from product to service design, landscape design to architecture, software and interaction design, was originally framed by Richard Buchanan (1992) where he outlined that the subject matter of design is potentially universal in scope. Buchanan expanded on Horst Rittel's idea of 'wicked problems' (1972), which are "a class of social system problems which are ill-formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where ramifications in the whole system are thoroughly confusing" (Buchanan, 1992, p. 15). For Buchanan, design can be applied as an iterative process to solving 'wicked problems'. Climate change has been defined as a wicked problem (Termeer *et al*, 2013) to which design thinking can be applied to help solve some of its intractable problems.

To begin with, *sustainable design* can be situated in a tradition first expressed by Papanek in *Design for the Real World (*1972) which urged designers to take responsibility for the external consequences of their work on users, society, and the environment, rather than see themselves only as service providers to industry, which inherently 'defutures' (Fry, 1999). Sustainable design entailed a 'first do no harm' ethos, arguing that the manifestations of our designed and engineered enterprises should sustain the natural environment that provides the raw materials to realise them, as well as the ecosystems necessary to maintain those environments. The landscape architect John Tillman Lyle (1996) first outlined *regenerative design* for sustainable development. He argued for design to be understood in 'a large and inclusive sense' in the conceiving and shaping of complex systems, "where the earth and its processes join with human culture and behavior to create form" (1994, p. ix). He argued for a collaborative, interdisciplinary design process that is inherently self-renewing.[1] Lyle was aware that complex multi-goal regenerative systems that involved both natural and social processes, which might not be entirely understood, would be challenging for the design process. Lyle outlined strategies for regenerative design:

1. letting nature do the work;
2. considering nature as both model and context;
3. aggregating, not isolating;
4. seeking optimum levels for multiple functions, not the maximum or minimum level for any one;
5. matching technology to need;
6. using information to replace power (i.e. work smarter not harder);
7. providing multiple pathways (e.g. not just one source of energy but several renewable options),
8. seeking common solutions to disparate problems;
9. managing storage as a key to sustainability (e.g. storing water, ready for replenishment and release);
10. shaping form to guide flow (e.g. design to support natural air ventilation rather than mechanical one);
11. shaping form to manifest process (e.g. windmills as integral part of landscape rather than a hidden infrastructure); and
12. prioritising for sustainability.

Lyle arguably outlined 'wicked problems' and argued that systems should be designed for optimum levels across multiple functions, rather than one. His regenerative strategies extended beyond Papanek's arguments but have not achieved the same influence; in this paper, they represent some principles on which we build.

Papanek's influential work appeared in the same year as the seminal Limits to Growth (Meadows *et al*. 1972, 1992, 2004) reports which raised profound warnings about the ecological and social limitations of linear growth of the economy. The Meadows reports also contained a message of hope outlining that if humankind could create a society which imposes limits on growth and the production of material goods, then humanity and its interdependent ecosystems of non-humans could achieve a sustainable state and live indefinitely on Earth in a carefully managed dynamic process of balancing human and non-human flourishing and uses of resources and spaces. Early challenges to the orthodox neoclassical economy that underpinned the indefinite linear growth model, argued for a more devolved, localised and connected economy which supported (local) labour and resources (Boulding, 1966; Schumacher, 1973). More recently, the case for 'prosperity without growth' (Jackson, 2010), 'a new green deal' (Pettifor, 2019), or 'doughnut economics', "offers a vision of what it means for humanity to thrive in the twenty-first century" (Raworth, 2017). Lyle's ethos for regenerative

[1] In the Center for Regenerative Studies which John T. Lyle ran, the core team of twelve people included two architects, two landscape architects, two agronomists, an anthropologist, an aqua culturist, an energy analyst, a geologist-hydrologist, an agricultural economist as well as two graduate assistants (Lyle, 1994, p. 31)

design can arguably be found in the doughnut economy model outlined by economist Kate Raworth (fig. 1), where the nine planetary boundaries set out by Rockström et al (2009-) form the ecological ceiling which, if crossed, pose a significant risk of irreversible ecological changes. In 2023, six of the nine global boundaries assessed were crossed (Stockholm Resilience Center, 2023). The safe space for humanity is one which is based on a solid social foundation and which operates within the ecological ceilings of our global ecosystems. The doughnut economy model thus provides a framework within which regenerative design makes sense.

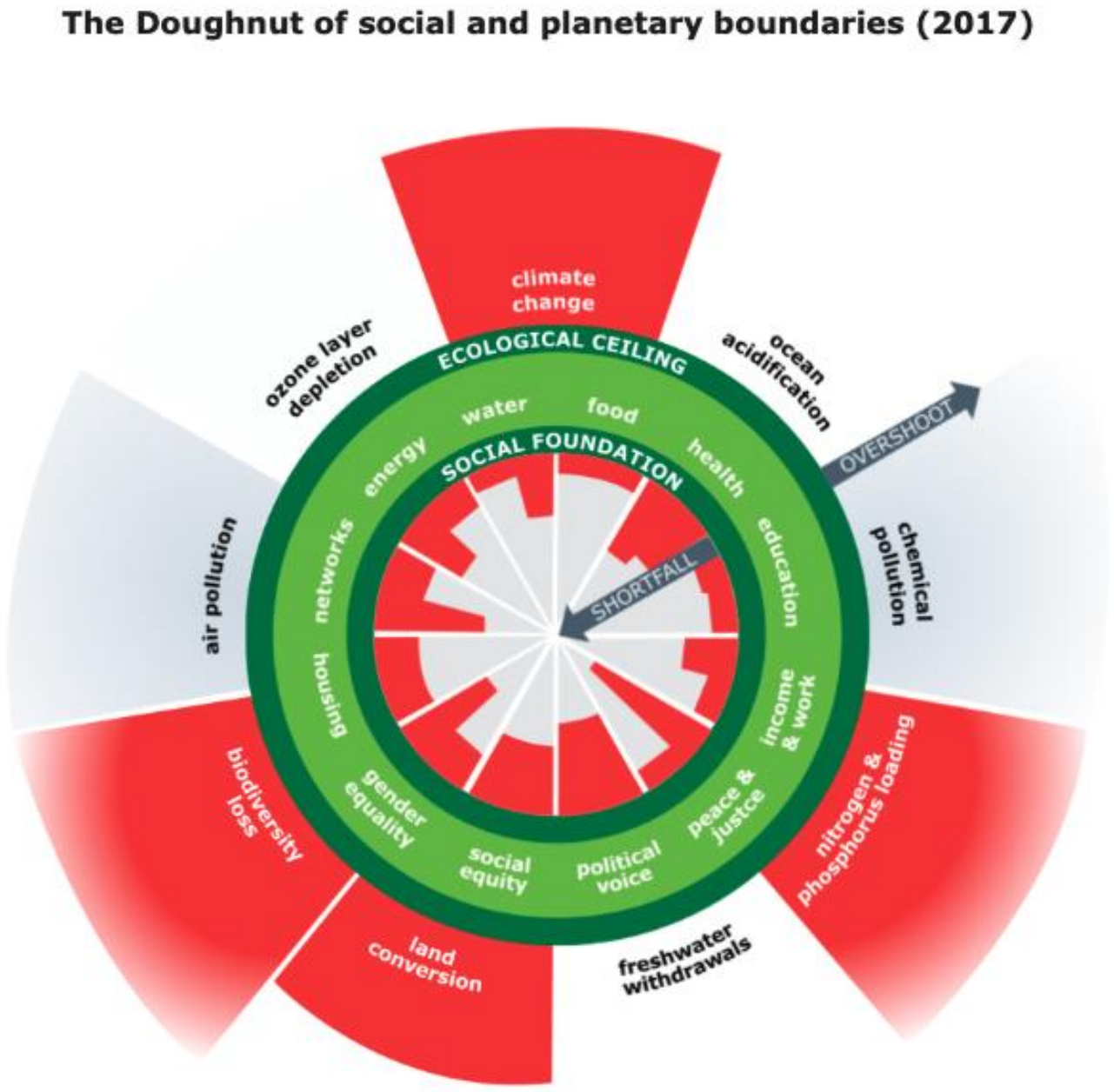

Figure 1: The Doughnut of social and planetary boundaries (2017) Credit: Credit: Kate Raworth and Christian Guthier. CC-BY-SA 4.0. Source; https://www.kateraworth.com/doughnut/#

However, designing within planetary limits poses significant challenges and requires insights and understandings which go beyond design. To achieve its potential, regenerative design requires a multi-disciplinary approach which transcends the disciplines of design only and requires supportive and integrated policy approaches.

The correlation between financial, social, and environmental sustainability had already been made in the 'triple bottom line' concept (Elkington, 1994) but the circular economy as outlined by the Ellen MacArthur Foundation (n.d.) (EMAF) argues for "an industrial economy that is restorative or regenerative *by design and aims"*. The concept of the Circular Economy (CE) cannot be attributed to a single author or date (Wautelet, 2018), and describes a closed loop economy, that favours re-use and repair over new goods and delivers

positive impact for not only job creation and economic competitiveness but also resource savings and waste prevention (Stahel and Reday-Mulvey, 1981), based on the understanding that there is an extensive interdependence between the economy and the natural environment (Pearce and Turner, 1990). The CE came to prominence with the publication of a study by the EMAF (2013) with consultancy firm McKinsey at the global economic forum in Davos in 2012 (BBC, 2012), which outlined the significant financial benefit of a CE (Lacy and Rutqvist, 2015; Stahel, 2020).

The CE considers the life cycle of material goods and "tries to put human beings in the same 'species' picture as other living things" (Braungart and McDonough, 2002) and tends to focus on design of materials and systems. Braungart and McDonough's (2002) 'cradle to cradle' ethos promotes a circular *design* approach that examines the life cycle journey of material goods. The butterfly diagram of the circular economy model (Fig. 2.) articulates the 'technical cycle' which involves the management of stocks of finite materials into a circular economy through repair, reuse, redesign, redeployment and refurbishment. The 'biological' cycle instead focuses on the flow of renewable materials into the generation of nutrients as part of the natural ecosystem.

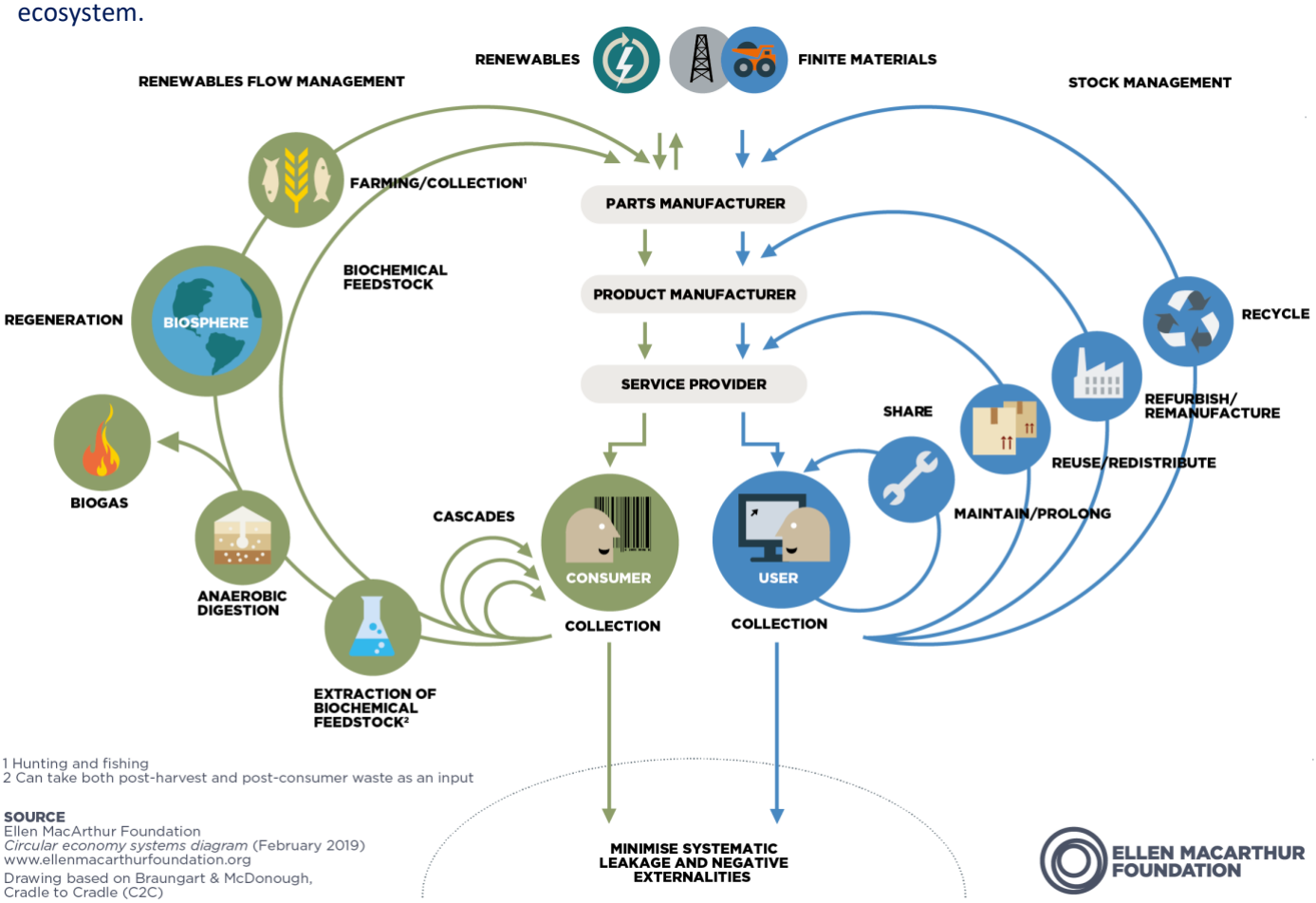

Figure2: The Circular Economy Butterfly Diagram. Ellen MacArthur Foundation (February 2019) – drawing based on Braungart and McDonough Cradle to Cradle (source: https://www.ellenmacarthurfoundation.org/circular-economy-diagram)

Critiques of the CE have argued that it does, however, not address ontological and epistemological questions, such as what might be considered the ethical value of, or what is or who the economy is for? Temesgen et al (2021) posited that the CE foregrounds efficiency and resource management which they contrast with the paradigm of 'Ecological Economics' where the goal is to achieve and secure a higher quality of life. This arguably aligns with the doughnut economics outlined earlier. Furthermore, the CE tends to fail to acknowledge the impossibilities of a 'closed loop' in terms of biophysical limitations, and the difficulties in implementing CE principles in both policy and business models that are dominated by corporate thinking, lack holistic approaches, and ultimately do not challenge the growth agenda of the current capitalist system (Corvellec, Stowell and Johansson, 2021). We will return to this need for a new 'ontopolitics' (Chandler, 2018) in our discussion later on. This 'depoliticization agenda' (Valenzuela and Böhm, 2017) of the CE is challenged in the concept of 'regenerative design'.

The distinction between technological and biological cycles in context of a CE is useful in discussion of regenerative design. Morseletto (2020) argues that most CE activity focuses on *restoration* as products are repaired, upgraded, refurbished, or remanufactured which restores them rather *regenerates* them. As Pawlyn

(2019) argues, "Sustainability hasn't made enough headway to ensure our society persists beyond the middle of the century. We need to start doing more." Regenerative design therefore aims to create outcomes "in which whole-system health and wellbeing increase continually" (Gibbons, 2020). In other words, it is no longer enough to do no harm, we must also design to repair the harm we have done. As design relates to both 'technical' – use of technology, equipment, infrastructure etc - as well as 'biological' cycles – use of natural resources – this framing is helpful to explore the different interpretations of 'regenerative' from different disciplinary perspectives. Despite the use of the terms restoration and regeneration, these have not been readily defined in the context of a circular economy (Morseletto, 2020).

In response to the critique that design risks accelerating the technological optimisation of carbon manufacturing (business as usual) and ignoring other ways of knowing and doing that are more in tune with ecological living, such as indigenous knowledge, design scholars have proposed (Hernandez and Goñi,2020) and developed the Responsible Design Framework (Boehnert, Sinclair & Dewberry, 2022) for research and practice that is both regenerative and inclusive (fig.3).

Figure 3: Six Principles of Responsible Design (Boehnert, Sinclair and Dewberry) – with kind permission from the authors

The six principles include 1) ethical, 2) pluriversal, 3) planet centric, 4) decolonial , 5) transdisciplinary and 6) optimistic.

Designers can be valuable agents of social change, but as the Design Council (2021) notes "for the most part, designers are not yet using their skills and knowledge to deliberately support the green transition in the way that they should and could". Responsible Design requires that designers accept "(a) the responsibility to avoid harm, (b) the responsibility to do good, and (c) the responsible governance of the design process" (UAL, 2019). In so doing, it demands that designers engage in transdisciplinary practices, that they avoid proposing discrete, single issue 'solutions' and instead confront a key aspect of ecological theory, namely the systemic nature of the earth's problems and the efforts necessary to address them. Regenerative approaches recognise that humans are active agents in ecosystems (global and local); a key tenet of the Anthropocene.

3. Case Studies

The three case studies we present here are drawn from different disciplinary perspectives and collated here to highlight how 'design' is applied in different contexts to encourage restorative and regenerative practices and highlights that these terms have different interpretations for different stakeholders. The first case study is taken from marine science where restoration programmes are designed to support the regeneration of depleted ecosystems. The second case study looks at regenerative design applied within the craft industry but from an ecological restoration perspective. The third case study outlines regenerative design practices applied to robot design. These three different disciplines all outline regenerative design but have different understandings of what this means in practice.

3.1 Regenerative Design for Mangrove Restoration

Mangroves support the livelihoods and well-being of millions of coastal inhabitants globally by providing coastal protection, regulating water quality, providing food security and sequestering large quantities of carbon. They are in short, key ecosystem infrastructures. Mangrove degradations and loss (20-25% globally) has impacted communities and economies worldwide. The successful restoration of these ecosystems has been the result of both failures and successes of restoration projects and these learnings collated in a 'best practice guidelines for mangrove restoration' by the Global Mangrove alliance (Beeston et al, 2023). Following the earlier description of design as the process of applying creativity to 'everything not made by nature, we argue that the restoration process can be considered a design process which has resulted in restoration guidance documents and tools to design and create the right conditions for mangroves to grow back naturally. If the "most successful way to restore mangroves is to create the right biophysical and socio-economic conditions" (Beeston et al, 2023, p. 18), then creating those conditions is a process of design.

The key stages in this process are as follows: 1) setting goals and assessing feasibility, 2) project design, 3) engagement and implementation, and 4) monitoring and evaluation.

The guiding principles for successful restoration are summarised in six key core principles:

1. safeguard nature and maximise biodiversity,
2. employ the best information and practices,
3. empower people and their needs,
4. align to the broader context – operate locally and contextually,
5. design for sustainability and
6. mobilise high-integrity capital.

The principles outlined above support a restoration process that should enable the mangrove ecosystem to look after itself without any further human intervention. The impact of restorative practices on the connection between ecological, social, and economic ecosystems has been evidenced repeatedly and is captured in these guidelines. Getting the hydrology right optimises the chances that the mangrove will not require any more intervention as it will function in balance. The ecological restoration here facilitates ecological regeneration. The restoration process in turn supports the reversal of coastal erosion, increased biodiversity, increased natural stock and thus improved economic benefit. Restoration is defined here as the "act of bringing an ecosystem back as near as possible, to its original condition" (p.7). It is, however, not always clear or defined what the original condition might have been, in which timeframe and by whose definition. Ecologists however, call this process a restoration rather than regeneration even if the system has been restored to such a level that it can now repair and sustain itself after having been improved, if degraded, and is in better condition than it was before. Conversely, natural regeneration is defined as "a process where propagules or seeds of mangrove (or other ecosystem components) are naturally recruited. This may occur in both degraded and non-degraded areas" (p. 6). The differentiation between restoration that has an implied human intervention, and regenerative, as an implied non-human process. All of Lyle's twelve strategies for the *regenerative design* process have clear resonances with the restoration processes outlined in the design methodology of the restoration process for mangroves.

3.2 Regenerative Design in Crafts Industry

The demise of traditional knowledge and its concomitant social values in the wake of industrialisation and globalisation was observed already by the nineteenth-century British industrial designer, social activist, and proponent of the Arts and Craft Movement, William Morris (1834–1896) who perceptively noted in 1884 that the globalised market economy affected craftworkers adversely globally. Yet, many indigenous communities retain strong connections with their local environments through artisanally produced products such as textiles, pottery, basketry and blacksmithing which are made of, and speak of place. The tensions between

producing craft products that attract a global audience and their associated carbon footprint, has focused attention on local markets and maintaining local customs and traditions which often encapsulate multi-generational knowledge of materials, habitats and ecosystems. Truly regenerative design has been most successful were initiatives to restore habitats have incorporated social and material innovations (Watson, 2020; Panneels, 2023).

One such example is the Khoriya ko Kagaj project: the planting of broom grasses on the bare hills of the Mahabharat mountains in central Nepal by the Chepang community to stop erosion.[2] The 'amliso', or broomgrass, is traditionally used to produce 'brooms' for the domestic market and generates income for this marginalised community. As only the flowers are used for the brooms, the stems were a waste product which has now been developed into a higher value product by working closely with traditional paper making artisans to develop a new, robust handmade paper from this waste material, thereby generating a new income stream. Although the waste produce could be easily absorbed back into biological cycle, here the natural waste is used to create more product that generates income as much as it restores the local ecosystems. The project has thus incentivised the Chepang community to restore the hills with broomgrass, stopping erosion and landslides and creating income streams. The system was designed to thus optimise the restoration of both the ecological habitat and the social community which depends on it. The design process followed several of the twelve principles of regenerative design outlined by Lyle by 1) letting nature do the work, 2) considering nature as both model and context, 3) aggregating, not isolating, 4) seeking optimum levels for multiple functions rather than one, 7) providing multiple pathways, 8) seeking common solutions to disparate problems (erosion and ecological degradation and poor economic prospects) and 12) prioritising for sustainability.

A key argument in sustainable design is to re-connect and re-evaluate traditional knowledge and indigenous ways of knowing which often harness nature's inherent restorative capacities and was recently captured in the phrase 'Lo-TEK' coined by designer Julia Watson, as radical indigenism (2020). She argued for a design movement to reconnect with lesser-known, local (Lo) technologies, both traditional and recent innovations, borne from Traditional Ecological Knowledge (TEK) to design and build climate-resilient infrastructures. This intersection of innovation, conservation and indigenism, she argues could offer a new path to "exponentially shrink the ecological footprint of humankind and mitigate the forecast collapse" (p. 18). Like Lyle, her perspective is from a built environment point of view, but we argue can also be applied to other sectors of the economy as its principles of design can be applied universally.

3.3 Regenerative Design for Robots in a Circular Economy

The CE distinction between technological and biological cycles are critical in the discussion on regenerative design. The previous two case studies have unequivocally engaged with natural ecosystems and their intersections with social ecosystems and economies. In this last case study, we briefly outline the use of regenerative design in context of a technological cycle: the concept of regenerative design for robots.

Robots have often been designed in a linear way: when parts break, they cannot be replaced, and the robot becomes obsolete. A circular design approach would 'fix' the problem by implementing a design approach that enables the repair and replacement of broken or faulty parts until no further repairs can be enacted. All parts are to be designed to be taken apart and recycled into the waste stream. Recent developments have included robots that are able to 'fix themselves' with built in automated repair functions, mostly driven by the deployment of robots in hostile or inaccessible environments (e.g. deep sea mining or outer space) where human intervention and repair might not be possible. A second development is that with the increased miniaturisation of robots, existing power infrastructures such as motors and gas engines are no longer serviceable and engineers and designers have increasingly turned to 'biohybrid' robots which integrate living cells "by benefiting from the intrinsic microscale self-assembly of living tissues and high energy efficiency, which, among other unprecedented properties, also feature flexibility, self-repair, and even multiple degrees of freedom" (Lin et al, 2022). Mini robots have been deployed in search and rescue situations, or in medical procedures, where they can enter the human body to perform noninvasive surgery for example. New research, however, is also exploring how robots might not only be able to use biomimicry (Benyus, 1997), but also combining bio engineering, nano technology and 3D bio printing (Lin et al, 2022), for example bio hydrogels which expand and contract using ultraviolet light to propel a swimming robot (Shi et al in: Lin et al, p. 119). Increasingly biomaterials are being used to develop robots which have a high biocompatibility and biodegradability, which is important in medical situations for example. Thirdly, robot design has now included the use of biomaterial for robots to self-replicate (Kriegman et al, 2021). This approach is considered regenerative design.

Here too several key strategies of Lyle's framework for regenerative design can be aligned; 1) letting nature do the work, 2) considering nature as both model and context, 3) aggregating, not isolating, 4) seeking optimum levels for multiple functions, not the maximum or minimum level for any one, 6) using information

[2] This project was supported by the British Council in Nepal through the In Our Hands programme in that supported nature inspired innovation in the creative economy. A short video of the project can be viewed here: https://www.youtube.com/watch?v=_Dmq5OIQYhQ&t=6s

to replace power, 8) seeking common solutions to disparate problems, 9) managing storage as a key to sustainability, 10) shaping form to guide flow, 11) shaping form to manifest process and 12) prioritising for sustainability.

4. Discussion

This paper argues that regenerative design in context of the Circular Economy is misunderstood and needs clearer definitions that support a genuinely restorative economy. If 'regenerative design' is to be a tool for facilitating a truly circular, regenerative economy which restores the ecosystems on which it depends, and which by implication relies on interdisciplinary collaboration, co-operation and understandings, then a universally understood definition of regenerative design needs to be agreed on. As outlined in our case studies, the concept of regenerative design has acquired different disciplinary understandings.

Regenerative design as understood in the context of our case studies enables an ecosystem to look after itself without any further human intervention: mangroves, bare hillsides, or human bodies. Critically, it also highlights the 'agency' of humans in this process – a very Anthropocenic approach indeed.

The idea of the Anthropocene has particularly highlighted how human ecosystems (economic, social, and political) are irrevocably enmeshed with ecological ecosystems. However, the emergence of critical theory in the twentieth century as a philosophical approach has provided a kaleidoscopic lens of feminism, critical race theory, post-structuralism, queer theory, and post-colonialism of the kind needed to shift the conceptual understandings of Modernity and its concomitant drive for human-centred enlightenment and progress towards a more nuanced understanding that makes space for other ways of knowing and doing. Critical theory has refocused attention on alternatives offered by traditional, indigenous, or artisanal approaches, which often preceded industrialization (Haraway, 2008). Modernity and its process of globalisation had profound implications not only for the loss of traditional knowledge and practices but also for the social values they embodied. For the anthropologist Anna Tsing, the Anthropocene makes it possible to realise that Modernity itself is a barrier to living fuller lives:

> "Progress is a forward march, drawing other kinds of time into rhythms. Without that driving beat, we might notice other temporal patterns. Each living thing remakes the world through seasonal pulses of growth, lifetime reproductive patterns, and geographies of expansion. [ ] Instead, agnostic about where we are going, we might look for what has been ignored because it never fit the time line of progress". (Tsing, 2015, p. 21)

These multi species, pluriverse (Escobar, 2017) insights are needed to respond to the challenges of climate change in the Anthropocene.

Scholars from International Relations have focussed attention on the implications of the Anthropocene on international governance, which commands an 'ontopolitics' (Chandler, 2018): new forms of governing and new conceptual frameworks which are more at home with "discursive framings of contingency and complexit" (Chandler, 2018, p. 4) that acknowledge that the world is complex and interdependent. The U.N.'s *Our Common Future*—also known as the Brundlandt Report (WCED, 1987) - argued for sustainable development (growth) that "meets the needs of the present without compromising the ability of future generations to meet their own needs" and called governments, civic society and businesses to action. The Report laid the groundwork for the Earth Summit in 1992, which led to the establishment of the U.N. Convention on Climate Change (UNFCC), which established the Convention of the Parties (CoP) as the decision-making arm. Despite the early scientific warnings in the 1980s, such as NASA chief scientist John Hansen (Kolbert, 2018), it took until the landmark Paris Agreement (UNCC, 2015) at COP21 in 2015 for a first legally binding document with widespread international agreement on the need to reduce emissions to a level that limits global temperature rise to 1.5 degrees (IPCC, 2021, 2023) by 2030, requiring sustained international collaboration and co-operation. It is clear however, that several decades of climate policymaking through the U.N. COPs has failed to deliver. Governance will require a new ontopolitics. We argue that this new ontoplitics will also require regenerative design to be embedded at all levels of policymaking, funding and innovation strategies and economic development. Regenerative design has been adopted by establishment organisations such as the Royal Society of Arts, the Royal Institute of British Architects, and the 1851 Commission3 and carries an inherent critique of the concept of Net Zero. As outlined earlier, the Net Zero targets by many governments to stop emissions of greenhouse gases into the atmosphere are hopelessly inadequate. Emissions are currently at record levels but would need to be halved by 2030 (IPCC, 2021) if we are to achieve Net Zero. A circular economy as currently proposed which has no theoretical energy loss, and is biophysically impossible, and suggests an improvement on current manufacturing but does not improve the status quo in ecological or social terms. The 'depoliticization agenda' (Valenzuela and Böhm, 2017) of the CE

[3] Royal Commission 1851 was established in 1850 to specifically support advanced study and research in science, engineering and design. It established a Fellowship in Regenerative Design to support the research of regenerative design in the built environment. See: https://royalcommission1851.org

is challenged in the concept of 'regenerative design'. The case studies we put forward outlined how regenerative design in mangrove restoration has resulted from explicit regeneration policies, whilst the regenerative craft example operated on the fringes of a creative green economy policy and the regenerative robots emerged from innovation policies. The term 'regenerative' thus needs to be claimed firmly as a more robust terminology to describe design processes that should be applied to any industry or sector to describe a process that a) supports both environmental and social regeneration, of which the economy is a defacto by-product – thus flipping the CE mode, and b) which explicitly challenges the continued growth model, which is implicit in the CE.

If regenerative design principles are understood to improve the conditions of the ecological, social and economic conditions in the context of which this is applied, then this is often achieved by applying Nature based solutions or Biomimicry which requires an interdisciplinary knowledge. Furthermore, in order to be able to argue that regenerative design principles have been successfully applied, an understanding of what constitutes a baseline from which conditions can be improved, needs to be agreed on. It is clear from our discussions with ecologists that knowing the baseline from which to start are not always clear, nor universally agreed on by all stakeholders.

Instead, we must adopt a regenerative mindset that rethinks how systems, products and services are designed to service and operate a regenerative doughnut economics which serves ecosystems rather than economies. It is worth remembering the ancient Greek origin of the word economy where 'oikos' refers to 'house' and 'nemein' refers to 'manage'.

Conclusion

We have argued in this paper that applying genuine restorative design principles in different disciplinary and economic contexts might simply not be possible. It requires us to move beyond 'business as usual' and beyond a circular economy which, although aspires to be regenerative, is inherently an oxymoron: a contradiction of terms. In this paper we suggest that the lens of regenerative design is a useful way of introducing the embodied complexities and interconnected nature that is the wicked problem of climate change, which requires a new ontopolitcs of the Anthropocene. In order to devise policy frameworks that support complexity, and contingency, we suggest that regenerative design frameworks need to be firmed up to support the development of governance structures which can cope with the unpredictability and urgency of the climate crisis. We are suggesting that regenerative design needs to be re-framed and articulated by trans-, inter- and multi-disciplinary teams in the context of the new ontopolitics of the Anthropocene. Regenerative design goes beyond sustainability and seeks instead opportunities for re-imagining society.

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