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Changing the Nature of 'Things'

Design for Digitalisation & Regeneration

Tomas Diez and Stephanie Hankey

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Changing the Nature of 'Things'
Design for Digitalisation & Regeneration

Policy Paper for the D4S-Network

30th September 2022

Tomas Diez, Stephanie Hankey

Abstract

This paper is the first in a series of transdisciplinary explorations. Bringing together reflections from two design and technology practitioners and educators with nearly 20 years of experience working respectively in the areas of digital fabrication, and the impact of technology on society, within leading international non-profits (the FabLab Network and Tactical Tech). The texts are a synthesis of a series of discussions, built off a shared understanding of the role of design and technology and the current challenges we as societies and as a planet face. The urgency of climate and environmental challenges invites a complex reading of design in the context of digitalisation. We need to think about design as a creative problem-solving process and as a catalyst for radically changing the nature of things. The integration of digital and hybrid solutions into design practice is an opportunity to revise approaches to design, with the potential to drive the regeneration of our natural ecosystems, and not just mitigate their destruction, moving from a human-centred to a life-centred design mode.

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ABOUT THIS PAPER

This paper is the first in a series of transdisciplinary explorations. It brings together reflections from two design and technology practitioners and educators from leading international non-profits (the FabLab Network and Tactical Tech) with nearly 20 years of experience in digital fabrication and the impact of technology on society. The texts are a synthesis of a series of discussions, built on a shared understanding of the role of design and technology and the current challenges we, as societies, and the planet face.

The urgency of climate and environmental challenges invites a complex reading of design in the context of digitalisation. We need to think about design as a creative problem-solving process and as a catalyst for radically changing the nature of things. The integration of digital and hybrid solutions into design practice is an opportunity to revise approaches to design, with the potential to drive the regeneration of our natural ecosystems and not just mitigate their destruction, moving from a human-centred to a life-centred design mode. Data-driven technologies are increasingly becoming a part of many environmental and climate-related responses, from geo-engineering to ecological conservation to disaster mitigation and management, as well as being essential to the facilitation of new approaches to designing products and services. Design for digitalisation and regeneration can facilitate the move away from designing objects towards designing material flows and from designing 'things' to designing systems.

Digital regenerative design is a dynamic and evolving field of practice, and there is therefore a pressing need to approach it in a more entangled way, embedding methods that support experimentation, impact analysis, learning and iteration. For this approach to succeed, there is a need for a planetary-scale digital design intervention that entails continuous focused efforts for at least a decade and considers its effects for at least a century. If designers, technologists, communities and industries around the world are able to support and champion independent spaces for critical reflection across disciplines, as well as support design-led environments that foster open learning and iteration, then a regenerative digital design movement may emerge that can play a significant role in enabling the transition that our societies and our planets need.

The paper brings together different perspectives on the gap between the intention of how 'digitally mediated' and hybrid things are designed and the way they are realised. The dialogue, and resulting texts, are an exploration of the synergies and tensions between these perspectives: the potential and realities of digital technologies for regenerative design; the shared hopes and limitations of the implementing environment and the ways in which we, the authors, incorporate these dimensions into design teaching, theory and practice and into the continuation of our work with international non-profits over the last two decades.

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INTRODUCTION

Design is an exercise of creation. A way of improving and rethinking 'things'. But it can also be an act of destroying old ways of operating and dismissing logics that no longer serve us: a radical act of disruption and destruction, one that replaces previous ways of doing things (Fry, 2010) and a vehicle to trigger desires. This way of thinking about design is an invitation to think of design not only as a creative or problem-solving process but as a catalyst for radically changing the nature of things. The integration of digital and hybrid solutions into design practice is an opportunity to revise approaches to design, with the potential to create new processes that drive the regeneration of our natural ecosystems, and do not just mitigate their destruction. It is an opportunity to move from a human-centred to a life-centred design mode.

We, the authors of this paper, argue that the urgency of climate and environmental challenges invites such a complex reading of design in the context of digitalisation. It is time to change the nature of 'things' and how they are made. A regenerative approach to design combined with 'wise' innovation in digital technologies has the potential to make this change happen. Yet first, we need to establish a dialogue that brings a critical perspective on how it is that digitalisation can effectively enable regenerative design and what its limitations are. This perspective needs to be combined with learnings from alternative non-profit technology initiatives from the past twenty years – from the maker movement to the open data movement.

Data-driven technologies are increasingly becoming a part of many environmental and climate-related responses, from geo-engineering to ecological conservation to disaster mitigation and management. Design for digitalisation is a dynamic and evolving field of practice and therefore there is a pressing need to approach digital regenerative design in a more entangled way, embedding methods that support experimentation, impact analysis, learning and iteration. This text thus aims to join up conversations across environmental activism, design thinking and technology critique, reflecting on the need to bring together critical thinking and progressive practice across disciplines in order to start filling a gap between disparate discourses.

I HOW TO THINK ABOUT DESIGN, DIGITALISATION AND REGENERATIVE PRACTICES

The current rate of consumption of planetary resources and biodiversity loss are leading us to possible mass extinction. The last two centuries have been especially catastrophic for the loss of natural habitats of species needed to keep planetary-scale systems in balance. Repeated efforts to find common agreements to reduce carbon emissions and the depletion of natural ecosystems have failed. Not enough has been done and what is being done is not

effecting change fast enough, as evidenced in the more recent IPCC report, in which the word 'extinction' is literally present to express the catastrophic consequences of human-centred planetary living (IPCC, 2022). It has been recognised for some time that design principles following the idea of industrial progress and economic growth are insufficient for the challenges that lie ahead (Papanek, 1992), and the claims for sustainable design across sectors in the industry, agriculture, construction and consumer products in general (Mau et al., 2004) have been insufficient and unable to overcome incentives of economic growth or overpower dominant models. Moreover, unless improved, they may even exacerbate or extend the complex web of problems that industrial societies, in particular, have to solve to find a balance within planetary limits.

Precisely because design is so integral to the systems, products and services we live with, how we design and how we learn to design needs to change. Designers urgently need to think differently about their role and responsibilities in creating tools, modes and infrastructures for living. Understanding themselves not only as problem-solving but also problem-making and world-shaping. As data-enabled technologies become integrated into most systems, there is an urgent need to move away from the dominant logic of commercial product and service design and to critique and rethink dominant methodologies that lead to techno-solutionism. This urgency is especially true when designing large-scale projects and grand schemes that seek to resolve environmental, sustainability and climate-related challenges.

Why design for regeneration?

Popular design methods and models that have enabled extractive operating principles have to change. Multidisciplinary thinkers, makers and activists have long recognised the extractive and damaging patterns that fueled industrial development and the mistake of separating natural ecosystems from human beings (Schumacher & McKibben, 2010). Turning nature into a resource for human 'development' puts at risk the same prosperity promised by new technological advances that have allowed products and services to be more desirable, efficient and convenient. For over a century, design and designers have been called to be the mediators between human needs and the material ecology around them. The entangled relationship between design and ecology is not new, but it remains unresolved and needs to be reimagined at a widespread practical level.

Sustainability could not be understood without the definition from the Brundtland Commission in the 1980s: "meeting the needs of the present without compromising the ability of future generations to meet their own needs." (Brundtland Commission, 1987, p 15). However, there is much debate about whether sustainability as a goal is enough. That debate reaches from positions advocating technical innovation to enable ongoing growth (and pitching green innovation as an opportunity for both economic opportunity and environmental mitigation), to positions advocating degrowth: a global realignment of what wealth, growth and well-being mean to us as societies, together with calls to reimagine how such indicators are measured globally. Along with this realignment are different positions about what is 'fair' and 'ethical' in terms of who should make what changes in high-income and low-income countries, as well as questions of intergenerational responsibility and intragenerational burden-sharing.

Some critics of sustainability argue that sustainability in climate and environmental terms can never be achieved as demand is always on the increase (Hickel, 2020). Other critics of sustainability would claim that sustainability does not go far enough to reverse the damage already done and that is still to come (that it is too late for optimisation, and we need to move towards restoration). Others would argue that a consumer-driven way of framing the problem avoids the more difficult truth (that we are dealing with the fall out of a long-term extractive and colonial history, a path we have to change) (Ghosh, 2021). Regardless of the nature of the criticisms, what they have in common is their resistance to the idea that we can innovate in order to continue with business as usual, and their belief that it is not enough to perpetuate the status quo. Current reflections on the urgency and scale of the problems demand attempts to actively protect, support, redevelop and artificially construct webs of life that can actively decrease the ongoing rise of CO2 levels and temperatures while striving to extend and create healthy natural systems.

While a wide range of terms can be used to encapsulate different positions of the problem and the solution, for the purposes of this paper, we have chosen to work with the concept of regeneration (Raworth, 2017). We use this concept because we believe there is a need to design and aspire to create systems with an in-built logic that aims to create balanced and circular natural systems that are restorative by design and simultaneously harmonious with complex societal needs. We understand this term as one that foregrounds the need for life-centric and regenerative design principles, such as those promoted by Sarha Ichioka and Michael Pawlyn (2022). It is a term that can help society to redefine its relationship with natural ecosystems and, where necessary, (re)create or create them, while simultaneously taking into account issues of equity, justice and imbalances and abuses of power.

Regenerative design offers a systemic view, one that helps in understanding problems and responds to them through interventions into parts of a complex set of relations between resources to be exploited and the outputs produced with them to support human life on earth, as outlined in Figure 1. In regenerative design, everything is connected. Its origins can be linked to permaculture design (Mollison, 1997) or bioregional development (Glotfelty & Quesnel, 2015), introducing a more ambitious goal of understanding design as a process of creating interventions into systems that are shaped by a web of actors and the exchange of energy and information between them. Because humans have dramatically assisted in the deterioration of many of these life-support systems, the need for restorative, reinforcing, responsive and re-energising principles by design is not merely an option; it is a necessity. A shift that challenges the existing models of production and consumption, one in which externalities that are often left out of the equation become central, starting from evaluating and validating the logic and impact of a 'thing' and how it feeds into and supports a greater system of flows and interactions.

The potential strength of regeneration as a design end-goal is that it takes on board de-growth, anti-extractivist and anti-colonialist considerations by seeking a more ambitious approach to design and decision making. It offers an approach to making things that strive to feed into an interconnected and interdependent set of systems with the potential to restore and generate positive feedback loops. This approach can extend as far as artificial coral reefs and carbon sequestering technologies, through more efficient local regenerative systems to deal with the practicalities of daily production, consumption and waste of essential commodities such as food. Some of these regenerative solutions

can rely on changes to natural flows within their design and engineering logic, such as agricultural, landscape and building designs, but many are increasingly designed to rely on data-driven technologies to develop new ways of managing, generating and creating alternative systems. For this reason, digital and data-driven design is becoming integral to regenerative design principles, and therefore, finding new ways of designing not only regenerative but also hybrid digital things is an essential part of the challenge ahead.

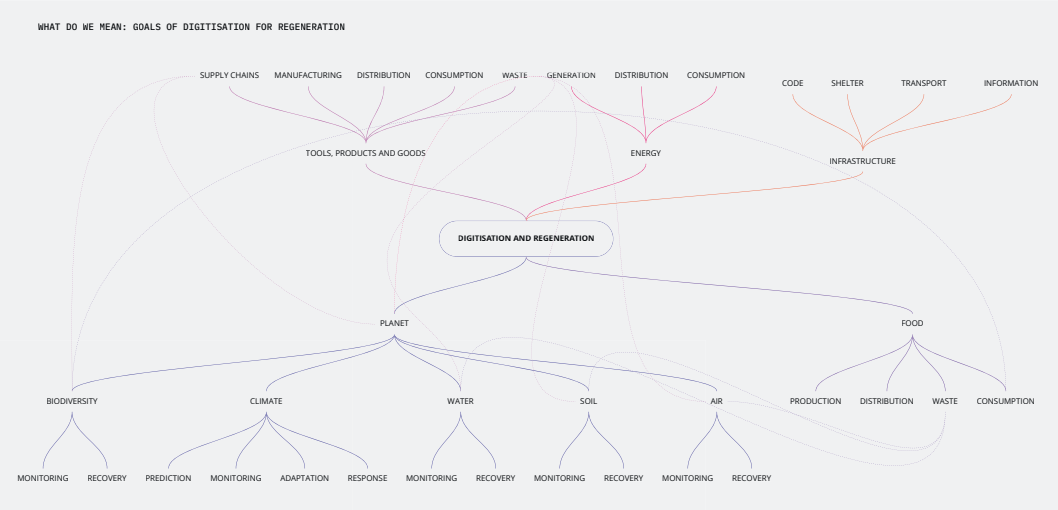

Figure 1: Overview of planetary-scale boundary elements to be considered in design for digitalisation and regeneration

Thinking critically about design

Design has great power, not only in the solutions it has the potential to conceive of and realise and the systems it can imagine and create but also in the behaviours it invites, the habits it forms and the norms it sets. As the design theorist, Tony Fry states, "Whatever we say design is, it is also direction, force, power and imposition" (Fry, 2010, p. 6). It, thus, holds great potential to develop solutions to some of the challenges that lie ahead. But, as stated before, it can also perpetuate inequities and exacerbate and extend systemic problems and unsustainable modes of living. This conviction is held by advocates of 'Transition Design' and design theorists such as Cameron Tonkinwise, who see design as not only having great potential but also a significant responsibility (Tonkinwise, 2015).

The act of design creates the rules and processes of how things work (code as law, modes of ownership, notions of value, etc) and how we, as humans, communities and societies act, adapt and develop in response. Design has the potential to change not only a product or a service but also the behaviours and cultures that grow up around that 'thing' and ultimately the way we, as individuals and societies, operate (Willis, 2018). Design can shift the way things function and the things we want and need to make in the future. In this sense, design is not merely facilitative but can be instrumental in shifting between the status quo and new habits, the way things are and the way things ought to be, and can even be proactive in closing the gap between product and policy. More specifically, shifts in design logics and priorities can act as complements to policies that serve to set standards, incentivise

best practices and penalise malpractice. If picked up by the creative industries, the market and the communities they serve, design can potentially go even further, faster than policy changes. It can initiate momentum, setting trends and establishing best practices for creating digital solutions that are, from the outset, 'regenerative-by-design'.

Why does the way we design need to change?

In times of need for collective action, it is essential that we, as societies, producers and consumers, move away from convenient, cheap products that have high hidden costs, both environmentally and socially, and create a shift from 'individual benefits' toward 'communal benefits'. We, as a design discipline and as those who engage in practices, need to ask not only how products and services can be designed in a more regenerative way but also how we can incorporate the lessons learned over the last decade of digitalisation to create different digital design logics and methods of world-making.

The mantra of convenience (Wu, 2018) and the goal of meeting individual needs, efficiency, at the correct scale and at low cost, for both the producers and consumers of products and services, have dominated design-thinking of both physical and digital products. A culture of consumerism and services as 'free', cheap, convenient and disposable has prevailed. Much, however, has been written in recent years about the true costs of these products and their extractive nature. These hidden costs can be seen, at the individual level, in the context of digital platforms, such as the hidden costs of personal data in return for 'free' services (Zuboff, 2019). And at the planetary level, they arise in product design, such as the hidden material costs of cheap, convenient designs (Braungart et al., 2002). Equally, recognition is growing that dominant forms of capitalism rely on 'cheap nature' and the logic of 'cheapening' to make profits (Moore & Patel, 2017). Capitalism pays neither the true cost of its extraction and labour nor the impact of its emissions, and this logic forms the design of the products and services we, as consumers, use. It is important when designing digital regenerative solutions that these models are not extended or reproduced.

The age of the 'I' period in design for both consumers and producers has led to a wide range of marketable and profitable yet inequitable practices and ways of living. It has focused decision-making on the needs and priorities of individuals as opposed to those of societies and ecosystems. This focus has spread from design into policy – giving regulatory priority to benefits to 'consumers' rather than benefits to 'citizens or communities' or 'natural systems'. This has been instrumental in shaping Western commerce and product development since the 1980s, leading to the creation of market monopolies and the transformation of entire regions, towns and neighbourhoods, to their detriment. From the loss of industrial sites in cities in Europe and the Americas to the urbanisation of China, consumerism and globalisation have cornered the productive capacity of regions and citizens to extremes. The design logics emerging from this colonial and Western context have been extended into digital design, with a similarly individualistic mindset, prioritising private gain over public benefit with a high level of hidden costs. Ultimately, these market logics and the designs that have enabled them have led to a small number of global companies accruing extraordinary wealth and control of insights and therefore markets.

In designing digital solutions for environmental needs, we need to move not only toward an 'energy transition' and 'ecological reparations' but also toward a 'just transition'. A

'just transition' requires recognition that social and political issues of power, equity and inclusion are a necessary part of the change to be worked through if systemic problems are to be resolved. Current industrial designs, especially those that prioritise scale and mass production, have often relied heavily on extractivist tendencies and mechanisms where the true cost is hidden – not only for the planet, as outlined above, but also for communities and individuals (Papanek, 1992). Understanding questions of justice and equity as integral to future solutions is essential. Answering these questions requires an effort to find ways of simultaneously working on a digital, social and environmental transition without privileging one of those concerns over the other. While there are limits to what digital and regenerative design can do – especially when broader political, social and economic changes are at play – it can still carry some of the responsibility and go part of the way toward regeneration. If designed for regeneration and just transition, the efficiency, ubiquity, synchronisation and abundance that digitisation can offer can open up new potential paths for planetary regeneration in some important areas, from design principles that overcome dominant extractive dynamics to the global articulation of local efforts driven by situated communities.

II DIGITALISATION DESIGN OPPORTUNITIES AND CHALLENGES

Design has the potential to take place at multiple scales (from the local to the global) and in areas that range beyond products, technologies and services to impact business development and strategies, and also beyond legal frameworks and public policies. In this context, open sharing, evaluating successes and failures and a learning-based culture are essential elements in allowing impactful design practices to emerge. Increasing attention is being paid to the importance of technology transfer in the context of climate change, and this attention creates an additional opportunity for rethinking digital design approaches. Attempts to share and scale-up technologies need to have an open and decentralised format and a culture of multi-directional regional sharing from the outset. If they are to work, technology transfer initiatives need to include honest reflection, not only on the opportunities but also on the challenges. Critical reflection needs to be embedded in new design methods and models and built into a more radical rethink in approaches. This transition needs to happen not only in terms of current practice but also within design education in order to provide a new generation of designers and engineers with the knowledge, skills and methods they need to build a more regenerative future.

Many innovations are gradually being adapted to existing systems at varying scales – from the production of goods to advances in urban mobility. However, it is early stages in their integration and a lot is still to unfold about how these innovations will work and what impact they will have. Questions must be covered about how these solutions become financially viable in the long term, what happens to them when they re-scale, how they may be co-opted or become embedded in larger more problematic systems and what kind of external pressures they will face in terms of competition and market forces.

Opportunities for design and digitalisation

Ecologically driven design goals have played a role in spurring design innovation and creating new opportunities for digitalisation and sustainability over the last decade. Politically, economically and culturally, some of these shifts have only been popularised or scaled up due to external factors, such as shifts in mobility patterns due to the pandemic or shifts in material flows due to ongoing disruptions to supply chains. The extent of, and the motivation for, change vary from country to country, yet digital technologies are increasingly seen as desirable facilitative tools for transition: helping to improve adaptation to challenges and mitigate them, find solutions and reduce negative impacts (Lange & Santarius, 2020).

Digital design for regeneration includes creating digital technologies that increase efficiency and optimisation, making products and services that are less wasteful by design, maximising the effectiveness of material flows and creating new economic opportunities. These design goals have led to innovations in self-learning and self-managing technologies as well as to adaptive decision-making and automation technologies, creating more efficient systems, such as those in the field of sustainable energy consumption. Similarly, shifts in value-based models and principles for design have led to new systems and logics. For example, the concept of 'dematerialisation' (Kramer, 2012) has already led to the rethinking of some products, such as documents and cultural objects like books and music, moving them from 'atoms' to 'bits'. More can be done to 'dematerialise' objects and services, including rethinking material elements along the supply chain. Figure 2 shows a summary of some of these possible changes in the production and management of goods and services as well as material flows.

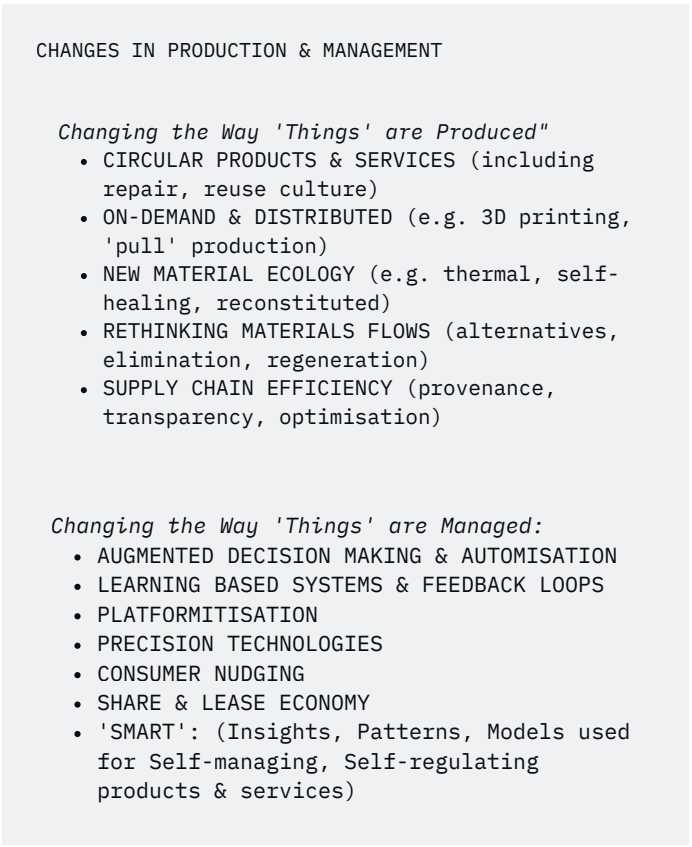

Figure 2: Summary of dominant trends in digitalisation for regeneration

The 'sharing economy' has an equally strong environmental impetus. Car sharing is a case in point, not only aiming to make urban transportation more efficient, convenient and low-cost but also intending to reduce pollution and emissions and the amount of material production, or how many 'things', we collectively need to begin with. The beneficial impact of experiments in urban sharing-based systems is still being debated. Equally, their unintended consequences are still being worked through, such as the corrosive impact of the Airbnb culture on local communities in popular neighbourhoods. While the sharing economy attempts a move from a digital 'I' culture to a digital 'we' culture, and some services achieve this, others struggle and can unintentionally create new forms of digital exclusion.

In parallel, circular design is going through a period of innovation and scaling, built on a set of principles that aim to increase cultures of maintenance, repair and reuse. Several examples are already scaling up and being widely used – the rise in popularity of second-hand clothing platforms among consumers and a move towards recycled material used by fast fashion are examples here. Digitalisation can create opportunities in the design process to improve the management of materials, facilitate opportunities for maintenance and repair, extend the life-cycle of products and facilitate their exchange, thus ultimately reducing waste. Some approaches to circular design go further, proposing an ideological shift away from current dominant Western models of ownership towards products as services that are never owned but leased or rented, from high-end outdoor clothing to washing machines. These methods require cultural shifts that can be challenging, including shifts in our relationship to 'property' and the ownership of 'things' along with trade-offs that create increased dependencies and lock-ins to certain producers or vendors. Such frictions need to be considered in the design process and in what factors need to be accounted for in how 'things' are conceived and socialised when designing products and services and when seeking to popularise and normalise them.

Developments in technological innovation, such as data-driven analysis and decision making, and advances in infrastructure, such as sensors, batteries and wireless technologies, have played an integral role in the development of emerging opportunities. Going beyond first-stage transformative digitalisation design, such as those examples outlined above, these emerging technologies promise to provide ever more potential. The logic of 'insight-driven', 'self-learning', 'precision-based' and 'adaptive' ways of operating has emerged from advances in big data, machine learning and artificial intelligence and is gaining popularity in how materials, products and systems could become potentially 'smarter' and better managed. Data-driven technologies aim to either increase automation and therefore efficiency or enable the augmentation of human decision-making processes with more accurate data. Similarly, behavioural insight technologies can potentially help producers acquire better insights into markets with the hope of reducing waste. Innovations in infrastructure and industry models are changing the way some 'things' are designed, including creating new opportunities to rethink the supply chain. Approaches to materials and their flows are gradually changing, along with efforts to reimagine and rethink the way 'things' are designed in a digitised world. With these shifts, designers need to learn new skills, such as how to design dynamic, shape-shifting systems.

At this stage, more work is needed to resolve which solutions are truly moving regeneration agendas forward and which have unintended consequences or even extended challenges,

such as rebound effects. Rigorous, open and results-based reflection is needed to share learning about which designs truly advance issues and therefore should be built on and scaled up and which do not. As well as which methods for scaling are the most appropriate, such as local replication and horizontal scaling, also referred to as 'scaling out'. Digitalisation must play a fundamental role in restoring planetary-scale systems. Yet there is still so much to be tested, learned and shared about how to move beyond the status quo, and this knowledge needs to be fed back into the design process. Integrating digital and data-driven technologies into systems, infrastructures and 'things' to make them more regenerative is still at the beginning of the process of innovation. Within this process, open learning and sharing in technology transfer are essential, and initiatives to do so require long-term inter-regional access and support in order to realise and expedite the sharing of knowledge and develop strong communities of practice.

Designing for emerging opportunities

A particular set of emerging technologies on the horizon holds a range of opportunities for reimagining the design process linked to modes of production, knowledge creation and distribution mechanisms. With the widespread adaptation of more advanced and complex technologies such as artificial intelligence, digital fabrication, distributed ledgers and synthetic biology, to name a few, the potential for changing the nature of things has increased exponentially, as have the risks associated with such technological integration. These emerging technologies can, potentially, allow communities to extend their capacity and systems to handle more complex amounts of data, not only individually but also collectively. With these technologies, it is possible to envision access to new fabrication technologies that can support communities to increase their resilience, make better use of their local resources and reshape their relationship with their environment. In principle, collaboration on a larger scale is possible thanks to the introduction of tools for coordinating efforts, validating contributions, attributing authorship or distributing value. Additionally, the recreation of synthetic materials that do not compromise wildlife or depend on fossil fuels could enable designers to rethink the source of materials needed to build every single object, device or product around us.

Trends in emerging technologies that hold significant potential, yet require further testing and development, along with robust guidelines for ethical development and deployment, include:

- → Augmented intelligence
- → Automation and precision technologies
- → Facilitation of collaboration at scale
- → Distributed production capabilities
- → Transformations in material ecologies
- → Innovation in natural systems restoration technologies.

Many of the principles behind the tools, the technology roadmaps and knowledge could shape the future of design, manufacturing and, therefore, the next industrial revolution could affect massive change and transform the current paradigm from within. Yet they are still part of the extractive paradigm of production and consumption, and the change they could facilitate depends on how they are deployed. Accordingly, distributive and regenerative design principles need to go hand-in-hand with experimentation with emerging technologies in the field and beyond the lab, in an independent and alternative context, allowing for learning from interactions with communities and the environment and enabling the creation of feedback loops for incremental iterations through open source collaboration.

These different elements need to come together and be balanced. Figure 3 below represents a summary of some of the current elements to be considered in rethinking design methodologies for regeneration. As with all figures in this text, these are not intended to be exhaustive but rather a starting point for thinking about the balance of elements in the design process.

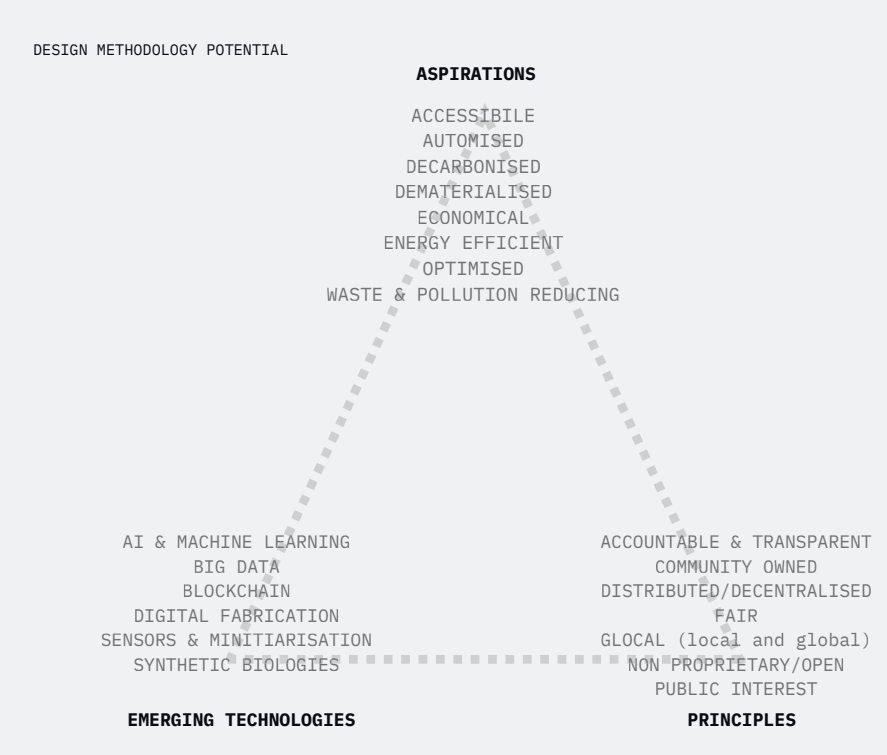

Figure 3: Overview of Drivers for Innovation in Emerging Technologies and Digital Design for Regeneration

Challenges for digital design for regeneration

Digitalisation has impacted our social lives, how we learn, how we work and how we move around and manage our lives, and this impact has been identified as an opportunity for decarbonisation. The shift in work, consumption and mobility habits during the pandemic in 2020/21 in many parts of the world has been seen by some as a test case for the potential of this transition. Digital technologies have already played an important role in transforming the industry behind our planetary model of production and consumption (Gershenfeld

et al., 2017). They have enabled production processes to become more efficient, more informed, more connected and, in general, contributed to improving the quality of human life by helping improve products and services for consumers, especially in the Global North (Negroponte, 1996). However, these benefits have not come without costs and trade-offs, and these are increasingly forming themselves as design challenges.

The shift to digital has brought extended costs on a planetary and temporal scale, from social and political conflicts over territorial control of natural resources to the breakdown of the balance in natural systems (Moore & Patel, 2017). While digitalisation contributes to the dematerialisation of certain processes, it still requires an important amount of material needed to deliver its function (Erwitt & Smolan, 2012). This need arises from several sources – manufacturing the electronic components of digital technologies utilises a complex supply chain of minerals, important amounts of energy are required to power the computer servers needed to run services in the cloud and process data, large amounts of e-waste are generated from the fast pace of development – and these produce externalities such as social conflicts derived from political control over territories of exploitation (Arboleda, 2020). Moreover, digitalised consumption patterns can be extremely resource-intensive, as massive annual increases in data processing, transfer and storage require increasing digital infrastructures (i.e. data centres) and energy in the use phase. In a context of increased pressure from the current model of production on ecosystems and societies, we must review how we also design the technologies themselves – from the resources they require to the energy they use and the plastics and electronic material waste they create.

Alongside reflections on the material costs of technologies, the number of concerns related to 'the tech industry' itself are widespread and increasing. While current problems may seem specific to the tech industry, in particular solutions that involve extracting and analysing large amounts of data, these challenges will inevitably need to be considered in the design of digitalized regenerative solutions. These issues are widespread, yet by way of summary for the purposes of this paper, they include:

- → Inherent challenges of bias and fairness in data-driven technologies and their design (Costanza-Chock, 2020; O'Neil, 2017);
- → Concerns over the ethics of data-driven technologies and AI (Crawford, 2021);
- → The hazards of techno-solutionism (Morozov, 2014);
- → The unprecedented accumulation of knowledge, wealth and power that platform economies create (Srnicek, 2017; Khan, 2017);
- → The rise of digital neo-colonialism (Kwet, 2022);
- → The polarising impact of information and communications technologies on our media and our democracies;
- → Unresolved political and market forces around issues of privacy, security and surveillance capitalism (Zuboff, 2019).

Responses to these challenges tend to centre on proposed changes to policy making. Governance and regulatory changes (such as the Digital Services Act in Europe) are certainly necessary to resolve some of the worst problems. However, there is growing recognition from a wide range of sectors, including the tech industry itself, that changes in the design process are a necessary part of creating more responsible products. And there are increasing examples of how effective this can be: privacy-by-design, security-by-design, equity-by-design, personal AI, etc.

The challenges that lie within the tech industry and the solutions that are slowly being identified at a regulatory and a design level have not yet been explored in the context of digitalisation and sustainability. However, if data-driven technologies are deployed at a large scale by industry, similar challenges will inevitably have to be addressed in the design process. For example, through large-scale efficiency and energy-saving initiatives, huge amounts of personal data will be aggregated and analysed and therefore anonymity and privacy will become critical challenges. Similarly, data of high public interest value, such as weather, pollution or eco-system data, will be held by proprietary companies and will therefore need to be negotiated for by researchers, nonprofits and governments. Equally, environment and climate justice dynamics will be amplified through data-driven technologies and questions of bias and digital colonialism will need to be navigated. Successful models of digital design for regeneration will need to incorporate these challenges and seek solutions in the development process.

Ultimately, in the design process, we need to find ways to embrace not only the opportunities that the process of digitalisation brings but also the problems they extend. Understanding this need is an essential step in designing stronger and more robust solutions for the future, as is anticipating challenges within the creative, engineering and deployment process as central to design boundaries.

Tools for thinking and acting

The task for design is not to be blind to the opportunities technology brings nor to be blind to its challenges but rather to find a way to navigate the complexities it amplifies and the entanglements it creates with, and through, design. There is a need to develop a strong position that recognises both the potentials and the limitations of design solutions, seeing them as both problem-solving and problem-making, and technologies as amplifying both the enabling and prohibitive contexts from which they emerge. Moreover, the tensions that emerge from these stresses and strains are essential elements, which we must learn to work with and around. Such tensions are needed to enrich critical reflection, which should turn them into creative forces (Disalvo, 2015).

Ultimately, a business-as-usual approach from government, corporate and citizen perspectives will not be sufficient to solve either the problem of planetary health or the challenges digitalisation brings. More importantly, we need to find radically transformative solutions through experimentation and learning in the real world, ones that bring the triple challenges of digitalisation, decolonisation and decarbonisation together. The changes that need to take place are systemic and thus require cultural, social, political and economic shifts. Simultaneously, they also require changes in design methods and design processes, where many of the decisions about a product, object or service are

made. If this duality is recognised and connected with a change across a product or services ecosystem and supported by an enabling environment, then it is possible to begin to imagine a more regenerative planetary living, one that enables constant transformation and invites ongoing innovation.

A reflexive culture of design can enable the transition from designing objects to designing material flows and from designing 'things' to designing digitally enabled systems. By defining new design methods, practices and learning spaces that rethink current models, products and services, designers will be able to combine the best in digital and in regenerative design. New methods should be built on principles that prioritise collective action efforts and mitigate both environmental and social impacts, fostering cultures of care. The conditions for learning and open innovation are needed on different scales, including hyper-local scales of neighbourhoods in cities, in smaller rural towns or in hotspots of collaboration between like-minded enthusiasts across geographic constraints. Society needs to be involved in the co-design and co-creation of these new solutions, and they need to be adaptable to the diversity of the planet, with shared protocols for the production of exponential impact (Diez, 2012).

Designing enabling environments for transitioning to regenerative technologies

Overall, digital design for regeneration has great potential for resolving a wide range of environmental challenges and for resetting how large-scale infrastructures and systems can work. Increasingly, we see the emergence of initiatives that attract investment from governments, large-scale, investors, corporations and communities, who are in turn setting new precedents for what is possible. This is an essential first step, with a level of readiness and openness across design, engineering and technology fields and the creative industries, and increasingly within large companies. Yet more needs to be done to extend, replicate and learn from existing initiatives – both successes and failures – and to move from innovation to learning, iteration and widespread transformation. An enabling environment for practitioners, decision-makers and leaders is an essential part of this process and needs to be navigated with a range of values in mind.

A transition to regenerative forms of digital design is possible, yet the dominant paradigm still prioritises profit and control over social and environmental values. Systemic change cannot be enabled through isolated efforts in writing extensive policies for regulation or theoretical approaches to design and sustainability, or by relying on market incentives. Instead, we, the authors of this paper, advocate the creation of experimentation spaces in which novel approaches to regulation, incentives, theory and practice in deploying disruptive technologies can find the minimum conditions for prototyping, testing and iterating through design interventions in the real world. Such enabling environments need to provide designers with the right amount of freedom and limitations to foster creativity and innovation while keeping externalities as controlled as possible. Some examples of enabling environments can be seen in large research laboratories of the past. Concentrated efforts to understand, develop and study the design and management of planetary-scale systems have existed since the 1970s, as have other focused efforts to develop breakthrough technologies. For example, Bell Labs in the US were instrumental in advancing computer

and communication technologies that paved the way for the development of the Internet, setting a precedent for how this could be done in other fields.

More recently, the European Commission has launched ambitious programmes through its Horizon Europe initiative, providing participating research institutions, governments and civil society organisations with resources and innovation frameworks to advance the implementation of novel technologies, methodologies and approaches that aim to foster more sustainable urban living, as well as prototyping and testing on the ground, with industry or in neighbourhoods in cities. The Green New Deal aims to concentrate these efforts and calls for a more ambitious approach to transition to a more sustainable model of development for Europe.

Even more recently, the New European Bauhaus initiative has extensively promoted a new framing of design. This framing is based on three main principles: "beautiful, sustainable, together", looking toward an ideal of design, based on 100-year-old principles of the Bauhaus School. While this is a great effort celebrating the Bauhaus legacy, it is not without its critics, who are concerned that, despite the stated principles of the initiative, a new Bauhaus rooted in the same principles as the old one could replicate not only its benefits but also its negative consequences, some of them related to inclusivity, sustainability and equality (Khalidi & Vázquez, 2021). This effort may succeed in supporting the transfer of knowledge between some universities, research institutions, industries and governments. However, the interconnectedness of challenges at the planetary-scale demand more radical, risk-taking approaches to design research, learning and innovation, just as the Bauhaus School did at the beginning of the 20th century. The Bauhaus emerged as an enabling environment in a moment of convergence of crisis and technological advances, as a new school of thought (and action) for design, and it is this aspect of the legacy of the Bauhaus that should be celebrated. One hundred years later, the aggregated complexity of our time and the addition of new universal rights, technological paradigms, political agendas and, in general, much greater human capacity should invite us to go further in imagining more forward-thinking and advanced design approaches to such challenges. Some of the critical and unresolved issues that should be included are

Reimagining the relationship between digital design for regeneration and business:

- → Transforming priorities from market satisfaction to planetary regeneration with innovation in business models that move towards ethical, equitable and sustainable best practices;

- → Reframing design models away from a paradigm of individual needs, low-cost, disposability, convenience and up-scaling and towards a paradigm of collective action, durability, adaptability and cultures of care, designing for 'society-as-user';

- → Reimagining intellectual property models, reevaluating what constitutes public good technologies and public interest data and revisiting investment models and incentives.

Shifting dynamics of learning and dominant modes of practice:

- → Evolving the Western and Global-North-driven narrative of design and technology, creating spaces for intercultural, intergenerational and interspecies dialogue;

- → Promoting and extending design practices that recognise the potential of multi-directional technology transfer and knowledge sharing, creating a fertile ground for innovation exchange (South-North, South-South, etc);

- → Supporting the open source experimentation and deployment of radical digitally driven approaches to small-scale, decentralised, alternative, replicable and local or worker-owned initiatives.

Defining the protocols for a planetary-scale approach to digital design for regeneration:

- → Facilitating impact-based learning and R and D of digital technologies that can enable and ascertain the efficacy of digital technologies that reconfigure, manage, monitor and enable regenerative systems;

- → Developing and expanding methods of design for regeneration that address a range of digital issues including privacy, data ownership, bias, open source and creative commons principles, transparency and accountability as well as the problem of energy use, resource extraction and electronic waste generated by the technologies themselves;

- → Enabling learning across disciplines and fostering constructive and contextualised critical thinking approaches to design that develops systems-led and consequential models, focusing on the full life-cycle and impact of a product or service, understanding them as hyper-objects in larger systems (Morton, 2013).

To forge a way toward these principles we, the authors of this paper, propose a planetary-scale digital design intervention that entails continuous focused efforts for at least a decade and considers its effects for at least a century. Design schools such as ULM, the Bauhaus, and technical innovation universities such as MIT and Stanford University, have been, and are, influential in how societies define and transfer their values. The influence from these institutions on technology and design practices emerged from continuous, consolidated and concentrated efforts supported by national agendas, as well as from economic interests. In finding an approach to create momentum towards regenerative practices in digital design, we advocate investment in alternative mechanisms for innovation, learning and discovery.

We propose exploring the potential of distributed yet coordinated structures that create alternative sites of innovation, learning and experimentation. These structures would be locally situated interventions that enable a transition towards regenerative digital design as standard practice. This transition would entail bold investment and efforts from different sectors, as well as the definition of protocols for global collaboration and exchange, while maintaining the need for local diversity. A connected network of situated interventions could allow for a response to some of our most common urgent issues, creating new potential for innovation to come from anywhere, for multi-directional knowledge sharing and for the

spread of effective solutions that can be rapidly built upon, replicated and adapted in different contexts. To respond to the urgency of our multiple interconnected planetary crisis, these enabling environments could and need to be designed to train and form at least 10,000 new innovators, makers and change-makers. While being independent, to leverage their impact, these centres need to also connect with ongoing efforts within academia, industry and government toward action-based research, ethical and conscious entrepreneurship and agile and responsive policymaking. If designers, technologists, communities and industries around the world are able to support and champion independent spaces for critical reflection across disciplines, as well as support design-led environments that foster open learning and iteration, then a regenerative digital design movement may emerge that can play a significant role in enabling the transition that our societies and our planets need.

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